ISSN : 0021-3721
Volume : 48
Number(2) : 2014

JNKVV
Research Journal
(May - August, 2014)

Volume 48 Number 2
2014

Contents

Issued : 07 September 2014

Available on website (www.jnkvv.nic.in)

JNKVV Res J 48(2): 120-135 (2014)

Advances in the cultivation technology of tropical mushrooms in India

M.P. Thakur and **Harvinder K. Singh***
Director Extension
Indira Gandhi Krishi Vishwavidyalaya 492 012 (Chhattisgarh)
E mail: mp_thakur@yahoo.com
*Department of Plant Pathology
College of Agriculture, Raipur
Indira Gandhi Krishi Vishwavidyalaya 492 012 (Chhattisgarh)
E mail: harry.0452@gmail.com

Summary

Mushrooms are the fruiting bodies of macro fungi devoid of leaves, and of chlorophyll-containing tissues. Yet, they grow and produce new biomass year after year. Mushrooms are very nutritious and serve as food, tonic as well as medicine. They are rich in crude fiber, proteins and good vitamins but low in fat and calories. They possess multi-functional medicinal properties. Mushroom cultivation has great scope in India because of the cheap and easily available raw materials needed for this activity. Mushroom farming is a business which requires precision. It is friendly to the environment and is a labour intensive activity. It serves as means of generating employment, particularly for rural women and youths in order to raise their social status. It also provides additional work for the farmers during winter months when the farming schedule is light. It is hoped that the advocation of mushroom farming will become a very important cottage industry activity in the integrated rural development programme, which will lead to the economic betterment of not only small farmers but also of landless labourers and other weak sections of communities.

The production of tropical mushrooms like oyster (*Pleurotus* spp.), paddy straw mushroom (*Volvariella volvacea*) and milky mushroom (*Calocybe indica*) by utilizing locally available substrates viz., paddy straw, wheat, soybean, cotton wastes and lignocellulosic wastes have great potential to exploit and convert it in to a highly nutritious food within less period of time per unit area. Tropical mushroom production in India is also becoming very popular in almost all the states of the country having temperate, sub tropical and tropical climate. The production of oyster mushroom in India is estimated to be around 15-20,000 metric tonnes. However, the production of paddy straw and milky mushroom is about 10,000 tonnes each. Paddy straw (*Volvariella volvacea*) is the sixth mushroom of the world in terms of production. Its production is very much popular in state of Orissa. Low cost house for growing paddy straw mushroom in Orissa has been developed. Milky mushroom (*Calocybe indica*) is a relatively new introduction from India to the world mushroom growers. Its robust size, sustainable yield, attractive color, delicacy, long shelf-life and lucrative market value have attracted the attention of both mushroom consumers and prospective growers. Its cultivation is now spreading very fast in many states of the country. In the present paper, an attempt has been made to review the production scenario and advances in cultivation technology of tropical mushrooms with possible constraints in further expansion of mushroom industry in the country.

Keywords: Tropical mushrooms, oyster mushroom, paddy straw mushroom, milky mushroom, production technology.

Mushrooms, also called 'white vegetables' or 'boneless vegetarian meat' contain ample amounts of proteins, vitamins and fiber apart from having certain medicinal properties (Thakur and Singh 2013). Mushrooms contain about 85-95% water, 3% protein, 4% carbohydrates, 0.1% fats, 1% minerals and vitamins (Tewari 1986 and Thakur 1998). It contains 19-35% protein on dry weight basis as compared to 7.3% in rice. 13.2% in wheat and 25.2% in milk (Chang and Miles 1988). It is rich in essential minerals and trace elements (Chadha and Sharma 1995). Mushroom contains 20-35% protein (dry weight) which is higher than those of vegetables and fruits and is of superior quality. Mushrooms are now getting significant importance due to their nutritional and medicinal value and today their commercial cultivation is being done in

more than 100 countries of the world. At present, world production is estimated to be around 27 million tonnes including 21.54 million tonnes by China alone (Li, 2012) and is ever increasing. Among various methods of cultivation, mushroom cultivation is the most economical and relatively short biological process for the biotransformation of organic materials into protein rich food (Chiu and Moore 2001; Martinez-carrera et al., 2000). The production of tropical mushrooms viz., oyster mushroom (*Pleurotus* spp.), paddy straw mushroom (*Volvariella volvacea*) and milky mushroom (*Calocybe indica*) utilizing locally available substrates viz., paddy straw, wheat, soybean, cotton wastes, coffee waste, water hyacinth, tree saw dust, sugar cane bagasse, wild grasses and various categories of refuse and lignocellulosic wastes have great potential to exploit and convert it in to a highly nutritious food within less period of time per unit area (Singh et al. 2011). Cotton wastes and sunflower stalks are examples of agro-industrial wastes which are of limited/no economic use. Cotton waste is a by-product of the textile industry. In recent years, cotton wastes have become popular as substrates for straw mushroom (Chang 1982) and oyster mushroom (Hamlyn 1989) cultivation.

Oyster mushroom (*Pleurotus ostreatus*) occupies third position in terms of production led by China (Li 2012). In India, it is largely adopted by the women of the Self Help Groups in a small to medium scale. It constitutes an important source of their income. It is followed by several NGO's with buy back purchase guarantee. Its production in India is also becoming very popular in almost all the states of the country having temperate, sub tropical and tropical climate (Thakur et al. 2011). Paddy straw mushroom (*Volvariella volvacea*) is another mushroom dominating whole of Odisha and available in every nook and corner of the state. It is the sixth mushroom of the world in terms of production (Ahlawat 2007). Paddy straw mushroom is a quick growing fungus, which can be harvested on 12th or 13th day. Low cost house for growing paddy straw mushroom in Orissa has been developed. Outdoors cultivation of paddy straw mushroom under trees like coconut, casurina, cashewnut, etc. is very much successful during summer (Mohapatra 2013-Personal communication). Odisha is the only state where paddy straw mushroom is grown commercially for nine months in a year involving common people. The paddy straw mushroom is successfully cultivated in the plains of Kerala throughout the year where the temperature ranges between 28-32ºC (Prakasam 2012). In India, at present, four mushroom varieties viz., *Agaricus bisporus*, *Pleurotus* spp., *Volvariella* spp. and *Calocybe indica* have been recommended for the year round cultivation. The Indian subcontinent is known worldwide for its varied agro climatic zones with a variety of habitats that favour rich mushroom biodiversity (Verma et al. 2003; Thakur 2005; Thakur et al. 2005; Thakur et al. 2006 and Thakur et al. 2011). Among, tropical mushrooms, oyster mushroom, paddy straw and milky mushrooms are very much common in cultivation in India whose details about the production scenario, production structures, type of cultivation, method of cultivation followed in different parts of the country would be discussed in the present article. An attempt has also been made to review the possible constraints in further expansion of mushroom industry in production of tropical mushrooms in India.

Indian Scenario of Mushroom Production

In India, the total production of mushroom is about 1,13,315 tonnes (Wakchaure 2011), of which major share (80%) goes to button mushroom and that too by a single unit i.e. Agro Dutch, Lalru (Patiyala), Punjab producing around 50,000 tonnes/annum (Verma 2013). Rest of the share (20%) goes to tropical mushrooms such as oyster, paddy straw and milky mushrooms.

Oyster Mushroom Production

The seasonal production of tropical and subtropical species of oyster mushroom in States, such as Tamil Nadu, Karnataka, Kerala, Maharashtra, Andhra Pradesh, Rajasthan, Chhattisgarh, Bihar, Assam, Jharkhand and NEH, as well as the industrial unit, M/s Zuari Agro-Chemicals Ltd. in Goa, has risen to about 15-20,000 TPA (Verma 2013, Thakur and Mohapatra 2013). Obviously, the extremely large number of these seasonal units, although each small in size, has had an enormous impact on mushroom output and diversity in India. Oyster mushroom is now produced in several states of the country in a small to large scale (Table 1).

Table 1. Tropical mushroom production in India in 2013 (tonnes)

Mushroom species	Yield (t)
Oyster mushroom	15,000-20,000
Paddy straw mushroom	10,000
Milky mushroom	10,000

Source. Verma (2013), Thakur and Mohapatra (2013) and Krishnamoorthy and Amutha (2007).

In Madhya Pradesh, it is grown by SAMUHA called Satpuda Mushroom Utpadak Sahkarita Maryadit, Sukhtawa, Hoshangabad for the last 25 years involving 250 rural women whose production is nowhere documented. It has been attempted to collect the primary data on sale of mushroom spawn directly from SAMUHA office based on their audit sheet and presented in a Table 2.

Similarly, the data collected on dry oyster mushroom is presented in Table 3. It is mandatory for each women to dry the fresh mushroom produced using prevailing sunlight and bring it to the main centre of PRADAN at Sukhtawa (Hoshangabad) where they get the price of dry mushroom immediately after deducting all the cost price maintained in a yellow card like BPL card. The basic inputs like oyster mushroom spawn, polypropylene bags, bavistin, formalin, nuan, plastic rope etc. are given to 250 women of the SAMUHA through their well developed distribution system at the doorstep of each village women. These women then grow oyster mushroom in the close supervision of SAMUHA officials. Upon harvesting and drying, it is essential for each one of them to bring dried mushroom to the SAMUHA office and get the price of the dried product. This system of SAMUHA is wonderfully operating and 250 women are very well organized and getting handsome amount in a crop of three months.

Table 2. Spawn production of oyster mushroom by Satpuda Mushroom Utpadak Sahkarita Maryadit, Sukhtawa, Hoshangabad in Madhya Pradesh during different years (Kg)

Years	Spawn Production	Amount (Rs.)
2004-2005	613	16,577.00
2005-2006	-	-
2006-2007	-	-
2007-2008	3793	1,28,963.00
2008-2009	5443	1,85,095.00
2009-2010	4109	1,39,716.00

Source: Satpuda Mushroom Utpadak Sahkarita Maryadit, Sukhtawa, Hoshangabad (2013)

Table 3. Oyster mushroom production by Satpuda Mushroom Utpadak Sahkarita Maryadit, Sukhtawa, Hoshangabad in Madhya Pradesh during different years (kg)

Years	Dry oyster mushroom
2004-2005	4700
2005-2006	5139
2006-2007	3758
2007-2008	2677
2008-2009	3015
2009-2010	1591
2010-2011	5834
2011-2012	6355
2012-2013	3543

Source: Satpuda Mushroom Utpadak Sahkarita Maryadit, Sukhtawa, Hoshangabad (2013)

Oyster mushroom is also grown in almost all the districts of Chhattisgarh namely Raipur

There is a strong need to follow this method by other NGO's/SHG's operating throughout the country. Many of the SHG's are idle and non functional which can be effectively utilized in oyster mushroom growing activity adopting SAMUHA model in the country. After drying preferably on the wire mess net or woven rope in cots on the top of the floor, oyster mushroom is categorized into "A", "B" grade (Rs. 325/-per kg) in which mushrooms of normally large size and small size is considered. However, stem portion is removed and separately purchased at lower rates (Rs. 250/- per kg). Stem portion of mushroom is mostly used in powder making. Thus, the figure indicated in Table 3 includes all categories of mushrooms.

Oyster mushroom is also grown in almost all the districts of Chhattisgarh namely Raipur, Dhamtari, Korea, Jangjgir-Chanpa, Rajnandgaon, Kanker, Jagdalapur, Beejapur, Dantewada, Bilaspur Korba, Raigarh, Kabirdham, Durg and the total oyster mushroom production is estimated to be around 400 tonnes/annum based on the sale of mushroom spawn by different units (Table 4). There are different units in Raigarh and Janjgir-Chanpa which is adjoining to Odisha and directly getting the supply of spawn from Odisha by bus services and spawn is available in most of the seed selling centres. The medium scale oyster mushroom production units in Chhattisgarh state are presented in Table 5.

The production of oyster mushroom in Odisha is also increasing and is about 4003.60 tonnes/annum

Table 4. Mushroom spawn production in Chhattisgarh

Name of the firm	Districts	Quantity (qtls/annum)
Mushroom spawn lab, IGAU	Raipur	15-20
Mushroom spawn lab, IGAU	Jagdalpur	10-15
Mushroom spawn lab, IGAU	Kawardha	5-7
Chhattisgarh mushroom, Tendua, Abhanpur owned by Mrs. Namrata Yadu)	Raipur	45-50
Osheen Mushroom Spawn Lab	Rajnandgaon	5-6
Osheen Mushroom Spawn Lab	Bhairamgarh (Beejapur)	4-5
Osheen Mushroom Spawn Lab	Beejapur	4-5
Satguru Kabir Biotek ATMA Samuh	Kapadah (Kabirdham)	4-5
Dewangan Spawn Lab, Dhamtari Road	Dhamtari	8-10
Chhattisgarh Mushroom Swayatt Sahkarita Maryadit, Gudihari	Raipur	25-30
Sraddha Suman Mahila Samuh (Tarra)	Raipur	8-10
Bose Mushroom Lab	Raipur	8-10
Roverent Mushroom	Durg	8-10
Chhattisgarh Resource Organization	Durg	20-25
Querishi Mushroom Farm	Durg	8-10
Deshmukh Spawn Lab	Durg	8-10
Om Mushroom Farm	Rajnandgaon	12-15
Biotech Lab, Govt. of Chhattisgarh	Ambikapur	10-12
Pradeep Shah Mushroom Lab	Ambikapur	10-12
Basant Gupta Mushroom Lab	Bilaspur	12-15
Raghav Mushroom Lab	Bilaspur	15-20
Precious Mushroom Spawn Lab	Bilaspur	22-25
Rupak Mushroom Lab	Korba	40-50
Annapurna Mushroom Farm	Korba	8-10
Chakrabarty Mushroom Lab (Mrs. Chakraborty)	Durg	8-10
Tamrakar Mushroom Lab	Durg	5-7
Saheed Gundadhoor College of Agriculture and research Station	Jagdalpur	5-6
Krishi Vigyan Kendra,	Kanker	5-6
Kanha Korea Mushroom	Korea	12-15
	Total	349-406

Table 5. Commercial units of oyster mushroom production and marketing in Chhattisgarh

Name of Firm	Place	Proprietors	Targets
Chhattisgarh Mushroom	Tendua (Abhanpur) Raipur	Mrs. Namrata Yadu	95 Kg/day production
Chhattisgarh Mushroom processing unit	Tendua (Abhanpur) Raipur	Mrs. Namrata Yadu	-
Mushroom Production and Training Centre	Jagdalpur	Smt. Dadsena	Production and training on Mushroom Technology
Mushroom Corner (Sale counter)	Sastri Market, Raipur	Ms. Namrata Yadu	Sale of fresh, dry mushroom and processed product
Om mushroom	Dongargarh, Rajnandgaon	Shri D. K. Shukla	90 Kg/day production
Annapurna mushroom	Korba	Shri Ajay Vishwakarma	70 Kg/day production
Roverent mushroom (Sale counter)	Durg	Shri Rahul Gupta	Sale of fresh, dry mushroom and processed product
Sraddha Suman Mahlia Samuh	Raipur (Tarra)	Self Help Group	Sale of fresh, dry mushroom and processed product

(Table 6) which is about 33 percent of the total mushroom production.

Paddy straw Mushroom

The per annum production of paddy straw mushroom is estimated to be approximately 10,000 tons (Verma 2013). However, Odisha alone contributed about 8007.20 tons of paddy straw mushroom per annum. It is also popular in Tamil Nadu, Kerala, West Bengal and Punjab. Orissa is now known for production of paddy straw mushroom in the entire state especially in the coastal areas from April to December months when moderate temperature with high humidity prevails. Bhubaneswar city alone has more than 120 mushroom spawn laboratory supplying quality spawn of not only paddy straw but also of oyster and milky to the growers of not only Orissa but to the adjoining states like Chhattisgarh.

Milky mushroom

Annual production of the milky mushroom in seasonal farms are concentrated in the Southern states of Tamil Nadu, Kerala and Karnataka has now been estimated to be nearly 10,000 tons. Milky mushroom (*Calocybe indica*) is purely of Indian origin and highly suitable for the tropical climatic conditions of Central India, Northern India and Southern India. Its cultivation is now spreading very fast in many states of the country like Tamilnadu, Kerala, Orissa, Haryana, West Bengal due to its longer shelf life and adaptability to warm and humid conditions.

Oyster Mushroom

Oyster mushroom (*Pleurotus ostreatus*) is an edible

Table 6. Mushroom production scenario in state of Odisha

Mushroom	Production in tons/year	Per cent of total production
Paddy straw mushroom	8007.2	66
Oyster mushroom	4003.6	33
Button mushroom	109.5	1
Total	12120.3	100

Source: Mohapatra (2013-Personal communication)

mushroom having excellent fragrant and taste. Wide spread malnutrition with ever increasing protein gap in our country has necessitated the search for alternative source of protein because the production of pulses has not kept pace with our requirement due to high population growth. Animal protein is beyond the reach of the most people in this country because most of the people (over 86%) live beyond poverty level (World Bank, 1992). Edible mushrooms are recommended by the FAO as food, contributing to the protein nutrition of developing countries dependent largely on cereals. Cultivation of Mushroom is eco-friendly and profitable agribusiness but labour-intensive (Chadha and Sharma 1995). Currently mushroom cultivation represents the only economically viable biotechnology process for the conversion of waste plant residues from forests and agriculture (Wood and Smith 1992). The species of these genera show much diversity in their adaptability to the varying agro-climatic condition and there are more cultivated species of this mushroom than any other mushrooms (Zadrazil and Dube 1992). The different species of *Pleurotus* grow within a temperature range from 15-25oC and it can be grown on various agricultural waste materials as substrate (Block et al. 1958, Thakur et al. 2006, Thakur 2011). Compost of wheat and paddy straw, banana leaves, sugarcane bagasses and leaves, wheat barn, rich husk, sawdust etc. can be used as substrate for growing mushroom (Gupta 1986, Thakur 2005). *Pleurotus* oystreatus is produced in large quantities in a short time and provides more protein per unit area than any other crop (Gupta 1986). The materials of these treatments used for mushroom production are easily available in our country.

Oyster mushrooms are the delicious mushrooms grown in several parts of the world. The scientific name of the cultivated oyster mushroom is *Pleurotus* sajor caju. The word *Pleurotus* originates from the Greek word 'Pleura' which means formed laterally referring to the lateral position of the stipe (stem like structure between mycelium and pileus which is a fan like structure) relative to the position of pileus. Species of *Pleurotus* generally live in nature on dead wood as saprophytes and primary decomposers. They are also known as wood fungus and in Northern India they are sold in the market under the local name 'Dhingri'. Oyster mushroom is very popular in the countries of South East Asia where it can be grown all round the year. *Pleurotus* species are characterized by the rapidity of the mycelial growth and high saprophytic colonization activity on cellulosic substrates. They have the ability to directly break-down cellulose and lignin bearing materials without fermentation (Gupta et al. 2002). Cultivation of any type of mushroom implies principles of microbiology, environmental engineering and solid state fermentation in the conversion of domestic agricultural, industrial, forestry wastes into food for humans. In Chhattisgarh, we have estimated that about 60 lakh tonnes of paddy straw is generated every year as a result of cereal crop production which can be suitably utilized for cultivation of varieties of oyster mushroom liked by the peoples of Chhattisgarh (Thakur 2005).

The advantages of growing oyster mushroom are it grows on most cellulosic farm wastes, elaborate composting is not required, softening of composting material is sufficient for growing this mushroom, it can be grown using a variety of containers such as polythene bags, nylon nets, baskets, shelves, trays, etc., spawn run is very rapid and the first crop of mushrooms can be harvested in about two weeks, casing is not required, can be cultivated under a wide range of temperatures (22-28°C), and gives high yield

Cultivated Species

Under AICRP on mushroom at IGKV, Raipur, several species have been evaluated for cultivation all round the year which includes (1) *Pleurotus florida* (2)


Pleurotus sajor-caju. (3) *Pleurotus flabellatus* (4) *Pleurotus eous*, (5) *Pleurotus platypus*, (6) *Pleurotus memebranaceus*, (7) *Pleurotus ostreatus* (8) *Pleurotus eryngil* (9) *Pleurotus sapidus* (10) *Pleurotus cystidiosus*, (11) *Pleurotus cornucopiae*,

Methods of cultivation

Species of *Pleurotus* are grown in indoors, in thatched house, in thatched house with bamboo woven mat, kuchha house with wall and khaprel roofing, hollow brick wall with tiles roofing, brick wall with asbestos roofing, any available room, basement, garage or even an abandoned shed, provided there is adequate light and ventilation. Mushroom beds are placed using hanging method of cultivation or beds are placed in bamboo racks. It is a pre-requisite also that the roof is insulated by thatching to protect it from getting heated by direct sun.

White oyster mushroom

Pleurotus florida (Bano and Srivastava 1974; Zadrazil 1978; Sohi and. Upadhyay 1989, Dhar et al. 2011, Thakur et al. 2001; Thakur et al. 2012), the white oyster mushroom, is white in color from primordia/pin head formation to maturity, and this mushroom also grows in bunches. The pileus of this mushroom is with thin margins, smooth and pileus thickness is lesser as compared to *P. ostreatus* and *P. sajor-caju*. The mushroom looks like a white disc, growing on a thick stipe with decurrent gills extending to the base of the stipe, unlike *P. ostreatus*/*P. sajor-caju*. This mushroom grew excellently well at 22-28ºC temperature range but

can grow up to 30ºC. White oyster looks graciously white, with delicate flesh which is turgid in texture and can be very well distinguished using DNA finger printing (Singh et al. 2010). The marketability of this mushroom is quite high with increased demand in the niche market in India. These mushrooms are real gourmet mushroom, with high culinary value, and with intense mushroom aroma when used fresh. This mushroom was locally collected from Narayanpur area and its yield was compared with existing varieties. Based on the lab and farmers growing conditions, it was released as a variety i.e. Indira Sweta in 2006 for commercial cultivation throughout the state of Chhattisgarh (Thakur et al. 2006).

Pink oyster mushroom

Pleurotus djamor (Sohi and Upadhyay 1989), the Pink oyster mushroom looks gracious on the bed and yields profusely. The cultivation process for this mushroom is similar as described for *P. sajor-caju*, excepting that this mushroom requires limited water spraying during its cropping. The mushroom pileus is thinner as compared

Table 7. Names of specialty mushrooms grown and their temperature range

Common name	Scientific name	Optimum Temperature Range
Grey Oyster	*Pleurotus sajor-caju*	20-28ºC
Black Oyster	*Pleurotus ostreatus*	18-22ºC
White Oyster	*Pleurotus florida*	20-28ºC
Pink Oyster	*Pleurotus djamor*	20-26ºC
King Oyster	*Pleurotus eryngii*	18-22ºC
Black Ear Mushrooms	*Auricularia polytricha*	22-26ºC
Shimeji Mushroom	*Hypsizygus tessulatus*	18-22ºC
Shiitake Mushroom	*Lentinula edodes*	18-22ºC
Milky Mushroom	*Calocybe indica*	28-32ºC
Paddy Straw Mushroom	*Volvariella volvacea*	30-35ºC

to above species, leathery in texture and looks like a pink queen on the beds. The pileus is up to 3-4 inches in diameter, with little or no stipe and pileus thickness is 3-4 mm at the outer edges. Outer boarder on pileus top is pink, gills on the lower side are pinkish too. This mushroom is not fleshy as compared to above described 3 species. The marketability of this mushroom is excellent and is sold at attractive prices in the niche market in India. It fruits profusely at lower and higher air temperature of 18-20 to 28-32 ºC in the cropping room under Chhattisgarh conditions (Annual Report of AICRP, 2006). It is very much liked by the people who are non vegetarian.

Gray oyster mushroom

Pleurotus sajor-caju (Bano and Srivastava 1974; Block et al. 1958; Chang and Miles 1982; Jandaik 1976 and Zadrazil 1978, Annual Report 2004-2005), the Grey Oyster mushroom, has its pileus color at pin head formation grey to dark grey in color. The color of the pileus changes to light grey on maturity, with fan shaped fruit body and thick texture. The fruit bodies are weighty when fully grown, and the pileus diameter may extend up to 4 inches. This Oyster mushroom is very commonly grown in India under seasonal growing conditions at temperature ranging between 20-28ºC, but growth stops at air temperature above 28ºC (Thakur et al. 2001). This mushroom performs excellently when grown under controlled environment conditions. In winter of Chhattisgarh, it performs excellently well and did not change much upon dehydration.

Black oyster mushroom

Pleurotus ostreatus, (Block et al. 1958; Chang and Miles 1982, Zadrazil 1978; Dhar 1978) is the Black Oyster mushroom, as the pileus is black in color at the time of primordia/pin head formation. The entire process of its cultivation is similar to *P. sajor-caju*, except that this mushroom grows in vertically long bunches, with bunch growing in acropetal order (lower mushrooms younger/ smaller, upper mushrooms larger). This mushroom is also called Hiratake mushroom in Japan, and this mushroom prefers the lower temperature range of 18-22 ^{0}C. This mushroom is a prolific yielder, and yields 20-25% mushrooms of wet weight of substrate over a cropping period of 3-4 weeks. The mushroom shows distinct black color when young, which turns lighter on maturity. This mushroom is harvested in bunches, and packed/marketed like *P. sajor-caju*. This mushroom is in greater demand because of its velvety look/texture and excellent aroma. The diameter of the pileus of this mushroom is 2-3 inches, but mushroom length comprising of pileus and stipe is about 3-4 inches. The entire length of this mushroom is fleshy in texture, with decurrent gills on lower side. The fruit body looks like a horse shoe. This mushroom has preferred marketability value, and is readily accepted in the market by the consumers and the executive chefs of star hotels for its excellent taste.

Pleurotus ostreatus if produced in a standard size green house (667m^2) without air handling takes a schedule of 3-4 months with an output of 15-20 tons which is an equivalents of grain produced in 0.30 ha of land, 4.5 times its efficiency (Li 2012).

Paddy Straw Mushroom

The edible straw mushroom, *Volvariella volvacea* is a fungus of the tropics and subtropics and has been traditionally cultivated in rice straw for many years in China and in South East Asian countries. In 1971, cotton wastes were first introduced as heating material for growing the straw mushroom (Yau and Chang 1972) and in 1973, cotton wastes had completely replaced the traditional paddy straw to grow the mushroom (Chang 1974). This was a turning point in the history of straw mushroom cultivation, because the cotton-waste compost through pasteurization process brought the cultivation of the mushroom into an industrial scale first in Hong Kong and then in Taiwan, Thailand, and China. Several techniques are adopted for the cultivation of the mushroom, which thrives in the temperature range of 28-36 ^{o}C and a relative humidity of 75- 85%. Detailed descriptions of the various methods are given by Chang and Quimio (1982), Chang and Miles (2004), Kaul and Dhar (2007) and Quimio et al. (1990). Choice of technology usually depends on personal preference, and on the availability of substrates and the amount of resources available. While the more sophisticated indoor technology is recommended for an industrial-scale production of the mushroom, most of the other technologies are low-cost and appropriate for rural area development, especially when production is established at the community level.

Paddy straw mushroom (*Volvariella volvacea*) is a world famous edible mushroom variety that has high demand due to its deliciousness and nutritive value. It is a popular variety among people because of its distinct flavor, pleasant tastes, higher protein content and shorter cropping duration compared to other cultivated mushrooms. Paddy straw mushroom (*Volvariella volvacea*) is the 6th most important cultivated mushroom in the world (Ahlawat 2007). No other vegetable or cultivated mushroom can be served as a table dish within a short time from its planting, but *V. volvacea* can do this as it comes to harvest on 10th day. The paddy straw mushroom, *Volvariella* sp. prefers to grow on paddy straw hence it is known as paddy straw mushroom. It's cultivation was started in China during 18th century. It originally grows in rice straw stack in tropical and sub tropical zones that have high temperature and a rainy climate. Chinese growers developed its cultivation more than 300 years ago. Therefore, it was named "Chinese Mushroom" (Zhanxi and Zhanhua 2000). *Volvariella* requires a high temperature (35 ± 2 ºC) for better and early hyphal growth. Also 32±2 ºC and 80-90 % RH (relative humidity) are needed for the formation of fruiting bodies (Chang and Hayes 1978). In India, it was cultivated for the first time in Coimbatore. There are three species of *Volvariella*, grown in India viz., *V. esculenta*, *V. displasia* and *V. volvacea*. The climatic conditions prevailing in India are best suited for the cultivation of this mushroom. Many researchers have exploited the biological and practical knowledge of *Volvariella* sp. (Su and Seth 1940; Thomas et al. 1943; Sangeetha 2002). Cultivation techniques for commercialization still remain to be in infant stage in India owing to its poor and unstable yields. Thomas et al. (1943) for the first time, gave the method of cultivation of *V. esculenta* on three twisted bundles of 10 kg paddy straw soaked with water and placed on wooden platform (75x75x30 cm) in a haphazard manner. The paddy bed (prepared separately) was spawned and covered with the third twist. The whole bed was covered with the polyethylene sheet to maintain moisture.

Production of straw mushroom

The yield of straw mushroom depends on the cultivation methods and compost (growing) medium. Prior to 1970, rice straw was practically the only material used for preparing the growing medium for *Volvariella volvacea*. Straw alone is not sufficient as a composting material as it contains a little quantity nutrients and has a slow rate of decomposition (Anonymous 1983). Therefore, straw mushrooms presently are grown in some other materials such as cotton waste, sugarcane bagasse, dried banana leaves, oil farm bunch waste etc (Jandaik 1976). However, paddy straw is the material freely available in Sri Lanka and therefore, this cultivation is ideal in rural area where paddy straw is abundant after each paddy harvest and it can provide additional income. Low cost house for growing paddy straw Mushroom has been developed. Outdoors cultivation that is growing paddy straw mushroom under trees like coconut, casurina, cashewnut, etc is very much successful during summer. Paddy straw Mushroom is quick growing fungus, which can be harvested on 12th or 13th day. Orissa is the only state where paddy straw Mushroom is grown commercially for nine months in a year involving common people. There are several and big units of spawn production in Odisha as a result not only paddy straw mushroom but oyster mushroom spawn is also produced in bulk quantity and is the only

Table 8. Cultivation of paddy straw by various methods at AICRP (Mushroom) Raipur

Treatments	Spawn run (days)	Pin head (days)	No. of fruit bodies in 10 kg dry straw/ bed	Av. Fruit body wt (g)	Yield (kg/100kg dry straw)	BE (%)
Hollow bed 96" hollow dia.	7	9.66	105.66	15.70	16.77	16.77
Compact bed (Square)	7	10.00	106.33	17.15	16.40	17.40
Compact bed (round)	7	9.00	93.33	17.94	16.64	16.64
Bundle method (hollow) (4 bundles x 5 layers + 2 bundles opened	7	8.50	111.00	13.89	15.28	15.28
Bundle method (5 bundles x 4 layers + 2 bundles opened at top)	7	9.33	78.33	15.71	12.16	12.16
SEM (±)			14.97	1.50	2.09	

reason for popularity of this mushroom in whole of Odisha State.

There are different methods for cultivation of paddy straw mushroom viz., outdoor cultivation by bed method, frame method, spiral method and indoor method with and without composting the substrates. In one of the study conducted under AICRP on mushroom at Raipur (Annual Report 2006-2007) indicated the yield difference from 12.16 to 17.40 % Biological Efficiency depending upon the orientation of beds, its compactness, shape and number of the beds (Table 8). Of these, outdoor method is very common in India which is followed by the majority of the growers in various parts of the country. However, other methods are used by the growers in a small scale depending upon the climatic conditions prevailing in their areas. There are very few units where paddy straw mushroom is cultivated in a multilayered bed after composting. This method is industrially utilized in China and many other Asian countries of the world.

Outdoor cultivation of paddy straw mushrooms

An outdoor cultivation method was introduced for paddy straw mushroom by the Department of Agriculture in the middle of the 1980's. However, farmers are reluctant to produce mushrooms using this method because of the uncertainty of production with irregular and low yield, due to difficulties to control environment factors such as temperature, RH and pest problems. Unlike the oyster mushroom, the straw mushroom is highly sensitive to the climatic conditions and their fluctuation. The traditional outdoor method uses the bed-type approach and utilizes a number of agricultural wastes like dried paddy straw, rice stubbles, water lily, banana leaves, and stalks (Reyes and Abella 1997). The use of these wastes as mushroom substrates depends on their local availability. The following is a description of the step by step procedure for the preparation of mushroom cultivation beds. 11. Mushroom for the Tropics 250

Site selection and preparation

Growers should choose an area that is free from potential insect pests such as ants, termites and rodents. The selected site should preferably be under trees with a wide canopy. In order to ensure that the selected site is pest free, growers can spread rice hulls onto the area and burn them until they turn into ashes. This physical method of eliminating pests also reduces the occurrence of soil-borne pathogens.

Collection and preparation of bedding materials

The bedding materials collected from the field should be sun dried. The platform of the bed should be raised either using sand or bamboo poles or wooden planks or bricks. Growers should trim and bundle the substrates into bundles 45 cm long, 10 cm width with a diameter of two inches. The bundled substrates should be soaked for twelve hours in running water or in 2% $CaCO_3$ solution and washed with clean water.

Layering of bundled substrates into bed and spawning

The bundled substrate should be drained of excess water to attain a 65% moisture content. Growers should pile the bundled substrates one after the other in a layer of bundles (5 bundles x four layers) into the bed forms followed by spot spawning and covering spawn with gram dal powder. Lay 4 layers of bundles during summer months and 7 layers during rainy season. Topping of bed with 20 cm deep layer of rice straw followed by covering with polythene sheet. On top of every layer, spawn should be sprinkled thinly over the bundled substrates. An ideal bed size consists of six layers and has a length of three meters.

Incubation and fruiting

A plastic sheet should be used to cover the entire mushroom bed. This sheet maintains the appropriate

temperature for the mycelial ramification (30-35 °C) and fruiting body formation (28-30 °C). Remove polythene sheet after 4 days and sprinkle water carefully on 6th day. Water spray can be avoided during rainy season. It usually takes 10-14 days before the first flush of marketable fruiting bodies (button stage) come out from the edge of the mushroom bed. Biological efficiency varying from 2-5% was obtained at Raipur in AICRP trials (Thakur et al. 2003) and trials conducted by Godara (2002).

Harvesting

With bare hands, growers should harvest the button stages of *V. volvacea* by simply pulling the cluster out from the bed.

Spiral Method of cultivation

This method was developed by Thakur et al. (2003) at Raipur in Chhattisgarh in which, period of cultivation was prolonged for one and half months from September to 15th October, yield was several times more (18.71% BE) than bed (3.23%) and frame method (8.17%). More yield and quality parameters attributed to spiral method may be due to more exposed surface area, more penetration of light and more aeration of the bed compared to that of cage and bed of cultivation (Thakur et al. 2003).

Indoor cultivation

Construction of growing room, raw materials, composting, filling, pasteurization and spawning (Rajapakse 2011).

Composting

Pre-wetting of the substrates, keeping composting aerobic, reaching homogeneity and time of turning depending on outside temp. and the temperature of the pile.

Filling

Checking the pH, moisture and keeping same amount of compost in anywhere.

Spawning

The amount depending on composting method and experience, in the surface, covering plastic sheet and move plastic sheet up and down two times a day.

Management

1 day: keeping compost temp. 38
2 day: cooling to compost temp. 36
3 day: cooling to compost temp. 34
4 day: pinning depending on mycelium growing
Cooling to compost temp. 32
Moving in light
Fresh air
Increasing humidity
Watering if necessary

Management of fruiting

Protect the crop from cold shock, anti-drying out of surface, light sprinkling after the head of primordia changing to black and sprinkling the space frequently.

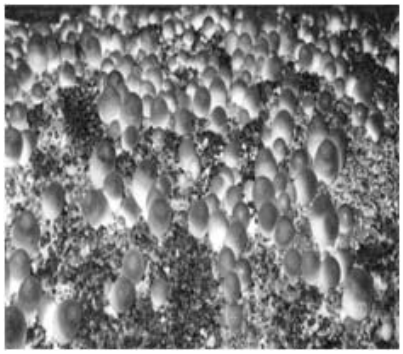
Key Points

The temp. of compost, humidity of air, Fresh air (ventilation), moisture of compost, light

Milky mushroom (*Calocybe indica*)

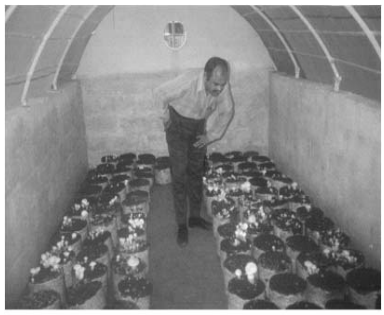
About two decades ago, *Calocybe indica* P. & C. was identified as a wild edible mushroom in India. Only limited attempts were made for its cultivation until 1998 (Purkayastha and Nayak 1981; Chakravarty et al. 1981a; Chakravarty et al. 1981b; Doshi et al. 1989). However, complete commercial production techniques were evolved for the first time in Tamil Nadu (Krishnamoorthy 1995). The milky mushroom (*Calocybe indica*) is a potentially new species to the world mushroom growers. It is a robust, fleshy, milky white, umbrella like mushroom, which resembles button mushroom (Pani 2012). Its robust size, sustainable

yield, attractive colour, delicacy, long shelf-life and lucrative market value have attracted the attention of both mushroom consumers and prospective growers (Chakraborty and Sikdar 2010). The mushroom is rich in protein, lipids, fibres, minerals, carbohydrate and contains an abundant amount of essential amino acids (Alam et al. 2008), Mallavadhani et al. 2006). It is an excellent source of thiamine, riboflavin, nicotinic acid, pyridoxine and ascorbic acid (Breene 1990). The species is suitable for hot humid climate and can be cultivated indoor in high temperature and high humidity areas like Chhattisgarh (Shukla 2004), Tamilnadu, Odisha etc. It grows well at a temperature range of 25-35°C and relative humidity more than 80%. Milky mushrooms can be cultivated throughout the year in the entire plains of India. The cultivation technology is very simple, involves less cost and no special compost is needed for the cultivation. It was very well cultivated in paddy straw, wheat straw and combination of both paddy + wheat in the ratio of 1:1 in AICRP on mushroom at Raipur (Annual Progress Report, 2006-2007). The cultivation process resembles that of oyster mushroom but for the additional process of casing. Casing is an important cultural practice of milky mushroom cultivation which was done for the first time by Purkayastha et al. (1976). The mushroom can be harvested from 24-28 days after spawning and the total crop cycle is only 45-50 days. Most importantly, the milky mushroom has an extended shelf life of 3-5 days compared to other cultivated species, making it more amenable to handling, transportation and storage. So, there is a growing interest among the farmers towards milky mushroom. *Calocybe indica* is rich in protein, lipids, fiber, carbohydrates and vitamins and contains an abundant amount of essential amino acids and low fat product (Ruhul et al. 2010). These qualities make it suitable for food supplement in diet.



Commercial milky white mushroom growers are mostly confined to Tamil Nadu in India, particularly in Erode, Salem, Coimbatore, Trichy, Madurai and other districts (Lakshmipathy et al. 2012). Among vital growth requirements, environmental factors play a major role in the growth and reproduction of edible fungi. Cultivation of *C. indica* is influenced by temperature and relative humidity for its yield. However, optimum conditions favorable for the growth of *C. indica* have not been clearly defined under controlled conditions.

In Tamil Nadu, this mushroom is commonly grown in sunken beds where humidity and temperatures are ideal for the vegetative growth and fruit body development. Similarly, it is gaining popularity in Punjab, Haryana, Karnataka and even Odisha. In Southern states of the country, it is very much used in preparation of pickles and in value added products.



Tricholoma giganteum Heim, a new edible mushroom pure white in colour resembling the morphology of *Calocybe indica*, was reported growing widely in summer in Indo-gangetic plains of Howrah district, Hooghly in India (Chakravarty and Sarkar 1982). The possibility of commercial cultivation of Tricholoma lobayense was already explored in Tamil Nadu during 2002 (Anandh and Prakasam 2002). The simple production techniques, substantial and sustainable yield, increased shelf life, attractive color, flavor and shape are the attractive features of this new edible mushroom. As a new introduction to the edible mushroom world, no doubt that our country has greater prospects and potentiality to exploit this mushroom. Development of mushroom strains well adapted to the hot climatic plains of India with suitable simpler cultivation technology, higher yield potential and prolonged shelf life are the present day needs of

commercial cultivation.

Its yield can very well compared with the existing strains of *C. indica* used for commercial cultivation that would suit the hot climatic zones of our country. A better strain well adapted to the hot climatic plains of India with suitable simpler cultivation technology, higher yield potential and prolonged shelf life can be studied.

However, there are few constraints in production of tropical mushrooms and further expansion of mushroom industry in India.

- Non awareness about nutritional and medicinal values of mushrooms through mass media. Lack of awareness to incorporate in mid day meals, in regular diet of school children, in daliya, in Dal Bhat Centres, in Aaganbadi programme, to pregnant ladies, old age people, in Govt. Canteens and Hospital Wards to alleviate undernourishment and malnourishment.
- Lack of good quality mushroom spawn laboratory, cold storage facility, and small scale processing units in a district place to facilitate mushroom production, processing and marketing.
- Non awareness to blend mushroom powder in Atta, dalia, or dal, papad, badi, murku to improve the nutritional qualities of the food/food product.
- Lack of mushroom processing units to enhance the shelf life, prolong the availability of mushroom products and promote indirect marketing of mushrooms.
- Unavailability of cheap and easy mushroom production technology to people who are mainly dependent on forest produce including mushrooms.
- Absence of proper mushroom marketing channels to dispose off of the fresh, dehydrated and processed mushrooms involving Self Help Groups, NGO's and private organisations.
- Lack of dissemination of generated mushroom technology/knowledge through recent means of communication like internet etc. to the entrepreneurs, tribal women, school dropouts, consumers and preferably middle class families.
- Lack of efforts to trap solar energy for drying and processing of mushrooms.
- Improper development of cultivation methodology of mushroom in a identified areas looking to the availability of local resources.
- Lack of proper designing and construction of mushroom huts/farms for small, medium and commercial scale cultivation of different mushrooms under different climates. Appropriate agencies are not involved in taking care of local ethos and culture and also considering maximum community involvement and community participation.

References

Ahlawat OP, Tewari RP (2007) Cultivation technology of paddy straw mushroom (*Volvariella volvacea*).Technical Bulletin, National Research Centre for Mushroom, Chambaghat, Solan (HP) p 36

Alam N, Amin R, Khana A, Ara I, Shim MJ, Lee MW, Lee TS (2008) Nutritional analysis of cultivated mushrooms in Bangladesh:*Pleurotus ostreatus*, *Pleurotus sajor-caju Pleurotus florida* and *Calocybe indica* Mycobiol 36 : 228-232

Anandh K, Prakasam V (2002) *Tricholoma lobayense*, a new edible mushroom for commercial exploitation. In: Abstracts of paper presented in 3rd Indian Mushroom Conference held during 6-7, March-2002 at Tamil Nadu Agricultural University, Coimbatore p 65

Anonymous (1983) Growing mushrooms, Cultivation of *Volvariella volvacea* pp 56-63

Annual Progress Report (2004-2005) All India Coordinated Mushroom Improvement Project, Deptt of Plant Pathology, IGKV, Raipur p 41

Annual Progress Report (2006-2007) All India Coordinated Mushroom Improvement Project, Deptt. of Plant Pathology, IGKV, Raipur p 45

Bano Z, Srivastava HC (1974) Studies on the cultivation of *Pleurotus* spp on paddy straw. J Food Sci 12 : 363-365

Block SS, Tsao G, Han LH (1958) Production of mushrooms from sawdust. J Agric Food Chem 6 : 923-927

Breene W (1990) Nutritional and medicinal value of specialty mushroom. J Food Prot 53 : 883-94

Chadha KL, Sharma SR (1995) Advances in Horticulture (Mushroom), Malhotra Publication house, New Delhi 13 : 649

Chakravarty DK et al. (1981a) Cultivation of *Calocybe indica*, a tropical edible mushroom. Curr Sci 50 : 550

Chakravarty DK et al. (1981b) Cultivation of tropical edible mushroom, *Calocybe indica*. Indian Agric 25 : 57-60

Chakravarty DK, Sarkar BB (1982) Tricholoma lobayense -A new edible mushroom from India. Curr Sci 53 : 531-532

Chakraborty U, Sikdar SR (2010) Intergenic protoplast fusion between *Calocybe indica* (milky mushroom) and *Pleurotus florida* aids in the qualitative and quantitative improvement of sporophore of milky mushroom. World J Microbial Biotechnol 26 : 213-

225

Chang ST (1974) Production of the straw mushroom (*Volvariella volvacea*) from cotton wastes. The Mushroom J 21 : 348-353

Chang ST (1982) Cultivation of *Volvariella* mushrooms in Southeast Asia, In: Tropical mushrooms : Biological nature and cultivation methods (Chang and Quimio eds.), The Chinese Univ Press, Hong Kong

Chang ST (2006) The world mushroom industry: trends and technological development, Int J Med Mush 8(4) : 297-314

Chang ST, Hayes WH (1978) Biology and cultivation of edible mushrooms. Paddy straw mushroom (*Volvariella volvacea*) pp 102-109

Chang ST, Quimio TH (eds.) (1982) Tropical Mushrooms-Biological Nature and Cultivation Methods. The Chinese University Press, Hong Kong p : 493

Chang ST, Miles PG (1982) Introduction to mushroom science. In: Tropical Mushrooms: Biological nature and cultivation methods, S.T Chang T.H Quimio Eds p: 3-10

Chang ST, Miles PG (1988) Edible Mushroom and their cultivation. CRC Press, Inc Boca Raton, Florida USA p : 27 : 83-88

Chang ST, Miles PG (2004) Mushrooms: Cultivation, Nutritional Value, Medicinal Effect, and Environmental Impact (Second Edition).CRC Press.Boca Raton 451pp

Chiu SW, Moore D (2001) Threats to biodiversity caused by traditional mushroom cultivation in China, In: Fungal Conservation (Moore, Nauta and Rotheroe eds), The 21st Century Issue, Cambridge

Dhar BL (1978) Japanese method of cultivation of wood inhabiting mushrooms, Indian J Mush 2: 26-32

Dhar BL, Shrivastava N, Himanshu A, Kumar J, Tyagi S, Priyanka A (2011) Cultivated edible specialty mushrooms - scope in India and EU countries. Proceedings of the 7th International Conference on Mushroom Biology and Mushroom Products (ICMBMP7) pp 537-547

FAO Stat (2011) http://faostat.fao.org/site/567, 30/I/2013

Gupta RS (1986) Mushroom cultivation, Indian Horticulture 31(1): 1

Gupta SB, Bachkaiya KK, Tedia K, Ravi R, Saxena Anurag, Thakur MP (2002) Proceeding of ICAR Short Course on 'Beneficial Microbes for Increasing Crop Production' published by Deptt. of Soil Science, IGAU and printed at Yugbodh Digital Print Raipur p 239

Hamlyn PF (1989) The Mycologist 3(4) : 171-173

Jandaik CL (1976) Commercial cultivation of *Pleurotus sajor-caju*. Indian J Mush 2: 19-24

Kaul TN, Dhar BL (2007) Biology and Cultivation of Edible Mushrooms. Westville Publishing House. New Delhi p 240

Koopmans A, Koppejan J (1997) Agricultural and Forest Residues - Generation, Utilization and Availability, Regional Consultation on Modern Application of Biomass Energy, Kula Lumpur, Malaysia

Krishnamoorthy AS (1995) Studies on the cultivation of milky mushroom, *Calocybe indica* P. & C, PhD Thesis, Tamil Nadu Agricultural University, Coimbatore, India p 124

Krishnamoorthy AS, Amutha G (2007) Potential of Milky Mushroom in the Mushroom Crop Diversification in the Tropical Regions In: Mushroom Biology and Biotechnology, eds. Rai, Singh, Yadav & Tewari, p.215--?227, MSI, Solan (HP) India

Lakshmipathy G, Jayakumar A, Abhilash M, Raj SP (2012) Optimization of growth parameters for increased yield of the edible mushroom *Calocybe indica*. African Journal of Biotechnology 11(11) : 7701-7710

Li Yu (2012) Present development situation and tendency of edible mushroom industry in China. Proceedings of the 18th Congress of the International Society for Mushroom Science (eds. Jinxia Zhang, Hexiang W and Mingjie C), China Agriculture Press p 1-9

Mallavadhani UV, Sudhakar AV, Satyanarayan KV, Mahapatra A, Li W, Van-breemen RB (2006) Chemical and analytical screening of some edible mushrooms. Food Chem 95 : 58-64

Martinez carrera D, Aguilar A, Martinez Z (2000) Commercial production and marketing of edible mushrooms cultivated on coffee pulp in Mexico, In: Coffee Biotechnology and Quality (Serra, Soccol and Pandey eds), Klewer Academic Publishers, Dordrecht

Mohapatra KB (2013) Status of mushroom production in Odisha (Personal communication)

Pani BK (2012) Sporophore production of milky mushroom (*Calocybe indica*) as influenced by depth and time of casing. Int J Advanced Bot Res (IJABR) 2(1) : 168-170

Prakasam V (2012) Mundkur Memorial Lecture Award- Current scenario of mushroom research in India. Indian Phytopath 65 (1) :1-11

Purkayastha RP, Mondal T, Jana KK (1976) An improved method of cultivation of *Calocybe indica* - an edible white mushroom. Indian J Mushroom 7: 3-9

Purkayastha RP, Nayak D (1981) Analysis of protein patterns of an edible mushroom by Gel-Electrophoresis and its amino acid composition. J Food Sci Technol 18: 89

Quimio TH, Chang ST, Royse DJ (1990) Technical guidelines for mushroom growing in the tropics. FAO, Rome p 155

Rajapakse P (2011) New cultivation technology for paddy

straw mushroom (*Volvariella volvacea*). Proceedings of the 7th International Conference on Mushroom Biology and Mushroom Products (ICMBMP7) p 446-451

Reyes RG, Abella EA (1997) Mycelial and Basidiocarp Performance of *Pleurotus sajor-caju* on theMushroom Spent of *Volvariella volvacea*. Proceedings of International Seminar on the Development of Agribusiness and its Impact on Agricultural Production in Southeast Asia. Tokyo NODAI Press p 491-497

Ruhul A, Abul K, Nuhu A, Tae SL (2010) Effect of different substrates and casing materials on the growth and yield of *Calocybe indica*. Mycobiol 38(2) : 97-101

Sangeetha G (2002) Exploring the possibilities of increasing the yield potential of paddy straw mushroom. M Sc (Ag) Thesis Tamil Nadu Agric Univ Coimbatore

Satpuda Mushroom Utpadak Sahkarita Maryadit (SAMUHA) (2013) Status of oyster mushroom spawn and crop production at Sukhatawa (Hoshangabad) of Madhya Pradesh (Personal communication)

Shukla CS (2004) Role of agronomical and biochemical parameters on growth and yield of on *Calocybe indica* (P&C). PhD Thesis submitted to Deptt of Plant Pahology, IGKV, Raipur, p 148

Singh P, Thakur MP, Kotasthane AS (2010) RAPD Based DNA Fingerprinting of Strains of *Pleurotus florida* and *Pleurotus sajor-caju*. J Mycol Pl Pathol 40 (3) : 436-440

Singh M (2011) Mushroom Production: An Agribusiness Activity. In : Mushroom-Cultivation, marketing and consumption (eds. Manjeet Singh, Bhuvnesh V, Shwet Kamal, Wakchaure GC), Directorate of Mushroom Research, ICAR, Solan (HP) p 1-10

Sohi H, Upadhyay RC (1989) Effect of temperature on mycelial growth of *Pleurotus* and their yield on selected substrates. Mush Sci 12 (2): 49-56

Su UT, Seth LN (1940) Cultivation of straw mushroom. Indian farming 1 : 332-333

Thakur MP (1998) Food and medicinal values of mushrooms. In : Health Care and Development of Medicinal Plants (Eds. S. Puri and W.J William), Baba Printers, Raipur p 107-119

Thakur MP (2005) Biology of edible mushrooms. In : Fungi: Diversity and Biotechnology by M.K. Rai and S.K. Deshmukh, eds., Scientific Publishers (India), 5-A, New Pali Road, PB No 91, Jodhpur-342003 p 305-348

Thakur MP, Ram RN, Shukla CS (2001) Effect of environmental conditions and substrates on vegetative and fruiting stages of *Pleurotus florida* (oyster mushroom). In : Frontiers in fungal biotechnology and plant pathogen relations (eds. C Manoharachary, G Bhagyanarayana, B Bhadraiah, K Satya Prasad, BN Reddy and A Nagmani), Allied Publishers Ltd, Mumbai p 275-281

Thakur MP, Godara DR, Shukla CS, Sharma RL (2003) Recent advances in the production technology of paddy straw mushroom (*Volvariella volvacea*). In : Current Vistas in Mushroom Biology and Production (eds. RC Upadhyay, SK Singh and RD Rai), Mushroom Society of India, National Research Centre for Mushroom , Chambaghat, Solan (HP) p 194-209

Thakur MP, Shukla CS, Yadav VK (2005) Mushroom wealth of C. G., their conservation and exploitation. In :National Mushroom Workshop on "Awareness creation on biodiversity and conservation of Mushrooms" organized by IGAU, Raipur from December 1-2, 2005 p 3

Thakur MP, Shukla CS, Saxena RR, Yadav V (2006) Proceeding of ICAR Short Course on 'Emerging areas in Mushroom Diversity, Production and Post Harvest Developments'. Published by Deptt of Plant Pathology, IGAU and printed at Yugbodh Digital Print, Raipur p 235

Thakur MP, Shukla CS, Vijay Yadav (2011) Biodiversity and conservation of mushroom in Chhattsigarh. In : Microbial biotechnology and ecology (eds. Deepak Vyas, G.S.Paliwal, P.K.Khare and R.K.Gupta), Daya Publishing House, New Delhi p 320-343

Thakur MP, Ranjan S, Shukla CS, Gupta SB (2012) Effect of biofertilisers on the vegetative growth and yield of oyster mushroom (*Pleurotus* spp.). Mushroom Research 21(1): 17-21

Thakur MP, Singh HK (2013) Mushrooms, their bioactive compounds and medicinal uses: A review. Medicinal Plants 5(1) : 1-20

Thakur MP, Mohapatra KB (2013) Presented a Key note Address on Tropical mushrooms : present status, constraints and success story in Technical Session IV on Indian Mushroom Conference-2013 organized by Mushroom Society of India in collaboration with Directorate of Mushroom Research, Solan and Punjab Agricultural University, Ludhiana from 16-17th April, 2013 p 42-43 (Abs)

Tewari RP (1986) Mushroom cultivation. Extension Bulletin. Indian Institute of Horticulture Research. Bangalore, India 8 : 36

Thomas KM, Ramakrishnan TS, Narasimhan L (1943) Paddy straw mushroom. Madras Agric J 31 : 57-59

Verma RN, Uphadhyay RC, Singh SK, Rai RD (2003) Genetic resources of commercial mushrooms, their conservation, characterization and improvement. In: Current Vistas in Mushroom Biology and Production. Eds, Mushroom Society of India p 1-9

Verma RN (2013) Indian mushroom industry- past and present. Bulletin 8 of World Society for Mushroom Biology and Mushroom Products p 16

Yau CK, Chang ST (1972) Cotton waste for indoor cultivation of straw mushroom. World Crops 24 : 302-303

Wakchaure GC (2011) Production and Marketing of Mushrooms: Global and National Scenario. In : Mushroom-Cultivation, marketing and consumption (eds. Manjeet Singh, V Bhuvnesh, Shwet Kamal, GC Wakchaure), Directorate of Mushroom Research, ICAR, Solan (HP) p 15-22

Wood DA, Smith JF (1992) The cultivation of mushroom. In: essay in agricultural and food microbiology edited by Norris JR and Pettipher GL, John Wiley and Sons Ltd pp 310-343

World Bank (1992) World development report. Oxford University Press, Inc New York

Zadrazil F (1978) Cultivation of *Pleurotus*. In: The biology and cultivation of edible mushroom. ST Chang and WA Hayes Eds pp 512-558

Zadrazil F, Dube HC (1992) The Oyster Mushroom importance and prospects. Mushroom Res. 1(I) : 25-32

Zhanxi and Zhanhua (2000) Training Manual of APEMT China-Chapter 11, *Volvariella volvacea* cultivation p 100-109

(Manuscript Receivd : 17.04.2014 ; Accepted : 20.08.2014)

JNKVV Res J 48(2): 136-142 (2014)

Influence of chickpea genotypes for late sown high temperature conditions of chickpea varieties combating climate change under Kymore plateau zone, Madhya Pradesh, India

Karuna Meshram, S.D. Upadhyaya, S. Rao, S. K. Pandey and **K.C. Meena**
Department of Plant Physiology
Jawaharlal Nehru Krishi Vishwa Vidyalaya
Jabalpur 482004 (MP)
Email: karunameshram2@gmail.com

Abstract

Field experiment was conducted to investigate the morphological development in different chickpea (*Cicer arietinum* L.) genotypes for late sown high temperature conditions of Kymore plateau zone of Madhya Pradesh. The crop is well adapted within temperature range of 30/15^{0}C (day maximum and night minimum) for optimum growth and pod filling stage. The investigations with sowing dates viz., 22nd November, 9th Junevary and 31 genotypes of chickpea were made in Randomized Block Design having three replications. Highest pod weight (g) plant^{-1} (38.51) in Dohad yellow, seed weight (g) plant^{-1} (31.46) in PG 5, 100 seed weight (g) (30.96) in JGK 2 under normal sown planting was recorded. In late sown planting the highest pod weight (g) plant^{-1} (30.34) in JGK 2, seed weight (g) plant^{-1} (20.48) in JGG 1. 100 seed weight (g) (29.37) in JGK 2. were found in the Dohad yellow, PG 5 and JGK 2 under normal planting for aforesaid parameters and late planting JGK 2 and JGG 1 exhibited the best performance. The result obtained from present investigation suggested that selection for morphological traits such as pod development could not only improve the heat tolerance of chickpea but could boost up the crop production under climate change, in addition to flowering period is an important factor limiting yield in chickpea.

Keywords: Pod weight, Seed weight, Genotype

Chickpea (*Cicer arietinum* L.) is one of the most drought-tolerant cool-season food legumes; heat stress still limits chickpea production. With terminal drought, seed yields can be reduced by 58-95% compared to irrigated plants and reductions in pod production and abortion are key factors impacting final seed yield (Leport et al. 2006). It is widely cultivated under a range of climatic conditions. The sowing time may vary in different locations depending on the temperature experienced. Global warming is predicted to increase temperature by up to 5°C by the end of this century, with associated changes in mean maximum temperature (Berger et al. 2004) A water shortage and high temperature as the plant enters its reproductive phase induces the end of reproductive development (Siddique et al. 2000, Turner 2003, 2004, 2006) that is termed 'terminal heat stresses. Yields of Kabuli chickpeas are less than desi chickpea under terminal stress and pod abortion by Kabuli chickpea is more sensitive to water stress than that of desi chickpea (Shukla 2013). In the present study, promising genotypes were used to determine the effect of high temperature on total pods, pod weight and seed weight. High temperature was imposed when both cultivars had flower buds, flowers, and developing pods.

Material and methods

The present investigation was carried during Rabi 2012-13 and 2013-14 under All India Coordinated Research Project on Chickpea (lead center) at Seed Breeding Farm, College of Agriculture, JNKVV, Jabalpur (MP). The main features are hot and dry summer and cold winter with occasional showers. The average rainfall is about 1200 mm which is received mostly during July to September. The temperatures varied from 4.0°C minimum in January to 42°C maximum in May. The experimental material comprised of 31 genotypes of chickpea. Grown in a Randomized Block Design with three replications on two different dates under normal planting (Environment I) on 22nd November 2012-13, and late planting on 9th January 2013-14 as Environment II. Each Plot size was 3.0 1.2 m. Fertilizer

was applied in the ratio of 20N:60P_2O_5:40K_2O kg/ha. The experiment was conducted with recommended agronomic practices.

Results and discussion

Environment- I (Normal planting)

The maximum pod weight was observed in Dohad yellow (38.51) followed by PG 5 (38.04) and K 850 (37.36) while it minimum in Pusa Green 112 (12.48). Out of thirty one genotypes, the maximum seed weight was recorded in PG 5 (31.46) followed by Dohad yellow (28.59), and minimum in RGS 991 (11.12) the maximum 100 seed weight noted in genotype JGK 5 (30.96) followed BGD 103 (30.79) while it was recorded minimum in Vijay (12.94) in normal planting (Table 2-4).

Table 1. Weekly meteorological parameters during pod filling stage in the year 2012-13 and 2013-14

Months	Meteo. week	Temperature (^{0}C) Max.	Min.	RH (%) Morn.	Even.
Nov.	47	27.9	10.6	88	29
	48	28.4	11.5	83	33
Dec.	49	28.7	10.6	85	26
	50	29.0	14.0	92	41
	51	25.3	7.1	88	29
	52	23.8	5.0	90	30
Jan.	1	23.3	7.2	87	42
	2	23.0	5.2	87	32
	3	26.7	10.1	84	36
	4	21.4	5.0	86	36
	5	24.6	7.4	91	36
Feb.	6	25.9	11.3	88	49
	7	25.2	13.0	91	60
	8	25.0	11.0	93	49

Months	Meteo. week	Temperature (^{0}C) Max.	Min.	RH (%) Morn.	Even.
Feb.	6	28.0	10.0	91	39
	7	23.9	9.5	88	41
	8	25.5	11.9	93	55
	9	24.8	14.3	91	60
March	10	26.6	11.9	87	42
	11	30.5	12.6	84	45
	12	34.0	13.4	79	27
	13	36.4	17.6	77	20
	14	37.4	18.5	55	16
	17	39.7	19.9	50	13

Environment - II (Late planting)

The pod developments for late planting genotypes were slightly less as compared to the normal planting. The maximum pod weight was noted in genotype JGK 2 (30.34) followed by Pusa 240 (28.06) and JGG 1 (24.15). The minimum pod weight was accounted in the RGS 991 (8.81). The maximum seed weight was observed in the JGG 1 (20.48) followed by ICVV 92944 (19.86) and Dohad yellow (19.51) whereas it was noted minimum in the RGS 991 (6.04). The maximum 100 seed weight noted in BGD 103 (30.37) followed by Dohad yellow (23.21) while it was recorded minimum in Vijay (12.61) in late planting (Table 2-4). Yadava et al. (1999) identified the traits determining tolerance against drought and temperature in chickpea through correlation analysis by evaluating all the studied yield component traits accept genotype of seed index, pod weight per plant, seed weight, during seed filling period, pods per plant and day matter accumulation responded to soil moisture availability while flowering period, reproductive period, and harvest index were least influenced. ICC 4958, Pusa 362 and KPG 59 appeared as drought tolerant genotypes. Among them, ICC 4958 KPG 59 required comparatively high being temperature susceptible.

In present state of climate change and shifting of date of showing the genotype having maximum pod weight with maximum seed weight should be given due consideration either they preferred any date of showing. In normal date of sowing Dohad yellow (38.51) and PG 5 (38.04) Pusa exhibited maximum seed weight with. Similarly in second date of sowing late planting JGK 2 (30.34) followed by Pusa 240 (28.06) and JGG 1 (24.15). Performed better to other genotypes under study.

The overall study indicated that the chickpea genotypes Dohad yelow, PG 5 and JGK 5 found promising for normal date of sowing while genotype JGK 2, JGG 1 and BGD 103 were noted for late planting. The present results are in the conformity of the findings reported by (Xiangwen Fang et al. 2009).

ऐसे जातियाँ जो कि सामान्य और देर तक के लिए उपयुक्त हैं उनका महत्व हम आखिरी तापमान की स्थिति में ज्ञात कर सकते है। जिसे जलवायु में परिवर्तन करके और बोआई की तिथि बदलकर हम देख सकते है। वर्तमान अध्ययन के अनुसार यह पाया गया है कि, जिस समय

Table 2. Effect on pod weight (g) plant^{-1} in normal and late sown planting

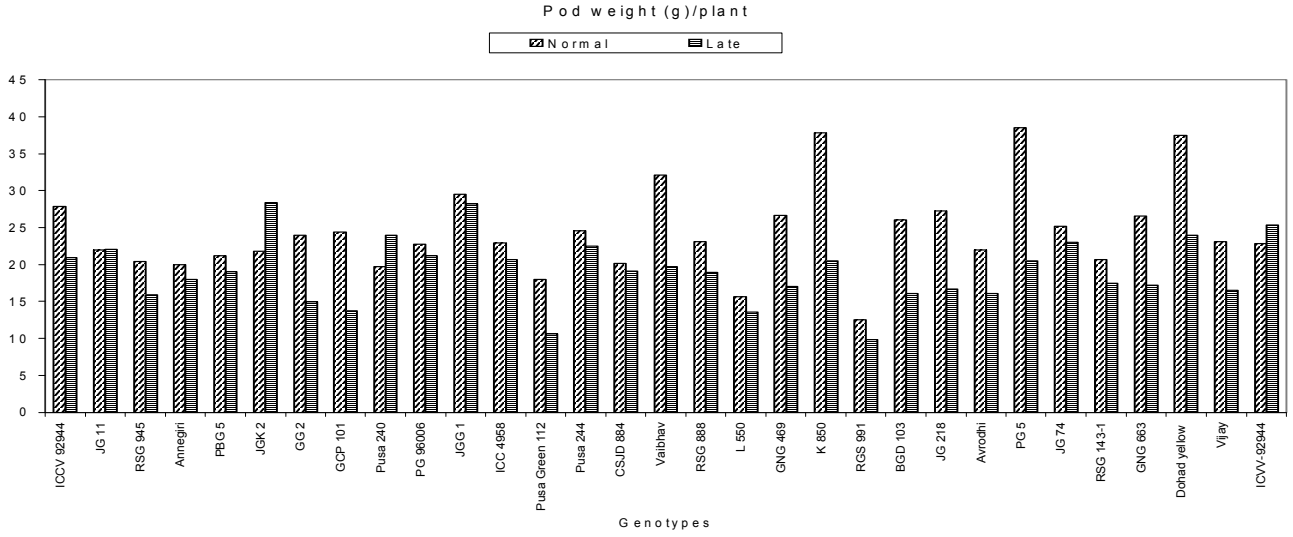
Genotypes	Pod dry weight (g) plant^{-1}					
	2012 - 2013		2013 - 14		Pooled	
	Normal	Late	Normal	Late	Normal	Late
ICCV 92944	28.54	21.57	27.11	20.34	27.82	20.95
JG 11	22.33	24.71	21.56	23.58	21.94	24.14
RSG 945	19.54	16.26	19.16	15.59	19.35	15.92
Annegiri	21.73	18.17	20.4	17.86	21.06	18.01
PBG 5	21.9	19.42	20.4	18.75	21.15	19.08
JGK 2	22.55	31.4	21.14	29.28	21.84	30.34
GG 2	24.76	15.1	23.17	14.8	23.96	14.95
GCP 101	25.13	13.98	23.75	13.49	24.44	13.73
Pusa 240	20.09	28.59	19.41	27.53	19.75	28.06
PG 96006	22.81	22.04	22.81	20.32	22.81	21.18
JGG 1	30.21	24.98	28.83	23.32	29.52	24.15
ICC 4958	23.84	20.99	22.11	20.26	22.97	20.62
Pusa Green 112	12.52	8.62	12.44	9.63	12.48	9.12
Pusa 244	24.97	24.38	24.17	22.82	24.57	23.60
CSJD 884	20.55	19.21	19.75	18.97	20.15	19.09
Vaibhav	32.48	20.02	31.79	19.39	32.13	19.70
RSG 888	23.5	19.08	22.77	18.77	23.13	18.92
L 550	16.01	13.69	15.24	13.46	15.62	13.57
GNG 469	27.13	17.25	26.27	16.92	26.70	17.08
K 850	37.94	20.68	36.78	20.25	37.36	20.46
RGS 991	18.22	8.89	17.78	8.74	18.00	8.81
BGD 103	26.79	15.58	25.38	15.26	26.08	15.42
JG 218	27.83	17.07	26.71	16.31	27.27	16.69
Avrodhi	26.22	16.99	25.58	16.6	25.90	16.79
PG 5	38.89	20.6	37.19	20.36	38.04	20.48
JG 74	25.89	23.47	24.4	22.65	25.14	23.06
RSG 143-1	21.18	17.63	20.21	17.24	20.69	17.43
GNG 663	26.92	17.36	26.16	17.08	26.54	17.22
Dohad yellow	39.65	22.17	37.37	21.73	38.51	21.95
Vijay	23.45	16.73	22.8	16.4	23.12	16.56
ICVV 92944	23.03	22.41	22.7	21.09	22.86	21.75
Mean	25.05	19.32	24.04	18.67	24.54	18.99
SEm±	3.21	1.83	2.46	1.31	2.83	1.57
CD (5%)	10.11	5.75	7.74	4.13	8.92	4.94

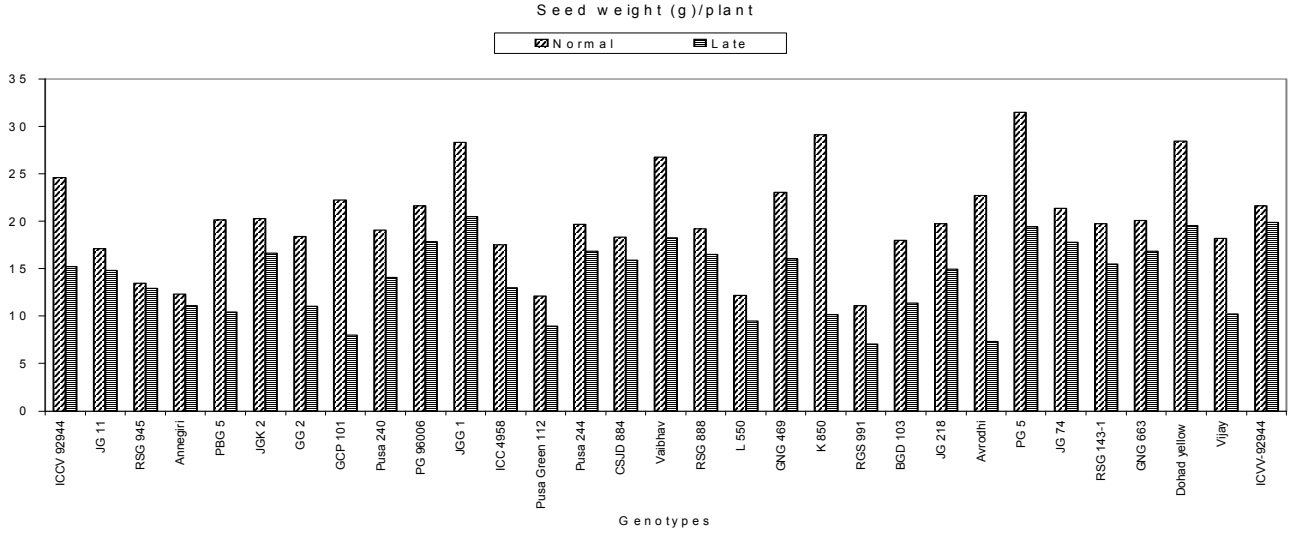
Table 3. Effect on seed weight (g) plant^{-1} in normal and late sown planting

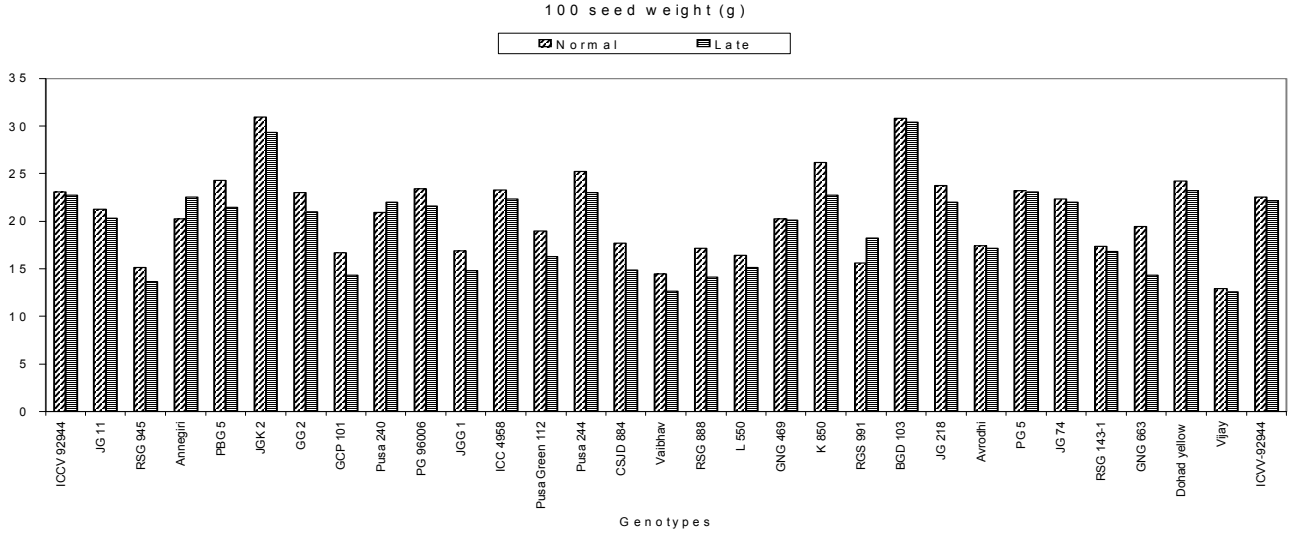
Genotypes	Seed weight (g) plant^{-1}					
	2012 - 2013		2013 - 14		Pooled	
	Normal	Late	Normal	Late	Normal	Late
ICCV 92944	24.79	15.49	24.45	14.98	24.62	15.23
JG 11	17.28	15.03	16.95	14.51	17.11	14.77
RSG 945	13.71	12.99	13.28	12.89	13.49	12.94
Annegiri	12.44	11.34	11.97	10.90	12.20	11.12
PBG 5	20.37	10.62	19.97	10.20	20.17	10.41
JGK 2	20.44	16.87	20.11	16.47	20.27	16.67
GG 2	18.63	11.21	18.10	10.86	18.36	11.03
GCP 101	22.42	8.09	22.04	7.88	22.23	7.98
Pusa 240	19.03	14.25	19.03	13.85	19.03	14.05
PG 96006	21.82	18.03	21.39	17.65	21.60	17.84
JGG 1	28.62	20.67	27.97	20.30	28.29	20.48
ICC 4958	17.66	13.16	17.28	12.79	17.47	12.97
Pusa Green 112	12.31	9.93	11.86	8.00	12.08	8.96
Pusa 244	19.76	17.03	19.58	16.71	19.67	16.87
CSJD 884	18.48	16.01	18.12	15.71	18.30	15.86
Vaibhav	26.98	18.50	26.53	18.01	26.75	18.25
RSG 888	19.47	16.72	18.88	16.31	19.17	16.51
L 550	12.40	7.99	12.25	7.95	12.32	7.97
GNG 469	23.18	16.23	22.84	15.87	23.01	16.05
K 850	29.74	10.32	28.23	9.96	28.98	10.14
RGS 991	11.36	6.22	10.88	5.86	11.12	6.04
BGD 103	18.27	11.60	17.78	11.09	18.02	11.34
JG 218	19.86	15.19	19.56	14.72	19.71	14.95
Avrodhi	22.88	6.46	22.53	6.12	22.70	6.29
PG 5	32.16	19.61	30.77	19.14	31.46	19.37
JG 74	21.56	17.95	21.19	17.63	21.37	17.79
RSG 143-1	19.95	15.64	19.48	15.34	19.71	15.49
GNG 663	20.23	17.05	19.92	16.68	20.07	16.86
Dohad yellow	28.70	19.81	28.48	19.22	28.59	19.51
Vijay	18.38	10.38	17.96	10.09	18.17	10.23
ICVV 92944	22.08	20.05	21.20	19.68	21.64	19.86
Mean	20.48	14.20	20.01	13.78	20.24	13.99
SEm±	2.08	1.47	2.50	1.26	2.29	1.36
CD (5%)	6.56	4.63	7.86	3.98	7.21	4.30

Table 4. Effect on 100 seed weight (g) in normal and late sown planting

Genotypes	1000 seed weight (g)					
	2012 - 2013		2013 - 14		Pooled	
	Normal	Late	Normal	Late	Normal	Late
ICCV 92944	23.32	22.93	22.81	22.58	23.06	22.75
JG 11	21.45	20.80	21.10	19.91	21.27	20.35
RSG 945	15.33	13.80	14.93	13.47	15.13	13.63
Annegiri	20.45	22.73	20.05	22.31	20.25	22.52
PBG 5	24.47	21.70	24.09	21.21	24.28	21.44
JGK 2	31.23	29.47	30.70	29.28	30.96	29.37
GG 2	23.20	21.17	22.79	20.84	22.99	21.00
GCP 101	16.80	14.53	16.55	14.20	16.67	14.36
Pusa 240	21.07	22.13	20.75	21.80	20.91	21.96
PG 96006	23.57	21.73	23.25	21.40	23.41	21.56
JGG 1	17.14	15.13	16.58	14.47	16.86	14.80
ICC 4958	23.33	22.53	23.17	22.11	23.25	22.32
Pusa Green 112	19.27	16.50	18.72	16.12	18.99	16.31
Pusa 244	25.43	23.07	24.96	22.95	25.19	23.01
CSJD 884	17.83	13.40	17.58	16.31	17.70	14.85
Vaibhav	14.63	12.87	14.29	12.38	14.46	12.62
RSG 888	17.23	14.27	17.00	14.00	17.11	14.13
L 550	16.53	15.20	16.31	15.00	16.42	15.10
GNG 469	20.50	20.27	20.02	19.97	20.26	20.12
K 850	26.41	23.00	25.89	22.50	26.15	22.75
RGS 991	15.50	18.37	15.73	18.08	15.61	18.22
BGD 103	31.00	30.67	30.58	30.08	30.79	30.37
JG 218	23.87	22.40	23.61	21.58	23.74	21.99
Avrodhi	17.63	17.27	17.28	17.07	17.45	17.17
PG 5	23.40	23.20	22.97	22.94	23.18	23.07
JG 74	22.60	22.13	22.11	21.80	22.35	21.96
RSG 143-1	17.63	17.07	17.13	16.54	17.38	16.80
GNG 663	19.53	14.40	19.32	14.25	19.42	14.32
Dohad yellow	24.47	23.27	23.98	23.15	24.22	23.21
Vijay	13.17	12.80	12.71	12.43	12.94	12.61
ICVV 92944	22.80	22.33	22.30	22.00	22.55	22.16
Mean	20.99	19.71	20.62	19.44	20.80	19.57
SEm±	0.48	0.88	0.45	0.94	0.46	0.91
CD (5%)	1.52	2.78	1.41	2.95	1.46	2.86


Pod weight (g)/plant
Normal
Late
45
40
35
30
25
20
15
10
5
0
ICCV 92944
JG 11
RSG 945
Annegiri
PBG 5
JGK 2
GG 2
GCP 101
Pusa 240
PG 96006
JGG 1
ICC 4958
Pusa Green 112
Pusa 244
CSJD 884
Vaibhav
RSG 888
L 550
GNG 469
K 850
RGS 991
BGD 103
JG 218
Avrodhi
PG 5
JG 74
RSG 143-1
GNG 663
Dohad yellow
Vijay
ICVV-92944
Genotypes


Seed weight (g)/plant
Normal
Late
35
30
25
20
15
10
5
0
ICCV 92944
JG 11
RSG 945
Annegiri
PBG 5
JGK 2
GG 2
GCP 101
Pusa 240
PG 96006
JGG 1
ICC 4958
Pusa Green 112
Pusa 244
CSJD 884
Vaibhav
RSG 888
L 550
GNG 469
K 850
RGS 991
BGD 103
JG 218
Avrodhi
PG 5
JG 74
RSG 143-1
GNG 663
Dohad yellow
Vijay
ICVV-92944
Genotypes


100 seed weight (g)
Normal
Late
35
30
25
20
15
10
5
0
ICCV 92944
JG 11
RSG 945
Annegiri
PBG 5
JGK 2
GG 2
GCP 101
Pusa 240
PG 96006
JGG 1
ICC 4958
Pusa Green 112
Pusa 244
CSJD 884
Vaibhav
RSG 888
L 550
GNG 469
K 850
RGS 991
BGD 103
JG 218
Avrodhi
PG 5
JG 74
RSG 143-1
GNG 663
Dohad yellow
Vijay
ICVV-92944
Genotypes

अधिक देर तक अनावृष्टि नहीं होती उस समय पुष्प और फलियों का उत्पादन कम हो जाता है तथा पुष्प और अनउत्पादक फलियों की संख्या बढ़ जाती है। अतः दोनों ही स्थितियों में चना फसल के बीजों की उपज घट जाती है। जिससे यह पता चलता है कि पुष्प और फली भ्रूणहत्या दोनो ही महत्वपूर्ण भूमिका निभाते है। बीज उत्पादन ज्ञान करने में दूसरी ओर यह देखा गया है कि, शुरूआत के दिन पुष्प और फली विकास को प्रभावित करते हैं ऐंसे पुष्प और फलियॉ जो जल्दी आ जाते है। उनमें नष्ट होने की क्षमता कम होती है। जबकि जो पुष्प देरी से आते हैं वो ज्यादा मात्रा में नष्ट होते है।

References

Berger JD, Turner NC, Siddique KHM, Knights EJ, Brinsmead RB, Mock I, Edmondson C, Khan TN (2004) Genotypes by environment studies across Australia reveal the importance of phenology for chickpea (*Cicer arietinum* L.) improvement. Aus J of Agri Research 55: 1-14

Leport L, Turner NC, Davies SL, Siddique KHM (2006) Variation in pod production and abortion among chickpea cultivars under terminal drought. European J Agro 24: 236-246

Malhotra RS, Pundir RPS, Slinkard AE (1982) Genetic resources of chickpea. In the chickpea Saxena MC, Singh KB, editors, Aberystwyth, UK. CAB International, 67-81

Shukla N (2013). Flower numbers, pod production, pollen viability are reduced with flower and pod abortion increased in chickpea under heat stress. Res J Recent Sci 2: 116-119

Siddique KHM, Brinsmead RB, Knight R, Knights EJ, Paull JG Rose IA (2000). Adaptation of chickpea and faba bean In: Knight R, editor. Linking research and marketing opportunities for pulses in the 21st century. Dordrecht, the Netherlands: Kluwer Academic Publishers 289-303

Turner NC (2003) Adaptation to drought lessons from studies with chickpea. Indian J Plant Physiology Special issue 11-17

Turner NC (2004) Agronomic options for improving rainfall-use efficiency of crop in dryland farming systems, J Experi Bot 55, 2413-2425

Turner NC, Abbo S, Berger JD, Chaturvedi SK, French RJ, Ludwig C, Mannur DM, Singh SJ , Yadava HS (2006) Osmotic adjustment in chickpea results in no yield benefit under terminal drought. J Experi Bot 58: 187-194

Xiangwen F, Turner NC, Fengmin GY, Siddique KHM (2009) Flower numbers, pod production, pollen viability, and pistil function are reduced and flower and pod abortion increased in chickpea under terminal drought. J Experi Bot 61(2): 335-345

Yadav VS, Dherendra Singh, Yadav SS, Panwar JDS (1999) Morpho-physiological basis of yield variation in chickpea under late planting conditions. Annals Agric Res 20(2): 227-230

(Manuscript Receivd : 20.01.2014; Accepted : 05.05.2014)

JNKVV Res J 48(2): 143-149 (2014)

Effect of cropping systems and production management practices on soybean under rainfed condition

M.D. Vyas and **Rupendra Khandwe**
Rafi Ahmad Kidwai College of Agriculture
Rajmata Vijaya Sindhia Krishi Vishwa Vidyalaya
Sehore 466 001 (MP)
Email: vyasmd@rediffmail.com

Abstract

A field experiment conducted at RAK, College of Agriculture, Sehore to evaluate the response of organic and inorganic nutrient management system on productivity of soybean based cropping system in Madhya Pradesh during 2007-08 and 2008 - 09. The soybean - chickpea cropping recorded the highest pooled yield 2157 kg/ha of soybean as compare to soybean - wheat system (1980 kg/ha). Application of organic 50 % plus inorganic 50 % fertilizers gave the highest soybean yield 2183, respectively followed by organic (2064 kg/ha) and inorganic (1980 kg/ha) on the basis of pooled analysis. Cropping system and production management practices gave significant differences for soybean equivalent yield in both the year of experimentation. Soybean - chickpea crop sequence fetched significantly maximum net monetary returns Rs 27017 /ha over soybean - wheat (Rs 24779 /ha) in 2007 - 08. The cost benefit ratio gave significant differences were recorded with cropping system and production management practices. In terms of soil health soybean - chickpea cropping system was improved NPK 25.0, 1.0 and 15 kg/ha as compare with soybean - wheat cropping system 8.0, 0.0 and 5.0 kg/ha, respectively. The maximum gain in the availability of NPK was 36.0, 2.0 and 20.0 kg/ha was received with management practice of organic alone followed by organic 50 % plus inorganic 50 % and inorganic alone practice.

Keywords : Cropping system, Production management practice, Soybean equivalent yield, Net returns

Imbalance nutrition is one of the important constrains of soybean productivity (Chandel 1989, Tiwari 2001). Continuous use of high level of chemical fertilizers has led to problems of soil degradation which is proving detrimental to soybean production. Soybean - wheat / chickpea system are more preferable since three decades in Madhya Pradesh under both irrigation and rainfed condition. Soybean is preferred by farmers to grow as a cash crop followed by wheat as high yielding food grain crop or chickpea as pulse. The productivity of soybean, wheat and chickpea ranges from 0.7 to 0.9, 1.5 to 2.2 and 4.6 to 7.8 tonnes/ha, respectively in the state as against their genetic potential of 2.5, 5.0, and 2.2 tonnes/ha. Now the productivity of these crops in the state is showing slight decreasing trend. Therefore, adequate and balanced fertilization is necessary and complementary uses of organic manures improve physical, chemical and biological properties of soil and fertilizer use efficiency. Depletion of soil fertility status and poor crop stands due to deviation in sowing time as a result of climatic fluctuations lead to low and unstable productivity of entire cropping system (Hegde 1993). Further the organic sources unlike inorganic ones have substantial residual effect on the succeeding crops (Duraisami and Mani 2001). Hence the present investigation made to find out cropping system, manure and fertilizer requirement for maximization of the productivity of soybean.

Materials and methods

The field experiment was laid out in strip plot design during the kharif and rabi seasons of 2007 - 08 and 2008 - 09 at the RAK, College of Agriculture, Sehore. The treatments comprised cropping system, viz. soybean - wheat and soybean - chickpea in main plots. The production management practices, viz. organic fertilizer 100 %, inorganic fertilizer 100 % and organic 50 % plus inorganic 50 % were allotted to sub- plots with replicated four times. The soil of the experimental field was clay loam in texture, neutral (pH 7.5) in reaction with low in organic carbon (0.60 %) content, available N (220 kg/ha) and P (14.5 kg/ha) and medium in available K (310 kg/ha). Sowing of soybean cv. JS -

335, wheat cv. Sujata and chickpea cv. JG - 315 were done by drilling the seeds in rows 45, 30, 30 cm apart, respectively by using the recommended seed rates. The soybean crop was sown during first week of July while wheat and chickpea crop were sown during last week of October after the harvest of soybean crop followed by pre - sowing irrigation. The recommended inorganic fertilizer dose were 20:60:20 kg NPK/ha for soybean and chickpea and 120:60:40 NPK kg/h for wheat and in organic manure 10 tonnes/ha for sole organic treatment and 5 tonnes/ha where 50 % organic manure was applied. Net monetary returns and cost benefit ratio were calculated based on prevailing market price of inputs and produce.

Results and discussion

Grain yield of soybean and rabi crops

The soybean - chickpea cropping system significantly influenced the soybean grain yield, which culminated into the higher final yield in both the years. Application of 50 % organic plus 50 % inorganic recorded significantly higher soybean grain yield compared to alone organic and inorganic fertilizers in the year 2008 - 09 and pooled data of both the year. This performance may be attributed to improved soil fertility and microflora activity in rhizosphere with the application of organic sources of nutrients with RDF. Similar findings confirmed by Chaturvedi and Chandel (2005). Likewise Kumar et al. (2006) also reported higher yield of soybean due to combined application of nutrient sources by their complimentary effect on soil bio-fertility. On an average in cropping system the yield of rabi crops wheat and chickpea recorded 1640 and 1826 kg/ha, respectively. During the second year (2008 - 09) soybean - chickpea cropping system recorded significantly higher rabi crop yield which was 19.19 % higher than soybean - wheat system. Combined application of organic 50 % and inorganic 50 % recorded 2.17 and 6.82 % increased the rabi crop yield over the organic alone and inorganic alone treatment, respectively on the basis of pooled analysis.

Soybean equivalent yield (SEY)

Cropping system and production management practices gave significant differences for soybean equivalent yield in both the year as well as in pooled analysis. Between the two cropping systems, soybean - chickpea cropping system recorded the highest soybean equivalent yield

Table1. Effect of cropping system and production management practices on soybean, rabi crops, soybean equivalent yield, net monetary returns and benefit cost ratio

Treatment	Soybean grain yield (kg/ha)			Rabi crop yield (kg/ha)			Soybean equivalent yield (kg/ha)			Net monetary returns (Rs/ha)			B: C ratio		
	2007 -08	2008 -09	Pooled	2007 -08	2008 -09	Pooled	2007 -08	2008 -09	Pooled	2007 -08	2008 -09	Pooled	2007 -08	2008 -09	Pooled
Cropping System															
Soybean - Wheat	2306	1644	1980	1559	1724	1640	3629	3356	3583	24779	21689	23234	2.24	1.91	2.06
Soybean - Chickpea	2315	2008	2157	1595	2055	1826	4693	3435	4064	27017	24623	25820	2.57	2.16	2.38
SEm +	36	44	50	39	52	44	81	92	88	505	435	490	0.09	0.10	0.09
CD at 5 %	NS	150	170	NS	180	150	280	316	304	1742	1479	1675	0.30	0.32	0.30
Production Management Practices															
Organic (100 %)	2293	1663	1980	1500	1839	1670	4112	3240	3676	24977	20229	22605	2.36	1.92	2.14
Inorganic (100 %)	2300	1828	2064	1602	1889	1746	4141	3386	3749	25992	24105	25047	2.41	2.07	2.24
Organic (50 %) + Inorganic (50%)	2337	2029	2183	1628	1940	1784	4231	3561	3897	26726	25135	25931	2.45	2.11	2.28
SEm +	33	42	48	47	53	38	16	18	24	118	213	180	0.04	0.05	0.03
CD at 5 %	NS	142	168	NS	NS	130	58	61	79	409	736	621	NS	0.16	0.14

as compare to soybean - wheat system. In general, the organic 50 % and inorganic 50 % fertilizers recorded the highest soybean equivalent yield than the inorganic and organic alone practices. The reduction in SEY under organic and inorganic alone practices were 2.89, 9.90, 6.01 and 2.17, 5.16 and 3.94 % during 2007 - 08, 2008 - 09 and pooled data, respectively. Deshmukh et al. (2005) reported that 100 % RDF along with 2.5 t FYM/ ha in soybean and soil mulch in chickpea recorded the highest yield in soybean - chickpea cropping system, indicating that addition of organic along with 100 % RDF is necessary for higher productivity of soybean.

Net monetary returns and B:C ratio

The effects of cropping system and production management practices were observed significant in respect of net monetary returns and cost benefit ratio during both the years and also in pooled analysis. Soybean - chickpea crop sequence fetched significantly maximum net monetary returns Rs 27017 /ha over soybean - wheat (Rs 24779 /ha) in 2007- 08. Application of organic 50 % plus inorganic 50 % fertilizers enhanced 7.00, 2.82, 24.25 and 4.09 % net monetary returns over organic and inorganic alone treatment in 2007 - 08 and 2008 - 09, respectively. The cost benefit ratio significantly influenced with cropping system as well as production management practices. The benefit cost ratio of the cropping system was observed maximum in soybean - chickpea cropping system i.e. 2.57 against 2.24 of soybean - wheat system in 2007 - 08. In respect to production management practice 50 % organic plus 50 % inorganic practices gave maximum B: C ratio 2.45 over to inorganic alone (2.41) and organic alone (2.36) in 2007 - 08. While the lowest B:C ratio 1.92 was recorded for organic alone management practice in 2008 - 09. Deshmukh et al., (2005) too reported higher monetary returns in soybean - chickpea cropping system due to combined application of organic and 100 % RDF.

Nutrient balance

The availability of nitrogen, phosphorus and potash in the soil after harvest of third crop of soybean was increased. The soybean - chickpea cropping system was improved NPK 25.0, 1.0 and 15 kg/ha as compare with soybean - wheat cropping system 8.0, 0.0 and 5.0 kg/ha. The maximum gain in the availability of NPK was 36.0, 2.0 and 20.0 kg/ha was recorded with management practice of organic alone followed by organic 50 % plus inorganic 50 % and inorganic alone treatment. This increase was owing to better soil health due to application of organic fertilizer. Abraham and Lal (2003) too reported that the percentage of organic carbon and available status of P and K in the soil increased due to the integration of organic and inorganic sources of nutrients in soybean based cropping system in north eastern plains zone of India. Walia and Kler (2007) also observed positive balance of available P with combination of organic sources of nutrients in soybean - wheat cropping system. (Jain et al. 2005, Nambiar 1994 and Hegde 1998) also reported the beneficial impact of organic fertilizers incorporation along with inorganic fertilizers in soybean - wheat / chickpea cropping system as a whole with improving soil properties.

It was concluded that combined application of organic 50 % plus inorganic 50 % management practice to soybean - chickpea cropping system will be helpful

Table2. Effect of cropping system and production management practices on NPK (kg/ha) status of the soil after the harvest of third crop of soybean

Treatment	Available N		Available P		Available K	
	Actual	Difference	Actual	Difference	Actual	Difference
Cropping System						
Soybean - Wheat	228	8.0	14.5	0.0	315	05
Soybean - Chickpea	245	25.0	15.5	1.0	325	15
Production Management Practices						
Organic (100 %)	256	36.0	16.5	2.0	330	20
Inorganic (100 %)	230	10.0	14.8	0.3	315	05
Organic (50 %) + Inorganic (50 %)	243	23.0	15.0	0.5	324	14
Initial Status	220	14.5	310			

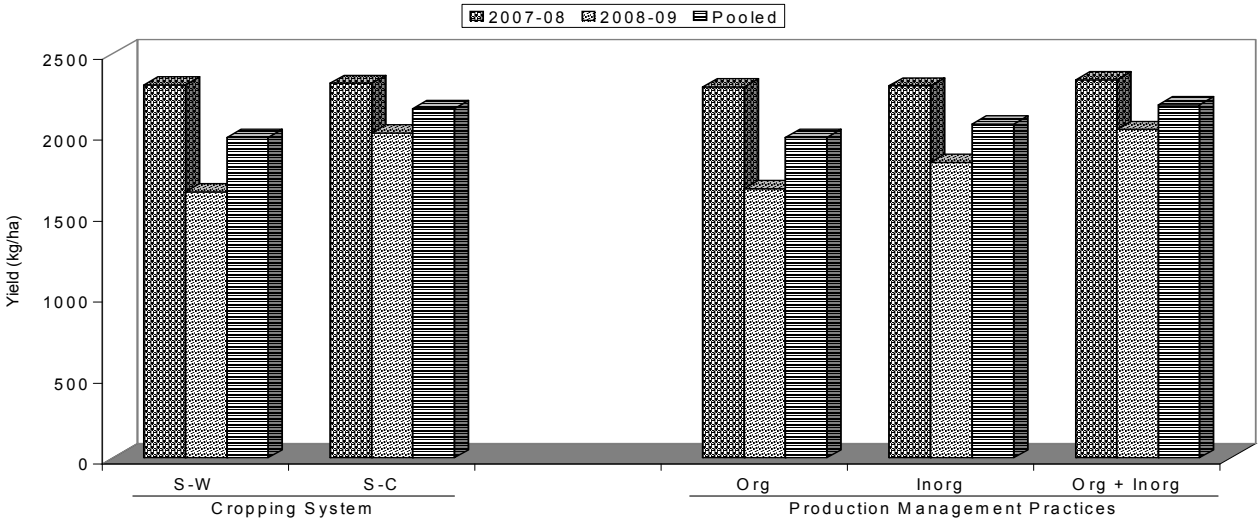


Fig 1. Soybean grain yield as influenced by treatments

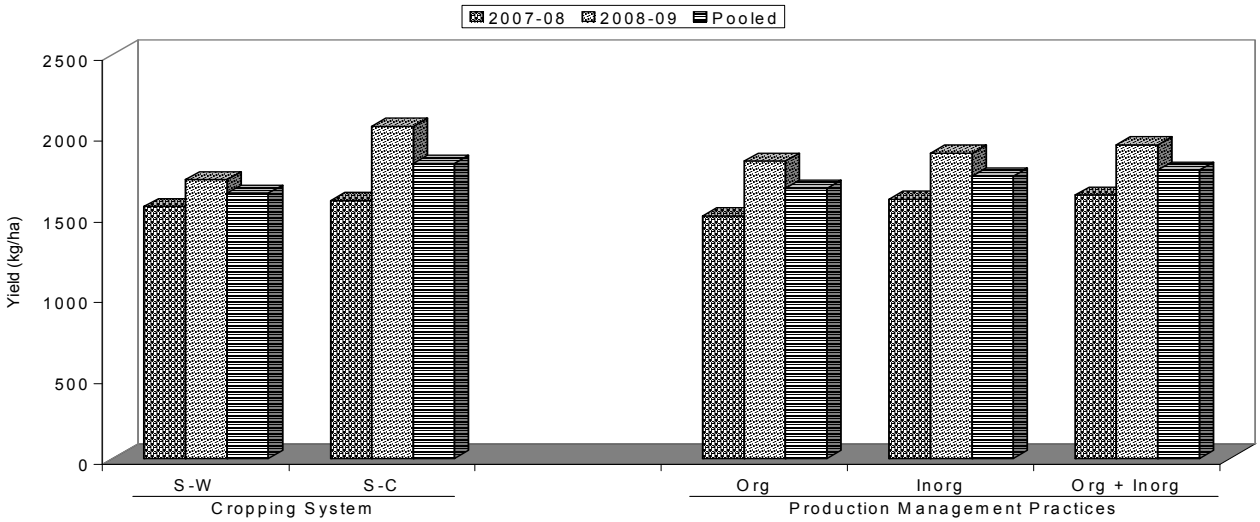


Fig 2. Rabi crop yield as influenced by treatments

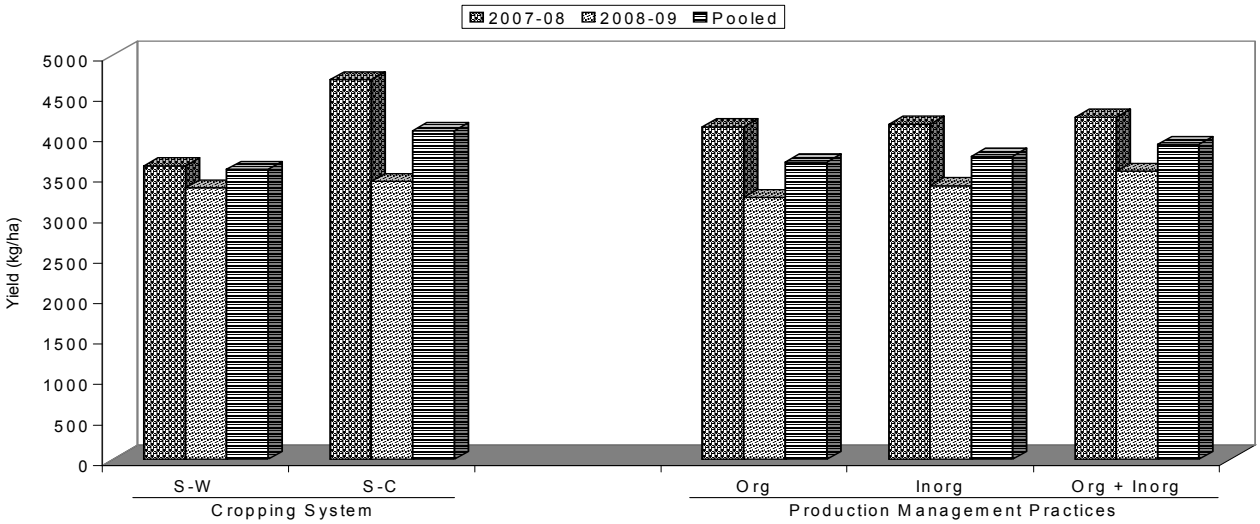


Fig 3. Soybean equivalent yield as influenced by treatments

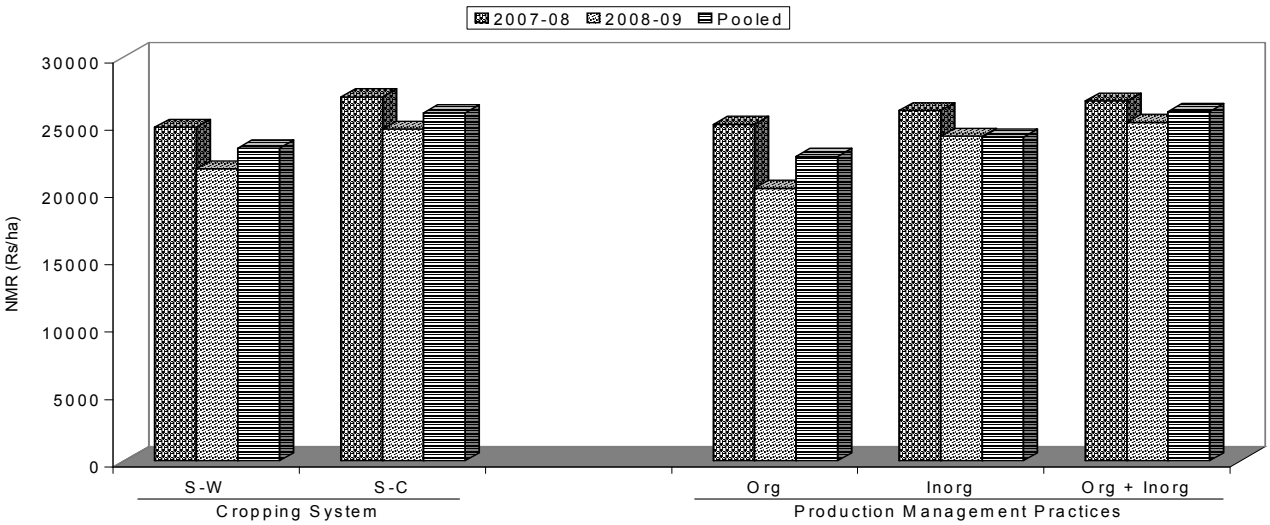


Fig 4. Net monetary returns as influenced by treatments

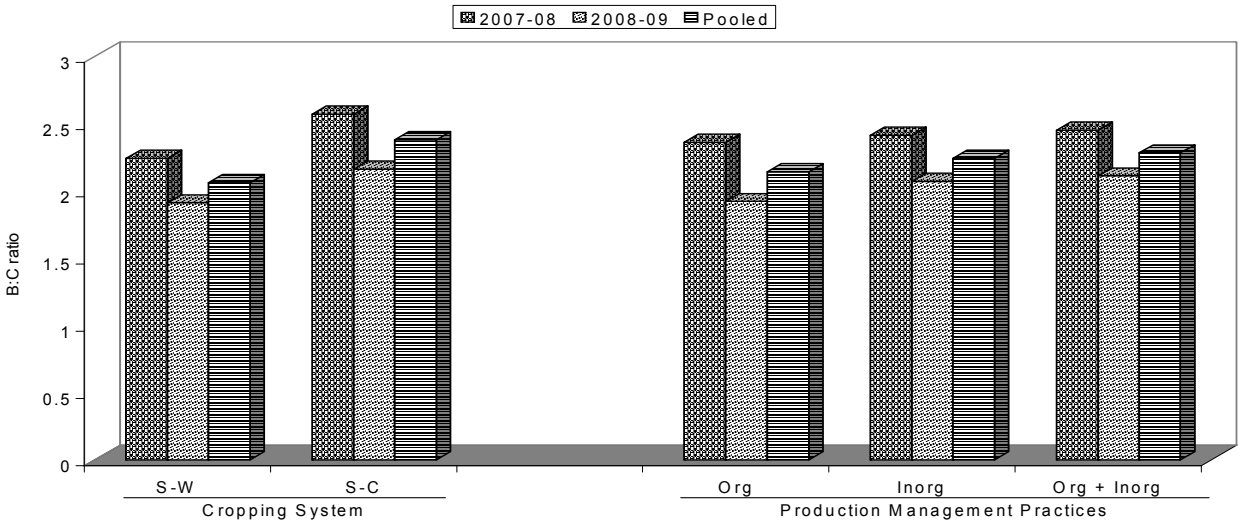


Fig 5. B:C ratio as influenced by treatments

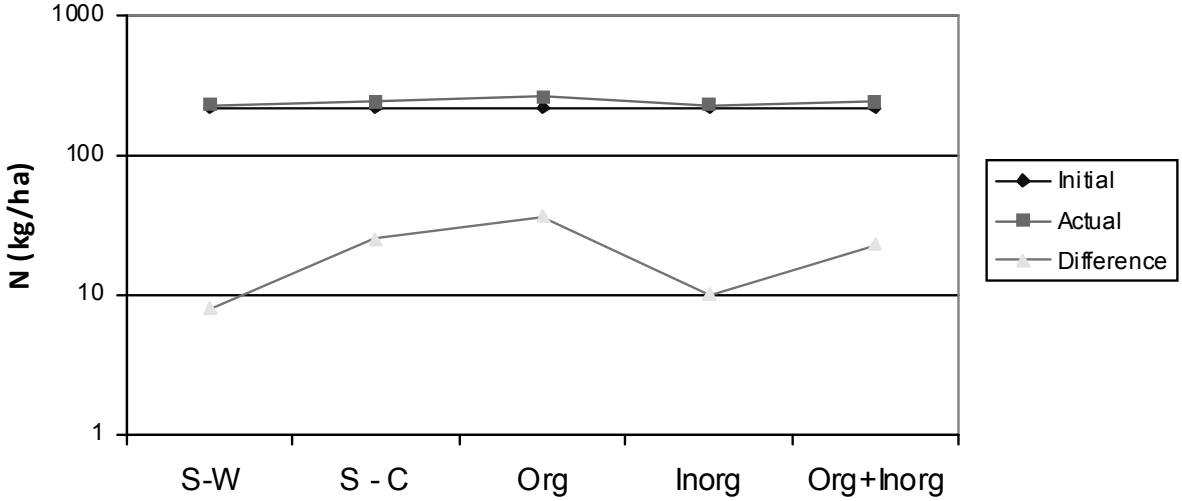


Fig 6 : N as ifluenced by differents

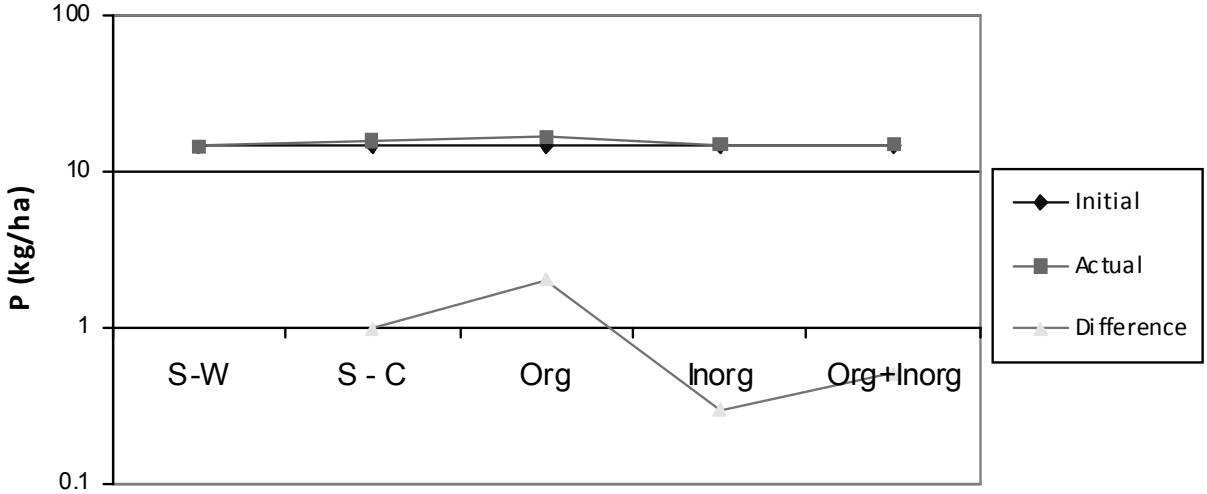


Fig 7 : P as ifluenced by differents

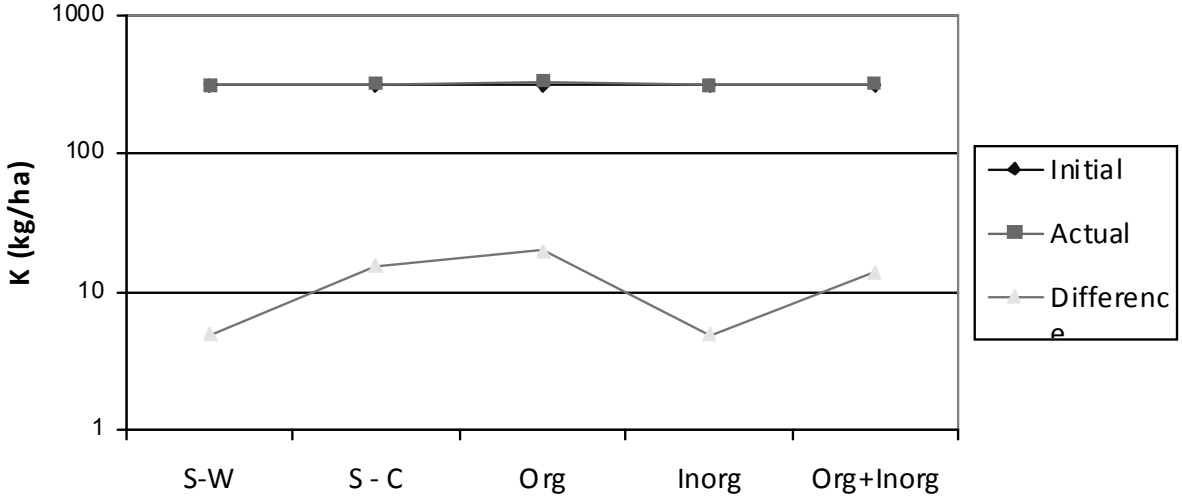


Fig 8: K as influenced by treatmets

in realizing higher productivity and net returns from both crops individually as well as from soybean - wheat cropping system. These treatments also helped in maintaining higher status of NPK of soil.

राजमाता विजयाराजे सिंधिया कृषि विश्वविद्यालय के कृषि महाविद्यालय, सीहोर में वर्ष 2007-08 एवं 2008-09 में किये गये प्रयोगों के आधार पर सोयाबीन - चना फसल पद्धति में अधिकतम औसत सोयाबीन उपज 2157 किलोग्राम प्रति हेक्टेयर ऑकी गई जोकि सोयाबीन - गेहूँ फसल पद्धति (1980 किलोग्राम प्रति हेक्टेयर) की अपेक्षा से उत्तम पायी गई है। कार्बनिक 50 प्रतिशत एवं अकार्बनिक 50 प्रतिशत उपचार से अधिकतम उपज 2183 किलोग्राम प्रति हेक्टेयर ऑकी गई जिसके बाद कार्बनिक तत्व मात्र (2064 किलोग्राम प्रति हेक्टेयर) एवं अकार्बनिक तत्व मात्र (1980 किलोग्राम/ हेक्टेयर) दो वर्षो के औसत गणना पर पाया गया। फसल पद्धति एवं उत्पादन प्रबंधन प्रयास द्वारा सोयाबीन तुल्य उपज सांख्यिकी दृष्टिकोण से दोनो वर्षो में सार्थक पायी गई। सोयाबीन -चना पद्धति से अधिकतम शुद्ध लाभ रू. 27017/- है जो कि सोयाबीन -गेहूँ (रू. 24779/हेक्टेयर) से अधिक पाया गया है। मिट्टी की गुणवत्ता के सुधार में सोयाबीन-चना पद्धति एवं मात्र कार्बनिक तत्व से नत्रजन, स्फुर, पोटास की मात्रा 25.0, 1.0, 15.0 किलोग्राम प्रति हेक्टेयर एवं 36.0, 2.0, 20.0 किलोग्राम प्रति हेक्टेयर क्रमशः बढ़ी हुई ऑकी गई।

References

Abraham T and Lal R B (2003) Strategies for INM technology in sustainable edapho - cultivar management for a legume based (soybean - mustard - fodder cowpea) cropping system for the inceptisols in the NEPZ. Crop Research, Hisar 26 (1): 33-41

Chandel AS (1989) Soybean productivity constraints in north Indian plain. An Agronomist View, World Soybean Research Conference, held in Beunos Aires, Argentina, during 5-9 March 1989, 1: 672-676

Chaturvedi Sumit, Chandel AS (2005) Influence of organic and inorganic fertilization on soil fertility and productivity of soybean (*Glycine max*). Indian J Agro 50 (4): 311 - 313

Deshmukh KK, Saraiya AB, Dubey DP (2005) Effect of integrated nutrient management on productivity trends, economics and soil fertility in soybean - chickpea cropping system. JNKVV Res J 39 (2): 29-32

Duraisami VP, Mani AK (2001) Residual effect of inorganic, composted coir - pith and biofertilizer on yield and uptake of soybean in an inceptisol. Madras Agricultural J 88 (4/6): 277 - 280

Hegde DM (1993) Management strategy for increasing the productivity of rice-wheat system under late sown conditions. Indian J Agro 38 (1): 1 - 5

Hegde DM (1998) Long term sustainability of productivity in rice - wheat system in subhumid ecosystem through integrated nutrient supply. Indian J Agro 43 (3): 189 - 198

JainVikas, Jain Vinamrata, Vishwakarma SK, Sharma RS (2005) Maximization of productivity for soybean (*Glycine max*) - wheat (*Triticum aestivum*) system in Kymore plateau of Madhya Pradesh. Indian J Agro 50 (1): 19 - 21

Kumar YKD, Ananda MR, Rehaman HMA, Vishwanath AP, Vittal Navi (2006) Nutrient uptake, availability and yield of soybean as influenced by integrated nutrient management. Environment and Ecology 24 (4): 1056 - 1058

Nambiar KKM (1994) Soil fertility and crop productivity under long term fertilizer use in India. Indian Council of Agriculture Research, New Delhi

Tiwari SP (2001) Shattering the production in soybean based cropping system. Research Journal, JNKVV Res J 35 (1&2): 1 - 10

Walia SS, Kler DS (2007) Ecological studies on organic verses inorganic nutrient sources under diversified cropping systems. Indian J Fertilisers 3(7) : 55 - 62

(Manuscript Receivd : 06.11.2013; Accepted : 05.05.2014)

JNKVV Res J 48(2): 150-153 (2014)

Influence of time and methods of propagation in aonla on different growth parameters under conditions of Jabalpur, Madhya Pradesh

Akshata Tomar and **S. K. Pandey**
Department of Horticulture
Jawaharlal Nehru Krishi Vishwa Vidyalaya
Jabalpur 482004 (MP)
Email: akshatatomar20@gmail.com

Abstract

Standardization of technique and best suitable time of propagation in aonla under Jabalpur condition was carried out. On the basis of data received during the investigation showed that the chip budding from August to September is most suitable for propagation of aonla. The maximum percentage of bud sprouting and bud take success percentage and survival percentage was obtained in chip method of budding during first week of August.

Keywords: Vegetative propagation, patch budding, T-budding, nutritive value

Aonla (*Emblica officinalis* Gaertn.) occupies an important place among indigenous fruits of India. Aonla fruits are highly valued for medicinal properties and essential nutrients of diet. It is an excellent source of ascorbic acid (Vit. C) 500-600 mg /100g of pulp (Morton et al.1972).

In Madhya Pradesh aonla is potentially cultivated in Dewas, Seoni, Tikamgarh, Betul, Shivpuri, Panna, Rewa and Satna districts. Because of area under aonla plantation is not increasing due to non availability of genuine plant material in large number for the commercial plantation. Hence, there is urgent need to provide vegetatively propagated plants to orchardists for the commercial plantation.

Limited work has been conducted on the aonla propagation by vegetative techniques. Known cultivars of aonla are propagated by inarching which is cumbersome, expensive and time-consuming process. Few attempts have also been made to propagate aonla by different methods of budding, hence present investigation was undertaken.

Material and methods

The experiment on the effect of various methods and time interval of budding in aonla was conducted during 2010-2011, with a view to standardize the suitable method and time of budding under Jabalpur condition (MP). Plant materials consist of 9-12 months old uniform seedlings of aonla were selected from the nursery of experimental orchard. Vigorous, pencil thickness scion shoots were selected from trees of aonla cv. Francis available at a Fruit Research Farm, Imaliya, Department of Horticulture, Jabalpur. The experiment was laid out in Asymmetrical Factorial CRD with three methods of budding i.e. patch, chip and T-budding and 5 time intervals (commencing from last week of July to last week of September at 15 day interval) of budding replicated thrice with 10 plants as a unit under controlled condition.

Results and discussion

Days taken for 50% bud sprouting

The method of T budding (M_3) took maximum days (15.8 days) for 50 percent bud sprouting whereas minimum days (11.6 days) taken by chip budding (M_2) (Table 1). As regards the dates of budding, treatment D_5 took maximum time (14.66 days) for 50% of bud sprouting whereas, treatment D_2 required minimum time (12.33 days) for 50% bud sprouting. In interaction effect of methods and dates, D_4M_2 took minimum days (10 days) for 50% bud sprouting.

The chip method of budding took minimum days (11.6 days) for bud sprouting. It might be due to good sap flow in the bark of rootstock, which might be the

factors those favoured early callusing and proliferation at the bud union. As regards time, minimum days for bud sprouting (12.33 days) was taken in the month of August, which may be due to the favourable temperature and humidity during the month of August, which facilitated favourable factor for better callus formation and better union of graft interface resulting high percentage of success (Giri and Lenka 2007).

Table 1. Influence of time and propagation methods on days taken for 50% bud sprouting

Days/Methods	M_1	M_2	M_3	Mean (Di)
D_1	14	12	17	14.33
D_2	12	11	14	12.33
D_3	11	13	15	13.00
D_4	15	10	17	14.00
D_5	16	12	16	14.66
Mean (Mi)	13.6	11.6	15.8	

Shoot length

The different dates of budding as well as methods of budding significantly increased the shoot length at 120 days after budding (Table 2). As regards the method of budding, significantly maximum shoot length (16.10 cm) was recorded in the chip method of budding (M_2). It was also found superior over T budding (M_3) (14.26 cm) and was at par with patch budding (M_1) (15.35cm). As regards the different dates of budding, the maximum shoot length (16.69 cm) was recorded in D_1. It was also found significantly superior over the other dates (D_3, D_4) and was at par with D_2 and D_5. The Interaction effect was not significant. However, maximum shoot length was recorded with D_1M_2 (17.69cm) (Table 2).

Table 2. Influence of time and propagation methods on shoot length (cm) (at 120 after budding)

Days/Methods	M_1	M_2	M_3	Mean (Di)
D_1	17.17	17.69	15.21	16.69
D_2	14.36	16.59	14.51	15.15
D_3	14.25	14.64	13.20	14.03
D_4	15.48	15.71	13.65	14.94
D_5	15.47	15.86	14.73	15.35
Mean (Mi)	15.35	16.10	14.26	
	Date	Method	Interaction	
S. Em±	0.55	0.42	0.96	
CD at 5%	1.60	1.24	-	

Shoot diameter

The different dates of budding as well as methods of budding were significantly increased the shoot diameter at 240 days after budding. The maximum shoot diameter (1.60 mm) was recorded in chip budding method (M_2). It was also found significantly superior over T budding (M_3) (1.41 mm) and was at par with patch budding (M_3) (1.52 mm). The maximum shoot diameter (1.69 mm) was recorded in D_1.It was also found significantly superior over the other dates (D_2, D_5) and was at par with D_3 and D_4.

Interaction effect of methods and dates were also found significant and maximum shoot diameter (1.84 mm) was recorded with D_1M_2. The interaction D_1M_2 was significantly superior over D_2M_1, D_2M_3, D_3M_1, D_4M_3, D_5M_2 and D_5M_3.

Table 3. Influence of time and propagation methods on shoot diameter (mm) (at 240 days after budding)

Days/Methods	M_1	M_2	M_3	Mean (Di)
D_1	1.53	1.84	1.72	1.69
D_2	1.46	1.72	1.01	1.40
D_3	1.19	1.56	1.75	1.50
D_4	1.82	1.50	1.27	1.53
D_5	1.62	1.40	1.29	1.44
Mean (Mi)	1.52	1.60	1.41	
	Date	Method	Interaction	
S. Em±	0.06	0.05	0.11	
CD at 5%	0.19	0.15	0.33	

Number of leaves

The different dates of budding as well as methods of budding were significantly increased the number of leaves at 120 days after budding (Table 4). Significantly maximum number of leaves (5.38) was recorded in the chip method of budding (M_2). It was also found significantly superior over T budding (M_3) (3.64) and was at par with patch budding (5.02). In case of different dates of budding, the maximum number of leaves (6.02) was recorded in D_1.It was found significantly superior

over D_2 and D_4 dates.

Interaction effect of methods and dates were also found significant and maximum number of leaves (7.93) was recorded with D_1M_2. The interaction D_1M_2 was significantly superior over all other interaction except D_1M_3, D_3M_2, D_4M_1, D_5M_1 and D_5M_2 interaction (Table 4).

Table 4. Influence of time and propagation methods on number of leaves (at 120 days after budding)

Days/Methods	M_1	M_2	M_3	Mean (Di)
D_1	4.36	7.93	5.79	6.02
D_2	3.98	4.34	3.50	3.94
D_3	4.71	5.56	3.12	4.46
D_4	5.17	3.58	4.42	4.39
D_5	6.90	5.50	1.38	4.59
Mean (Mi)	5.02	5.38	3.64	
	Date	Method	Interaction	
S. Em±	0.55	0.42	0.96	
CD at 5%	1.60	1.24	2.77	

Shoot length, Shoot diameter and Number of leaves

Shoot length, shoot diameter, number of leaves were influenced by different budding methods and dates of budding. In chip budding maximum shoot length, shoot diameter and number of leaves were recorded. These morphological characters seem to be higher percentage of bud sprouting, bud take and survival percentage Kumar et al. (2004) observed maximum number of shoot in aonla with patch budding done during the month of September under Haryana eco-system.

August budding proved superior over other operation date for influencing the morphological characters, the month of August-September seems to be congenial for the growth of aonla crop. Singh et al. (2006) reported that the increase in higher diameter and number of leaves in patch budding done during June in Jamun. Nayak and Sen (2000) reported increased sprout length, and leaf emergence in mango crop by fokert budding.

Interaction effect of dates and methods also influenced the morphological character. Zinginbal et al. (2007) reported highest mean shoot diameter and shoot length in the chip budding, performed on 15th August in Kiwifruit probably due to sufficient food material and enough amount of plant growth regulators contain the chip obtained from the mother plant and also favourable weather conditions.

Leaf area index

The different dates of budding as well as methods of budding were significantly increased the leaf area index. The maximum leaf area index (0.21 cm^2) was recorded in the chip method of budding (M_2). However, differences amongst them were not significant. The maximum leaf area index (0.21 cm^2) was recorded in D_4. However, differences amongst them were not significant.

Interaction effect of methods and dates were found significant and maximum leaf area index (0.25 cm^2) was recorded with D_1M_2. The interaction D_1M_2 was significantly superior over D_1M_1, D_1M_3, D_2M_1, D_3M_2, D_5M_2 and D_5M_3 interactions.

Table 5. Influence of time and propagation methods on leaf area index (cm^2)

Days/Methods	M_1	M_2	M_3	Mean (Di)
D_1	0.17	0.25	0.17	0.20
D_2	0.17	0.20	0.19	0.19
D_3	0.21	0.17	0.20	0.20
D_4	0.19	0.21	0.24	0.21
D_5	0.24	0.16	0.08	0.16
Mean (Mi)	0.20	0.21	0.18	
	Date	Method	Interaction	
S. Em±	0.012	0.010	0.02	
CD at 5%	-	-	0.06	

Leaf area index influenced the production of biomass in a crop and its relationship with biological yield was well established in cereals, Welbank et al. (1968) and the maximum values were obtained under direct seedling (Gill et al. 2005). Leaf area index is an important character depends on leaf orientation. The vertically oriented leaves had a higher photosynthesis rate than those with horizontal leaves (Tanaka et al. 1996). The results reveal (Table 5) that among different methods of budding the highest leaf area index (0.21cm^2) was recorded in chip budding which may be attributed to the early attachment of scion with the rootstock which might have provided the nutrition to the developing bud resulted in rapid development of leaf area and subsequently leaf area index. On the other hand it has been recorded that when the budding was

exercised on 6th September (D_4) it resulted in increased magnitude of leaf area index (0.21cm^2) which may be due to fulfilment of optimum temperature and light intensity required for a successful budding.

The study of interaction reveal that the chip budding when exercised on 23rd July resulted in a higher increase in leaf area index over other treatment combination which suggests that success of type of budding is specific for a specific time period.

आँवले में पौध प्रवर्धन की वानस्पतिक तकनीक के मानकीकरण हेतु उपयुक्त समय एवं प्रवर्धन तकनीकों का जबलपुर की परिस्थितियों में परीक्षण किया गया । प्राप्त वृद्धि सूचकांकों के आधार पर चिप कालिका प्रवर्धन तकनीक का उपयोग अगस्त से सितम्बर माह के मध्य आँवले में प्रवर्धन हेतु सर्वाधिक उपयुक्त पाया गया है । अधिकतम कालिका अंकुरण (11.6 दिवस), नव-अंकुरित कालिका की लम्बाई (16·10 से. मी.), नव-कालिका व्यास (1.60 मि.मि.) तथा अधिकतम पर्ण संख्या (5.38) चिप प्रवर्धन द्वारा अगस्त माह के प्रथम सप्ताह में अंकित किया गया ।

References

Gill M S, Kumar P, Kumar A (2005) Growth and yield of direct seeded rice as influenced by seedling technique and seed rate under irrigated conditions. Indian J Agro 51(4): 28-287

Giri B, Lenka P C (2007) A short note on Effect of time on grafting success in Jamun (*Syzigium cumini*). The Orissa J Horti 35(2):122-123

Kumar Anuj, Bhatia S K, Joon M S (2004) Standardization of in situ patch budding time in aonla (*Emblica officinalis*). Haryana J Horti Sci 83(4):194-195

Mortan R M J, Bautitan C Y, Bermudez R J, Calzada B J, Chavez F W B (1972) The Cherimoya (*Annona cherimola* Mill). Ancient La Malina, 10:158-76

Nayak G, Sen S K (2000) Evaluation of vegetative propagation methods of mango. Environment and Ecology 18 (1):243-245

Singh V K, Singh Anans, Singh I S (2006) Vegetative propagation of Jamun (*Syzygium cumini*). Ad Pl Sci 59 (1):224-229

Tanaka A K (1996) Photosynthesis, respiration and plant type of the tropical rice plant. Int. Rice Res. Inst. Bult 7. Los Banos

Welbank P J, Wilts K J, Thorne G N (1968) Effect of radiation and temperature on efficiency of cereal leaves during grain growth. Ann Bot 32: 79-95

Zinginbal Hamdi, Ozcan, Muharem, Hazendar, Ayhan, Demir Taki (2007) Comparisons of time methods and time of budding in kiwifruit (*Actinidia deliticiosa*, A chev). Internati J Natural and Engineering Sci 57(1):23-28

(Manuscript Receivd :30.09.2013; Accepted :06.05.2014)

JNKVV Res J 48(2): 154-158 (2014)

Correlation and path studies for yield attributing traits in capsicum (*Capsicum annuum* L.)

Meenakshi Ramgiry
Department of Horticulture
Jawaharlal Nehru Krishi Vishwa Vidayalay
Jabalpur 482004 (MP)
Email : meenakshi.ramgiri@gmail.com

Abstract

The correlation and path coefficient analysis were studied in 30 F_{1s} and 13 parents including three lines (JNKVVA1, ACBGA1, and ACBGA2) and ten testers (JM 218, Sankeshwar, Phule Jyoti, Hissar Vijay, Phule Mukti, Pant C1, G4, HO413, K1 4C and KA2) in chilli for 16 different quantitative characters. The correlation study indicated that significant and desirable correlation between dry fruit yield plant-1 with seed yield per plant, seed per-cent, fruit length, and fresh fruit weight. Path analysis revealed that importance should be given to fruit length, fresh fruit weight and seed yield.

Keywords: Chilli, correlation, path direct and indirect effects

Chilli is an important spice cum vegetable crop grown almost all parts of country has multiple use in human diet. Capsicum annuum is the most commonly cultivated species. The varieties of chillies are broadly divided into two groups, first is long pungent, hot pepper and second is bell-shaped, non pungent, mild types. The breeding of chilli is directed towards higher green fruit production. To meet out the objective, the knowledge on genetic behaviour of parents and its segregating population is a prerequisite for its further improvement. Genetic improvement of traits depends upon the nature and magnitude of heritable variation on which efficiency of selection depends (Patil et al. 2008). Similarly correlation and path analysis have been successfully used for architectering the suitable plant ideotype or variety for enhance productivity for a particular situation.

Material and methods

The present investigation was carried at the Vegetable Research Farm Maharajpur, Deptt. of Horticulture, JNKVV, Jabalpur during 2009-2010. One month old, thirty F_{1s} crosses obtained by line x tester method were transplanted in RBD with three replications. Each treatment was planted as 60x60cm inter and intra spacing. The observations on 16 traits were recorded on 5 plants from every F_1 hybrid in each replication.

The list of Parents

Parents	Source	Parents	Source
JNKVVA1 (lines)	JNKVV (Jabalpur)	Phule Mukti (tester)	Rahuri
ACBGA1 (lines)	Dharwad	Pant C1 (tester)	Pant (Ag.)
ACBGA2 (lines)	Dharwad	G4 (tester)	Guntur/Lam
JM218 (tester)	JNKVV	HO413 (tester)	Dharwad
Sankeshwer (tester)	Dharwad	K1-4C (tester)	Dharwad
Phule Jyoti (tester)	Rahuri	KA2 (tester)	IIVR, Varanasi
Hisar Vijay (tester)	Hisar		

Table 1. Estimate of genotypic and phenotypic correlation coefficient between fruit yield and its components in chilli

		NFP	NSB	DFFI	DFPF	DM	NFP	FL	FD	FFW	DFW	NS	TSW	SPC	SYP	DFY
PH	G	0.163	-0.115	0.065	0.020	0.059	0.104	0.260	-0.131	0.272	0.219	0.153	0.16	0.207	0.218	0.269
	P	0.135	-0.115	0.075	0.04	0.057	0.104	0.255	-0.115	0.262	0.189	0.147	0.11	0.162	0.211	0.259
NPB	G		0.271	0.005	0.170	0.042	-0.04	0.069	-0.240	-0.1	-0.064	-0.17	-0.16	0.012	-0.10	0.076
	P		0.247	0.025	0.10	0.035	-0.05	0.060	-0.257	-0.10	-0.032	-0.150	-0.10	0.028	-0.10	0.063
NSB	G			-0.39**	-0.250	0.229	-0.050	-0.006	0.293*	-0.27	-0.159	0.006	-0.30	-0.17	-0.08	-0.10
	P			-0.25	-0.08	0.188	-0.040	-0.005	0.239	-0.22	-0.099	0.027	-0.18	-0.14	-0.09	-0.081
DFFI	G				0.560**	0.269*	0.289*	-0.174	-0.203	0.08	0.041	0.08	-0.010	0.09	0.25	0.114
	P				0.79	0.192	0.236	-0.132	-0.164	0.055	0.049	0.111	0.070	0.039	0.222	0.113
DFPF	G					0.43**	0.454**	0.036	-0.291	0.201	0.231	0.093	-0.07	0.075	0.41	0.293
	P					0.294*	0.297*	0.023	-0.191	0.133	0.186	0.111	0.020	-0.02	0.278	0.213
DM	G						-0.05	0.128	-0.029	0.083	0.105	0.105	-0.37	0.167	-0.07	0.152
	P						-0.05	0.127	-0.0282	0.081	0.100	0.087	-0.27	0.119	-0.06	0.018
NFP	G							-0.043	-0.024	0.162	0.263	0.066	0.27	0.091	0.871**	0.567**
	P							-0.041	-0.017	0.16	0.240	0.059	0.22	0.073	0.851**	0.560**
FL	G								-0.056	0.413**	0.541**	0.523**	-0.08	-0.06	0.204	0.167
	P								-0.053	0.409**	0.505**	0.492**	-0.07	-0.05	0.198	0.162
FD	G									0.119	0.172	0.33*	-0.27	0.175	0.061	-0.135
	P									0.116	0.128	0.276	-0.22	0.114	0.064	-0.128
FFW	G										0.934**	0.479**	0.07	0.06	0.375**	0.319*
	P										0.876**	0.44**	0.05	0.049	0.359*	0.315*
DFW	G											0.586**	0.10	-0	0.542**	0.307*
	P											0.517**	0.09	-0.01	0.475**	0.280
NS	G												-0.28	-0.03	0.449**	0.094
	P												-0.14	-0.03	0.422**	0.080
TSW	G													-0.28	0.337*	0.025
	P													-0.21	0.306*	0.019
SPC	G														0.002	0.034
	P														-0	0.027
SYP	G															0.504**
	P															0.495*

*, **Significant at p = 0.05 and 0.01, respectively, PH = Plant height (cm), NPB = Number of primary branches, NSB = Number of Secondary branches, DFFI = Days to first flower initiation, DFPF = Days to fifty per cent flowering, DM = Days to maturity, NFP = Number of fruits plant-1, FL = Fruit length (cm), FD = Fruit diameter (cm), FFW = Fresh fruit weight fruit-1 (g), DFW = Dry fruit weight fruit-1 (g), NS = Number of seeds fruit-1, TSW = 1000 seed weight (g), SPC = Seed per cent, SYP = Seed yield plant-1, , DFY = Dry fruit yield plant-1

Table 2. Estimate of genotypic and phenotypic path coefficient between fruit yield and its components in chill

		PH	NPB	DFFI	DFPF	DM	NFP	FL	FFW	DFW	NS	TSW	SPC	SYP
Plant height	G	-0.2708	-0.0442	-0.0176	-0.0048	-0.0159	-0.0282	-0.0704	-0.0737	-0.0595	-0.0414	-0.0439	-0.0561	-0.0591
	P	0.1407	0.019	0.0105	0.0053	0.008	0.0147	0.0359	0.0368	0.0267	0.0207	0.0156	0.0227	0.0296
No. of primary branches	G	0.0227	0.1393	0.0007	0.024	0.0059	-0.0055	0.0097	-0.0135	-0.009	-0.0235	-0.0226	0.0016	-0.0139
	P	0.0082	0.0606	0.0015	0.0059	0.0021	-0.0028	0.0036	-0.0058	-0.002	-0.0091	-0.0058	0.0017	-0.0061
Days to first flower initiation	G	0.0533	0.0043	0.8199	0.706	0.2203	0.2366	-0.1426	0.0653	0.0337	0.0654	-0.0098	0.0739	0.2047
	P	-0.006	-0.002	-0.0807	-0.0638	-0.0155	-0.019	0.0106	-0.0044	-0.004	-0.0089	-0.0058	-0.0032	-0.0179
Days to fifty per cent flowering	G	-0.0221	-0.2153	-1.0743	-1.2477	-0.5365	-0.5661	-0.0452	-0.2508	-0.2891	-0.1165	0.0879	-0.0933	-0.512
	P	0.0039	0.0101	0.0825	0.1042	0.0306	0.031	0.0025	0.0139	0.0194	0.0115	0.0022	-0.0019	0.029
Days to maturity	G	0.0193	0.0139	0.0881	0.141	0.3279	-0.0156	0.042	0.0272	0.0344	0.0343	-0.1202	0.0548	-0.023
	P	-0.0014	-0.0008	-0.0046	-0.007	-0.0238	0.0011	-0.003	-0.0019	-0.0024	-0.0021	0.0063	-0.0028	0.0015
Number of fruits plant^{-1}	G	-0.2299	0.0867	-0.6365	-1.0007	0.1048	-2.2056	0.0938	-0.3568	-0.5805	-0.1448	-0.6016	-0.2016	-1.9212
	P	0.0612	-0.0266	0.1386	0.1746	-0.0268	0.5873	-0.0239	0.0938	0.1413	0.0348	0.1314	0.0427	0.4998
Fruit length	G	0.1962	0.0523	-0.1312	0.0273	0.0967	-0.0321	0.7544	0.3119	0.4081	0.3942	-0.0639	-0.0454	0.1542
	P	0.0354	0.0083	-0.0182	0.0033	0.0176	-0.0056	0.1386	0.0567	0.07	0.0682	-0.0101	-0.0064	0.0274
Fresh fruit weight fruit^{-1}	G	0.7171	-0.2555	0.2098	0.5296	0.2184	0.4262	1.0894	2.6352	2.4633	1.2618	0.1747	0.1579	0.9869
	P	0.1104	-0.0406	0.023	0.0562	0.0341	0.0674	0.1725	0.4217	0.3694	0.1857	0.0206	0.0207	0.1515
Dry fruit weight fruit^{-1}	G	-0.6161	0.1819	-0.1151	-0.6493	-0.2944	-0.7374	-1.5158	-2.619	-2.8019	-1.6423	-0.2919	0.0098	-1.5193
	P	-0.0516	0.0088	-0.0134	-0.0507	-0.0273	-0.0654	-0.1374	-0.2381	-0.2718	-0.1406	-0.0243	0.0038	-0.129
Number of seeds fruit^{-1}	G	-0.3296	0.3627	-0.1718	-0.2012	-0.2256	-0.1414	-1.1253	-1.0312	-1.2624	-2.1538	0.6064	0.0629	-0.9665
	P	-0.0148	0.0152	-0.0111	-0.0111	-0.0087	-0.0059	-0.0494	-0.0443	-0.052	-0.1005	0.0145	0.0033	-0.0424
1000 seed weight	G	-0.2168	0.2165	0.0159	0.0941	0.4901	-0.3645	0.1132	-0.0886	-0.1392	0.3763	-1.3364	0.3703	-0.4509
	P	-0.0156	0.0135	-0.01	-0.003	0.0373	-0.0313	0.0102	-0.0068	-0.0125	0.0202	-0.14	0.0291	-0.0428
Seed per cent	G	-0.0643	-0.0036	-0.028	-0.0232	-0.0519	-0.0284	0.0187	-0.0186	0.0011	0.0091	0.086	-0.3104	-0.0006
	P	-0.0132	-0.0023	-0.0032	0.0015	-0.0098	-0.0059	0.0038	-0.004	0.0012	0.0027	0.017	-0.0818	0.0002
Seed yield plant^{-1}	G	1.0098	-0.4625	1.1546	1.8983	-0.3246	4.0291	0.9455	1.7323	2.5083	2.0758	1.5607	0.0096	4.6257
	P	-0.0012	0.0006	-0.0013	-0.0016	0.0004	-0.005	-0.0012	-0.0021	-0.0028	-0.0025	-0.0018	0	-0.0058
Correlation with DFY plant^{-1}	G	0.269	0.0765	0.1145	0.2935	0.0152	0.5671	0.1674	0.3196	0.3072	0.0944	0.0255	0.0341	0.5048
	P	0.2559	0.0638	0.1137	0.2139	0.0182	0.5603	0.1627	0.3154	0.2806	0.0801	0.0199	0.0279	0.495

*, **Significant at p = 0.05 and 0.01, respectively

PH = Plant height (cm), NPB = Number of primary branches, NSB = Number of Secondary branches, DFFI = Days to first flower initiation, DFPF = Days to fifty per cent flowering, DM = Days to maturity, NFP = Number of fruits plant^{-1}, FL = Fruit length (cm), FD = Fruit diameter (cm), FFW = Fresh fruit weight fruit^{-1} (g), DFW = Dry fruit weight fruit^{-1} (g), NS = Number of seeds fruit^{-1}, TSW = 1000 seed weight (g), SPC = Seed per cent, SYP = Seed yield plant^{-1}, DFY = Dry fruit yield plant^{-1}

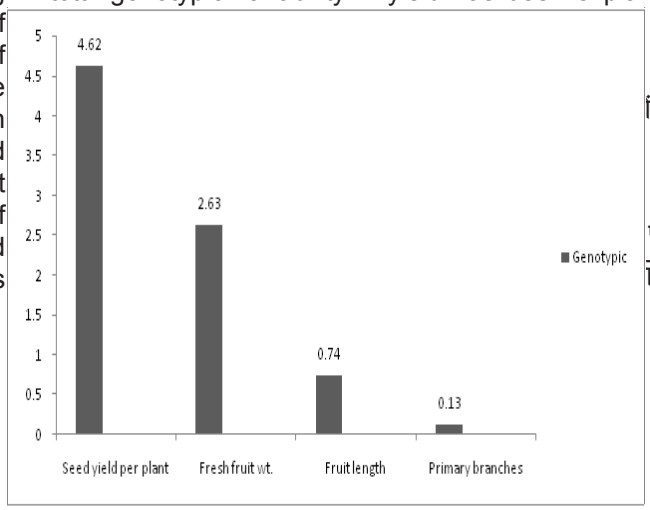
The statistical analysis was carried out by using standard procedure. The genotypic and phenotypic correlation and path coefficient were estimated by the method given by Miller et al. (1958) and Dewey and Lu (1959) respectively.

Results and discussion

Correlation coefficient measures the relationship between two or more variables. It is useful in determining component characters for complex trait namely dry fruit yield (Table 1). In the present investigation the result revealed that dry fruit weight exhibited significantly positive association with number of fruits per plant, seed yield per plant, fresh fruit weight and plant height both at genotypic and phenotypic levels. These finding are supported by many authors Kohli and Chaterjee (2000), Tembhurne et al. (2008), Gupta et al. (2009). All the character expects number of secondary branches and fruit diameter should significant positive correlation with dry fruit yield at both levels.

The path coefficient analysis helps to avoid complication by measuring the direct and indirect influence of one variable upon the other by partitioning the total correlation coefficients into the component of direct and indirect effects, revealing the causes of association between characters (Table 2). The true picture of characters relationship and their contribution towards the final fruit yield in chilli have been determined by path analysis as indirect and direct effects of different traits on yield which revealed the real contribution of each component to end product i.e. Dry fruit yield could be precisely assessed so that judicious selection of traits can be practiced for effective gain in desirable character under improvement. Seed yield per plant had the highest positive direct effect on dry fruit yield followed by fresh fruit weight, primary branches per plant and fruit length. Similar finding in chilli have been reported by Rajamony (2004), Mishra et al. (2003) and Kumar et al. (2003).

Similarly plant height, 1000 seed weight, number of fruits per plant, dry fruit weight, number of seeds per fruit and seed (%) exhibited negative direct effect on dry fruit yield therefore selection on these traits should be avoided however, its indirect effect via days to maturity, fresh fruit weight, days to 50% flowering, fruit length, seed yield per plant clarifies more contribution on dry fruit yield. Overall result from correlation and path conducted that character viz., seed yield per plant, fresh fruit weight, fruit length, days to maturity and primary branches per plant showed positive association as well positive direct effect on dry fruit yield per plant, should be given direct selection pressure on these traits for economic improvement of yield. While restricted selection number of fruits per plant, days to 50 per cent flowering, plant height as these showed negative contribution on dry fruit yield. It was very interesting to note that residual effect was (0.012). This infers the total genotypic variability in yield has been explained



ों का
प्रति
प्रति
फल)
ों में

Graphic presentation of significant correlation coefficient

Genotypic path coefficient

सुधार सीधे चयन से किया जा सकता है। जबकि पकने की अवधि फल व्यास का उपज (सूखे फल) के साथ ऋणात्मक संबंध दिखा

References

Abu NE, Uguru MI (2006) Evaluation of genetic variations in growth and yield components of aromatic pepper lines in a derived savanna ecology of Nigeria. Agro Sci 5(1): 1-7

Dewey DR, Lu KH (1959) A correlation and path coefficient analysis of component of crested wheat grass seed production. Agron J 51: 515-518

Gupta AM, Singh D, Kumar A (2009) Genetic variability, genetic advance and correlation in chilli (*Capsicum annuum* L). Indian J Agric Sci 79(3): 221-223

Kohli UK, Chatterjee (2000) Correlation and path coefficient analysis in bell pepper (*Capsicum annuum* L.). Haryana J Horti Sci 29 (1-2): 90-93

Kumar BK, Munshi AD, Joshi S, Kaur C (2003) Correlation and path coefficient analysis for yield and biochemical characters in chilli (*Capsicum annuum* L.). Capsicum and Eggplant Newsl 22: 67-70

Miller PA, Williams JC, Robinson HF, Comstock RE (1958) Estimates of genotypic variance and covariance in upland cotton. Agron J 50: 126-136

Mishra AC, Singh R V, Ram HH (2003) Path coefficient analysis in sweet pepper (*Capsicum annuum* L.) genotypes under mid hills of Uttaranchal. Veg Sci 29(1): 71-74

Patil SD, Bidari BI, Shashidhara GB, Hegde NK (2008)Genetic variability in chilli (*Capsicum annuum* L.) genotypes. Asian J Horti 3(2): 310-312

Rajmony L, Sreelathakumary I (2004) Variability, heritability and genetic advance in chilli (*Capsicum annuum* L). J Trop Agric 42(1-2): 35-37

Tembhurne B V, Revanappa, Kuchanur PH (2008) Varietal performance, genetic variability and correlation studies ion chilli (*Capsicum annuum* L.). Karnataka J Agric Sci 21(4): 541-543

(Manuscript Receivd : 01.04.2014; Accepted : 08.08.2014)

JNKVV Res J 48(2): 159-161 (2014)

Effect of rooting inducers on root and shoot parameters of *Polyscias* spp. under water culture

Pooja Thatte and **Alka Singh**
Department of Floriculture and Landscape Architecture
ASPEE College of Horticulture and Forestry
Navsari Agricultural University
Navsari 396 450
Email: thattep.2512@gmail.com

Abstract

The *Polyscias* spp. (the Aralia) is a slow growing shrub belonging to Araliaceae family. It is most commonly used as a houseplant and is valued for its attractive foliage and compact form which is suitable for indoor gardening purposes. This experiment was conducted with an objective to study the effect of rooting inducers like NAA (Naphthelene Acetic Acid) and IBA (Indole-3 Butyric Acid) on root and shoot parameters of Aralia. The results showed that IBA @ 250 ppm had significant effect on the days taken for initial rooting (4.80 days), maximum number of roots (35.27) and root length (8.20 cm). The effect of these PGRs on shoot parameters was also observed and significantly maximum shoot length (15.91 cm) and least days for leaf initiation (19.01 days) was observed with application of IBA @ 150 ppm.

Keywords: *Polyscias* spp. (Aralia), rooting, Indole-3 Butyric Acid, Indoor Gardening, Indoor Air Quality,

With the increase in urbanization in India, a residential culture of 'flats and apartments type' has been witnessed. Under these circumstances people face paucity of space to pursue their gardening interests. Further, in recent times, awareness about the concept of 'indoor air quality' of urban residences is also on the rise as urban dwellers spend ninety percent of their time indoors (Tarran et al. 2007). Under this context, use of foliage plants for indoor gardening and ornamentation becomes very important as their selective use is one of the strategies to reduce indoor pollution and improve Indoor Air Quality (Farghaly 2003). A NASA-funded project concluded that, foliage plants can remove nearly 87% of air pollutants and Volatile Organic Compounds (VOCs) from sealed chambers within 24 hours. The indoor plants also purify the air off CO_2, reduce particulate matter or dust accumulation and increase humidity (Mc Connell and Kobayashi 2007). The growing importance of the foliage plants has therefore lead to its emergence as one of the leading sectors in global floricultural trade. The Polyscias spp. or the Aralia, as it is commonly called, is one of the most popular foliage plants. It is a slow growing, perennial shrub belonging to family Araliaceae. It grows well in full sun to full shade. The plants have a compact form and shape which makes them ideal for indoor uses. They have spine-less stem and leaves which are entirely dark green but can also be variegated in some species.

Use of rooting inducers in the field of commercial propagation in horticulture is very popular. The most widely used auxins for rooting purpose in ornamental plants are IBA, NAA and IAA (Hartman et al. 1997). The Polyscias cutting generally root in one to two months under normal conditions and in soil media. But application of rooting inducers such as those mentioned above leads to quicker and better rooting. A strong root system is ideal for the growth of the plant. Use of such rooting inducers can lead to easy propagation of Polyscias under water culture in indoor conditions.

Despite the growing demand and trend of use of foliage plants, holistic research on the different aspects related to them is not available. Keeping the above point in view, the study was aimed at determining the optimum concentration of the different rooting inducers in inducing quicker and better rooting in semi hardwood cuttings of Polyscias so as to develop a better and an easy technique of propagations which can be practiced easily under water culture in homes by nurserymen and amateur gardeners.

Materials and methods

Site

The experiment was carried out in Gallery area (Indoor Conditions) of Floriculture and Landscape Architecture Department, ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari during 2012-13. The NAU campus is located near the coast of the Arabian Sea and at an average elevation of 9 m above the mean sea level. It is at 75^0 95' East longitudes and 20^0 95'North latitude. It is 13 km away from the historical Dandi seashore.

Experimental material

Terminal, semi hardwood cuttings of Polyscias of 15 cm length were obtained from three year old pot plants grown in the Experimental Learning Project Greenhouse located in the University premises. The experiment was laid out in CRD with seven treatments viz., T_1- IBA 150 mg/L, T_2- IBA 250 mg/L, T_3- IBA 500 mg/L, T_4- NAA 150 mg/L, T_5- NAA 250 mg/L, T_6- NAA 500 mg/L and T_7- Control. The experiment was set up with three replications having five plants in each replication. The basal portion of the cuttings was dipped in the aqueous solutions of the rooting inducers for three hours. Aqueous solution of Indole-3 Butyric Acid and Naphthalene Acetic Acid of 150 mg/L, 250 mg/L and 500 mg/L concentrations were prepared by dissolving 150 mg, 250 mg and 500 mg of the hormone powder respectively in small quantity of 0.1 N NaOH and making the final volume one litre by adding distilled water. The treated cuttings were then transferred to conical flasks containing RO water and further observed for rooting. The parameters chosen for the study were classified into root and shoot parameters. The observations of root parameters were recorded 15 days after application of treatment while the shoot parameters were recorded after 45 days.

Result and discussion

Effect on Root Parameters

Significant effect of the rooting inducers was observed on the root and shoot parameters of the Polyscias cuttings. Among all treatments, IBA @ 250 ppm produced rooting in significantly less number of days (4.80 days). This could be because of the presence of auxins that are reported to increase the enzymatic activity, hydrolysis of starch and thus facilitate its mobilization which can trigger energy for root initiation (Nanda and Anand 1970). Further, Taiz and Zeiger (1998) attributed effectiveness of IBA in promoting rooting to the activation of Rhizocaline (a growth co-factor present in the plant tissue), beside activation of cell division from which roots are initiated. Hence, application of exogeneous auxin might have led to faster root initiation. It was also observed that IBA @ 250 ppm produced significantly longest (8.20 cm) and maximum number of roots (35.27). The plausible reason for this effect could be that auxin controls root elongation through its effects on cell division and expansion (Davies 2004; Woodward and Bartel 2005). Apart from the effect of auxin on the cell division and elongation, it also controls certain stages of differentiation (Davies 2004) which could have increased the number of roots per

Table 1. Effect of IBA and NAA on root and shoot parameters of *Polyscias* spp.

Treatment	Days taken for initial rooting (days)	Number of roots	Length of roots (cm)	Length of shoot (cm)	Days required for leaf initiation (days)
T_1 - IBA 150 ppm	6.10	24.56	8.07	15.91	19.01
T_2 - IBA 250 ppm	4.80	35.27	8.20	15.40	21.99
T_3 - IBA 500 ppm	8.10	23.73	7.60	15.90	21.06
T_4 - NAA 150 ppm	9.30	18.66	5.50	15.46	26.72
T_5 - NAA 250 ppm	7.53	23.28	6.44	15.31	29.69
T_6 - NAA 500 ppm	8.90	18.14	4.60	15.76	31.33
T_7 - Control	10.30	14.60	4.50	15.12	35.33
C. D. at 5 %	0.48	1.37	0.54	0.46	2.27

plantlet. Hence, pronounced effect of auxin was noticed on the root number and length of the Polyscias cuttings. These findings resonate to the conclusions of Bhuse et al. (2003) who reported that, treatment of IBA in basal, middle or terminal cuttings of Pelargonium graveolens at optimum concentrations activated internal auxins and hence induced maximum length of root per cutting.

Effect on Shoot Parameters

It was observed that IBA @ 150 ppm produced longest shoot (15.91 cm) which was statistically at par with T3 (IBA 500 ppm; 15.90 cm) (Table 1). Also, IBA @ 150 ppm produced earliest initiation of leaves on the cuttings (19.01 days). The positive effects of IBA on the vegetative growth of the Polyscias cuttings is attributed to the fact that better root growth and elongation on account of auxin application enables better absorbtion of water and nutrients in higher quantities from the growing medium, which subsequently contributes to a good vegetative growth (Devlin 1972).

Conclusions

On the basis of the abridged results of the investigation presented, it is concluded that IBA @ 250 ppm produced significantly best effects on the root parameters while better shoot parameters or vegetative growth was observed with the application of IBA @ 150 ppm. Application of IBA at specified concentrations to the terminal, semi- hardwood cuttings of Polyscias leads to quicker and better rooting and vegetative growth under water culture in indoor conditions. This technique can be profitable used by nurserymen and amateur gardeners to obtain good plantlets within shortest period of time.

पॉलीशिआस एक धीमी गति से बढ़ने वाला पौधा है जो कि घरो के अंदर, छायादार जगह पर उगाया जाता है । नेफेथेलिन एसिटिक एसिड, इंडोल 3-व्यूट्रिक एसिड को जड से ऊगाने में सहायता करने वाले रसायन की तरह प्रयोग किया जाता है । प्रस्तुत शोध से यह निष्कर्ष निकाला गया कि इंडोल 3-व्यूट्रिक एसिड (250 पीपीएम) से पॉलीशिआस की बेलो को उपचारित करने पर सर्वाधिक जड़े (35.27) सबसे कम समय (4.80 दिन) में सबसे लंबी जड़े (8.2 सेमी) प्राप्त हुई । इस रायासन का प्रभाव (150 पीपीएम) सर्वाधिक तने की लंबाई (15.91 सेमी) तथा सबसे कम दिनों में पत्तो के उगने (19.01 दिन) की प्रक्रिया में दिखाई दिया ।

References

Bhuse V H, Lad B L, Patil D K, Karade V M (2003) Effect of time of planting, type of cutiing and plant growth regulators on rooting in *Pelargonium graveolens* L. Indian J Agric Res 37(1): 29-33

Davies P J (2004) The plant hormones: their nature, occurrence, and function In Plant Hormones: Biosynthesis, Signal Transduction, Action. Dordrecht: Kluwer Academic Publishers1-15

Devlin R M (1972) Plant Physiology, 3rd Edition Van Nostrand Company New York 1001

Farghlay T A (2003) Improving indoor air quality. Alexandria Engineering J 42(4): 483-495

Hartmann H T, Kester D E, Davies F T, Geneve R L (1997) Plant Propagation: Principles and Practices. Prentice Hall, Inc., New Jersey

Mc Connell J, Kobayashi K D (2007) Using House plants to clean indoor air. Cooperative Extension Services, College of Tropical Agriculture and Human Resources University of Hawaii 39: 1-7

Nanda K K, Anand V K (1970) Seasonal changes in auxin effects on rooting of stem cuttings of *Populus nigra* and its relationship with mobilization of starch. Physiologia Plantarum 23: 99-107

Taiz L, Zeiger E (1998) Plant Physiology. 2nd Ed. Sinauer Associates Inc Publishers, Sunderland, Massachusetts, USA 559 and 573-585.

Tarran J, Torpy F, Burchett M (2007) Use of Living Pot-Plants to Cleanse Indoor Air - Research Review. Proceedings of Sixth International Conference on Indoor Air Quality, Ventilation & Energy

Woodward A W, Bartel B (2005) Auxin: Regulation, Action and Interaction. Annal Bot 95(5): 707-735

(Manuscript Receivd : 15.04.2014; Accepted : 25.08.2014)

JNKVV Res J 48(2): 162-169 (2014)

Collection and evaluation of kodo millet land races for agro-morphological traits and biotic stresses in Madhya Pradesh

R.P. Joshi, A.K. Jain and **S.S. Chauhan**
All India Coordinated Small Millets Improvement Project
Jawaharlal Nehru Krishi Vishwa Vidyalaya
College of Agriculture, Rewa 486 001 (MP)
Email : rpjoshi_rewa@rediffmail.com

Abstract

Utilization of plant genetic resources for specific need based characters is important to make rapid strategies in crop improvement programme. Four hundred twenty eight land races collected from 7 districts of Madhya Pradesh were evaluated for agro-morphological traits and biotic stresses during two consecutive years 2009 and 2010. Large variation in plant height, number of basal tillers, inflorescence length, grain yield plant^{-1} and 1000 grain weight was recorded in 428 evaluated land races. Average maturity period ranging from 90.5 to 107.5 days was recorded. Among the biotic stresses, incidence of head smut, sheath blight and shoot fly ranging from 2.1 to 39.1%, 13.7 to 49.5% and 2.1 to 60.7%, respectively were recorded. High coefficient of variation (CV) was recorded in shoot fly incidence (65.3%) followed by head smut incidence (43.6%), number of basal tillers (30.9%) and grain yield plant^{-1} (21.2%) where as lowest CV was noted in days to maturity (2.6%) followed by days to 50% flowering (3.9%) and 1000 grain weight (7.9%). Desirable characteristics like earliness, dwarf type, higher grain yield, higher test weight and non-shattering types were recorded in 15.9, 8.2, 18.7, 3.3 and 57.7% land races, respectively. Land races possessing resistance against head smut (3.3%), sheath blight (11.0%) and shoot fly (11.2%) were also identified. These land races of kodo millet may be utilized for the improvement programme of kodo millet.

Keywords: Kodo millet, land races, collection, evaluation, agro-morphological traits and biotic stresses

Kodo millet (*Paspalum scrobiculatum* L.) is one of the major coarse cereal crop cultivated in undulating, sloppy low fertile lands as sole or mixed crop with legumes and oilseeds by tribal and poor farmers in Kharif season. The crop is highly drought resistant and nutritionally as well as medicinally superior or at par than the other cultivated cereals. In India, the crop is cultivated in an area of 224 thousand hectares with annual production of 73 thousand tones. The productivity of kodo millet is 312 kg ha^{-1} (Anon 2011), which is very less as compared to other cereals. Madhya Pradesh ranks first in area of kodo millet, which shares about 60% of its total area of the country. A comprehensive collection of land races / germplasm is the base of any crop improvement programme. Its evaluation leads to identification of genotypes with desirable characters that may be utilized in breeding programme. Due to cleistogamous nature of flowering in kodo millet, crop improvement through hybridization is a difficult task. Hence, available variability in the genotypes or variability created by mutation breeding is the alternative for improvement in kodo millet. The passport and evaluation data serve as a means while selecting accessions as per the individual needs. Ramakrishna et al. (2002) evaluated and classified 1038 accessions of kodo millet for various morpho-agronomical traits using 27 descriptors. Conservation of such valuable germplasm for utilization in future is very important. The crop also suffers due to few biotic stresses like head smut (Sorosporium paspli-thunbergii) , sheath blight (*Rhizoctonia solani*) and shoot fly (*Atherigona* species) that can cause substantial economic loss (Patel and Rawat 1982, Nagesh Chandra and Musthak Ali 1983, Jain and Yadava 1997, Nemade 2012)) in yield under favourable environmental conditions. Keeping these facts in view, attempts were made towards collection of land races from diverse geographic region of kodo millet growing areas, their evaluation for quantitative and qualitative traits along with biotic stresses.

Materials and methods

During 2008-09 and 2009-10, land races of kodo millet were collected from seven kodo millet growing districts of Madhya Pradesh. The collections were made through personal visit to the farmers and through contacts with farmers and personnel of agriculture department from remote and tribal areas. About 50 to 100 g seeds of kodo millet were collected along with passport information about the samples like name of the farmer, village, block, district, cropping pattern and about biotic stresses occurred in kodo millet. The collected samples were kept in cloth bags and cleaned in the laboratory prior evaluation in the field for various morphological, phonological characters and reaction to biotic stresses.

Four hundred seventy nine land races collected from seven districts of Madhya Pradesh, India were sown in two rows of 3.0 m length with 25 cm row to row and 7.5 cm plant to plant spacing in augmented design at the experimental area of Agriculture College, Rewa (MP) during Kharif 2009-10 and 2010-11. The seeds of kodo millet land races were treated with viable teliospores of Sorosporium paspli-thunbergii @ 3g kg^{-1} seed (Jain 2004) for uniform head smut infection. Recommended dose of fertilizers i.e. 40 kg nitrogen and 20 kg P per ha and agronomic practices were adopted for optimum plant growth. Ten healthy plants were tagged in each land races to record the observations on plant characters. Twenty five descriptors were recorded in the material at different stages of plant growth as per guidelines given for kodo millet (Ramakrishna et al. 2002).Growth habit was recorded 40 days after sowing based on tillering attitude. Degree of culm branching, pigmentation was recorded at tillering stage. Degree of lodging, shattering of inflorescence, spikelet arrangement on the rachis and uniformity of plant maturity was noted at maturity. All the ear heads of each plants were harvested and threshed separately and grain yield per plant (g) was recorded. Test weight (1000 grain weight), grain shape and grain colour were recorded after harvesting of the grains. Among biotic stresses, shoot fly incidence was recorded 25 days after sowing by counting dead hearts in the entire row and per cent incidence was estimated. Kodo millet land races were grouped in different categories of reaction against shoot fly (Maithy et al, 1988) as Highly resistant (HR) = 0.0 to 5.0%, Resistant (R) = 5.1 to 10%, Moderately resistant (MR) = 10.1to 15.0%, Moderately susceptible (MS) = 15.1 to 20.0%, Susceptible (S) = 20.1 to 30.0% and Highly susceptible (HS) = > 30.0% of shoot fly damage. Head smut incidence was recorded by counting healthy and smutted plants in the entire row at dough stage and percent disease incidence was calculated. The accessions were classified for disease reaction according to scale of Nagaraja et al (2007) as : Highly resistant (HR) = 0.0%, Resistant (R) = up to 1.0%, Moderately resistant (MR) = 1.1 to 5.0%, Moderately susceptible (MS) = 5.1 to 10.0%, Susceptible (S) = 10.1 to 20.0% and Highly susceptible (HS) = > 20.0% head smut incidence. Quantitative grouping of all the land races of kodo millet were carried out on the basis of morphological and phonological characters.

Results and discussion

Collection of kodo millet land races

A total of 479 land races of kodo millet were collected from 9 blocks of Rewa, 6 blocks of Satna, 6 blocks of Sidhi, 3 blocks of Singrauli, 5 blocks of Shahdol, 3 blocks of Umaria and one block of Anuppur district of Madhya Pradesh during 2009 and 2010. Among different districts, maximum 151 land races were collected from Rewa district followed by Shahdol (102) and Satna (63) district. The maximum collections were made from Majhagavan (45) block of Satna district followed by Beohari (35) block of Shahdol, Hanumana block (34) of Rewa and Jai Singh Nagar (34) block of Shahdol district. Collected samples were numbered, cleaned and stored at room temperature for evaluation (Table 1).

Evaluation for quantitative traits

Out of 479 land races collected from different places, only 428 land races were germinated. Results of pooled variability analysis of kodo millet presented in table 2 for quantitative traits and biotic stresses revealed large variation in plant height, number of basal tillers, inflorescence length, grain yield and 1000 grain weight. Average plant height, number of basal tillers plant-1, inflorescence length, number of raceme above thumb, longest raceme length, grain yield plant-1 and 1000 grain weight ranging from 34.2 to 82.4 cm, 1.6 to 8.9, 7.6 to 32.4 cm, 2.5 to 12.2, 3.8 to 8.4 cm, 7.5 to 26.8 g and 3.35 to 6.65 g, respectively were recorded. Average days to 50% flowering and maturity period varied from 55.5 to 71.0 days and 90.5 to 107.5 days, respectively. Among important biotic stresses, head smut, sheath blight and shoot fly incidence ranging from 2.1 to 39.1%, 13.7 to 49.5% and 2.1 to 60.7%, respectively was recorded. High coefficient of variation (CV) was recorded in shoot fly incidence (65.3%) followed by head smut incidence 943.6%), number of basal tillers (30.9%)

and grain yield plant^{-1}(21.2%), where as lowest CV was recorded in days to maturity (2.6%) followed by days to 50% flowering (3.9%) and 1000 grain weight (7.9%). Wide range of variability for morphological characters and grain yield in land races of kodo millet was recorded by Tiwari and Janoria (1967), Verma and Singh (1983) and Kandaswamy et al. (1990). Ahluwalia et al. (1970) reported high heritable variability for days to flowering, ears per plant, and tillers per plant in kodo millet. High magnitude of phenotypic coefficient of variation was for dry matter production, grain yield per plant, panicle numbers per plant and basal tillers per plant, where it was low for developmental traits like days to flowering and days to maturity. Yadava et al. (2003) evaluated 260 genotypes of kodo millet comprising 136 early and 128 late maturing for yield and yield traits and reported higher magnitude of variation in late maturing lines as compared to early maturing genotypes of kodo millet.

Grouping of kodo millet land races on the basis of quantitative traits (Table 3) showed that 87.6% land races were semi-dwarf, 59.8% land races has medium tillering capacity. Medium maturity period (96 to 101 days) was recorded in 71.35 land races and 67.55 land races have medium grain yield potential (10.1 to 15.0 g per plant), where as 78.0% land races have medium test weight (4.6 to 5.5 g).

Evaluation for qualitative traits

All the evaluated kodo millet land races were grouped on the basis of 15 qualitative traits and results are presented in table 4. The majority of the land races have erect (69.2%) growth habit, where as 18.7% were prostrate and 12.1% genotypes were decumbent. All the evaluated land races showed sheath, sheath base, juncture and inter-node pigmentation; where as lamina pigmentation was observed in 97.7% land races. Based on spikelet arrangement on rachis, land races were categorized into regular rows, regular rows in upper half and irregular in lower half, two to three irregular rows and two to four irregular rows. Maximum land races i.e. 75.3% have regular rows on spikelets. Ear exertion was complete in 418 (97.7%) land races, while partial ear exertion was recorded in 10 (3.3%) land races. Ear appearance was open in 124 (28.9%), semi compact in 237 (55.2%) and intermediate in 68 (15.9%) land races. Shattering nature of inflorescence was observed in 181 land races, where as 247 were non-shattering type. Land races were grouped into orbicular, ellipsoidal and oval type grain shape. Maximum 99.8% land races have ellipsoidal grain shape and only one was orbicular type. Dark brown grain colour was observed in 199 land

Table 1. Locality wise collection of Kodo millet land races from 7 districts of Madhya Pradesh

District	No. of blocks	Block	No. of land races collected
Rewa	09	Rewa	07
		Raipur kurchulian	14
		Java	01
		Gangeb	23
		Mauganj	19
		Hanumana	34
		Sirmor	31
		Teonthar	07
		Naigarhi	15
		Total	151
Satna	06	Rampur Baghelan	02
		Ramnagar	05
		Sohawal	05
		Majhagavan	45
		Amarpatan	04
		Maihar	02
		Total	63
Sidhi	06	Sidhi	11
		Majholi	13
		Rampur naikin	06
		Sihawal	14
		Kusumi	09
		Churhat	05
		Total	54
Singrauli	03	Waidhan	13
		Chitrangi	22
		Deosar	08
		Total	43
Shahdol	05	Beohari	35
		Jai Singh Nagar	34
		Sohagpur	14
		Gohparu	03
		Budhar	16
		Total	102
Umaria	03	Karkeli	21
		Manpur	15
		Pali	16
		Total	52
Anuppur	01	Rajendragram	14
		Total	14
		Grand total	479

Table 2. Extent of variability in landraces of kodo millet for quantitative traits and biotic stresses

Character	Range		Mean	Standard Deviation	CV(%)
	Minimum	Maximum			
Plant height (cm)	34.2	82.4	58.10	6.45	10.1
No. of basal tillers	1.6	8.9	4.26	1.32	30.9
Days to 50% flowering	55.5	71.0	63.23	2.50	3.9
Inflorescence length (cm)	7.6	32.4	20.22	3.72	18.4
Number of raceme above thumb	2.5	12.2	6.45	1.34	20.8
Longest raceme length (cm)	3.8	8.4	6.59	0.57	8.6
Days to maturity	90.5	107.5	97.52	2.55	2.6
Grain yield per plant (g)	7.5	26.5	12.97	2.75	21.2
1000 grain weight (g)	3.35	6.65	4.83	0.38	7.9
Head smut (%)	2.1	39.1	17.27	7.54	43.6
Sheath blight (%)	13.7	49.5	25.71	5.39	20.9
Shoot fly (%)	2.1	60.7	25.18	12.53	65.3

Table 3. Quantitative grouping of 428 Landraces of Kodo Millet on the basis of pooled data

Character	Group	No. of land races	Percent (%)
Plant height	Dwarf (50 cm)	35	8.2
	Semi dwarf (50.1 to 70 cm)	375	87.6
	Tall (> 70 cm)	18	4.2
Number of basal tillers	Low (up to 3)	63	14.7
	Medium (up to 5)	256	59.8
	High (Above 5)	109	25.5
Degree of culm branching	Low (up to 3)	88	20.6
	Medium (up to 5)	182	42.5
	High (Above 5)	158	36.9
Inflorescence length	Low (up to 15.0)	31	7.2
	Medium (15.1 to 25.0 cm to)	363	84.8
	High (> 25 cm)	34	8.0
Number of racemes above thumb	Low (up to 4)	24	5.6
	Medium (5 to 8)	369	86.2
	High (> 8)	35	8.2
Length of longest raceme	Low (up to 6.0 cm)	63	14.7
	Medium (6.1 to 7.0 cm)	281	65.7
	High (> 7.0 cm)	84	19.6
50% flowering	Early (up to 60 days)	39	9.1
	Medium (61 to 65 days)	310	72.4
	Late (> 65 days)	79	18.5
Maturity	Early (up to 95 days)	68	15.9
	Medium (96-101 days)	305	71.3
	Late (>101 days)	55	12.8
Grain yield per plant	Low (up to 10 g)	59	13.8
	Medium (10.1 to 15 g)	289	67.5
	High (Above 15 g)	80	18.7
1000 grain weight	Low (up to 4.5 g)	80	18.7
	Medium (4.6 to 5.5 g)	334	78.0
	High (Above 5.5 g)	14	3.3

Table 4. Qualitative grouping of 428 Landraces of Kodo Millet

Character	Group	No. of land races	Percent (%)
Growth habit	Erect	296	69.2
	Decumbent	52	12.1
	Prostrate	81	18.7
Sheath pigmentation	Absent	0	0.0
	Present	428.	100.0
Sheath base pigmentation	Absent	0	0.0
	Present	428	100.0
Juncture pigmentation	Absent	0	0.0
	Present	428	100.0
Internode pigmentation	Absent	0	0.0
	Present	428	100.0
Lamina (margin) pigmentation	Absent	21	4.9
	Present	407	95.1
Flag leaf at the second primary axis	Absent	10	2.3
	Rudimentary	143	33.4
	Well developed	275	64.3
Degree of lodging at maturity	Low	67	15.6
	Intermediate	227	52.9
	High	135	31.5
Ear exertion	Complete	419	97.7
	Partial	10	3.3
Ear appearance	Open	124	28.9
	Semi compact	237	55.2
	Intermediate	68	15.9
Spikelet arrangement on the rachis	Regular rows	323	75.3
	Regular rows in upper half & regular in lower	51	11.9
	2-3 irregular	30	6.9
	2-4 irregular	25	5.8
Shattering of inflorescence	Absent	247	57.7
	Present	181	42.3
Uniformity of plant maturity	Absent	03	0.69
	Present	426	99.3
Grain shape	Orbicular	01	0.2
	Ellipsoidal	427	99.8
	Oval	0	0.0
Grain colour	Grey brown	50	11.7
	Brown	180	41.9
	Dark brown	199	46.4

Table 5. Grouping of 428 kodo millet land races on the basis of resistance/susceptibility against important diseases and insect pests

Biotic stresses	Causal organism	Group	No. of land races	Percent (%)
Head smut	Sorosporium paspali-thunbergii	Resistant	0	0.0
		Moderately Resistant	14	3.3
		Susceptible	414	96.7
Sheath blight	Rhizoctonia solani	Resistant	47	11.0
		Moderately Resistant	377	88.1
		Susceptible	4	0.9
Shoot fly	Atherigona spp	Resistant	48	11.2
		Moderately Resistant	111	25.9
		Susceptible	269	62.9

Table 6. Resistant sources of kodo millet identified against important biotic stresses

Biotic factor	Reaction	Land races
Head smut	MR	RPS 539, 575, 581, 583, 590, 804, 818, 820, 830, 859, 886, 898, 910 & 977
Sheath blight	R	RPS502, 503, 508, 510, 516, 529, 531, 535, 543, 548, 550, 556, 566, 575, 577, 579, 585, 593, 607, 609, 621, 629, 634, 646, 649, 661, 662, 689, 691, 694, 695, 708, 739, 753, 755, 787, 789, 814, 830, 867, 881, 883, 918, 919, 923, 929, 956, 961
Shoot fly	R	RPS515, 583, 612, 628, 642, 685, 763, 806, 810, 811, 822, 823, 834, 842, 846, 871, 872, 901, 902, 904, 905, 909, 910, 914, 915, 917, 918, 921, 925, 927, 929, 930, 933, 934, 938, 939, 941, 943, 944, 945, 946, 948, 951, 953, 967, 968, 970 & 974

R = Resistant MR = Moderately resistant

Table 7. Economic genetic resources of kodo millet

Economic traits	Genetic sources
Dwarf	RPS 521, 529, 541, 546, 683, 733, 801and 926 (8)
Extra early	RPS 540, 541, 546, 632, 681, 687, 696 and 700 (8)
Higher grain yield	RPS 503, 556, 639, 649, 710, 712, 769, 775, 780, 798, 859, 910, 967 and 977 (14)
Higher 1000 grain weight	RPS 507, 540, 556, 612, 614, 620, 638, 639, 642, 648, 650, 700, 705, 708, 709, 910 and 912 (17)
Multiple Resistance to head smut, sheath blight and shoot fly	RPS 575, 583, 590, 830, 886, 898 and RPS 910 (7)

races, where as 180 were brown and 50 were grey brown.

Evaluation for biotic stresses

On the basis of two years pooled data, incidence of head smut and sheath blight ranging from 2.1 to 39.1% and 13.7 to 49.5%, respectively were recorded in evaluated land races of kodo millet and classified as resistant, moderately resistant and susceptible to the diseases. None of the land races were completely free from head smut under artificial inoculations. However, 14 land races (3.3%) namely RPS 539, 575, 581, 583, 590, 804, 818, 820, 830, 859, 886, 898, 910 and 977 were shown moderately resistant reaction showing less than 5% smut incidence. Rests of the land races (414) were susceptible to the disease. Forty seven (11.0%) land races were resistant, 377 (88.1%) were moderately resistant and 4 (0.9%) were susceptible to sheath blight. Shoot fly incidence ranging from 2.1 to 60.7% was recorded. Fort eight land races (11.2%) were found resistant to shoot fly by producing < 10% dead heart, 111 were moderately resistant and 269 (62.9%) were susceptible to shoot fly. Seven land races namely RPS 575,583, 590, 830, 886, 898 and RPS 910 were shown moderately resistant reaction to head smut, sheath blight and shoot fly (Table 5 and 6).

Identification of economic genetic resources

The donors for biotic resistance and economic land races of kodo millet for various desirable traits has been identified and presented in Table 7. Eight land races namely RPS 521, 529, 541,546, 683, 733, 801and 926 were dwarf (< 45 cm) and eight namely RPS540, 541, 546, 632, 681, 687, 696 and 700 were extra early (< 92 days). Higher grain yield per plant (> 18 g) was recorded in 14 land races namely RPS 503, 556, 639, 649, 710, 712, 769, 775, 780, 798, 859, 910, 967 and 977. More than 5.5 g test weight (1000 grain weight) was recorded in RPS 507, 540, 556, 612, 614, 620, 638, 639, 642, 648, 650, 700, 705, 708, 709, 910 and 912. Seven land races namely RPS 575, 583, 590, 830, 886, 898 and RPS 910 were found moderately resistant to head smut, sheath blight and shoot fly incidence. Yadava and Jain (2006) reviewed the economic genetic resources of kodo millet reported by various workers in kodo millet for different traits.

It may be concluded from the present study that a wide range of variation for agro-morphological traits and reaction to important biotic stresses exists in the present land races collected from different geographic areas of the Madhya Pradesh. However, there is ample possibility to enrich the variability for economic traits through vigorous collection from untouched kodo millet growing areas. These economic traits may be utilized as donor for improvement in kodo millet for earliness, higher grain yield coupled with in-built resistance against important biotic stresses.

Acknowlegements

The authors acknowledge the Madhya Pradesh State Biodiversity Board, Bhopal (MP) for providing financial assistance and the authorities of Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (MP) for providing facilities during the course of present study.

फसल सुधार कार्यक्रम के शीघ्र एवं सफल क्रियान्वयन हेतु आवश्यक रुप से चाहे गये लक्षणों के आनुवांषिक स्रोतों का उपयोग महव्वपूर्ण है । मध्य प्रदेश के सात जिलों से एकत्रित किये गये चार सौ अट्ठाईस स्थानीय प्रभेदों का परीक्षण सस्य आकार की एवं जैविक उद्दीपनों के विरुद्ध लगातार दो वर्षों 2009 एवं 2010 में किया गया । परीक्षित प्रभेदों में पौध ऊचाई, कल्लों की संख्या, पुष्पक्रम की लंबाई, प्रति पौधा दानों की उपज व 1000 दानों के वजन में ज्यादा विभिन्नता आंकलित की गयी । औसत पकने की अवधि 90.5 से 107.5 दिन आंकलित की गयी । विभिन्न जैविक उद्दीपनों में मुण्डक, कण्डवा, पर्णछाद, झुलसन एवं तना मक्खी का संक्रमण क्रमषः 2.1 से 39.1 प्रतिषत, 13.7 से 49.5 प्रतिशत तथा 2.1 से 60.7 प्रतिशत पाया । उच्च भिन्नता गुणांक तना मक्खी संक्रमण (65.3 %)के पष्चात मुंडक कण्डवा संक्रमण (43.61) आधार कंसे की संख्या (30.9%) एवं प्रति पौधा दानों की उपज (21.2%) मे था जबकि निम्न भिन्न्ता गुणांक पकने की अवधि (2.6%) के उपरांत 50% पुष्पन अवधि (3.9%) एवं 1000 दानों के वजन (7.9%) में अंकित किया गया । इच्छित गुणों जैसे शीघ्र परिपक्वता, बौनी एवं उच्च उपज, उच्च परीक्षण भार एवं प्रकीर्णन रहित वाले प्रभेद क्रमषः 15.9, 8.2, 18.7, 3.3 व 57.7 % थे । मुंडक कण्डवा (3.3%), पर्णछाद झुलसन (11.8 %) एवं तना मक्खी (11.2%) के लिए प्रतिरोधी प्रभेद भी चिन्हित किये गये । कोदों के इन स्थानीय प्रभेदों का उपयोग कोदों विकास कार्यक्रमों में किया जा सकता है ।

References

Ahluwalia M, Diljit S, Solaman C, Naqvi S (1970) Studies on variability in kodo millet (*Paspalum scrobiculatum* L.). Andhra Agric J 17 (2): 58-60

Anonymous (2011) Co-ordinators Review. Paper presented in Annual Workshop of AICRP on Small Millets, held at OUAT, Bhubaneshwar (Odisha) on April 23-25, 2011

Jain AK, Yadava HS (1997) Recent approaches in disease management of Small millets. Abstract of National Seminar on Small millets : Current research trends and future priorities as food, feed and in processing for value addition, held from 23-24 April, 1997 at TNAU, Coimbatore, India pp 31-33

Jain AK (2004) Increasing incidence of head smut of kodo millet in Madhya Pradesh. J Mycol Pl Pathol 34 (2): 593-594

Kandaswamy G, Ramamoorthy N, Manoharan V (1990) Genetic variability in kodo millet (*Paspalum scrobiculatum* L.). Madras Agric J 77: 9-12

Maithi BK, Mahapatra HK, Mishra BK (1988) Screening of little millet (*Panicum miliare*) germplasm against little millet shoot fly (*Atherigona miliaceae* M.) damage. Millets Newsl 7:

Nagesh Chandra BK, Musthak Ali TM (1983) Losses due to shoot fly on minor millets. MILWAI Newsl 2: 16.

Nagaraja A, Kumar J, Jain AK, Narasimhudu Y, Raguchander T, Kumar B, Hanumanthe Gowda B (2007) Compendium of Small Millets Diseases. Project Coordinating Cell, AICRP on Small Millets, USA, Bangalore pp 65

Nemade J (2012) Studies on vulnerability of kodo millet genotypes to head smut caused by *Sorosporium paspali thunbergii* (Henn) Ito. MSc (Ag) Thesis JNKVV, Jabalpur (MP)

Patel RK, Rawat RR (1982) Note on the estimation of loss in yield of kodo millet caused by the attack of shoot fly. Indian J Agric Sci 52(12): 880

Ramakrishna BM, Krishanappa M, Seenappa K, Halaswamy BH, Gowda J, Vasanth KR, Somu G, Gowda BTS, Seetharam A (2002) Evaluation of Kodo millet (*Paspalum scrobiculatum* L.) germplasm. Project Co-ordinating Unit, AICRP on Small Millets, UAS, GKVK campus, Bangalore-560 065 pp 1-59

Tiwari DK, Janoria MP (1967) Breeding potentialities of *Paspalum scrobiculaum* (L.). JNKVV Res J 1(1): 88-89

Verma SNP, Singh RP (1982) Association analysis in three maturing groups of kodo millet. Indian J Agric Sci 52(8): 488-491

Yadava HS, Tikle AN, Bhagat DV (2003) Effect of induced mutation through gamma rays on growth and yield parameters of kodo millet. J Soils and Crops 13(1) : 25-28

Yadava HS, Jain AK (2006) Recent advances in kodo millet. ICAR, New Delhi pp 20-22

(Manuscript Receivd : 13.12.2013; Accepted : 05.05.2014)

JNKVV Res J 48(2): 170-174 (2014)

Identification of host resistance against banded leaf and sheath blight of foxtail millet

A.K. Jain, R.P. Joshi and **Gyanendra Singh**
AICRP on Small Millets
Jawaharlal Nehru Krishi Vishwa Vidyalaya
College of Agriculture Rewa 486 001 (MP)
Email : akjagcrewa@rediffmail.com

Abstract

Seventy two land races of foxtail millet collected from diverse geographical regions of Madhya Pradesh were evaluated along with two national checks SIA 326 and PS 4 against banded leaf and sheath blight (BLSB) disease under artificial inoculations. The disease severity ranging from 10.8 to 68.9% was recorded. Twelve land races namely RFM 82, 83, 84, 85, 87, 88, 90, 93, 94, 95, 96 and 97 were shown resistance, where as 21 land races were moderately resistance, 29 moderately susceptible, 11 were susceptible and 1 was highly susceptible to BLSB. Average plant height was recorded 106.5 cm in resistant, 96.7 cm in MR, 86.3 cm in MS and 79.9 cm in susceptible and 76.4 cm in highly susceptible land races. Average 50% flowering period was 34 days in highly susceptible land races, where as it was 41 days in resistant land races. Dwarf and early maturing land races were shown susceptibility to BLSB as compared to tall and late maturing land races. These land races may be utilized in breeding programme for variety development.

Keywords : Foxtail millet, banded leaf and sheath blight, host resistance, morphological characters.

Foxtail millet (*Setaria italica*) is an important rainfed cereal crop grown for food and feed by the tribal people. In India, the crop is grown around 98 thousand hectares with annual production of 56 thousand tones and 656 kg ha^{-1} productivity (Anon 2011). The crop is predominantly grown in the state of Andhra Pradesh, Karnataka, Tamil Nadu and erratic pockets of Madhya Pradesh and Uttarakhand. In India, banded leaf and sheath blight of foxtail millet caused by Rhizoctonia solani has been reported from Uttar Pradesh (Dubey et al. 1989), Madhya Pradesh (Jain and Gupta 2010) and Andhra Pradesh (Anon 2013). The pathogen is a necrotrophic soil borne with high competitive saprophytic activity. The disease inflicts economical loss in yield and yield attributes if infection occur at tillering stage. Earlier the crop was reported susceptible to rice isolate (Kannaiyan and Prasad, 1978, Ahuja and Payak, 1985, Meena and Muthuswamy 1998) and moderately susceptible to maize isolate (Rathore et al. 1998). Morphological traits like plant height and heading date have been reported to affect the resistance of rice cultivars to sheath blight (Manian 1984, Lakpale et al. 1997 and Park et al. 2008) Very little efforts have been made to identify the resistant sources of foxtail millet against banded leaf and sheath blight disease. Host resistance is reported the most efficient, feasible and cheapest way to control banded leaf and sheath blight (BLSB) disease. In the present study, attempts were made to identify resistant sources of foxtail millet and morphological traits associated with resistance against banded leaf and sheath blight disease.

Materials and methods

Seventy two land races of foxtail millet collected from diverse geographic region of Madhya Pradesh were evaluated along with two national checks namely PS 4 and SIA 326 in randomized block design with three replications during Kharif 2010 and land races shown resistance were re-screened during kharif 2011 under artificial inoculation conditions. The seeds of foxtail millet genotypes were sown in 2 rows of 3.0 m length with 22.5 cm row to row and 7.5 cm plant to plant spacing. Recommended doses of fertilizers i.e. 40 kg N and 20 kg P_2O_5 per hectare and package of practices were adopted for optimum plant growth. Ten plants in each replication were artificially inoculated with infected leaf bit method 25 days after sowing. Leaf bits of about

Table 1. Performance of foxtail millet land races against banded leaf & sheath blight *Rhizoctonia solani*

S.No.	Land race	50% flowering (days)	Plant height	BLSB severity (%)	Reaction	S. No.	Land race	50% flowering (days)	Plant height	BLSB severity (%)	Reaction
1	RFM 21	37.0	93.8	31.9	MS	38	RFM 65	37.0	87.0	42.0	MS
2	RFM 22	42.0	88.5	25.7	MR	39	RFM 66	38.0	100.7	21.3	MR
3	RFM 23	40.0	89.5	24.9	NR	40	RFM 67	35.0	88.3	35.8	MS
4	RFM 24	35.0	88.3	29.0	MR	41	RFM 68	35.0	80.0	33.0	MS
5	RFM 25	38.0	92.0	37.9	MS	42	RFM 69	37.0	87.0	42.0	MS
6	RFM 27	38.0	78.8	40.1	MS	43	RFM 70	38.0	89.0	29.5	MR
7	RFM 29	34.0	76.4	68.9	HS	44	RFM 71	34.0	87.3	36.2	MS
8	RFM 30	38.0	83.6	31.5	MS	45	RFM 72	38.0	94.0	27.6	MR
9	RFM 31	36.0	83.3	53.8	S	46	RFM 73	34.0	93.3	32.8	MS
10	RFM 32	36.0	83.7	52.2	S	47	RFM 74	38.0	79.4	38.6	MS
11	RFM 33	35.0	80.7	57.7	S	48	RFM 75	37.0	96.6	26.2	MR
12	RFM 35	35.0	80.8	40.7	MS	49	RFM 76	35.0	90.8	33.3	MS
13	RFM 36	35.0	79.9	60.9	S	50	RFM 77	36.0	88.8	31.8	MS
14	RFM 37	34.0	82.5	37.8	MS	51	RFM 78	36.0	90.4	27.5	MR
15	RFM 38	34.0	82.2	53.7	S	52	RFM 79	35.0	98.4	20.8	MR
16	RFM 39	35.0	82.0	38.6	MS	53	RFM 80	35.0	92.6	33.6	MS
17	RFM 40	35.0	88.7	26.9	MR	54	RFM 81	35.0	99.6	22.6	MR
18	RFM 42	37.0	79.2	47.5	S	55	RFM 82	39.0	94.1	18.1	R
19	RFM 43	38.0	91.0	44.3	MS	56	RFM 83	40.0	99.4	17.6	R
20	RFM 44	35.0	88.7	26.9	MR	57	RFM 84	40.0	90.4	15.6	R
21	RFM 45	38.0	83.6	32.7	MS	58	RFM 85	39.0	85.3	18.2	R
22	RFM 47	33.0	72.0	55.9	S	59	RFM 86	40.0	83.5	21.7	MR
23	RFM 48	33.0	94.8	44.3	MS	60	RFM 87	39.0	90.4	18.6	R
24	RFM 50	34.0	86.8	41.6	MS	61	RFM 88	40.0	87.2	17.2	R
25	RFM 51	38.0	91.0	44.3	MS	62	RFM 89	40.0	86.8	22.3	MR
26	RFM 52	39.0	77.6	34.7	MS	63	RFM 90	42.0	98.7	17.3	R
27	RFM 53	34.0	86.8	37.2	MS	64	RFM 91	38.0	103.5	22.6	MR
28	RFM 54	34.0	87.3	37.5	MS	65	RFM 92	37.0	113.1	22.4	MR
29	RFM 55	38.0	91.0	44.3	MS	66	RFM 93	44.0	129.2	14.8	R
30	RFM 56	33.0	74.8	50.9	S	67	RFM 94	42.0	121.6	16.2	R
31	RFM 57	39.0	77.6	34.7	MS	68	RFM 95	45.0	131.2	18.3	R
32	RFM 58	34.0	86.3	46.3	S	69	RFM 96	41.0	124.7	10.8	R
33	RFM 59	41.0	83.5	22.2	MR	70	RFM 97	43.0	125.4	18.8	R
34	RFM 60	34.0	87.3	37.5	MS	71	RFM 98	38.0	127.3	21.6	MR
35	RFM 62	38.0	92.6	21.2	MR	72	RFM 99	35.0	124.3	22.4	MR
36	RFM 63	34.0	78.2	50.9	S	73	PS 4*	38.0	78.6	47.7	S
37	RFM 64	35.0	88.1	33.4	MS	74	SIA 326*	44.0	103.7	28.9	MS

* National checks

R = Resistant MR = Moderately resistant MS = Moderately susceptible

S = Susceptible HS = Highly susceptible

Table 2. Grouping of foxtail millet genotypes against banded leaf and sheath blight disease for their reaction

Reaction	BLSB severity (%)	No. of land races	Land races
Highly resistant	0	0	-
Resistant	Up to 20	12	RFM 82, 83, 84, 85, 87, 88, 90, 93, 94, 95, 96 and 97
Moderately resistant	20 - 30	21	RFM 22, 23, 24, 40, 44, 57, 59, 62, 66, 70, 72, 75, 78, 79, 81, 86, 89, 91, 92, 98, 99 and SIA 326
Moderately susceptible	31 - 45	29	RFM 21, 25, 27, 30, 35, 37, 39, 43, 45,48, 50, 51, 52,53,54, 55, 57, 60, 64,65, 67, 68, 69, 71, 73, 74, 76, 77 and 80 .
Susceptible	46 - 65	11	RFM 31, 32, 33, 36, 38, 42, 47, 56 58 ,63 and PS 4
Highly susceptible	Above 65	1	RFM 29

Table 3. Mean and range of disease severity, 50% flowering and plant height of foxtail millet genotypes in different categories of disease reaction

Reaction	BLSB severity (%)		50% flowering (days)		Plant height(cm)	
	Range	Mean	Range	Mean	Range	Mean
Resistant	10.8 - 18.8	16.8	39 - 45	41	85.3 - 131.2	106.5
Moderately resistant	20.8 - 29.5	24.5	35 - 44	38	83.5 - 127.3	96.7
Moderately susceptible	31.5 - 44.5	37.3	33 - 39	36	77.6 - 94.8	86.3
Susceptible	46.3 - 60.9	52.5	33 - 38	35	72.0 - 86.3	79.9
Highly susceptible	-	68.9	-	34	-	76.4

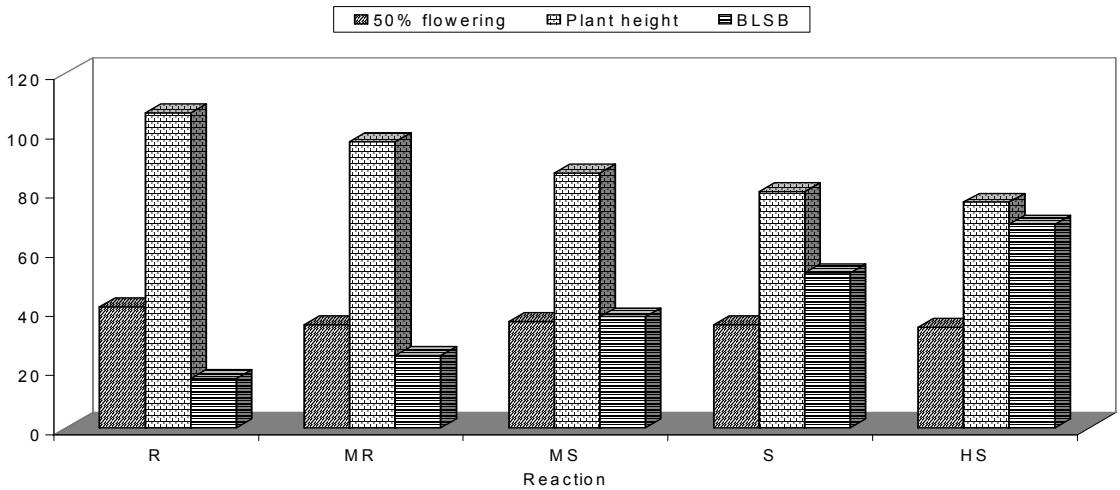


Fig 1. Crop duration (days) and plant height (cm) in relation to banded leaf and sheath blight (%) of foxtail millet

1 to 2 cm long were inserted between the stem of the middle tillers of each plant and leaf sheath of basal node. High humidity was maintained during disease development by frequent watering. The inoculated plants were observed daily for development of symptoms. Days to 50% flowering were recorded in each land races and plant height was recorded at dough stage. Lesion length (cm) was recorded at dough stage along with total length of plant. The severity of banded leaf and sheath blight was calculated based on relative lesion height of whole plant (IRRI 1996).

$$\text{Percent disease severity} = \frac{\text{Total lesion length}}{\text{Total length of plant}} \times 100$$

Foxtail millet land races were grouped into various categories of reaction against banded leaf and sheath blight adopting 0 - 9 grade scale where, 0 = no infection, 1 = lesions limited to lower 20% of plant height, 3 = lesions limited to lower 20 - 30% of plant height, 5 = lesions limited to lower 31 - 45% of plant height, 7 = lesions limited to lower 46 - 65% of plant height and 9 = lesions limited to > 65% of plant height.

Results and discussion

Banded leaf and sheath blight (BLSB) severity in 74 land races including two national checks of foxtail millet presented in Table 1 showed that all the genotypes were affected by the disease. The disease severity varied from 10.8 to 68.9% was recorded in the screened land races. None of the land races were completely free from BLSB, However, 12 land races namely RFM 82, RFM 83, RFM 84, RFM 85, RFM 87, RFM 88, RFM 90, RFM 93, RFM 94, RFM 95, RFM 96 and RFM 97 were shown resistant reaction under artificial inoculations. Twenty one land races namely RFM 22, RFM 23, RFM 24, RFM 40, RFM 44, RFM 57, RFM 59, RFM 62, RFM 66, RFM 70, RFM 72, RFM 75, RFM 78, RFM 79, RFM 81, RFM 86, RFM 89, RFM 91, RFM 92, RFM 98, RFM 99 and SIA 326 were moderately resistant. National check SIA 326 was earlier reported resistant to BLSB under natural conditions by Jain and Gupta (2010).Twenty nine land races were moderately susceptible and 11 were susceptible to BLSB. One land race RFM 29 was highly susceptible to BLSB showing > 65% disease severity (Table 2).

Average and range of BLSB severity, 50% flowering duration and plant height of foxtail millet land races in different categories of reaction are presented in Table 3. Average disease severity of 16.8% in resistant land races, 24.5% in moderately resistant, 37.3% in moderately susceptible, 52.5% in susceptible and 68.9% in highly susceptible land races was recorded. Average flowering period was 41 days in resistant land races, where as it was 34 to 35 days in susceptible and highly susceptible land races. Average plant height was 106.5 cm in resistant group of land races and 76.4 to 79.9 cm in susceptible and highly susceptible land races (Fig 1). A significant negative correlations were recorded between plant height and disease severity (r = -0.638) and 50% flowering duration and disease severity (r = -0.612). Manian (1984), Lakpale et al. (1997) and Park et al. (2008) also reported higher incidence of sheath blight in early maturing cultivars of rice as compared to medium and late maturing groups. Higher incidence of BLSB in early duration group of cultivars might be due to congenial interaction of pathogen with environmental conditions at early stages of crop growth. Severe incidence of sheath blight was also reported in dwarf cultivars of rice as compared to tall cultivars (Roy 1993) and corroborating with the present findings.

It may be concluded from the present study that none of the screened land races were highly resistant to banded leaf and sheath blight disease, however, 12 land races namely RFM 82, RFM 83, RFM 84, RFM 85, RFM 87, RFM 88, RFM 90, RFM 93, RFM 94, RFM 95, RFM 96 and RFM 97 were resistant under artificial inoculations. Dwarf and early maturing land races were more susceptible to banded leaf and sheath blight as compared to tall and late maturing land races.

मध्यप्रदेश के अपसारी भौगोलिक स्थानों से एकत्रित काकुन के 72 स्थानीय प्रभेदों का परीक्षण कृत्रिम निवेशन द्वारा सर्पिल पर्ण व पर्णछाद झुलसन के विरूद्ध दो राष्ट्रीय नियंत्रक किस्मों एस.आई.ए. 326 एवं पी.एस. 4 के साथ किया गया। रोग तीव्रता 10.8 से 68.9 प्रतिशत आंकलित की गयी। बारह स्थानीय प्रभेद आर.एफ.एम. 82, 83, 84, 85, 87, 88, 90, 93, 94, 95, 96 एवं 97 ने रोग प्रतिरोधकता प्रदर्शित की, जबकि 21 प्रभेद मध्यम प्रतिरोधी, 29 मध्यम रोगग्राही, 11 रोगग्राही एवं 1 प्रभेद सर्पिल पर्ण व पर्णछाद झुलसन के लिये सुग्राही पाया गया। रोगरोधी प्रभेदों में औसत पौधों की ऊंचाई 106.5 से. मी., मध्यम प्रतिरोधी में 96.7 से.मी., मध्यम रोगग्राही में 86.3 से. मी., रोगग्राही में 79.9 से.मी. तथा रोग सुग्राही में 76.4 से.मी. आंकलित की गयी। औसत 50 प्रतिशत पुष्पीय अवधि रोग सुग्राही प्रभेद में 34 दिन एवं प्रतिरोधी प्रभेदों में 41 दिन थी। बौने एवं जल्दी पकने वाले प्रभेदों ने लम्बे व देर से पकने वाले प्रभेदों की अपेक्षा सर्पिल पर्ण व पर्णछाद झुलसन के प्रति रोग सुग्राहिता प्रदर्शित की। पौधों की ऊंचाई

व रोग तीव्रता (-0.638) तथा 50 प्रतिशत पुष्पीय अवधि व रोग तीव्रता (-0.612) के बीच सार्थक ऋणात्मक सह संबंध पाया गया। इन स्थानीय प्रभेदों का उपयोग किस्मों के विकास हेतु प्रजनन कार्यक्रमों में किया जा सकता है।

References

Ahuja SC, Payak MM (1985) Comparative karyology, biology and pathology of maize and rice isolates of *Rhizoctonia solani* fsp. *sasakii*. Indian Phytopath 30: 771-773

Anonymous (2011) Co-ordinators Review. Paper presented in Annual Workshop of AICRP on Small Millets, held at OUAT, Bhubaneshwar (Odisha) on April, 23-25, 2011

Anonymous (2013) Annual Report 2012-13. All India Coordinated Small Millets Improvement Project. Project Coordinating Unit, ICAR, GKVK, Bangalore pp 35

Dubey SC, Dwivedi RP, Narain U (1989) Banded blight of Italian millet caused by *Thanetophorous cucumeris*. Farm Sci J 4(1-2): 1-6

IRRI (1996) Standard Evaluation System for Rice. 4th Edition. International Rice Research Institute, Manila, Philippines

Lakpale N, Trimurthy VS, Kumar R (1997) Influence of crop duration on development of sheath blight of rice. J Mycol Pl Pathol 27(3): 343-344

Jain AK, Gupta AK (2010) Occurrence of banded leaf and sheath blight on foxtail millet and barnyard millet in Madhya Pradesh. Ann Pl Protec Sci 18(1) : 268-270

Kannaiyan S, Prasad NN (1978) Reaction of certain cereal crop plant to sheath blight disease of rice. Indian Phytopath 31:541

Manian S (1984) Effect of maturity on the resistance of rice cultivars of sheath blight disease. Trop Agric (Trinidad) 61(2): 109-110

Meena B, Muthuswamy M (1998) Host range of *Rhizoctonia solani*, the incitant of sheath blight disease of rice. Indian J Plant Protec 26(1):62-63

Park DS, Sayler RJ, Hong YG, Nam MH, Yang Y (2008) A method for inoculation and evaluation of rice sheath blight disease. Plant Dis 92:25-29

Rathore RS, Singh P, Jain ML (1998) Varietal resistance and host range of *Rhizoctonia solani* fsp. *sasakii*, the incitant of banded leaf and sheath blight of maize. J Mycol Pl Pathol 28(1):71

Roy AK (1993) Sheath blight of rice in India. Indian Phytopath 46(3):197-205

(Manuscript Receivd : 07.01.2014; Accepted : 01.09.2014)

JNKVV Res J 48(2): 175-183 (2014)

Screening of pesticides against *Rhizoctonia bataticola* causing charcoal rot of soybean

R.K. Varma, A.B. Kale and **D.K. Pancheshwar**
Department of Plant Pathology
Jawaharlal Nehru krishi Vishwa Vidyalaya
Jabalpur 482004 (MP)

Abstract

Efficacy of the recommended pesticides viz. fungicides, insecticides, herbicides and botanicals on the growth and sporulation of *Rhizoctonia bataticola* causing charcoal rot of soybean under in vitro conditions was evaluated. Using poisoned food technique, radial growth and visual observations were taken. Captan + hexaconazole and carbendazim were found totally inhibitory at all three concentrations (250, 500 and 1000 ppm), while thiram, mancozeb and copper oxy-chloride were less inhibitory to *Rhizoctonia bataticola*. Kresoxil methyl was found inhibitory at 1000 ppm concentration (100 %). All the eight fungicides tested were found to reduce number and size of sclerotia. No formation of sclerotia was found in carbendazim, captan + hexaconazole and pyraclostrobin. Among eight insecticides, combination of chlorpyrifos + cypermethrin was found moderately effective at 250, 500 and 1000 ppm concentrations (43.56 to 59.89 %) to *R. bataticola*. Emamectin benzoate and quinalphos was found less effective. The number of sclerotia was found decreased in all the insecticides as compared to control, but increased in size of sclerotia were recorded in pyridalyl at 250 ppm. Out of seven herbicides tested pendimethalin, oxyfluorfen and imazethapyr were found to be moderately effective to *Rhizoctonia bataticola*, whereas glyphosate and butachlor were not inhibitory. Maximum number (29.5 to 44.4) and size (20.2 x 16.16 µm) of sclerotia was recorded in imazethapyr. All the eight botanicals were found less inhibitory to *Rhizoctonia bataticola* in reducing mycelial growth except neem (65.22 %) followed by nilgiri (51.88 %) at 30 per cent concentration. In lantana camera the number of sclerotia was increased as compared to control at 10 per cent concentration. All botanicals tested were found to decrease size of the sclerotia of *R. bataticola*.

Keywords: Soybean, pesticides, *Rhizoctonia bataticola*

Soybean is the wonder crop of 21st century which is highly important owing to its high protein and oil content. Over the past decade productivity trend of soybean indicates that the impressive yields achieved are not attained due to severally abiotic and biotic factors. Soybean suffers from many diseases such as charcoal rot (*Rhizoctonia bataticola*), collar rot (*Sclerotium rolfsi*i) and Yellow mosaic disease (Mungbean yellow mosaic virus).

Charcoal rot of soybean has been reported to cause epiphytotic in U.S.A, China, Argentina Brazil (Wrather et al. 1997).In India charcoal rot of soybean is the most common disease which is also found in Brazil (Wrather et al. 1997). Losses in yield to 50% have been experienced in northern part of the state Parana (Ferreira et al. 1979) and also in USA up to 20% (Sinclair and Gray 1972). Estimated annual losses in soybean of 25.2 million bushels are attributed to charcoal rot from 1989 to 1991 in North Central region.

In India 70% loss caused by charcoal rot has been reported. The disease is common in MP, Maharashtra, Rajasthan, Uttaranchal, Karnataka Punjab and Delhi. The pathogen has a very broad host range of 500 crops and weeds species (Wyllie 1993). The important hosts are soybean, sunflower, safflower, sesame, sorghum, rice, green-gram, black-gram, cowpea, pigeon-pea and potato.

Material and methods

Recommended fungicides, insecticides, herbicides were obtained from standard companies. *Rhizoctonia bataticola* causing charcoal rot was isolated from infected soybean plants collected from trials of AICRP on soybean, Jabalpur.

In vitro efficacy of fungicides

Poisoned food technique was used for evaluating the effect of fungicides on the growth of *Rhizoctonia bataticola* was evaluated at three concentrations. Eight recommended and new molecules viz. Carbendazim (Bavistin, BASF, India Ltd, Mumbai), Captan 70% + Hexaconazole 5% WP (Taquat, Rallis India Ltd, Gujarat), Mancozeb (Indofil M-45 75% WP, Bayer (India) Ltd), Carboxin (Vitavax 75% WP, Northern Minerals Ltd, New Delhi), Thiram (Thiride 5% DS. The Alkali Corp. of India Ltd, Calcutta), Pyraclostrobin (Insignia, BASF, India Ltd, Mumbai), Copper oxy chloride (Blitox-50, Ralis India Ltd.), Kresoxil methyl (Ergon, Rallis India Ltd., Gujarat) were used for this study.

In vitro efficacy of insecticides

The experiment was conducted to evaluate the effect of eight insecticides viz. Quinalphos (Dhanulux 25% EC, Dhanuka Pesticide Ltd, New Delhi), Meothrin (Fenpropathrin 30% EC, Sumitomo Chemical India Pvt, Ltd.), Spinosad 45% SC (Tracer, Dau Agro Science, India Pvt. Ltd.), Coragen 20 % EC, Pyridalyl 10% EC (Sumipleo 10% EC, Sumitomo Chemical India Pvt. Ltd.), Emamectin Benzoate 5% SG(Proclaim 5% SG, Syngenta India Limited), Chlorpyrifos 50% + Cypermethrin 5% EC (Action 505, Tropical Acasystem 4, Chenenaai), Trizophos (Hospaphion, Bayer Crop Science, Ltd., Gujarat) on the growth and sporulation of *Rhizoctonia bataticola*. The test was conducted using poisoned food technique as said above. Concentrations were worked out on the basis of formulated product.

In vitro efficacy of herbicides

Seven recommended herbicides viz. Imazethapyr (Pursuit 10 SL, BASF (I) Ltd.), Pendimethalin (Eraser 30% EC, Jai Shree Rashayen Udyog Ltd.), Glyphosate (Shriram Dart 41% SL, Shriram fertilizer and Chemical, New Delhi), 2, 4-D Ethyl ester 38% EC (Uniweed-38, Uniqe formaid Pvt. Ltd.), Butachlor 50% EC (Upchlor, United Pesticides, Raipur), Quizalofop (Targa super 5% EC, Dhanuka Pesticide Ltd, New Delhi), Oxyfluorfen 23.5% EC (Alto, Filamduztries Ltd.) were used in the study. Poisoned food technique was used for conducting the test. The concentrations were worked out on the basis of dosage applied.

In vitro efficacy of botanicals (Leaf extracts)

Poisoned food techniques were used for evaluating the effect of leaf extracts viz. Neem (*Azadirachta indica*), Ashoka (*Polyalthia longifolia*), Karanj (*Pongama pinnata*), Jatropha (*Jatropha curcas* Linn.), Nilgiri (*Eucalyptus globules*), *Ipomea*(*Ipomea*sp.), Dhatura (*Datura stramonium*), Lantana (*Lantana camera*) on the growth and sporulation of *Rhizoctonia bataticola*.

Result and discussion

In vitro efficacy of fungicides

Six fungicides and two new molecules were evaluated at three concentrations for their efficacy against *Rhizoctonia bataticola* using poisoned food technique (Table 1). Captan + hexaconazole and carbendazim were found totally inhibitory at all three concentrations (250, 500 and 1000 ppm). Similar finding have been reported by Reddy et al. (1991), Peshney et al. (1992), Giri and Peshney (1993), Vyas (1994), Haque and Ghaffar (1995), Cardoso et al. (1997), Amadioha, (1998), Hussain et al. (2000), Prashanthi et al. (2000), Prajapati et al. (2002), Sindhan et al. (2002), Jha and Sharma, (2006) and Anju and Varma (2007). In the present study mancozeb at 250 ppm was less effective at low concentration which was also reported by Jha and Sharma (2006). The fungicide copper oxy-chloride was less inhibitory to *Rhizoctonia bataticola*, whereas Amadioha (1998) has reported copper oxy-chloride as most effective in reducing the mycelial growth of *R. bataticola*. The contradiction may be due to the difference in isolate and concentrations used for the study. Kresoxil methyl and pyraclostrobin was found inhibitory to *R. bataticola*. These are new molecules and have not been evaluated before, therefore this finding is first report. Number and size of sclerotia in all the eight fungicides tested were found reduce. This observation is also a new finding.

In vitro efficacy of insecticides

Eight insecticides and new molecules were evaluated at three concentrations for their efficacy against *Sclerotium rolfsii* using poisoned food technique (Table 2). Combination of chlorpyrifos + cypermethrin was found moderately effective at 250, 500 and 1000 ppm concentrations (43.56 to 59.89 %), whereas at the same concentrations, emamectin benzoate was found less effective to *R. bataticola*. Evidence of earlier work on

Table 1. Mean radial growth, number and size of sclerotia of *Rhizoctonia bataticola* on PDA medium amended with fungicides at three concentrations

Fungicides / concentration	Radial growth (in mm) after* at 144 hrs	% inhibition after 144 hrs	No. of sclerotia/mf*	Size of sclerotia (Length x Width) in µm	
				Maximum	Minimum
Pyraclostrobin					
250 ppm	15.0 (3.9)	83.83	-	-	-
500 ppm	13.6 (3.7)	84.89	-	-	-
1000 ppm	10.0 (3.2)	88.89	-	-	-
Kresoxil methyl					
250 ppm	22.0 (4.7)	75.55	12.0	9.09 x 6.06	4.04 x 2.02
500 ppm	16.0 (4.0)	82.22	10.0	9.09 x 5.05	4.04 x 1.01
1000 ppm	0.0 (0.7)	100	-	-	-
Captan + hexaconazole					
250 ppm	0.0 (0.7)	100	-	-	-
500 ppm	0.0 (0.7)	100	-	-	-
1000 ppm	0.0 (0.7)	100	-	-	-
Carboxin					
250 ppm	50.0 (7.1)	44.44	30.2	10.1 x 6.06	5.05 x 3.03
500 ppm	26.6 (5.2)	70.44	27.1	9.09 x 7.07	4.04 x 1.01
1000 ppm	14.6 (3.8)	83.78	18.7	9.09 x 5.05	3.03 x 1.01
Thiram					
250 ppm	87.5 (9.3)	02.78	14.0	9.09 x 7.07	4.04 x 2.02
500 ppm	13.6(3.7)	84.89	13.0	9.09 x 7.07	4.04 x 1.01
1000 ppm	10.0 (3.2)	88.89	-	-	-
Carbendazim					
250 ppm	0.0 (0.7)	100	-	-	-
500 ppm	0.0 (0.7)	100	-	-	-
1000 ppm	0.0 (0.7)	100	-	-	-
Mancozeb					
250 ppm	86.6 (9.3)	03.77	25.3	9.09 x 7.07	5.05 x 2.02
500 ppm	85.8 (9.2)	04.67	14.0	9.09 x 6.06	4.04 x 2.02
1000 ppm	70.1 (8.4)	22.11	10.0	8.08 x 5.05	4.04 x 1.01
Copper Oxy Chloride					
250 ppm	89.0 (9.4)	01.11	32.0	10.1 x 6.06	4.04 x 1.01
500 ppm	85.5 (9.2)	05.00	-	-	-
1000 ppm	81.0 (9.0)	10.00	-	-	-
Control	90.0 (9.5)	00	46.0	20.2 x 16.16	9.09 x 5.05

*Mean of three replications
Value in parenthesis are transformed values
SEm + 0.77
C.D. at 5% 1.64

Table 2. Mean radial growth, number and size of sclerotia of *Rhizoctonia bataticola* on PDA medium amended with insecticides at three concentrations

Insecticides / concentration	Radial growth (in mm) after* at 144 hrs	% inhibition after 144 hrs	No. of sclerotia/mf*	Size of sclerotia (Length x Width) in µm	
				Maximum	Minimum
Meothrin					
250 ppm	72.0 (8.5)	20.00	16	20.2 x 17.17	10.1 x 6.06
500 ppm	63.8 (8.0)	29.11	14	12.12 x 7.07	5.05 x 2.02
1000 ppm	60.0 (7.7)	33.33	10	9.09 x 5.05	4.04 x 1.01
Spinosad					
250 ppm	63.3 (7.9)	29.67	24	11.11 x 7.07	4.04 x 1.01
500 ppm	62.0 (7.9)	31.11	19	9.09 x 5.05	4.04 x 1.01
1000 ppm	60.5 (7.8)	32.78	16	9.09 x 5.05	4.04 x 1.01
Chlorpyrifos+ Cypermethrin					
250 ppm	50.8 (7.1)	43.56	10	9.09 x 5.05	5.05 x 2.02
500 ppm	42.6 (6.5)	52.67	09	9.09 x 5.05	5.05 x 1.01
1000 ppm	36.1 (6.0)	59.89	07	9.09 x 4.04	5.05 x 1.01
Coragen					
250 ppm	80.0 (8.9)	11.11	20	9.09 x 6.06	5.05 x 2.02
500 ppm	75.1 (8.6)	16.56	14	9.09 x 5.05	5.05 x 2.02
1000 ppm	70.0 (8.3)	22.22	12	9.09 x 5.05	4.04 x 1.01
Pyridalyl					
250 ppm	77.0 (8.8)	14.44	33	21.21 x 15.15	10.1 x 6.06
500 ppm	70.8 (8.4)	21.33	13	20.2 x 16.16	9.09 x 5.05
1000 ppm	69.3 (8.3)	23.00	09	9.09 x 6.06	4.04 x 1.01
Emamectin benzoate					
250 ppm	90.0 (9.5)	00.00	11	10.1 x 7.07	5.05 x 2.02
500 ppm	90.0 (9.5)	00.00	10	10.1 x 6.06	5.05 x 2.02
1000 ppm	89.1 (9.4)	01.00	10	9.09 x 5.05	5.05 x 2.02
Quinalphos					
250 ppm	85.1 (9.2)	05.44	38	10.1 x 6.06	5.05 x 2.02
500 ppm	83.4 (9.1)	07.33	32	10.1 x 6.06	5.05 x 2.02
1000 ppm	81.0 (9.0)	10.00	26	9.09 x 4.04	5.05 x 2.02
Trizophos					
250 ppm	71.1 (8.4)	21.00	33	12.12 x 7.07	5.05 x 2.02
500 ppm	68.5 (7.6)	23.88	31	11.11 x 5.05	5.05 x 2.02
1000 ppm	63.6 (6.6)	29.33	25	10.1 x 6.06	4.04 x 1.01
Control	90.0 (9.5)	00	46.0	20.2 x 16.16	9.09 x 5.05

*Mean of three replications
Value in parenthesis are transformed values
SEm + 0.21
C.D. at 5% 0.44

Table 3. Mean radial growth, number and size of sclerotia of *Rhizoctonia bataticola* on PDA medium amended with herbicides at three concentrations

Herbicides/concentration	Radial growth (in mm) after* at 144 hrs	% inhibition after 144 hrs	No. of sclerotia/mf*	Size of sclerotia (LengthxWidth) in µm	
				Maximum	Minimum
Imazethapyr					
10 ppm	90.0 (9.5)	00	44.4	20.2x16.16	10.1x6.06
25 ppm	85.6 (9.2)	4.89	34.4	17.17x12.12	10.1x6.06
50 ppm	70.0 (8.3)	22.22	29.5	15.15x9.09	8.08x3.03
Glyphosate					
10 ppm	90.0 (9.5)	00	37.1	20.2x15.15	10.1x6.06
25 ppm	90.0 (9.5)	00	29.1	20.2x15.15	10.1x6.06
50 ppm	85.5 (9.2)	5.00	26.6	15.15x11.11	8.08x3.03
Pendimethalin					
10 ppm	68.5 (8.3)	23.89	33.6	20.2x15.15	12.12x7.07
25 ppm	53.0 (7.3)	41.11	28.9	20.2x15.15	11.11x7.07
50 ppm	42.6 (6.5)	52.67	28.8	20.2x14.14	8.08x5.05
Quizalfop					
10 ppm	87.0 (9.3)	3.33	42.1	20.2x16.16	10.1x6.06
25 ppm	86.6 (9.3)	3.78	34.0	15.15x11.11	8.08x3.03
50 ppm	83.5 (9.1)	7.22	28.0	12.12x7.07	5.05x2.02
Butachlor					
10 ppm	90.0 (9.5)	00	43.0	19.19x14.14	10.1x6.06
25 ppm	90.0 (9.5)	00	32.2	18.18x13.13	10.1x5.05
50 ppm	87.5 (9.3)	2.78	28.5	15.15x11.11	7.07x3.03
2,4-D					
10 ppm	85.1 (9.2)	5.44	45.2	20.2x16.16	9.09x5.05
25 ppm	70.0 (8.3)	22.22	34.1	18.18x13.13	9.09x5.05
50 ppm	56.3 (7.5)	37.44	27.4	18.18x13.13	5.05x2.02
Oxyfluorfen					
10 ppm	69.3 (8.3)	23.00	30.0	20.2x13.13	10.1x6.06
25 ppm	65.1 (8.0)	27.67	26.0	15.15x11.11	10.1x5.05
50 ppm	60.0 (7.7)	33.33	05.0	11.11x7.07	5.05x2.02
Control	90.0 (9.5)	00	46.0	20.2x16.16	9.09x5.05

*Mean of three replications
Value in parenthesis are transformed values
SEm + 0.29
C.D. at 5% 0.62

Table 4. Mean radial growth, number and size of sclerotia of *Rhizoctonia bataticola* on PDA medium amended with botanicals at three concentrations

Botanicals/concentration	Radial growth (in mm) after* at 144 hrs	% inhibition after 144 hrs	No. of sclerotia/mf*	Size of sclerotia (LengthxWidth) in µm	
				Maximum	Minimum
Eucalyptus globules					
10	90.0 (9.5)	00.00	43.9	9.09 x 5.05	4.04 x 1.01
20	87.0 (9.3)	03.33	42.0	9.09 x 4.04	4.04 x 1.01
30	43.3 (6.6)	51.88	38.0	9.09 x 4.04	4.04 x 1.01
Azadirachta indica					
10	90.0 (9.5)	00.00	44.7	11.11 x 9.09	5.05 x 1.01
20	84.6 (9.2)	06.00	43.1	10.1 x 7.07	4.04 x 1.01
30	31.3 (5.6)	65.22	42.8	9.09 x 5.05	4.04 x 1.01
Polyalthia longifolia					
10	85.0 (9.2)	05.55	8.6	10.1 x 6.06	4.04 x 1.01
20	80.0 (8.9)	11.11	-	-	-
30	47.6 (6.9)	47.11	-	-	-
Jatropha curcas Linn.					
10	90.0 (9.5)	00.00	25.7	14.14 x9.09	8.08 x 6.06
20	88.3 (9.4)	01.88	24.7	14.14 x 9.09	7.07 x 4.04
30	81.5 (9.0)	09.44	16.5	12.12 x 7.07	7.07 x 4.04
Lantana camera					
10	90.0 (9.5)	00.00	46.2	14.14 x 9.09	6.06 x 2.02
20	86.0 (9.3)	04.44	45.1	14.14 x 8.08	6.06 x 2.02
30	84.4 (9.2)	06.22	43.1	12.12 x 9.09	5.05 x 2.02
Datura stramonium					
10	88.3 (9.4)	01.88	40.0	14.14 x10.1	6.06 x 2.02
20	85.6 (9.2)	04.88	33.5	11.11 x 8.08	6.06 x 2.02
30	53.3 (7.3)	40.77	26.2	11.11 x 7.07	4.04 x 1.01
Ipomia sp					
10	90.0 (9.5)	00.00	41.0	14.14 x 10.1	8.08 x 4.04
20	80.0 (8.9)	11.11	30.5	14.14 x 9.09	7.07 x 4.04
30	77.3 (8.8)	14.11	25.4	12.12 x 7.07	5.05 x 1.01
Pongama pinnata					
10	83.3 (9.1)	07.44	43.4	14.14 x 9.09	6.06 x 2.02
20	81.3 (9.0)	09.66	42.4	11.11 x 8.08	5.05 x 2.02
30	77.6 (8.8)	13.77	36.8	10.1 x 7.07	4.04 x 1.01
Control	90.0 (9.5)	00	46.0	20.2 x 16.16	9.09 x 5.05

*Mean of three replications
Value in parenthesis are transformed values
SEm + 0.93
C.D. at 5% 1.98

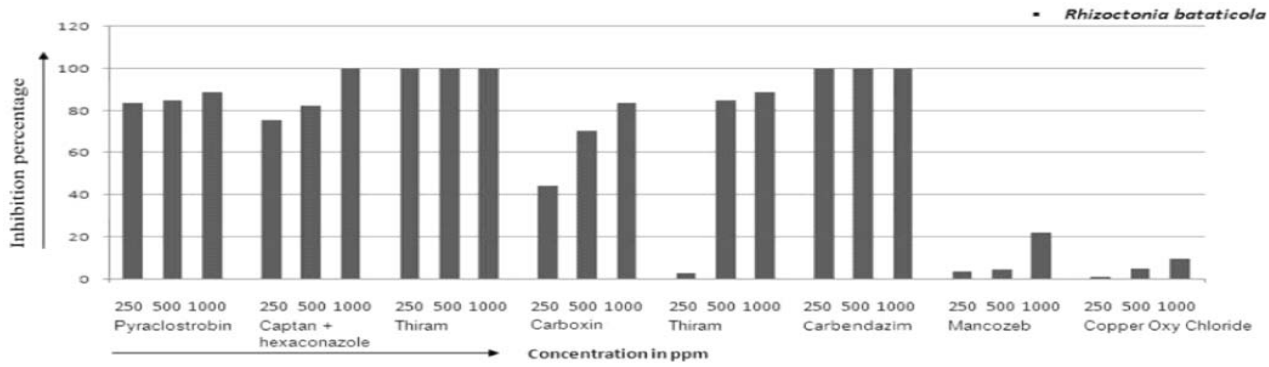


Fig 1 : Percent inhibition of *Rhizoctonia bataticola* due to fungicides

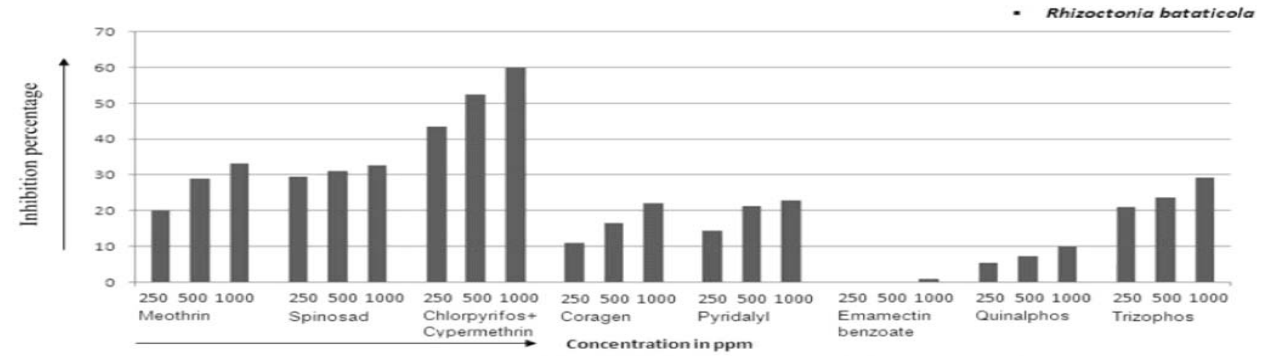


Fig 2 : Percent inhibition of *Rhizoctonia bataticola* due to insecticides

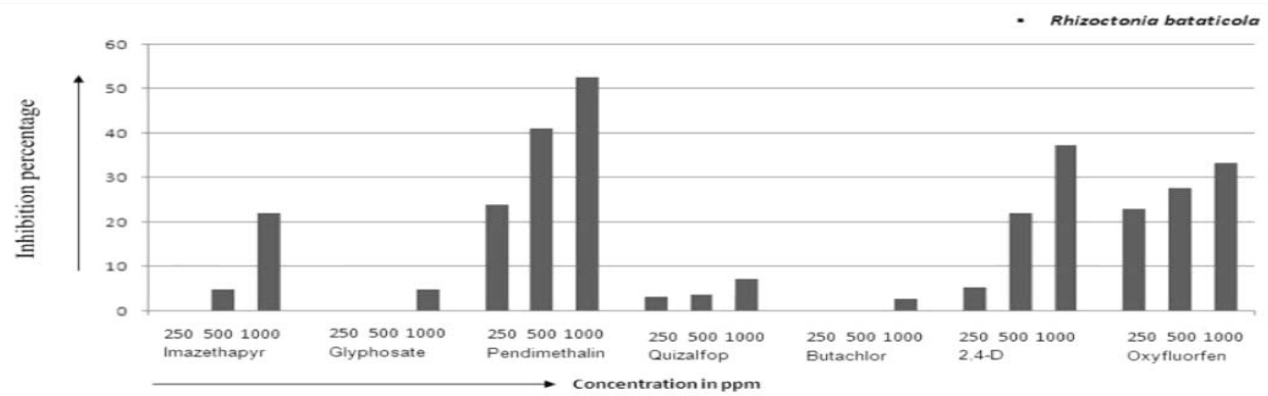


Fig 3 : Percent inhibition of *Rhizoctonia bataticola* due to herbicides

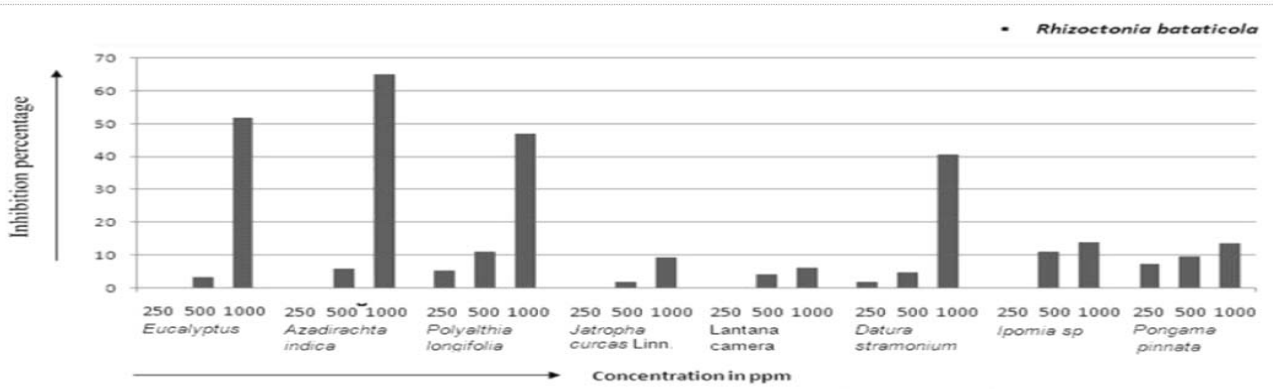


Fig 4 : Percent inhibition of *Rhizoctonia bataticola* due to botanicals

this study using the two above said insecticides is lacking. Therefore, this finding is the new finding. Quinalphos was found less effective against *R. bataticola* which is in agreement with the finding of Anju and Varma (2007). The number of sclerotia was found decreased in all insecticides as compared to control, but increased size of sclerotia were recorded in pyridalyl at 250 ppm. Literature related to this study is lacking, therefore this is the first report.

In vitro efficacy of herbicides

Effect of seven herbicides tested against *R. bataticola* indicates that imazethapyr, pendimethalin and oxyfluorfen were found to be moderately effective to *Rhizoctonia bataticola* as reported by Jha and Sharma (2006) and Anju and Varma (2007). Glyphosate and butachlor were not inhibitory. Maximum number (29.5 to 44.4) and size (20.2 x 16.16 µm) of sclerotia was recorded in imazethapyr. Literature related to this study is not available; therefore this observation is the new finding.

In vitro efficacy of botanicals

Effect of eight botanicals indicated that all the botanicals tested were found less inhibitory to *Rhizoctonia bataticola* in reducing the mycelial growth except neem (65.22 %) followed by nilgiri (51.88 %) at 30 per cent concentration confirming the findings of Sindhan et al. (1999), Mandhare and Suryawanshi (2008) and Ammajamma et al. (2009). In Lantana camera the number of sclerotia was increased as compared to control at 10 per cent concentration. Size of sclerotia was decreased in all the botanicals tested. Literature related to these aspects are not available, therefore this is the first finding.

सोयाबीन में अनूमोदित फफूंदनाशक, शाखनाशी एवं वनस्पति का प्रभाव गलन का कारक राईजोकटोनिया बटाटीकोला के बढ़वार एवं बीजाणु बनाने की क्षमता पर प्रयोगशाला में अध्ययन किया गया । प्रयोग में पाया गया कि कैप्टन + हैक्साकोनेजोल एवं कार्बोन्डाजीम सभी तीनों संध्रता में असरकारक पाये गये, जबकि थायरम, मेनकोजेम एवं कापरअक्सीक्लोराइड कम असरकारक थे । क्रोसोकजील (1000 पी.पी.एम.) पर असरकारक पाया गया । प्रयोग में उपयोग किए गए सभी आठ फफूंदनाशक बीजाणु की संख्या एवं क्षेत्रफल आकार को कम करते है । कारर्बेन्डाजीम एवं कैप्टन + हैक्साकोनेजोल में बीजाणु नहीं बने । आठ कीटनाशकों में कलोरोफाइरीफास + साइपरमैथ्रीन तीनो संध्रता में मध्यम असरकारक पाया गया । इमामेक्सीन बैन्जोएट एवं क्लोलफास कम असरकारक थे । सभी कीटनासकों में बीजाणु कम बने परन्तु अरीडालिल (200 पी.पी. एम.) में बीजाणु के परिमाण में वृद्धि पाई गई । सात खरपतवारों में पैन्डामैथीलीन, आक्सीप्लोरफेन और इमेजाथपिर मध्यम असरकारक पाए गए जबकि ग्लाइफोसेट एवं व्यूटाक्लोर का कोई प्रभाव नहीं देखा गया । स्लेरोशिया के सबसे अधिक संख्या एक आकार इमेजाथापर में देखा गया । सभी आठ वनस्पति राईजोकटोनिया बटाटीकोला के माइसीलियम की बढ़वार को कम करने में असरकारक नहीं पाए गए सिर्फ नीम (65.22%) एवं नीलगिरी (51.88%) के 30% सान्द्रता पर असरकारक पाया गया । लेनटाना कैमरा में बीजाणु की संख्या ज्यादा नापी गई । सभी वनस्पति में बीजाणु के परिमाण को कम करने की क्षमता पाई गई ।

References

Amadioha AC (1998) Control of post harvest tuber rot of potato incited by *Rhizoctonia bataticola*. Archives Phytopath and Plant Protection 31(3): 225-231

Ammajamma R, Hegde YR Lingaraju S, Sreedevi SC, Hegde L (2009) Studies on biological management of *Rhizoctonia bataticola* infecting *Coleus forskolii* Biomed 4(1): 28-32

Anju G, Varma RK (2007) Non-target effect of agro-chemicals and Bio-controls agents on important soil-borne pathogen of Soybean. JNKVV Res J 4(1): 65-71

Cardosa JE, Silva SAG, Marques EE (1997) Chemical and biological control of bean root rot. Fitopathologia Brasileira 22(1): 39-44

Giri GK, Peshney NL (1993) Efficacy of some fungicides in vitro against fungi causing leaf spots in mung bean. J Soils and Crops 3(2): 112-114

Hussain SZ, Anandam RJ, Rao AS (2000) Effect of different fungicides and homeopathic drugs on seed borne fungi of sunflower (*Helianthus annuus* L.). Indian J Plant Protection 28(2): 148-151

Haque SE, Ghaffar A (1995) Role of *Bradyrhizobium japonicum* and *Trichoderma* specie in the control of root rot disease of soybean. Acta Mycologica 30(1): 35-40

Jha KM, Sharma ND (2006a) Studies on factor affecting *Rhizoctonia bataticola*: IV. Fungicides J Mycopatho Res 44(1): 67-71

Jha KM Sharma ND (2006b) Studies on factor affecting *Rhizoctonia bataticola*: V. herbicides. J Mycopatho Res 44(1): 73-77

Mandhare VK, Suryawanshi AV (2008) Efficacy of some botanicals and *Trichoderma* species against soil borne pathogens infecting chickpea. J Food Legumes 21(2): 122-124

Peshney NL, Gade RM, Thakare KG (1992) Sensitivity and adaptability of *Rhizoctonia bataticola* to different fungicides. J Soils and Crops 2(1): 35-38

Prajapati RK, Gangwar RK, Srivastava SSL, Shahid A (2002) Efficacy of fungicides, non target pesticides and bio-agents against the dry root rot of chickpea. Ann Pl Prot Sci 10(1): 154-155

Prashanthi SK, Kulkarni S, Sangam VS, Kulkarni MS (2000) Chemical control of *Rhizoctonia bataticola* (Taub.) Bdles, the causal agent of root rot of safflower. Pl Dis Reas 15(2): 186-190

Reddy GR, Reddy AGR, Rao KC (1991) Effect of different seed dressing fungicides against certain seed-borne fungi of groundnut. J Oilseeds Res 8(1): 79-83

Sinclair JB, Gray LE (1972) Three fungi that can reduce soybean yields. Illinois Research 14: 5

Sindhan GS, Hooda I, Parashar RD (1999) Effect of some plant extracts on the vegetative growth of root rot fungi. J Myco and Plant Patho 29(1): 110-111

Sindhan GS, Hooda I, Karwasra SS (2002) Biological control of dry root rot of chickpea caused by *Rhizoctonia bataticola*. Plant Dis Res 17(1): 68-71

Vyas SC (1994) Integrated biological and chemical control of dry root rot on soybean. Indian J Mycol Pl Pathol 24(2): 132-134

Wrather JA, Anderson TR, Arsyad DM, Gai J, Ploper DL, Porta-Puglia A, Ram HH, Yorinori JT (1997) Soybean disease loss estimates for the top 10 soybean producing countries in 1994. Pl Dis 81: 107-110

Wyllie TD (1993) Compendium of Soybean Diseases. 3rd ed. The American Phytopathological Society, St. Paul, MN

(Manuscript Receivd : 18.10.2013; Accepted :20.08.2014)

JNKVV Res J 48(2): 184-187 (2014)

Efficacy of phytoextracts in the management of sesame seeds associated *Macrophomina phaseolina*

Aasfa Tabassum, M.S. Bhale*, A.K. Pandey** and **A.R.G. Rangnatha**
All India Coordinated Research Project on Sesame and Niger Project Coordination Unit
Jawaharlal Nehru Krishi Vishwa Vidyalaya Campus
Jabalpur 482004 (MP)
*Department of Plant Pathology
Jawaharlal Nehru Krishi Vishwa Vidyalaya
Jabalpur 482004 (MP)
**Madhya Pradesh, Private Universities,
Regulatory Commission, Bhopal (MP)
Email: aasfatabassum@gmail.com

Abstract

Naturally infected sesame seeds treated with extracts of ginger rhizome was the most effective for the management of seedborne *Macrophomina phaseolina*. The treated seeds exhibited 3.0 per cent association as compared to untreated control seeds having 18.5 per cent. Extracts of castor seed, garlic clove, neem leaves and their leaves recorded more than 50 per cent reduction over untreated seeds.

Keywords: Phytoextracts, ginger extract, garlic extract, seed treatment

Sesame (*Sesamum indicum* L.) is an important oil seed crop of India that is preferred due to rich edible oil (about 50%) and nutritious protein (about 23%) and having sufficient carbohydrate (15%) (Singh and Duhoon 2001; Ranganatha et al. 2012).

The presence of ample amount of antioxidants (Sesamin, sesaminol, sesamolin) in seeds of sesame increases the many fold bio medicinal value (El-Bramway 2010). Among the various biotic-stresses, stem and root rot caused by *Macrophomina phaseolina* (= *Rhizcotonia bataticola*) is an important disease of sesame (*Sesamum indicum* L.). It has become a potential threat for the profitable cultivation especially in the changing warm climate and intensive farming situations (Saharan et al. 2005). The seedborne nature of the fungus has been reported (Verma et al. 2002; Worastit et al. 2007; Javed et al. 1995). The fungus is responsible for seed rot, seedling decoy, abnormalities, stem-discoloration and root rot (El Fikki et al. 2004; Zhang et al. 2001; Khare and Jharia 2002).

The losses due to disease range from 5-95% in farmers field. The chemical fungicide used for seed treatment are indiscriminately used by the end users and accumulation in the soil and its ultimate residual impact adversely affect the produce, it matters in the post-GATT-era of trade and increasing consumer health consciousness. Hence attempts were made to use some non conventional approaches for the management of seed associated *Macrophomina phaseolina*.

Material and methods

Seed sample

Seed of 65 sesame varieties obtained from 15 states and seed samples from farmers (145 seed samples) from 12 districts were analyzed by Standard Blotter method (ISTA 1996). Based upon the maximum natural seed infection of *Macrophomina phaseolina*, as evident under stereoscopic binocular microscope after 5 day incubation, two variety viz., TKG 22 and Swetha Til were selected for further investigation.

Efficacy of phyto-extracts

Collection of plants

In all, 15 plants having known microbial-germicidal properties were used (Table1).

Preparation of extracts

The extract of plant parts was prepared by crushing in a small grinder for 10 minutes and moistened with 15 ml sterile water. The pulverized mass, so obtained from each plant part was squeezed through a quadrifold clean muslin cloth. The crude solution was considered as standard plant extract. It was stored under aseptic condition for further under lower temperature (4 ^{0}C).

Treatment of seeds

Two hundred seeds of each of two varieties of sesame were soaked for 15 minutes in the extracts under ambient room temperature. The extracts were drained off and seeds were dried on butter paper for 120 minutes under shade. Extract soaked and air dried seeds were individually placed on the top of the blotter at equidistance in petridishes and incubated in the growth chamber (25 ± 2 ^{0}C) for 5 days as per Standard Blotter Method (ISTA, 1996). Untreated (unsoaked) seeds served as control.

Detection of mycoflora

In each Petridish, 25 seeds were placed on top of the blotter as per Standard Blotter method (ISTA 1996). The seeded plates were incubated for 5 day and association of *Macrophomina phaseolina* was recorded under stereoscopic binocular microscope based upon the habit characters (Neergaard, 1973; Karunanidhi et al. 1999).

Results and discussion

Seed sample

In all, 210 sesame seed samples were analyzed by Standard Blotter method. Based upon maximum natural infection of *Macrophomina phaseolina*, two sample TKG 22 (19%) and Swetha til (18%) were selected.

Effect on association of *Macrophomina phaseolina*

Seed treated with extracts of ginger rhizome exhibited only 3.0 percent association of *Macrophomina phaseolina* as compared to 18.5% in untreated (control)

Table 1. Plants and its parts used for extracts

Plant part used	Common name	Botanical name
Bulb	Onion	*Allium cepa* L.
Cloves	Garlic	*Allium sativum* L.
Leaves	Neem	*Azadirachta indica* A. Juss
	Sadabahar	*Cartheranthus roesus* (L.) G Don
	Eucalyptus	*Eucalyptus globosus* L.
	Lentana	*Lantana camera* L.
	Hina	*Lawsonia inermis* L.
	Parthenium	*Parthenium hysterophorus* L.
	Castor	*Ricinus communis* L.
	Chandani	*Tubernamantana coronarea* R.Br.
Leaves + stem	Aak	*Calotropis procera* (Ait) R Br.
	Dhatura	*Datura metel* L.
	Bhrangraj	*Eclipta alba* (L.) Hassk
	Tulsi	*Occimum sunctium* L.
	Ginger rhizome	*Zinger officinale* Rose

Table 2. Influence of seed treatment with plant extracts on the association of Macrophomina phaseolina with sesame seeds as detected by standard blotter method

Plant part used	Botanical name	Common name	Percent association of *Macrophomina phaseolina*				Average	Percent seed germination
			TKG 22	% seed germination	Swetha til 1	% seed germination		
Bulb	*Allium cepa* L.	Onion	8	90	6	92	7.0	91.0
Clove	*Allium sativum*	Garlic	4	95	5	95	4.5	95.0
Leaves	*Azardirachta indica*	Neem	5	95	7	94	6.0	94.0
	Cartheranthus roseus	Sadabahar	15	82	15	83	15.0	82.5
	Eucalyptus globosus	Eucalyptus	10	90	14	83	12.0	86.5
	Lantana camera	Lentana	10	86	11	87	10.5	86.5
	Lowsonia incruis	Hina	12	83	12	83	12.0	83.0
	Parthenium hysterophous	Parthenium	11	80	12	80	11.5	80.0
	Ricinus comunis	Castor	4	96	5	96	4.5	96.0
	Tubernamantana coronarea	Chandani	11	80	12	80	11.5	80.0
Leaves + stem	*Calotropis procera*	Aak	7	92	7	91	7.0	91.0
	Datura metal	Datura	15	82	12	83	13.5	82.5
	Eclipta alba	Bhrangraj	15	83	18	80	16.5	81.5
	Occimum sp.	Tulsi	7	91	8	91	7.5	91.0
Rhizome	*Zingiber officinale*	Ginger	3	96	3	97	3.0	96.5
	Control	-	19	75	18	78	18.5	76.5

seeds. Seed treated with castor seed (4.5%) and garlic clove (4.5%), neem leaves (6.0%), aak and onion (7.0%) exhibited association of *Macrophomina phaseolina* as compared to control (18.5%). Seed treated with tulsi leaves exhibited 7.5% association.

Seeds treated with extracts of ginger rhizome and garlic clove have exhibited 83.7 and 75.6% reduction in the seed association of *Macrophomina phaseolina*. The efficacy of phytoextracts against plant pathogens has been very well documented (Mamatha and Rai 2004; Bhatnagar et al. 2004). Water extracts *Datura alba*, decreased the seed mycoflora of soybean (Malhotra and Rai 1990). Owolade et al (2000) and Sharma et al (2003) observed the efficacy of *Ocimum sunctium, Azadirachta indica* and *Allium sativum* extracts in reducing the fungal growth El Fikki et al (2004) reported the efficacy of garlic cloves, ginger roots, cumin seeds and neem leaves against *Macrophomina phaseolina* affecting sesame crop.

Effect on seed germination

Seed treatment with phytoextracts of these plants had positive impact on seed germination. Seed germination from 80.0 to 96.5 was observed in treated seeds as compared to control 76.5%.

अदरक के पंजो के रस से बीजोपचार करने पर तिल बीज में मेक्रोफोमिना फेजिओलना फफूंद की मात्रा में भारी कमी देखी गई । उपचारित बीजों में 3 प्रतिशत फफूंद पाई गई जबकि अनुउपचारित बीजों में फफूंद की मात्रा 18.5 प्रतिशत थी । अरंडी के बीज, लहसुन की कली, नीम की पत्ती तथा तुलसी के पत्तों के रस से तिल बीजों के उपचार से फफूंद की मात्रा में 50 प्रतिशत की कमी आंकी गई ।

References

Bhatnagar K, Sharma BS, Cheema HS (2004) Efficacy of plant extracts against *Fusarium oxysporum* f. sp. *cumini* wilt in cumin. J Mycol Pl Pathol 34 (2): 360-361

El- Bramway, Maehsh (2010) Genetic analysis of yield component and disease resistance in sesame (*Sesamum indicum* L.) using two progenies of diallel crosses. Res J Agro 43: 44-56

El-Fiki AII, El-Deep AA, Mohmmad FG, Khalifa MMA (2004) Controlling sesame charcoal rot by *Macrophomina phaseolina* under field conditions by using resistant cultivars, seed and soil. Egypt J Phytopathol 32(1-2): 103-118

ISTA (1996) International Seed Testing Rules. Seed Sci& Technol 29: 1-335

Javed MS, Wahid A, Idress M (1995) Fungi associated with sesame seeds and their frequency. Pakistan J Phytopathol 7(2) : 174-176

Karunanidhi K, Muthusamy M, Seetharaman K (1999) Cultural and pathogenic variability among the isolates of *Macrophomina phaseolina* causing root rot of sesamum. Pl Dis Res 14 (2) : 113-117

Khare, MN, Jharia HK (2002) Biostresors and their management in sesame. In Integrated crop management of sesame and niger (S.S. Duhoon, A.K. Tripathi and H.K. Jharia ed.) PC Unit, AICRP Sesame & Niger, JNKVV, Jabalpur 82-94

Malhotra D, Rai PK (1990) Observation on the effect of leaf extracts on germination and fungi associated with seeds of *Glycine max*. L. Indian Journal Appl. Pure Biol 5 (1): 53-56

Mamatha T, Ravishankar Rai V (2004) Evaluation of fungicides and plant extracts against *Fusarium solani* leaf blight in Terminalia cotappa. J Mycol Plant Pathol 34(2) : 306-207

Neergaard P (1973) Detection of seed borne pathogens by culture test. Seed Sci & Technol 1 : 217-254

Owolade OF, Amusa AN, Osikanlu YOK (2000) Efficacy of certain indigenous plant extracts against seed borne infection of *Fusarium moniliforme* on maize in south western Nigeria, Cereal Research Comm 28(3): 323-327

Ranganatha ARG, Lokesha R, Tripathi A, Tabassum Aasfa, Paroha S, Shrivastava MK (2012) Sesame Improvement - Present Status and Future Strategies. J Oilseeds Res 29 (1): 1-26

Saharan GS, Mehta Naresh, Sangwan MS (2005) Diseases of oilseed crops. Indus Publishing Co New Delhi 643p

Sharma N, Tripathi A, Verma RP (2006) Synergistic bioefficacy of three plant extracts on sporulation of fruit rotting fungi. J Mycol Pathol Res 44(1) : 55-60

Singh NB and Duhoon SS (2001) Sesame: Technology for increasing production. Technical Bulletin 03/2001. All India Coordinated Research Project on Sesame and Niger, (ICAR), JNKVV, Jabalpur, India 37p

Singh NB, Duhoon SS (2001) Sesame: Technology for increasing production. Technical Bulletin 03/2001. All India Coordinated Research Project on Sesame and Niger, (ICAR), JNKVV, Jabalpur, India 37

Verma ML, Prasad D, Puri SN (2002) Fungal and bacterial diseases of sesame and their management. Crop pest and disease management: Challenges for the mellennium. Jyoti Publishers & Distributors. Dehra Dun, India: 161-192

Worasatit Naruatal, Suddhiyam Pornpan, Kampai Siripong (2007) Study of disinfecting method against Macrophomina sp. infected on sesame seed. Ubon Ratchathai Field Crops Research Center, Muang, Ubon Ratchathai, Thailand

Zhang Xlu Rong Cheng Y, Liu SI, Feng Xiang Yun, Zhang XR, Cheng Y, Feng XY (2001) Evaluation of sesame germplasm resistant to *Macrophomina phaseolina* and *Fusarium oxysporum*. Chines J Oil Seed Crop Sci 23(4): 23-27

(Manuscript Receivd : 25.09.2013; Accepted :02.02.2014)

JNKVV Res J 48(2): 188-191 (2014)

Techniques to test virulence of *Macrophomina phaseolina* responsible for stem & root rot of sesame

Aasfa Tabassum, MS Bhale*, AK Pandey** and **ARG Rangnatha**
All India Coordinated Research Project on Sesame and Niger Project Coordination Unit
Jawaharlal Nehru Krishi Vishwa Vidyalaya Campus
Jabalpur 482004 (MP)
*Department of Plant Pathology
Jawaharlal Nehru Krishi Vishwa Vidyalaya
Jabalpur 482004 (MP)
**Madhya Pradesh, Private Universities
Regulatory Commission Bhopal (MP)
Email : aasfatabassum@gmail.com

Abstract

Macrophomina phaseolina is responsible for seed rot, seedling decay, stem and root rot in sesame. The virulence of *Macrophomina phaseolina* was tested by seed, soil infestation and tooth pick method. The seeds from pretested seed lot with no natural infection rolled over the actively grown fungus, resulted in 59-80% seed infection. Seed sown in artificially inoculated soil resulted in 36.2- 38.0% pre emergence mortality while 22.5% seedling death due to fungus was noticed after 21 days. Typical symptoms were developed within 17 days of inoculation by tooth pick method under natural field condition.

Keywords: Sesame, *Macrophomina phaseolina*, root and stem rot, virulence, tooth pick method, seed infestation method, soil infestation method.

Sesame (*Sesamum indicum* L.) is an important oil seed crop of India that is preferred due to rich edible oil (about 50%) and nutritious protein (about 23%) and having sufficient carbohydrate (15%) (Ranganatha et al. 2012). The medicinal value of sesame seeds are worldwide accepted due to the rich source of linolic acid, Vitamin E, A, B_1 and B_2 (Brar and Ahuja 1979). The presence of antioxidants (sesamin, sesaminol, sesamolin) in sesame seeds increase the many fold medicinal value (Bedigian 1985, Moazzami 2006, El- Bramway 2010). Among the pathogen, *Macrophomina phaseolina* has been known to cause dry weather wilt. The pathogen is responsible for seed rot, seedling decay/ stem & root rot problem in sesame (Kolte 1985, Verma et al. 2005, Vyas et al. 1983). The seedborne nature of *Macrophomina phaseolina* has been reported by several workers (Verma et al. 2002, Javed et al. 1995, Sanaomung and Sirithorn 1996). In the present investigation the virulence of isolated *Macrophomina phaseolina* was tested bydifferent methods.

Materials and methods

The fungus, *Macrophomina phaseolina* was isotated on potato sucrose agar medium and the virulence was tested by (i) seed infestation technique (Bhale 1978) (ii) soil infestation technique (Singh 1976), (iii) tooth pick method (Bhale et al. 1999).

Seed infestation technique

Thirteen day old culture of *Macrophomina phaseolina* grown on potato-sucrose-agar medium was used. Seed sample free from natural infection of the target fungus was used. The seed sample was pre-tested by Standard Blotter method. The seeds were surface sterilized with 1% NaOCl for 60 seconds. These seeds were soaked in water for 45 minutes. Soaked sesame seeds were rolled over on actively grown culture of the test fungus, *Macrophomina phaseolina* for 30 minutes to facilitate adequate cohesion of mycelia bits of the fungus. Two hundred seeds were used. Seeds without fungal

infection (unrolled) served as control. Petri dishes containing these seeds were incubated in the chamber with expose of 12 hour light and 12 hour dark period. Observations were made on the fungal infection under stereoscopic binocular microscope.

Seed infestation was tried in another way, where the seed coat of pre-treated (surface sterilized) seeds from the same lot were used. Seeds were injured with the help of sterilized biological needles. Later rolled on the same culture (test fungus). Seeds were picked up carefully by sterile forcep and were plated on moist blotter as in Standard Blotter method. Seeds injured but without infestation (unrolled) were kept simultaneously that served as control. Observation on the fungal development were made after seven day incubation.

Soil infestation method

Inoculum of *Macrophomina phaseolina* was grown in 250 ml capacity Erlenmeyer conical flask each containing 150 ml potato-sucrose-broth. After sterilization of the medium, 5 mm disc of 7-day old culture was transferred in each flask and incubated at room temperature for 18 days. After incubation mycelial mat was removed and washed thoroughly in sterile water to remove culture filtrate and suspected metabolites. The washed mycelial mat was mixed in sterile soil at the rate of one flask per 250 g of soil. The infested soil was thoroughly mixed and was filled up in plastic pots (20 cm diametre). The fungus was allowed to grow and establish for 12 days at room temperature (25±3 ^{0}C). Ten surface sterilized seeds with no natural infection of *Macrophomina phaseolina* were sown in each pot. Uninfested but sterile soil served as control. Observations were recorded on mortality of seeds, seedlings and fungal infection. Isolations were made from the infected seeds and seedlings on PSA medium for the confirmation of infection by *Macrophomina phaseolina*.

Tooth-pick inoculation method

Small bits of mycelium were picked up from actively grown culture on PSA under aseptic conditions. Prior to pick-up the inoculation, the tooth pick was washed by 1% NaOCl and later with sterile water. The air dried tooth picks were used. The tooth pick with bits of mycelium were slightly inserted to the lower portion of the stem, under natural field conditions. Soon after insertion, the area was covered with sterile-cotton-swab, to provide adequate moisture. The inserted point was rapped with wet cotton swab and covered with transparent celoplane tape to conserve the moisture. Observations on the infection and disease development was recorded after 17 days by inoculation.

Results and discussion

The virulence of isolated *Macrophomina phaseolina* was tested by seed infestation technique; soil infestation and tooth-pick method.

Seed infestation technique

Pre-soaked sesame seeds (in water for 45 minutes) free from natural infection of the target fungus were rolled-on actively grown culture in Petri dishes. Seeds infested with culture were plated on moist blotters in Petri dishes

Table 1. Influence of seed and soil infestation with *Macrophomina phaseolina* in germination, pre-and post-emergence mortality in sesame

Fungus	No. of seed sown	Isolate	Seed infestation				Soil infestation	
			Percent seed germination		Percent infection		Percent mortality	
			U	I	U	I	Pre	Post*
Macrophomina phaseolina	200	Seed	97.0	95.0	80.0	69.5	38.0	22.5
	200	Stem	97.5	93.5	59.0	67.5	36.2	16.0
	200	Root	99.0	93.0	62.5	68.0	37.5	18.0
Control	200	-	97.5	95.0	0.0	0.0	0.5	0.0

U - Uninjured sesame seeds, I - Injured sesame seeds
* - Observations after 21 day in pots

and incubated in the growth chamber. Two hundred seeds were used. Seed without fungal dressing (unrolled) served as control. The method was also tried in an another way, where the seed coat of pre soaked and surface sterilized seeds from the same lot were injured with the help of sterilized biological needles. Then the injured seed were rolled upon the actively grown culture and plated on moist blotters. It was observed that initially no effect on seed germination was recorded. In uninjured seeds the germination ranged from 97.0 to 99.0% where as in injured seed the germination ranged from 93.0 to 95.0% (Table 1). In uninjured seeds, maximum 80.0% infection was recorded when the seeds were rolled over the seed isolate. The infection was 59.0 and 62.5 when the seeds were rolled-over on stem and root isolate, respectively. In case of injured seeds the infection ranged from 67.5 to 69.5. In control no infection was noticed.

It was concluded that injury made on sesame seeds did not increase the infection, however, among the three isolates the seed isolate was the most virulent as it resulted to 80.0 and 69.5% infection in uninjured and injured seeds, respectively (Table 1).

Soil infestation technique

The virulence of seed, stem and root isolates of *Macrophomina phaseolina* was tried by sowing the seeds in artificially inoculated soil. Mycilial met grown in potato-sucrose-broth was mixed in sterile soil that was filled in plastic pots. The fungus was thoroughly mixed in sterile soil and allowed to grow for 12 days at room temperature.

Pre emergence mortality ranged from 36.2 to 38.0% as compared to 3.0% as observed in the control pots (Table 1). Maximum seed rot (38.0%) was observed in seed isolate of the *Macrophomina phaseolina*. The ungerminated seed in control did not show any fungal infection where as in other set the fungus was found associated with rotted seeds. The association of the fungus with rotted seeds was confirmed by observation under microscope and by making isolations on PSA from the ungerminated seeds.

After 21 days, 22.5% mortality of the seedlings was recorded in pots with *Macrophomina phaseolina* infested sick-soil. The seedlings turned bown in colour. The rootlets had necrotic lesions. At the soil level, profuse fungal growth of the *Macrophomina phaseolina* was recorded. The dead seedlings were covered with the black mass of fungal bodies. Fungal structures, pycnidia were recorded on the rotted portion of decaying and drying seedlings. The association of the fungus was confirmed under microscope and subsequent isolations on PSA medium.

Tooth pick inoculation method

Infection by the fungus was observed. Typical symptoms were developed within 17 - days of inculation. Fungus was reisolated and identity was confirmed.

Pathogenicity of isolated cultures of *Macrophomina phaseolina* was tested by three methods viz., seed infestation, soil infestation and tooth pick method. In seed infestation method, the infection was in the range of 59.0 to 80.0%. The artificial injury did not affect the intensity of infection. The seeds from pre-tested seed lot with no natural infection of the fungus were soaked and rolled over the actively grown cultures. The seeds were sown in artificially inoculated soil. Pre-emergence mortality (36.2 to 38.0%) was recorded whereas after 21 day, 22.5% mortality of seedling was noticed. The cause of pre- emergence mortality (seed rot) and post emergence (seedling death) mortality indicated the association of fungus with dead tissues. Pre and post- emergence mortality has been discussed by Abdou et al. (2001), Saharan et al. (2005), Tikhonov et al. (1976).

मेक्रोफोमिना फेजियोलीना नामक फफूंद, तिल फसल में बीज सड़न, पौद सड़न, तना तथा जड़ सड़न रोग फैलाता है । अपरोक्त फफूंद की तीव्रता तथा रोग पैदा करने की शक्ति का आंकलन बीज, मृदा तथा टूथ पिक प्रक्रिया द्वारा आंकी गयी । लगभग 59-80% बीज संक्रमण पाया गया जब स्वछय बीजों को फफूंद से चिपका कर बोनी की गयी । कृत्रिम रूप से उपचारित मृदा में फफूंद मिलाकर बीजों की बोनी से 36.2 - 38.0% बीज सड़न तथा 22.5% पौद सड़न पाया गया । टूथ पिक विधी से 17 दिनों में रोग की तीव्रता तथा क्षमता देखी गयी ।

Reference

Abdou E, Abd-Alla-H M, Galal A A (2001) Survey of sesame root rot/wilt disease in Minia and their possible control by ascorbic and salicylic acid. Assiut J Agric Sci 32(3) : 135-152

Bedigian T (1985) Sesamin, sesamoline and the original of sesame biochem systematics. Ecology. 13:9-133

Bhale M S (1978) Studies on seed borne fungi of sorghum

with special reference to *Curvularia lunata* (Walker) Boeidjn. MSc (Ag) Thesis, JNKVV Jabalpur (M P)

Bhale M S, Bhale Usha, Khare M N (1999) A method of testing virulance in chilli anthracnose pathogens. J Mycol & Pl Pathol 29(2) : 253

Brar G S, Ahuja K L (1979) Sesame its culture, genetics, breeding and biochemistry. In Annual Review of Plant Physiology Kalyani Publishers, New Delhi. 245-313

El- Bramway, Maehsh (2010) Genetic analysis of yield component and disease resistant in sesame (*Sesame indicum* L.) using two progenies of diallel crosses. Res J Agro 4(3): 44-56

Javed M S, Wahid A, Idress M (1995) Fungi associated with sesame seeds and their frequency. Pakistan J Phytopathol 7(2) : 174-176

Kolte S J (1985) Diseases of annual edible oilseed crops Vol. II. Rapeseed- Mustard and Sesame Diseases. CRC Press Inc. Boca Raton Florida USA: 83-112

Moazzami Ali (2006) Sesame seed lignans. Ph.D. Thesis Department of Food Science, SLU Acta Universit Agriculturic Scieciae

Ranganatha A R G, Lokesha R, Tripathi A, Tabassum Aasfa, Paroha S, Shrivastava M K (2012) Sesame Improvement - Present Status and Future Strategies. J Oilseeds Res 29 (1): 1-26

Saharan G S, Mehta Naresh, Sangwan M S (2005) Diseases of Oilseed Crops. Indus Publishing Co. New Delhi: 643

Sanaomung N, Sirithorn P (1996) A summary of the research on sesame disease at Khon Khaen University during 1986-96. In sesame: 101-110. Ubonkit Offset Press, Ubon Ratchathani, Thailand

Singh V, (1976) Studies on seed borne *Colletotrichum* spp. associated with urid seeds. MSc (Ag) Thesis, JNKVV Jabalpur

Tikhonov O I, Nedelko O K, Persestova T A (1976) Methods for pathogenicity test for seed borne *Macrophomina phaseolina* isolated from different herb. Phytopathol Z 88: 234-237

Verma M L, Mehta N, Sangwan, M S (2005) Fungal and bacterial diseases of sesame p. 269. In Diseases of oil seed crops (ed. G S Saharan, N Mehta, M S Sangwan). Indus Publishing Co. New Delhi 634

Verma M L, Prasad D, Puri S N (2002) Fungal and bacterial diseases of sesame and their management. Crop-pest-and-disease-management: Challenges for the mellennium. Jyoti Publishers & Distributors. Dehra Dun, India: 161-192

Vyas S C, Prasad K V V, Khare M N (1983) Diseases of Sesame and Niger and their control. Technical Bulletin. Directorate of Research Services JNKVV Jabalpur, M P:1-18

(Manuscript Receivd : 03.04.2013; Accepted : 25.08.2013)

JNKVV Res J 48(2): 192-197 (2014)

Amylase production by soilborne *Aspergillus niger* under solid state fermentation at Jabalpur, Madhya Pradesh

Shikha Gauri, Shikha Bansal and **Priyanka Bhowate**
St. Aloysius' College (Auto)
Jabalpur 482001 (MP)
Email: Shikha877@yahoo.com

Abstract

Amylase producing fungi were isolated from soil samples of Botanical Garden of St. Aloysius' College (Auto.) Jabalpur (M.P) during 2014. Among isolated fungal species, *Aspergillus niger* was found prominent starch hydrolysing with corresponding inhibition of (42 mm). Solid state fermentation resulted in highest yield of amylase. Screening of crude enzyme extract was done to determine the antimicrobial activity against bacterial pathogens (*Listeria monocytogenus*, *Bacillus subtilis*, *Staphylococcus aureus*, *Staphylococcus epidermis*, *Pseudomonas aeruginosa* and *Escherichia coli*) and no inhibition zone was observed. The influence of physical and chemical factors such as pH, temperature, starch concentration and nitrogen source of the medium utilizing different substrate (wheat flour, steamed rice and tea waste) was investigated and maximum amylase production was found by using wheat flour as substrate. The maximum production of amylase was observed at 80ºC with a concentration of 2.489mg/ml/sec whereas optimum pH was 3 with a concentration of 0.8859mg/ml/sec. Among nitrogen source peptone had maximum concentration of 2.5 mg/ml/sec and TLC revealed of 1.77. The enzyme produced by this isolate *Aspergillus niger* can be used in industrial process after characterization since significance of amylase enzymes is well established due to potential application.

Keywords: Solid state fermentation, Antimicrobial activity, *Aspergillus niger*, Amylase production

Recent discoveries on the use of microorganisms as sources of industrially relevant enzymes have led to an increased in the application of microbial enzymes in various industrial processes. Nowadays, the new potential of using microorganism as biotechnological source of industrially relevant enzymes has stimulated interest in exploration of extracellular enzymatic activities in several microorganisms [Akpan et al. 1999, Bilinski and Stewart 1995, Buzzini and Martini 2002]. Microbial enzymes are preferred to those from both plant and animal sources because they are cheaper to produce, and their enzyme contents are more predictable, controllable and reliable (Burhan et al. 2003).The amylase family of enzymes is of great significance due to its wide area of potential application such as application in pharmaceutical and a clinical sector requires high purity amylases. Thus, it is significant to develop economic processes for their purification to obtain pure enzymes with maximum specific activity (Pandey et al. 2000). Solid State Fermentation holds tremendous potentials for the production of enzymes. It can be of special interest in those processes where the crude fermented product may be used directly as the enzyme source (Canel and Moo 1980). The free water is indispensable to the microorganism's growth and is adsorbed on a solid support or complexed into the interior of a solid matrix (Soccel 1992). In the present work, different solid substrates viz.; steamed rice, wheat bran, starch, tea waste have been used. Different process conditions were studied to achieve maximum yield of amylase production, using various experimental designs. This method has economic value for countries with abundance of biomass and agro industrial residues, as these can be used as cheap raw materials (Tunga and Tunga 2003). Amylase has been derived from several fungi, yeasts, bacteria and actinomycetes, however, enzymes from fungi and bacteria still dominate in industrial sectors. Fungal amylase is preferred for use in formulation for human or animal consumption involving application under acidic condition and around 37ºC. Studies on fungal amylase especially in the developing countries have concentrated mainly on

Rhizopus sp. and *Aspergillus* sp., probably because of the ubiquitous nature and non-fastidious nutritional requirements of these organisms. Amylases can be produced by several strains of *Aspergillus* under both submerged fermentation (SmF) and solid- state fermentation (SSF) utilizing various food and agronomic wastes (Francis et al. 2002). Over SmF system, SSF is reported to be the most appropriate process for developing countries in terms of less space needed for fermentation usage of agronomic wastes as substrates, lesser operational complexity, lesser water output, better product recovery and lack of foam build up (Suganthi 2011). Therefore, the aim of present research work was to study amylase production from *Aspergillus niger* using different substrate in solid state fermentation and the study of different factors such as pH, temperature, nitrogen source, starch concentration for the production of amylase from *Aspergillus niger*.

Material and methods

Sample collection

Soil sample were collected from the Botanical Garden of St. Aloysius' College (Autonomous), Jabalpur (M.P) and brought to the laboratory for microbial analysis.

Isolation and identification

One ml soil suspension from 10-5 dilution was spread over PDA plate and incubated at 28° C for 48 hr for the isolation of fungus. Sub culturing was done until pure culture of *Aspergillus niger* was obtained. The isolated fungal culture were characterized on the basis of colour and hyphae, kind of asexual spores, sporangiophore, conidiophores and the characteristics of spore head. Small portion of mycelia stained in a drop of lactophenol cotton blue and mounted with coverslip was examined under microscope for confirmation.

Screening for amylolytic activity of *Aspergillus niger*

Amylolytic activity of the test isolate was determined by starch agar plate method (Bertland et al. 2004). Accordingly the test organism was inoculated into PDA media supplemented with 1 g of starch. The plates were then incubated at 50°C for 5 days. After incubation period, Lugol's iodine solution was added to the culture plate to identify the zone around the cultures which was measured that represent the amylolytic activity.

Preparation of the medium to determine amylase production

The production medium was prepared (composition in grams/litre :KH_2PO_4 - 0.14g, NH_4NO_3 -0.1g, KCl-0.05g,$MgSO_4.7H_2O$ - 0.01g, $FeSO_4.7H_2O$ -0.001g, starch - 2g) and was autoclaved at 121°C for 45 mins. The media was then inoculated with isolated fungal culture and incubated at 28° C for 48 hr.

Extraction of Amylase from *Aspergillus niger*

Extraction of crude enzyme was done by centrifugation of the fermented media at 3000 rpm for 5 mins, supernatant collected and filtered by using whattman no 1 filter paper. The filtrate was used as crude enzyme extract (Ali et al. 1998, Oyeleke et al. 2009)

Antimicrobial potential of crude enzyme extract

Bacterial pathogens were chosen to evaluate the antibacterial activity of crude enzyme extract by agar well diffusion method, firstly the lawn was prepared by swabbing the surface of nutrient agar media bacteria pathogens procured from MTCC Chandigarh (*Listeria monocytogenus* MTCC (657), *Bacillus subtilis* MTCC (121), *Staphylococcus aureus*, MTCC (3160), *Staphylococcus epidermis*, MTCC (30886), *Pseudomonas aeruginosa* MTCC (424) and Escherichia.coli MTCC (40) and incubate for 15 minutes. Equally spaced wells were made in the solidified agar with the help of a pre-sterilized cork borer. Crude enzyme extract was poured in the well. The plates were incubated at 37°C for 2-3 days for bacterial growth.

Amylase enzyme Assay

Amylase activity was assayed by pipetting 0.5 ml of culture extract enzyme into test tube and 1ml of 1% soluble starch in citrate phosphate buffer having a pH of 6.4.The reducing sugar liberated were estimated by the 3, 5 Dinitrosalicycilc acid (DNSA) method (Bertland et al. 2004) The reaction mixture was incubated in a water bath at 40° C for 30 mins. A blank consisting of 1ml of soluble starch in citrate -phosphate buffer pH (6.4) was also incubated in a water bath at the same temperature and time with the other test - tubes. The reaction was terminated by adding 1ml of DNSA reagent

in each test -tubes and then immersing the tubes in a boiling water bath for 5 mins after which they were allowed to cool and 5ml of distilled water was added. The absorbance was measured at 540 nm.

Determination of reducing sugar

The reducing sugar liberated was estimated by using the 3, 5 Dinitrosalicyclic acid method as advocated by (Bertland et al.2004). The reaction mixed was incubated in a water bath at 40°C for 15 mins and the reaction was terminated by adding 1ml of prepared DNSA reagent in the reaction tubes and then immersing the tubes in a boiling water bath (100° C) for 5 mins after which they were allowed to cool under running tap water. The reducing sugar content was determined by referring the standard curve of known concentration of glucose.

Effect of different parameters on amylase production

Effect of different parameters such as pH, temperature, nitrogen sources and substrate on amylase production was studied.

pH - The effect of pH on amylase production was determined using pH values of 3,6,8 and 10 after which an assay was also carried out based on Dinitrosalicyclic acid method (DNSA) (Bertland et al. 2004).

Temperature -The effect of temperature on amylase production was carried out using the following temperature values of 30°C,40°C,60°C and 80°C after which an assay was also carried out based on Dinitrosalicyclic acid method (DNSA) (Bertland et al. 2004).

Nitrogen source-Different nitrogen sources (peptone, beef extract, tryptone) were used for the production of amylase after which an assay was also carried out based on (DNSA) (Bertland et al. 2004).

Substrates -The basal media was supplemented with 2 g of various substrates viz., tea waste, wheat flour, steamed rice. After inoculation of the fungus, the flasks were incubated at 30°C for 3 days. To determine the effect of substrates on fungal amylases a mixture of crude enzyme, with 1% soluble starch and citrate phosphate buffer pH 6.4 was first incubated for 30 min. Then the residual activity of the enzyme was determined by assaying the incubated crude enzyme while after which an assay was also carried out based on DNSA method.

Thin layer Chromatography

The type of amylase from the fungal isolates based on the starch hydrolysates TLC system (Kimura and Horikosh (1989) cited in Gashaw Mamo and Amare Gessesse 1999) was followed. First 0.9 ml 2% soluble starch mixed with 0.3 ml crude enzyme from the respective fungal sources was incubated for 30 minutes at 65°C respectively in the water bath. Thereafter each hydrolysate was spotted on TLC plate along with standard known sugar (glucose and maltose) solutions. A one dimensional ascend was done using a solvent system (v/v) of butanol: ethanol: water (5: 3: 2). After a total of 4 ascends air-dry TLC plates were sprayed with 50% (v/v) Methanol- H2S04 mixture and heated for 10 min. at about 100°C. The dark brown sugar spots appeared was identified by comparing with the standards.

Statistical analysis

Effect of each parameter was studied in triplicate and the data have been statistically analysed and represented by the procedure suggested by Panse and Sukhatme (1967).

Result and discussion

Isolation and Identification

The fungal culture was isolated by serial dilution method and was tentatively identified as *Aspergillus niger* on the bases of habit characters microscopic and macroscopic characteristics observation.

Screening for amylolytic activity of *Aspergillus niger*

Amylolytic activity of *Aspergillus niger* was determined by using starch agar plate method (Bertand et al. 2004).The clearing zone with diameter 42 mm for *Aspergillus niger* was observed.

Antimicrobial potential of crude enzyme extract

Crude enzyme extract of *Aspergillus niger* was studied for its antimicrobial potential against bacterial pathogens procured from MTCC Chandigarh (*Listeria monocytogenus* MTCC(657),*Bacillus subtilis* MTCC (121), *Staphylococcus aureus*, MTCC (3160),

Staphylococcus epidermis, MTCC (30886), *Pseudomonas aeruginosa* MTCC(424) and *Escherichia coli* MTCC (40) and no inhibition zone was observed.

Effect of pH on amylase production

The effect of pH on the activity of enzyme produced by *Aspergillus niger*. The optimum pH for *Aspergillus niger* for this study was recorded at pH 3, with a concentration of 0.859 mg/ml/sec (Fig 2).

Effect of temperature on amylase production

The optimum temperature for the activity of *Aspergillus niger* was recorded at temperature 80°C with a concentration of 2.489 mg/ml/sec (Fig 3).

Effect of nitrogen source on amylase production

The effect of nitrogen supplementation on amylase production under SSF showed that peptone supported the highest production of amylase by *Aspergillus niger* (4.189mg/ml/sec) (Fig 4).

Effect of substrates on amylase production

The effects of different substrate on the activity of enzyme produced by *Aspergillus niger*. Maximum amylase activity was found by using wheat bran with concentration of 2.591mg/ml/sec (Fig 5).

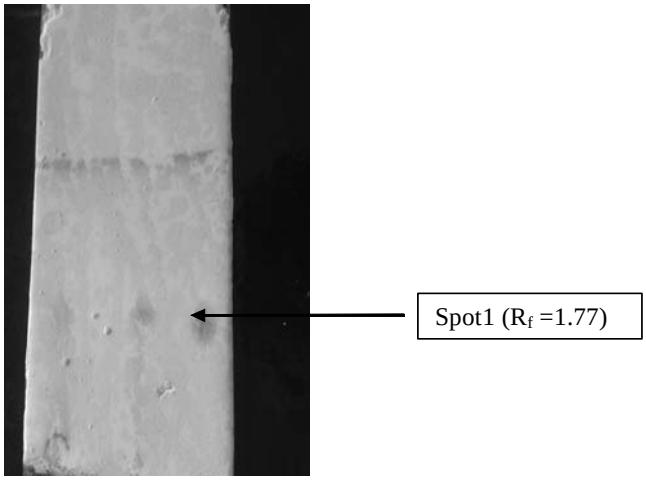


Fig 1. Thin layer chromatography of amylase production by *Aspergillus niger*

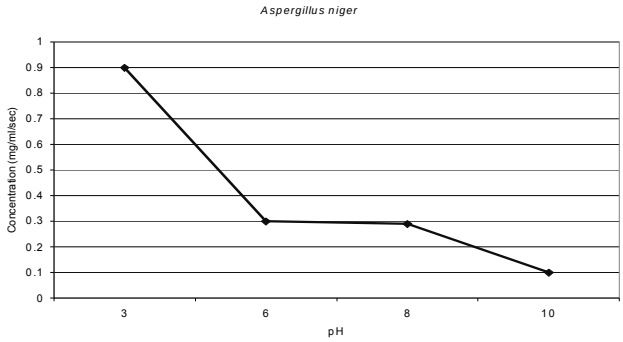


Fig 2. Effect of pH on amylase production

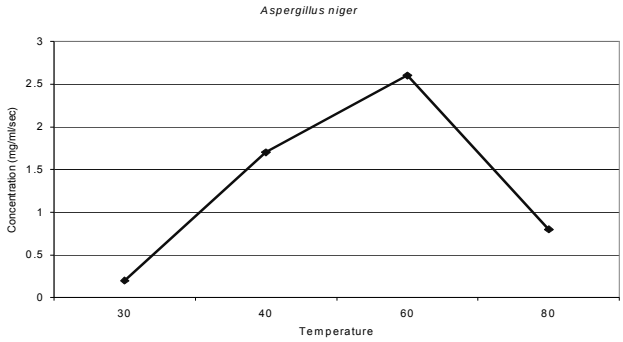


Fig 3. Effect of temperature on amylase production

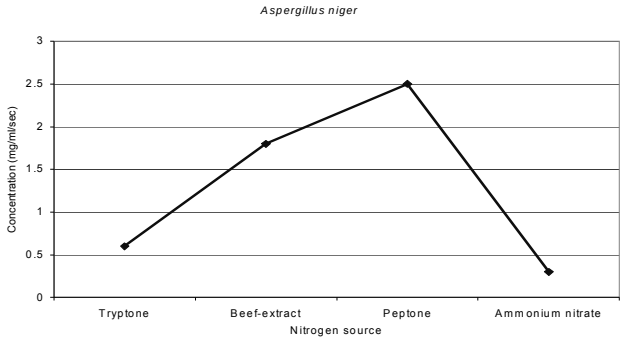


Fig 4. Effect of nitrogen on amylase production

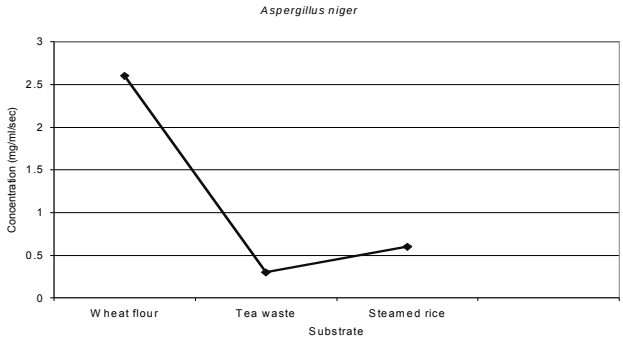


Fig 5. Effect of substrate on amylase production

Identification of the type of amylase by Thin layer Chromatography

The crude amylase enzyme produced by selected fungal isolates *Aspergillus niger* was spotted on pre coated silica plates with solvent system butanol:ethanol:water (5:3:2). TLC plates were sprayed with 50% (v/v) Methanol H_2SO_4 and heated for 10 min at about 100°C.The dark brown sugar spots appeared was identified by comparing with the standard with Rf value 1.77.

Starch degrading enzyme can be produced by microorganism. Amylase are important in many industrial process, A number of microbial source exist for the efficient production of this enzyme, but only few selected strains of fungi meet the objective for commercial production (Schafer et al. 2000). In the present study fungus that belongs to the genus *Aspergillus* were isolated from soil sample collected from botanical garden of St. Aloysius college (Auto). Screening of crude enzyme extract was done to check the antimicrobial activity against bacterial pathogens (*Listeria monocytogenus*, *Bacillus subtilis*, *Staphylococcus aureus*, *Staphylococcus epidermis*, *Pseudomonas aeruginosa* and Esherichia. coli) and no inhibition zone was observed. Different culture condition (Temp, pH, nitrogen source, starch concentration) greatly affect the production of amylase. Maximum enzyme production by *Aspergillus niger* was evaluated by growing it in SSF medium using different substrate wheat bran, tea waste and steamed rice. In the present study *Aspergillus niger* have proven to be useable in the conservation of wastes into useful products (enzymes). Therefore more waste should be screened for the ability to be utilized as possible substrate for the production of enzyme.

सन् 2014 में संत अलायसिस कालेज के वानस्पतिक उद्यान की मृदा से आमइलेज पैदा करने वाले फफूंदों को निकाला गया । स्टार्च गलाने की विधि द्वारा यह ज्ञात हुआ कि एस्परजिलिस नाइजर फफूंद बहुत ज्यादा मात्रा में मृदा में उपस्थित था । शाकाणु रोगकारकों जैसे लिस्टिरिया, बैसिलस, स्टेफिलोकाकस, स्यूडोमोनास तथा एस्कोरिशिया के विपरित इसको जाँचा गया । विभिन्न प्रभावकारों के विपरित प्रयोगो से ज्ञात हुआ कि एस्पजिलिस नाइजर द्वारा अमाइलेज का उत्पादन 80 डिग्री सेंटीग्रेड, पीएच 3 तथा नाइट्रोंजन सोर्स पेप्टोन की उपस्थिति में हुआ । इस अनुसंधान से यह पाया गया कि उपरोक्त एस्परजिलिस नाइजर का उपयोग इंड्रसट्रियल (औद्योगिक) रूप से अमाइलेज के उत्पादन में किया जा सकता है ।

Acknowledgement

Authors are thankful to the Principal, St Aloysius' College (Auto), Jabalpur for encouragement and providing necessary research facilities.

References

Akpan I, Bankjole Mo, Adesermowo Am, Lantunde (1999) Production of α- amylase by *Aspergillus niger* in a cheap solid medium using rice bran and agricultural material. Trop Sci 39: 77-79

Ali AI, Ogbonna CC, Rahman AR (1998) Hydrolysis of certain Nigerian starches using crude fungal amylase. Niger. J Biotechnl 9:24-36

Bertland TF, Frederic T, Robert N (2004) Production and partial characterization of a thermostable amylase from Ascomycetes yeast strain isolated from Strachy Sail. Mc Graw Hill Inc, New York, USA pp 20-152

Bilinski Stewart (1995) Production and Characterization of α-amylase from *Aspergillus niger*. 18: 551-556

Burhan A, Nisa U, Gökhan C, Ömer C, Ashabil A, Osman G (2003) Enzymatic properties of a novel thermostable, thermophilic, alkalineand chelatorresistant amylase from an alkaliphilic *Bacillus* sp. Isolate ANT-6. Proc. Biochem 38: 1397-1403

Buzuhi Martini (2002) Extracellular enzymatic activity profiles in yeast and yeast like strains isolated from tropical environments. Journal of Applied Microbiology 93: 1020-1025

Canel Moo Young (1980) Production of ?-amylase with *Aspergillus oryzae* on spent brewing grain by solid substrate fermentation. Applied Biochemistry and Biotechnology 102: 453-461

Cherry HM, Hossain MT, Anwar MN (2004) Extracellular glucoamylase from the isolate *Aspergillus fumigates*. Pakit J Biol Sci 7(11) : 1988-1992

Francis A Sabu, Nampoothiri K, Szakacs G, Pandey A (2002) Synthesis of amylase by alpha-*Aspergillus oryzae* in soild state fermentation. J Basic Microbiol 5: 320-326

Gashaw Mamo, Amare Gessesse (1999) Production and characterization of two raw starch digesting thermostable alpha amylases from thermophilic *Bacillus* sp. Enz Microbial Technol 25 : 433- 438

Oyeleke SB, Oduwole AA (2009) Production of amylase by

bacteria isolated from a cassava dumpsite in minna, Nigerstate, Nigeria. African J Microbiol Res 3(4): 143-146

Pandey A, Nigam P, Soccol CR, Soccol VT, Singh D, Mohan R (2000) Advances in microbial amylases (Review). Biotechnol Appl Biochem (31):135-152

Panse VG, Sukhatme PK (1967) Statistical methods for agriculture workers. II ed. ICAR publication, New Delhi 2 : 103-107

Soccol CR (1992) Physiologie et Metabolism de rhizopus en cultutre solide et submerge en relation avec la degradation d'Amidon et la Production d'Acide L (+) Lactique, these de doctorate, Universite de technologie de campiegne, France

Suganthi R, Benazir F, Santhi R, Ramesh Kumar V, Anjana Hari, Nitya Meenakshi KA, Nidhiya Kavitha G, Lakshmi R (2011) International J Engin Sci and Technol 3(2) : 1756-1763

Tunga R, Tunga BS (2003) Extracellular amylase production by *Aspergillus oryzae* under solid state fermentation. International Centre for Biochem, Olaka University, Japan : 12

(Manuscript Receivd : 01.06.2014; Accepted :28.08.2014)

JNKVV Res J 48(2): 198-202 (2014)

Factors associated with knowledge of Anganwadi workers in relation to Integrated Child Development services practices in Rewa, Madhya Pradesh

Priyanka Shukla M.K. Dubey and **A. S. Chouhan**
Department of Extension Education
College of Agriculture
Rewa 486114 (MP)
Department of Extension Education
College of Agriculture
Jawaharlal Nehru Krishi Vishwa Vidyalaya
Jabalpur 482004 (MP)
Email: Priyanka.shukla47@gmail.com

Abstract

The present study was undertaken in Rewa block of Rewa district in Madhya Pradesh with a sample of 100 respondents (Anganwadi workers) to study investigated the relationship of socio-economic personal, organization and communicational profile of Anganwadi workers with their knowledge from ICDS programme. Data revealed that majority (40%) of respondents had middle age group, (32%) belong to general caste, (42%) had educated higher secondary level, (64%) belong to rural background, (43%) respondents belong to medium annual income group,(45%) respondents had received three training programme and majority (72%) of respondents were married. As regards to their organizational and communicational variable, the majority (67%) of the respondents had more than 5 years service, (58%) had low job satisfaction, 63% had sufficient facility, 48% of respondents had used medium communication media, 46% had medium information source, 47% had medium cosmopoliteness level. Correlation (r) values indicating the socio-personal, communicational and economic attributes viz., Education, annual income, number of training received, marital status, total length of service, facilities available, communication methods used by Anganwadi workers, information source, cosmopoliteness were found significant correlation with given in knowledge.

Keywords: Anganwadi workers, Knowledge, ICDS

Malnutrition and under nutrition is a serious problem of slam area in both urban and rural population of India. This can be solved only supply of supplementary nutritional food through approaches like Institution of specific feeding programme to overcome malnutrition and to increase the food availability; to improve environmental sanitation and impart nutrition education to the women and increase their income.

ICDS is one of the most ambitious as well as multi-dimensional welfare programme to reach millions of children and their mothers who are caught in the grip of malnutrition diseases, illiteracy and Ignorance poverty. The main aim of this scheme is to reach all the needy children upto 6 years as pregnant (expectant), nursing mothers and to substantially alleviate the conditions of socio-economic deprivation-prevailing in society.

Madhya Pradesh (MP) has the highest prevalence of malnourishment among children. According to the Census 2011, MP's population and the IMR is 72 out of 1,000 children born. Madhya Pradesh (MP) has a child population of 10,548,295 (Census 2011). The share of children in the age group of 0-6 is 14.53 per cent, a decline of 3.34 per cent from 2001 Census. Nutritional knowledge have great important in proper management of food, application of balance diet and specific requirements of different nutrients for people of different age groups. Nutrition education should be practical and adopted to suit the socio-economic conditions, food habits and local food resources. It should include effective demonstration in which mothers take active part. It should form a part of the community development programme.

For keeping the view the present study was carried out with the help of following specific objective such as, to know the profile of selected AWWs, to find out knowledge level of AWWs in relation to ICDS practice and to assess the relationship if any between profile of AWWs with their knowledge.

Material and methods

The present study was carried in Rewa district Madhya Pradesh during 2012. In the Rewa district has pioneer work under 15 ICDS projects, in 9 blocks. Out of which only Rewa project block was selected purposively as it has highest numbers of Anganwadi centers are working amongst all the blocks under ICDS. Rewa block covers 380 Anganwadi centers out of which 201 centers are working in rural areas and remain working in urban area. The present study was confined to Anganwadi centers as these centers are working in the rural areas. Out of 201 rural Anganwadi centers, fifty per cent centers (100 centers) was selected on the basis of larger operational area.

One hundred Anganwadi centers were selected. In each AWWs centers one AWWs are performing their role in ICDS, thus the total 100 Anganwadi workers was the sample of the research study. The data were collected through personal interview method with the help of pre-structured interview schedule. The secondary data was collected from Child and Women Welfare Department of Rewa block and rural Anganwadi center of Rewa district. The correlation coefficient was applied to know the correlation between the profit of AWWs with the knowledge of ICDS practices to draw the valid conclusion.

Results and discussion

Socio-economic personal profile of the respondents

The maximum of 40 per cent of the respondents were belonged to the middle age group. The lowest 28 per cent of respondents were in old age group. The maximum of 32 per cent of respondents were belonged to general category, followed by OBC category (28%), schedule tribe category (21%) and schedule caste category (19%). Their maximum education qualification was upto higher secondary level (42 %) of respondents were educated upto higher secondary level, 31 per cent respondents were educated upto graduate level followed by 27 per cent were educated upto post graduate level. Similar finding is in accordance with the

Table 1. Distribution of the respondents and according to their profile

	Frequency	%
Socio-economic variables		
Age group of respondents		
Young	32	32.00
Middle	40	40.00
Old	28	28.00
Caste		
Schedule Caste	19	19.00
Schedule Tribe	21	21.00
OBC	28	28.00
General	32	32.00
Education of respondents		
Higher secondary	42	42.00
Graduate	31	31.00
Post graduate	27	27.00
Family backgrounds		
Rural	64	64.00
Urban	36	36.00
Annual income		
Low (Rs. < 1 Lakh)	27	27.00
Medium (Rs. 1 to 1.5 Lakh)	43	43.00
High (Rs. >1.5 Lakh)	30	30.00
No. of training received		
Less	29	39.00
Medium	45	45.00
More	26	26.00
Marital status		
Married	72	72.00
Unmarried	28	28.00
Organizational variables		
Total length of service		
Up to 5 years service	33	33.00
More than 5 years service	67	67.00
Job satisfaction		
Low (18-25)	58	58.00
Medium (26-33)	23	23.00
High (Above 33)	19	19.00
Facilities available		
Insufficient facility (8-11)	37	37.00
Sufficient facility (12-15)	63	63.00
Communicational variables		
Communication media used by Anganwadi workers		
Low (6-9)	23	23.00
Medium (10-13)	48	48.00
High (14-17)	29	29.00
Information source		
Low (3-5)	24	24.00
Medium (6-8)	46	46.00
High (9-11)	30	30.00
Cosmopoliteness		
Low (1-2)	32	32.00
Medium (3-4)	47	47.00
High (5-6)	21	21.00

results obtained by Patel (2007) and Patil (2007). Family background f the maximum family was (64 %) belonged to rural family background, while rest of them belonged to urban family. Hence, it is clear that majority of respondents were from rural family background. The finding is in accordance with Agarwal (2000) and Patil (2007). Their annual income was 1. to 1.5 lakh and most of them (43 %) were placed to medium annual income category, whereas 30 per cent respondents were high annual income and only 27 per cent respondents were low annual income. Therefore, it may be concluded from the data that higher percentage of respondents belonged to medium annual income group. The maximum number of training received was (45%) and most of them belonged to medium number of training received whereas, 26. per cent respondents received less number of training and only 29 per cent respondents received more number of training. Similar findings were reported by Patil (2007) and Manhas and Dogra (2012). Maximum number (72 %) of respondents had married and rest of the respondents were unmarried. Hence, the results are in conformity with the findings reported by Patel. (2007) and Patil (2007).

Organizational and Communicational variable

Findings indicated that more than half (67%) of respondents were more than 5 years service, while only 33 per cent respondents were having length of service upto 5 years. Therefore, it can be inferred that the majority of respondents having more than 5 years service. Similar findings were observed by Patil (2007). These facts indicate that lengths of service are improving knowledge of Anganwadi workers in relation to health and nutritional aspect (Table 2). More than half (58%) of respondents had low satisfied with their job compared to 23 per cent of them having medium satisfied and only 19 per cent respondents having high satisfied with their job. Hence, it is clear that maximum numbers of respondents (58%) were low satisfied with their job. This result is in conformity with the findings as reported by Patil (2007).

About half (48%) of the respondents had used medium communication media by Anganwadi workers compared to 29 per cent of Anganwadi workers used had high communication media and rest of the Anganwadi workers had used low communication media. Thus, it may be concluded that maximum Anganwadi workers were used medium communication methods such as home visits, demonstration methods, group discussion, special day or week and assembly for providing useful information at the center for better implementation of ICDS programme. Similar results were reported by Patel (2006) and Pal et al. (2008). About half (46%) of the respondents were used medium information source, while 30 per cent respondents were used high information source and only 24 per cent respondents were used low information source for performing their work. Therefore, it is concluded that source of medium information used by the Anganwadi workers for their work.

Cosmopoliteness is considered as an important factor which is largely affects the knowledge of Anganwadi workers in relation to health and nutritional aspect under ICDS programme. It can be observed that

Table 2. The knowledge level of Anganwadi workers in relation to health and nutritional practices

Level of knowledge	Number of respondents	Percentage
Low (55-56)	23	23.00
Medium (66-76)	31	31.00
High (above 76)	46	46.00
Total	100	100

Table 3. Correlation between independent variables and dependent variable i.e., level of knowledge of Anganwadi workers

Independent variables	Value of correlation co-efficent 'r' value
Age	-0.030^{NS}
Caste	-0.132^{NS}
Education	0.281 *
Family background	-0.134^{NS}
Annual income	0.264 *
No. of training received	0.267 *
Marital status	0.270 *
Total length of service	0.261 *
Job satisfaction	-0.183^{NS}
Facilities available	0.223 *
Communication methods used by Anganwadi workers	0.231 *
Information source	0.212 *
Cosmopoliteness	0.250 *

47 per cent respondents had cosmopoliteness, while 32 per cent respondents had low and 21 per cent respondents had high level of cosmopoliteness.

That the maximum number (46.%) of the respondents possessed high level of knowledge and 31. per cent respondents possessed medium level of knowledge whereas, 23. per cent respondents was low level of knowledge (Table 2.).

Thus, it is concluded that maximum number (46 %) of respondents possessed high level of knowledge in relation to health and nutritional practices. The work of Kaur and Sehgal (1995), Sharmah and Sithalakshm (2001), Devi and Padmavati (2006) and Kumari et al. (2010) confirmed this finding.

Correlation between independent variables and dependent variable i.e., level of knowledge of Anganwadi workers:

Education, number of training received, marital status, total length of service, job satisfaction, facilities available, communication media used by Anganwadi workers, information source and cosmopoliteness had positive significant correlation but rest of the variables had non-significant relationship (Table 3). This finding was found similar to the findings of Singh et al. (2003) and Kumari et al. (2010). Education of the respondents is key of success. Educated respondents are more likely to have more interest in acquiring the knowledge of Anganwadi workers in relation to health and nutritional aspects. Moverover, it was concluded that the annual income of Anganwadi workers had positive significant relationship with their knowledge. This means that Anganwadi workers with higher annual income had high level of knowledge. Furthermore, the Anganwadi workers with high annual income were more educated and cosmopolite as well as they had use more communication methods and getting more information for various sources. Since the success rate of this nation wide integrated programme solely depends upon the fact as to how we are preparing our ground workers to combat with the problem of malnutrition, it becomes really important to upgrade our ground worker i.e. Anganwadi worker with quality training and enhanced and advanced nutrition knowledge as nutrition knowledge was the most powerful determinant of performance (Gujral et al. 1992).

Conclusion

On the basis of findings it can be concluded that majority (40.%) of respondents had middle age group, (32%) belong to general caste, (42%) had educated higher secondary level, (64%) belong to rural background, (43%) respondents belong to medium annual income group,(45%) respondents had received three training programme and majority (72%) of respondents were married. As regards to their organizational and communicational variable, the majority (67%) of the respondents had more than 5 years service, (58%) had low job satisfaction, 63% had sufficient facility, 48% of respondents had used medium communication media, 46% had medium information source, 47% had medium cosmopoliteness level. Majority of the Anganwadi workers belonged to high level of knowledge group followed by medium and low knowledge group. A strategy for knowledge development in health and nutritional aspect for the Anganwadi workers under ICDS programme. The characteristics viz., education, number of training received, marital status, total length of service, job satisfaction, facilities available, communication media used by Anganwadi workers, information source and cosmopoliteness were significant with knowledge level of angawadi workers while age, caste, family background and job satisfaction were found non-significant relation with knowledge level of Anganwadi worker in relation to health and nutritional aspect.

वर्तमान अध्ययन म.प्र. मे रीवा जिले के रीवा विकास खण्ड मे किया गया है जिसमे 100 ऑगन बाड़ी कार्यकात्ताओ से संबंधित उनके सामाजिक आर्थिक व्यक्तिगत, संगठनात्मक एवं संचार संबंधी कारको को उनके समन्यवित बाल विकास परियोजना संबंधित ज्ञान को प्रभावित करने वाले विभिन्न कारको का अध्ययन षामिल है अनुसंधान से प्राप्त आकड़ो से यह निष्कर्श प्राप्त हुआ है कि ज्यादातर कार्यकर्त्ता मध्यम आयु वर्ग (32 प्रतिशत) के, सामान्य जाति वर्ग के उच्चतर माध्यमिक षिक्षा स्तर वाले एवं ग्रमीण पृष्ठ भूमि वाले पाये गये है। साथ-साथ मध्यम वार्शिक आय वर्ग के अधिकतम 3 बार विभागीय प्रशिक्षण प्राप्त किया है, अधिकतम कार्यकर्त्ता शादी-शुदा पाये गये हैं अधिकतर कार्यकर्त्ताओ की सेवाऍ पॉच वर्ष से अधिक का कार्य अनुभव पाया गया और उनमे कार्य के प्रति कम संतुष्टि पायी गयी एवं कम से कम कम संचार माध्यम का उपयोग किया । साथ-साथ कम से कम सूचनाओ का उपयोग किया इस अध्ययन से यह पाया गया कि ऑगनबाड़ी कार्यकर्त्ताओ की शिक्षा, वार्षिक आय, प्रशिक्षणो की संख्या, कार्य अनुभव, सुविधाओ की उपलब्धता, संचार विधियॉ, सूचना स्त्रोत, बाह्य संपर्क उनके ज्ञान से संबंधित रखते है।

References

Agarwal D (2000) Capacity building for rural women.Social welfare 47 (4): 7-9

Devi PY, Padmavati T V N (2006) Effect of nutrition and health education to rural women on the awareness, practices and nutritional status of ICDS children.Journal of Research ANGRAU. 34: 1: 78-81

Gujral S, Abbi R, Mujoo R, Gopaldas T (1992) Determinants of Community Health Workers' Performance in India. From< http://www.unu.edu/Unupress/food/8F134e/8F134E03. htm> (Retrieved on 15 October 2008)

Kaur Y, Sehgal S (1995) Impact of nutrition education on knowledge and practices of rural women. 31(1 to 4): 80-83

Kumari Rani, Srivastav AK, Sinha Nidhi (2010) Extent of knowledge of farm women on nutrition. Indian Res. J.Extn. Edu. 10 (1): 65-68

Manhas Shashi, Dogra, Annpurna (2012) Awareness among Anganwadi Workers and the Prospect of Child, Health and Nutrition: A Study in Integrated Child Development Services (ICDS) Jammu, Jammu and Kashmir, India. Anthropologist 14 (2): 171-175

Pal D K, Toppo NA, Tekhre Y L, Das J K, Bhattacharya, Menon Vandana, Nandan S Deoki (2008) An appraisal of Janani Sahyogi Yojana in the State of Madhya Pradesh. Health and Population - Perspectives and Issues. 31: 2, 85-93

Patel Poonam (2006) A study on job performance of ICDS programme works in Panagar block of Jabalpur (MP) M Sc (Ag) Thesis JNKVV, Jabalpur (MP)

Patel Poonam, Agrawal SK, Saxena KK (2007) Factors affecting job performance of integrated child development services (ICDS) programme workers. International Conference on Sustainable Agriculture for Food, Bio-energy and Livelihood security. Feb. 14-17, 2007, Abstracts, Vol.1, JNKVV, Jabalpur (M.P.): 254-255

Patil Rajesh (2007) A study on training needs of Anganwadi workers in ICDS in Pandhana block of Khandwa district (MP) MSc (Ag) Thesis JNKVV Jabalpur (MP)

Sharmah J, Sithalakshm S (2001) Knowledge check for assessing health and nutritional knowledge of women in ICDS programme. 37 (1& 2): 42-48

Singh V, Raghuvanshi RS, Kharayat S (2003) Nutritional gain of rural mothers regarding health and nutrition of infant using a multimedia approach. IX Asian congress of nutrition, New Delhi, India, Abstract-Nutritional Goals for Asia Vision 2020: 302

(Manuscript Receivd : 01.04.2014; Accepted :30.07.2014)

JNKVV Res J 48(2): 203-206 (2014)

Quality attributes of ber jam during storage

Himanshu Dubey, Pratibha Parihar and **S. Kumar**
Department of Food Science & Technology
Jawaharlal Nehru Krishi Vishwa Vidyalaya
Jabalpur 482004 (MP)
Email: Pratibha.parihar123@gmail.com

Abstract

A study was made to evaluate the quality of ber jam during storage period. The result showed that better quality of ber jam could be made at 70^{0}Brix with 0.3% acidity. The overall quality of the product was good and could be well stored at ambient temperature for the period of 4 months.

Keywords: Shelf-life of ber jam, quality of stored ber jam.

Ber (*Zizyphus mauritiana* lamk) is a tropical fruit belonging to family Rhamnaceae. It grows even as wild in the plains of Punjab, Haryana, Uttar Pradesh, Madhya Pradesh and Rajasthan. It thrives under adverse conditions of salinity, drought and water logging, where other fruits fail to grow successfully. At present ber cultivation is being taken up in arid and unirrigated regions of India. It is highly nutritious, rich in ascorbic acid and contains good amount of protein and amino acids (Bal and Maan 1978). It contains good amount of vitamins A, B complex and C in comparison to other fruits (Anon 1976). Ber fruits are also higher in calorific value and ascorbic acid as compared to apple and orange (Jawanda and Bal 1978). Ber fruits are eaten as raw or used in making beverages which are quite nutritious. In the present investigations, ber jam was made and evaluated its quality during different storage periods.

Material and methods

Fresh ber fruits (Umran cv) were procured from market and washed in running tap water to remove the dirt and dust. They were peeled, cut into small pieces and pulped. The weighed quantity of pulp were taken and cooked in open pan with continuous stirring with sugar and different quantities of citric acid (0.2 and 0.3%) till the products left out the pan and TSS of the product became 68-70 ^{0}Brix. The products were removed and mixed with pectin (1%) and filled in sterilized wide mouth glass bottles and stored for 120 days at ambient conditions. The samples were withdrawn at different intervals (30, 60, 90, 120 days) and used for quality analysis. The moisture content, ascorbic acid and acidity were estimated by the methods as described in AOAC (1980). The intensity of colour was measured by Hunter colour lab instrument (Anon 1992). Total sugar was determined by Lane and Eynon method (Lane and Eynon 1970), calcium by Black's method (Black 1965), phosphorus by Koening and Johnson's method (Koening and Johnson 1942). The overall acceptability of product was evaluated on 9 points hedonic scale as described by Amerine et al Amrine & Rossler (1965). The microbial load was measured by the method as described by Sharf (1966).

Results and discussion

The physicochemical attributes of ber jam results showed that there were slight differences in the various constituents of ber jam made on 0.2 and 0.3% citric acid. The ber jams contained moisture 29.16 % and 29.80%, pH 3.69 and 3.90, TSS 70^{0}Brix, acidity 0.5% and 0.57%, ascorbic acid 27.03 and 27.98 mg/100g, reducing sugars 19.23 and 19.10%, non reducing sugars 39.78 and 40.62%, calcium 9.01 to 9.95 mg/100g and phosphorus 4.02 and 4.33 mg/100g product, respectively (Table 1). The results indicate that there were slight differences in the above constituents except pH and acidity.

Table 1. Physicochemical attributes of ber jam

Constituents	Ber jam	
	Acidity (0.2%)	Acidity(0.3%)
Moisture (%)	29.16	29.80
TSS (^{0}Brix)	70.00	70.00
pH	3.69	3.90
Acidity (%)	0.51	0.57
Ascorbic acid (mg/100g)	27.03	27.98
Reducing sugars (%)	19.23	19.10
Non-reducing sugars (%)	39.78	40.62
Total sugars (%)	59.01	59.72
Calcium (mg/100g)	9.01	9.95
Phosphorus (mg/100g)	4.02	4.33

Results are average values of three replications

Table 2. Effect of storability on physico-chemical attributes of ber jam stored under ambient conditions

	Storage period (days)						
	0	30	60	90	120	SEm	CD at 5%
Moisture (%)	29.80	28.14	27.08	26.04	24.86	0.05	0.17
TSS 0Brix	70.00	70.40	71.23	71.70	72.20	0.09	0.29
pH	3.90	3.32	2.71	2.14	1.83	0.05	0.16
Acidity (%)	0.57	0.59	0.61	0.63	0.65	0.06	0.02
Reducing sugars (%)	19.10	20.44	21.78	23.12	24.49	0.18	0.57
Ascorbic acid (mg/100g)	27.98	26.98	26.25	24.90	23.52	0.26	0.80
Calcium (mg/100g)	9.95	9.56	9.50	9.26	9.09	0.14	0.40
Phosphorus (mg/100g)	4.33	4.30	4.23	4.16	4.06	0.02	0.06

Table 3. Effect of storability on overall acceptability, colour and microbial load of ber jam

Parameters		Storage period (days)				
			30	60	90	120
Overall acceptability		8.80	8.11	7.90	7.15	7.0
Colour	L*	26.60	25.95	25.67	24.89	24.09
	a*	15.03	14.17	13.67	13.04	12.74
	b*	12.41	12.34	11.81	10.98	10.12
Microbial load (cfu/ml)	-	-	3×10^{-3}	6×10^{-3}	8×10^{-3}	11×10^{-3}

Effect of storage on physicochemical attributes of ber jam

During storage, there was a gradual decrease in moisture content the maximum (29.80%) was recorded at initial stage and minimum (24.86%) after 120 days of storage period. Similar results were also made on aonla honey spreadby Sehgal et al (2000). The reduction of moisture content might be attributed due the evaporation of moisture during sampling process. The TSS was found to increase during storage. It was increased from 70.00 ^{0}Brix to 72.20 ^{0}Brix on storage for 120 days. This might be attributed due to the conversion of existing polysaccharides into monosaccharides sugars. Similar observations were also made by Rajput et al (2007).

There was a gradual decreasing trend in pH during storage. It was maximum 3.9 and minimum 1.83 after 120 days of storage. However, acidity showed a increasing trend. Initially, it was 0.57% which increased to 0.65% after 120 days of storage. Similar results were also made by Lal et al (1998).

There were significant variations in reducing sugar. It was minimum 19.10% at initial stage and increased to 24.49% after 120 days of storage. Attri et al (1998) suggested that increase in reducing sugar might be due to the partial hydrolysis of polysaccharides into sugars. However, the values of total carbohydrates remained constant. These results were confirmed by Kumar (1992).

The content of ascorbic acid was found to decrease gradually during storage. The maximum value was recorded at initial stage (27.98 mg/100g) and minimum (23.52 mg/100g) after 120 days of storage period. This gradual reduction might be due the oxidation of acid as reported by Sathi & Mani (1991).

Calcium was found to decrease during storage of ber jam. The maximum was 9.95 mg/100g at the initial stage and minimum 9.04 mg/100g after 120 days of storage period. This reduction might be due to the binding of calcium with other certain organic substances as reported by Yadav (1991). Similarly, the maximum phosphorus content was present at initial stage (4.33 mg/100g) and minimum (4.06 mg/100g) after 120 days of storage. This reduction might be attributed due to prolong heating, addition of additives and formation of complex molecules during storage. Similar results were made by Swaminathan (1985). The colour of the stored jam was found to decrease during storage period as observed in ber jam. This might be attributed due to the browning reaction as reported by Baramanray et al (1996).

The presence of microorganisms in ber jams lead to off flavor by producing undesirable compounds. The maximum microbial load was found in stored jam for 120 days. The major organisms were Aspergillus and Alternaria spores. It appears that, higher acidity and high sugar content may help in the prevention of mould growth during storage. Similar findings supported by Kanekar (1992).

The highest score of overall acceptability was recorded in fresh jam (8.80) and lowest (7.10) after storage for 120 days. The overall acceptability of product decreased with the increase of storage period. This might be attributed due to deterioration in colour, flavour, taste and texture of the product. Similar observations were also made by Mishra & Chopra (2006). Thus, on the basis of above observations, it was concluded that the ber jam having 0.3% citric acid could be well stored upto 60 days without deterioration of the product quality.

भंडारण के समय, बेर जेम की गुणवत्ता आंकलन पर एक उध्ययन किया गया, निष्कर्ष में पाया गया की अच्छी गुणवत्ता वाला बेर जेम 70^0 ब्रिक्स तथा 0.3% अम्लीता बनाया जा सकता है । इस जेम की गुणवत्ता, स्वाद तथा रंग के कारण यह ज्यादा पसंद किया गया तथा इसे 4 माह तक बिना किसी पोष्टिक हआस के सामान्य तापमान पर सुरक्षित रख सकते है ।

References

Amerine MA, Pangborn RM, Roessler EB (1965) Principles of sensory evaluation of Foods, Academic Press, New York & London

Anon (1976) In: Karnataka Statistics, Department of Horticulture Govt of India 1

Anon (1992) In: Karnataka Statistics, Department of Horticulture Govt of India 32

AOAC (1980) In: Official Methods of analysis 13th ed, Association of Analytical chemists, Washington, DC

Attri BC, Lal BB, Joshi VK (1998) Psychochemical characteristic, sensory quality and storage behaviors of blended fruit juice and pulp. Indian Food Packer 52(6) 36

Bal JS (1979) Ber, the poor man's fruit. Science Reporter 16 126

Bal JS, Mann SS (1978) Ascorbic acid content of ber during growth and maturity. Sci. & culture 44 238

Baramanray A, Gupta OP and Dhawan SS (1996) Evaluation of guava hybrids with commercial cultivars for making jelly. Haryana J Hort Sci 25(4) 196

Black CA (1965) Methods of Soil Analysis. Am Soc Agron. Inc, Wisconsin, USA 29

Jawanda JS, Bal JS (1978) Studies on physicochemical characteristics of ber CVS grown at Ludhiana. Hort J 1 42

Kanekar P, Sarnaik S, Joshi N (1992) Sugar and acid tolerance micro organism caused spoilage in mango jam. J Food Sci and Technol 29(5) 278

Koening RA, Johnson CR (1942) Colorimetric determination of biological material Ind. Engg. Chem: Ana. Ed 14:155

Kumar S, Ojha CM, Dee Bhagwan N, Awasthi OP, Nainwal NC (1992) Potentiality of ber cultivatorfor candy making. Progressive Horticulture 24(1-2) 74

Lal G, Siddappa, Tandan G.L (1998) Preservation of fruits and vegetables. ICAR New Delhi

Lane JH , Eynon L (1970) Estimation of sugar J. Soc. Chem. Ind, 60

Mishra H , Chopra CS (2006) Processing and storage studies on beal fruit products:Crush and Jam. Beverage and Food World 28(1) 21

Rajpoot A (2007) M.Sc. Thesis, Department of Food Science and Technology, JNKVV, Jabalpur(MP) India

Sehgal G, Singh N, Chauhan GS (2000) Souvenir ICFOST, Nov 22-24, Mysore, 183

Sethi V, Mani SB (1991) Studies on storage of mango pulp Indian J Hort. 48(8) 228

Sharf JM (1966) Recommended methods for microbial examination of foods, American Public Health Assoc Inc, New York

Swaminathan M (1985) Essential of food and nutrition volume applied aspects seconds edition Bupp publication Bangalore 559

Yadav JR, Singh PB , Singh RR (1991) Mineral composition of ber Haryana J Hort Sci 14(1-2) 50

(Manuscript Receivd : 30.07.2012; Accepted :05.03.2013)

JNKVV Res J 48(2): 207-211 (2014)

Measuring psychological and communicational attributes with productivity level of tribal farmers in Madhya Pradesh

Parvez Rajan and **N.K.Khare**
Deptt of Extension Education
College of Agriculture
Jawaharlal Nehru Krishi Vishwa Vidyalaya
Jabalpur 482004 (MP)
Email : parvezrajan@gmail.com, nalin_khare@yahoo.co.in

Abstract

Krishi Vigyan Kendra (KVK) under ICAR has been assigned responsibilities of catering the needs of farming community by adopting area-specific strategies and technologies. The mandated activities of KVK's is assessment, refinement and demonstrating the technologies for location specific farming situations, organizing On and off campus trainings, front line demonstrations, farm advisory services, production of seeds, and providing planting material. The present study was undertaken to assess the productivity level of beneficiaries and non-beneficiaries of KVKs working in the tribal district of Madhya Pradesh. The study was conducted with 300 tribal farmers randomly selected in 12 villages of Mandla, Dindori and Shahdol district, which were results showed that, tribal farmers were of comparatively high attitude towards technological demonstration, high knowledge about KVK's activities, high perception towards scientific agriculture, medium market orientation, high scientific orientation, high aspiration level, medium use of information sources and high training exposure. The productivity level of tribal farmers was high.

Keywords: Tribal farmers, Beneficiaries, Non-Beneficiaries, Productivity

Krishi Vigyan Kendra is an innovative science based institution which conducts On Farm Testing for technology assessment and refinement; undertakes vocational training of farmers, farm women and rural youths; and Frontline demonstrations to promptly demonstrate the latest agricultural technologies to the farmers as well as the extension workers. KVK function by the collaborative participation of scientists, subject matter experts, extension workers and farmers. There are 637 Krishi Vigyan Kendra in India which has been established to meet the mandates of KVK. In Madhya Pradesh state 47 KVK's are functioning, out of which 6 KVK's are working in tribal districts. These KVK's are primarily focused on dissemination of location specific technologies access to information for upliftment and empowerment of tribals.

Krishnan (1985) defines "tribe is a social group of simple and kind, the members of which speak a common dialect, have a single government act together for common purposes and have a common name, a contiguous territory, a relatively uniform culture or way of life and a traditions of common descent. The seclusion has been responsible for the slower growth dissimilar pattern of their socio economic and cultural development and inability to negotiate and cope with the consequences of their involuntary integration into mainstream.

The concept of tribes emerged in India with the coming up of British. The meaning of tribes, as the name implies, tribals are 'Adivasi' or original dwellers, living in the subcontinent from unrecorded time and possibly driven into forests by more aggressive settlers. Aryan's being the earliest one to socially subjugate them. In order to resist complete domination, tribals involved their distinct identity through endogamy, their cropping pattern, hunting and food gathering. Above all, in their intensely personal relationship with the forest around them they formed perfectly balanced rhythms which can best be described as symbiotic (Mehta 2000). The status of the tribals is still not satisfying. Crores of considerable budget have been spent on the development of tribals including tribal women. But the results are not been

visible and satisfying. This is substantiated by the evaluation report of steering committee of the Planning Commission (Anonymous).

Integrated Watershed Management Programme (IWMP), National Horticulture Mission (NHM), Agriculture Technology Management Agency (ATMA) and KVK is also one of the agency which is working in Mandla, Dindori and Shahdol district of Madhya Pradesh for upliftment of tribal people. The women specific programmes includes training, formation of SHGs, Front Line Demonstrations (FLD) on different crops, awareness programme on health, hygiene, sanitation and nutrition, seed treatment, production of vermicompost, blue green algae, mushroom and vegetables. It creates awareness among local tribal people by organizing plant protection day, hariyali diwas, kisan mela, field day, kisan ghoshthies, nutrition week, radio talk on AIR.

KVK's is supporting other extension agencies in public and private sector by acting as a knowledge resource centre for agricultural technologies. It is using mass media and information communication technologies for reaching tribal communities by disseminating need based technologies related to agriculture and allied sector, to empower tribal populations by increasing their land productivity for the sustainable livelihood of the tribal population.

Methodology

The study was carried out in three district of Madhya Pradesh in 2013-14 i.e. Mandla Dindori and Shahdol. As these districts come under tribal districts of M.P. The Mandla district comprises of seven blocks out of which two blocks were selected and from each selected block two adopted villages of KVK's were selected i.e., Prempur, Bhavarda, Silwara, Madanpur. The Dindori district also comprises of seven blocks out of which two blocks were selected and from each selected block two adopted villages of KVK's were selected i.e., Rusamal, Nariya, Bilasar, Chaura. The Shahdol district comprises of five blocks out of which two blocks were selected and from each selected block two adopted villages of KVK's were selected i.e., Sindu chunia, Kalyanpur, Shahpur, Kudeli. A comprehensive list of tribal farmers of each selected village was prepared with the help of KVK's of each district. 75 equal numbers of beneficiaries and 25 equal numbers of non-beneficiaries from each district was selected randomly, thus the total 300 tribal farmers was the sample size of the study.

Results and discussion

The study revealed that the majority of beneficiaries 54.66% belonged to middle age group. The data indicates that their level of education was high school about 23.33% of the beneficiaries had education up to high school. In case of occupation most of the beneficiaries 49.33% was doing agriculture + other as an occupation for livelihood of the family. In case of annual income most of the beneficiaries 42.33% had medium annual income (Rs. 1, 00,001 - 1, 76,000). The average land holding of beneficiaries was 2.01 - 4 ha. About 35.12% of beneficiaries had medium land holdings. In case of farming experience majority of beneficiaries 38.67% had medium experience. The data regarding attitude towards technological demonstration indicates that majority of beneficiaries 69.33% had high attitude towards technological demonstration, 77.78% had high knowledge about KVK activities. Perception of beneficiaries towards scientific agriculture highest 53.33% of beneficiaries had high perception. In case of market orientation highest 36.88% of beneficiaries had high market orientation and 77.77% of beneficiaries had high scientific orientation. It is evident from the data that about 67.56% of beneficiaries had high aspiration level. In case of participation 47.11% had medium participation in KVK activities, 80.00% had medium use of information sources and in case of training exposure highest percentage of beneficiaries 64.45% had high training exposure.

While in case of non-beneficiaries, the study revealed that the highest percentage of non-beneficiaries 50.66% belonged to middle age group, their level of education was high school about 26.67% of the non-beneficiaries had education up to high school. In case of occupation most of the non-beneficiaries 40.00% was doing agriculture + labour as an occupation for livelihood of the family. In case of annual income most of the non-beneficiaries 38.66% had come under below poverty line. The average land holding of non-beneficiaries was 2.01 - 4 ha. About 40.00% of non-beneficiaries had medium land holdings. In case of farming experience majority of non-beneficiaries 40.00% had low experience. The data regarding attitude towards technological demonstration indicates that highest percentage of non-beneficiaries 58.60% had medium attitude towards technological demonstration, 48.00% had medium knowledge about KVK activities. Perception of non-beneficiaries towards scientific agriculture highest 56.00% of non-beneficiaries had medium perception. In case of market orientation highest 45.00% of non-beneficiaries had low market orientation and 49.33% of non-beneficiaries had

Table 1. Psychological and Communicational characteristics of beneficiaries & non-beneficiaries

Independent Variable	Categories	Beneficiaries N-225		Non-Beneficiaries N=75	
		Freq	%	Freq	%
Attitude towards Technological Demonstration	Low (10 - 23)	40	17.77	10	13.33
	Medium (24 - 36)	29	12.88	44	58.60
	High (37 - 50)	156	69.33	21	28.00
Knowledge about KVK activities	Low (Up to 8)	30	13.33	25	38.33
	Medium (19 - 17)	20	08.89	36	48.00
	High (18 - 25)	175	77.78	14	18.67
Perception towards Scientific Agriculture	Low (7 - 21)	40	17.78	14	18.66
	Medium (22 - 35)	65	28.88	42	56.00
	High (36 - 49)	120	53.34	19	25.34
Market Orientation	Low (Up to 3)	63	28.00	34	45.33
	Medium (4 - 6)	79	35.12	25	33.33
	High (7 - 10)	83	36.88	16	21.34
Scientific Orientation	Low (6 - 18)	30	13.33	22	29.33
	Medium (19 - 30)	20	08.89	37	49.33
	High (31 - 42)	175	77.78	16	21.34
Aspiration level	Low (3 - 8)	12	05.33	41	54.66
	Medium (9 - 14)	61	27.11	16	21.34
	High (15 - 20)	152	67.56	18	24.00
Participation in KVK activities	Low (Up to 4)	17	07.55	43	57.33
	Medium (5 - 9)	106	47.11	20	26.67
	High (10 - 14)	102	45.34	12	16.00
Use of information sources	Low (0 - 6)	20	08.88	40	53.34
	Medium (7 - 13)	180	80.00	14	18.66
	High (14 - 20)	25	11.12	21	28.00
Training exposure	Low (Up to 2)	28	12.44	39	52.00
	Medium (3 - 4)	52	23.11	20	26.67
	High (5 - 6)	145	64.45	16	21.33

Table 2. Percentage distribution and statistical parameters of tribal farmers according to their productivity level

Categories	Beneficiary	Non-Beneficiary	Total
Low (14 - 18)	32 (14.22)	33 (44.00)	65 (21.66)
Medium (19 - 23)	76 (33.78)	23 (30.66)	99 (33.00)
High (24 - 28)	117 (52.00)	19 (25.34)	136 (45.34)
Total	225	75	300
Mean	24.11	19.10	
S.D.	3.89	3.60	
		t =9.26**	

**Significant at 0.01 probability level

medium scientific orientation. It is evident from the data that about 54.66% of non-beneficiaries had low aspiration level. In case of participation 57.33% had low participation in KVK activities, 53.34% had low use of information sources. In case of training exposure the highest percentage of non-beneficiaries 52.00% had low training exposure.

Out of the total beneficiaries, highest percentage i.e. 52.00 per cent was found in high productivity category, followed by 33.78 per cent in medium and 14.22 per cent in low productivity categories. While in case of non-beneficiaries 44.00 per cent had low productivity, whereas 30.66 per cent medium and 25.34 per cent had low productivity. Thus, it can be concluded that the higher 52.00% of the beneficiaries had high level of productivity while, 44.00% of non-beneficiaries had low productivity (Table 2).

Statistical parameters reveal that mean score for beneficiaries and non-beneficiaries 24.11 and 19.10 respectively with standard deviation of 3.89 and 3.60 respectively. The t-test calculated was found to be significant, this indicates that there was considerable difference between the productivity level of beneficiaries and non-beneficiaries.

The correlation coefficient of age, education level, occupation, annual income, land holding, farming

Table 3. Relationship of psychological and communicational factors with their productivity

Factors	Correlation Coefficient	
	Beneficiaries	Non-Beneficiaries
Attitude towards Technological Demonstration	0.496**	0.436*
Knowledge about KVK activities	0.553*	0.335**
Perception towards Scientific Agriculture	0.515*	0.277*
Market Orientation	0.114*	0.247*
Scientific Orientation	0.408*	0.374*
Aspiration level	0.270*	0.600**
Participation in KVK activities	0.342*	0.250*
Use of information sources	0.174**	0.270*
Training exposure	0.220**	0.872*

Table 4. Association between independent variables with their productivity

Variables	Productivity			
	Beneficiaries		Non-Beneficiaries	
	χ^2	Degree of freedom	χ^2	Degree of freedom
Attitude towards Technological Demonstration	25.451**	4	9.073*	2
Knowledge about KVK activities	25.340**	2	10.580**	2
Perception towards Scientific Agriculture	28.068**	4	6.405*	2
Market Orientation	23.398**	4	7.600*	4
Scientific Orientation	26.269**	4	6.681*	2
Participation in KVK activities	29.411**	4	9.532**	2
Aspiration level	11.706**	2	10.802**	2
Use of information	7.744*	4	15.484**	2
Training exposure	20.899**	4	11.543*	4

experience, attitude towards technological demonstration, knowledge about KVK activities, perception towards scientific agriculture, market orientation, scientific orientation, aspiration level, participation in KVK activities, use of information sources, training exposure were found to have positive and significant correlation of both the categories beneficiaries and non-beneficiaries with their productivity but market orientation was found to be non-significant of beneficiaries.

All the attributes of beneficiaries and non-beneficiaries have significant positive association with the productivity level. It suggest that in general, the tribal farmers productivity increases with the increase in their attitude towards technological demonstration, knowledge about KVK activities, perception towards scientific agriculture, market orientation, scientific orientation, aspiration level, participation in KVK activities, use of information sources, training exposure (Table 4).

Conclusion

Regarding the productivity of tribal farmer's highest percentage of beneficiaries had high level of productivity, while non-beneficiaries had low productivity level. The t-test calculated was found to be significant, this indicates that there was considerable difference between the productivity level of beneficiaries and non-beneficiaries (Singh 2009, Dhaka 2013).

In case of correlation coefficient, all the psychological and communicational factors except of market orientation were found to have positive and significant correlation of both the categories beneficiaries and non-beneficiaries with their productivity. It means if these characteristics of tribal farmers are increased by any means that will lead to their higher productivity (Shrivastava 2004).

Association between independent variables with their productivity, revealed that attitude towards technological demonstration, participation in KVK activities, knowledge about KVK activities, perception towards scientific agriculture, scientific orientation, aspiration level, use of information sources, training exposure were positively related with the productivity of their crops (Badhala 2012).

कृषि विज्ञान केन्द्र भारतीय कृषि अनुसंधान परिषद द्वारा पोषित कृषकों को उच्च तकनीकी हस्तांतरण, ज्ञानर्जन, नई नई जानकारी, प्रशिक्षण अग्रिम पंक्ति प्रदर्शन, प्रक्षेत्र प्रदर्शन कर कृषकों में तकनीकी प्रचार प्रसार कर म.प्र. के आदिवासी बाहुल्य जिलों मण्डला, डिंडौरी, शहडोल के 12 गॉव व 300 कृषकों का तुल्नात्मक अध्ययन कर पाया गया कि कृषि विज्ञान केन्द्र से जुड़े आदिवासी कृषकों की तकनीकी हस्तातरण क्षमता और गैर कृषि विज्ञान केन्द्र कृषकों के बीच बड़ा अंतर पाया गया कृषि विज्ञान केन्द्र से जुड़े कृषकों की स्थिति अच्छी पाई गई कृषि विज्ञान केन्द्र ने आदिवासी कृषकों के लिये प्रकाश पुंज का कार्य किया है।

References

Anonymous (2001) Census Report. Available at Registrar general of India. GovernmentofIndia.Availableof www.censusreport.registrargeneralofindia.org.co.in

Anonymous (2008-2012) Annual Progress Report of Krishi Vigyan Kendra Mandla, Dindori, Shahdol

Badhala BS, Lal H (2012) Association between level of yield obtained by beneficiary and non-beneficiary farmers with respect to groundnut production technology. Agriculture Update 7 (3/4): 450-452

Dhaka BR, Poonia BL, Meena MK , Bairwa BS, Singh RK (2013) Evaluation of improved maize production technology through frontline demonstrations in humid south-eastern plain (V) of Rajasthan. Annals of Agri Bio Res 18 (3): 401-405

Krishanan PG (1985) Constitutional and tribal welfare Cochin University Law Reviews, vol. IX (1 and 2) pp 45-46

Mehta PC (2000) Tribal Development in 20th century, Durga Taldar Shiva Publisher, Udaipur p 7

Planning Commission (2007) Government of India, Planning Commission steering committee report available at http://www.planningcommission.org reterived on 4.3.2012

Singh HP, Mishra AK (2009) Impact of KVK Jhansi on socio-economic condition of farmers in Bundelkhand tract of U.P. 5th National Extension Education Congress 4-5 p272 (Compendium)

Shrivastava D, Singh RP, Sharma RN (2004) Impact of institutional village linkage programme on productivity of crop. Asian J Ext Edu 22(1): 202-205

(Manuscript Receivd :05.04.2014; Accepted :10.08.2014)

JNKVV Res J 48(2): 212-216 (2014)

Correlates of socio personal profile with adoption level among tribals of Madhya Pradesh

N.K. Khare and **Parvez Rajan**
Deptt of Extension Education
College of Agriculture
Jawaharlal Nehru Krishi Vishwa Vidyalaya
Jabalpur 482004 (MP)
Email : parvezrajan@gmail.com, nalin_khare@yahoo.co.in

Abstract

Krishi Vigyan Kendra (KVK) is basically a mechanism to demonstrate the application of science and technology input for creating awareness and motivating farmers to learn and adopt latest production and management technological options of various agricultural enterprises through vocational training to different segments of farming community, in-service training to field functionaries, FLDs and OFTs on major crops and other land based activities. The present study was undertaken to assess the adoption level of beneficiaries and non-beneficiaries of KVK's working in the tribal district of Madhya Pradesh. The study was conducted with 300 tribal farmers randomly selected in 12 villages of Mandla, Dindori and Shahdol district, which were results showed that, tribal farmers were of comparatively middle age group, education up to high school, agriculture + other as their occupation, medium annual income, medium landholdings, medium experience. The adoption level of tribal farmers was high.

Keywords: Tribal farmers, Beneficiaries, Non-Beneficiaries, Adoption

Krishi Vigyan Kendra is an Institutional innovation of the Indian Council of Agricultural Research to demonstrate the recent technology and results of agricultural research on the farmer's field in the rural area with the help of multi-disciplinary team of scientists. It was also called as a "First-line transfer of technology of extension System" in the country. KVK is an innovative science based institution which conducts On Farm Testing for technology assessment and refinement undertakes vocational training of farmers, farm women and rural youths and Front Line Demonstrations to promptly demonstrate the latest agricultural technologies to the farmers well as the extension workers. KVK function by the collaborative participation of scientists, subject matter experts, extension workers and farmers.

India has different types of tribal population reflecting its great ethnic diversity. They are an integral part of Indian social fabric and accounts for 8.2 per cent of total population, which comprises of 4.26 crores tribal men and 4.17 crores tribal women. This accounts for 8.40 per cent men and 8.01 per cent women (Census Report 2011).

Tribals have traditionally lived in about fifteen per cent of the country's geographical areas, mainly forests, hills and undulating in accessible terrain in plateau areas, rich in natural resources. They have lived as isolated entities for centuries, largely untouched by the society around them (Mehta 2000). Though they are scattered all over the hilly and forest regions of the country, majority of them inhabitants in Central India, high concentration of tribal's live in Madhya Pradesh, Chhattisgarh, Orrisa, Andhra Pradesh, Jharkhand. The tribal economy is predominantly agricultural based the technology used is primitive, a large number of them still practicing shifting cultivation, dependent on Non Timber Forest Produce (NTFP) and seasonal labour. The impact of the specific economic upliftment programmes can be judged by the fact that though eighty (80 per cent) of the families are covered under tribal sub-plan but 79 per cent still fall below poverty line (Census Report of India 2011).

KVK's working in tribal districts of Madhya Pradesh is actively engaged in dissemination of location-specific technologies related to agriculture by organizing front line demonstration, trainings, on farm testing. Under the convergence programme with government and non government agencies covered these programmes namely Watershed Development Programme, MGNREGA, Backward Rural Area Grant fund (BRGF). Agriculture has been and will continue to be the lifeline of our national economy at least in the foreseeable future. Besides, sustaining livelihood and providing directly employment, it forms the backbone of the agro-based industries. The development of the nation is therefore directly or indirectly related to its agricultural advancement, realizing the scope and importance of agriculture. Although the research studies have been conducted to evaluate the impact of development programme on health, education, nutrition, status of tribal populations, involvement of tribal women in agricultural operations, but very few studies have been conducted to explore the contribution of KVK for empowering tribal populations.

Keeping the view, the present study was undertaken with the following specific objectives:

1. To study the profile of the KVK beneficiaries and non-beneficiaries.
2. To assess impact of KVK on tribal farmers in terms of adoption.
3. To establish the relationship in between independent and dependent variables.

Methodology

The study was carried out in three district of Madhya Pradesh in 2013-14 i.e. Mandla, Dindori and Shahdol. These districts come under tribal districts of MP. The Mandla district comprises of seven blocks out of which two blocks were selected and from each selected block two adopted villages of KVK's were selected i.e., Prempur, Bhavarda, Silwara, Madanpur. The Dindori district also comprises of seven blocks out of which two blocks were selected and from each selected block two adopted villages of KVK's were selected i.e., Rusamal, Nariya, Bilasar, Chaura. The Shahdol district comprises of five blocks out of which two blocks were selected and from each selected block two adopted villages of KVK's were selected i.e., Sindu chunia, Kalyanpur, Shahpur, Kudeli. A comprehensive list of tribal farmers of each selected village was prepared with the help of KVK's of each district. 75 equal numbers of beneficiaries and 25 equal numbers of Non-Beneficiaries from each district was selected randomly, thus the total 300 tribal farmers was the sample size of the study.

Results and discussion

The study revealed that the majority of beneficiaries 52.00% belonged to middle age group. The data indicates that their level of education was high school about 23.55% of the beneficiaries had education up to high school (Table 1).

In case of occupation most of the beneficiaries 49.33% was doing agriculture + other as an occupation for lively hood of the family. In case of annual income most of the beneficiaries 42.33% had medium annual income (Rs. 1, 00,001 - 1, 76,000). The average land holding of beneficiaries was 2.01 - 4 ha. About 35.12% of beneficiaries had medium land holdings. In case of farming experience majority of beneficiaries 38.67% had medium experience.

While in case of non-beneficiaries, the study revealed that the majority of non-beneficiaries 50.66% belonged to middle age group, their level of education was high school about 26.67 % of the non-beneficiaries had education up to high school. In case of occupation most of the non-beneficiaries 40.00% was doing agriculture + labour as an occupation for lively hood of the family. In case of annual income most of the non-beneficiaries 38.66 % had come under below poverty line. The average land holding of non-beneficiaries was 2.01 - 4 ha. About 40.00 % of non-beneficiaries had medium land holdings. In case of farming experience majority of non-beneficiaries 40.00 % had low experience.

Out of the total beneficiaries, highest percentage i.e. 52.88 per cent was found in high adoption category, followed by 29.33 per cent in medium and 17.78 per cent in low adoption categories. While in case of non-beneficiaries 53.33 per cent had low adoption, whereas 26.67 per cent medium and 20.00 per cent had low adoption. Thus, it can be concluded that the higher 52.08% of the beneficiaries had high level of adoption while, 53.33% of non-beneficiaries had low adoption (Table 2).

Statistical parameters reveal that mean score for beneficiaries and Non-Beneficiaries 32.31 and 22.98 respectively with standard deviation of 6.61 and 6.23 respectively. The t-test calculated was found to be significant, this indicates that there was considerable difference between the adoption level of beneficiaries and non-beneficiaries.

Table 1. Socio-personal profile of beneficiaries & non-beneficiaries

Independent Variable	Categories	Beneficiaries N-225		Non-Beneficiaries N=75	
		Freq	%	Freq	%
Age	Young age group (Up to 35 years)	66	29.34	27	36.00
	Middle age group (36-50yrs)	117	52.00	38	50.66
	Old age group (Above 50)	42	18.66	10	13.34
Education	Illiterate	39	17.34	15	20.00
	Up to primary school	31	13.78	10	13.33
	Up to middle school	34	15.11	07	09.33
	Up to High school	53	23.55	20	26.67
	Up to Higher Secondary	53	23.55	17	22.67
	Up to College	15	06.67	06	08.00
Occupation	Agriculture	35	15.55	10	13.34
	Agriculture + Labour	23	10.22	30	40.00
	Agriculture + Other	111	49.33	18	24.00
	Agriculture + Cast Occupation	11	04.88	09	12.00
	Agriculture + Independent Business	45	20.00	08	10.66
Annual income	BPL (Below Rs 24,000/-)	30	13.33	29	38.66
	Low income (Rs 24,000 - 1,00,000 /-)	59	26.22	16	21.34
	Medium income (Rs 1,00,001 - 1,76,000/-)	95	42.23	20	26.66
	High income (Rs 1,76,001 - 2,50,000/-	41	18.22	10	13.34
Land Holding	Marginal (Below 1 ha)	40	17.77	19	25.33
	Small (1.01 - 2 ha)	65	28.88	16	21.33
	Medium (2.01 - 4 ha)	79	35.12	30	40.00
	Large (Above 4 ha)	41	18.23	10	13.34
Farming Experience	Low experience (5 - 16 yrs)	78	34.66	30	40.00
	Medium experience (17 - 27 yrs)	87	38.67	29	38.66
	High experience (28 - 38 yrs)	60	26.67	16	21.34

Table 2. Percentage distribution and statistical parameters of tribal farmers according to their adoption level

Categories	Beneficiaries	Non-Beneficiaries	Total
Low (14 - 23)	40 (17.78)	40 (53.33)	80 (26.66)
Medium (24 32)	66 (29.34)	20 (26.67)	86 (28.67)
High (33 - 42)	119 (52.88)	15 (20.00)	134 (44.67)
Total	225	75	300
Mean	32.31	22.98	
S.D.	6.61	6.23	
		t =10.73**	

** Significant at 0.01 probability level

The correlation coefficient of education level, occupation, annual income, land holding, farming experience, were found to have positive and significant correlation of both the categories beneficiaries and non-beneficiaries with their adoption but age were found to have significant and negatively correlated with their adoption.

All the attributes of beneficiaries and non-beneficiaries except age, have significant positive association with the adoption level. It suggest that in general, the tribal farmers adoption increases with the increase in their education level, occupation, annual income, land holding and farming experience (Table 4).

Conclusion

Regarding the adoption of tribal farmers majority of beneficiaries had high level of adoption while, non-beneficiaries had low adoption. The t-test calculated was found to be significant, this indicates that there was considerable difference between the adoption level of beneficiaries and non-beneficiaries (Dubey 2008) (Sharma 2011) (Chauhan 2013).

In case of correlation coefficient socio-personal attributes, were found to have positive and significant association of both the categories beneficiaries and non-beneficiaries with their adoption. It means if these characteristics of tribal farmers are increased by any means that will lead to their higher adoption. But age was negatively correlated with their adoption level of beneficiaries and non-beneficiaries (Singh 1997) (Sharma 2013).

Association between independent variables with their adoption, revealed that education level, occupation, annual income, land holding and farming experience, were found to be significant and positively related with their adoption but age were found to be non-significant with adoption level of both the categories (Dubey 2010).

कृषि विज्ञान केन्द्र कृषकों के बीच मुख्यतः उच्च तकनीक और विज्ञान को पहुचाने मं सेतु को कार्य करता है साथ ही उनका उत्पादन और आर्थिक रूप से मजबूत कर कृषि को लाभ का व्यवसाय बनाने में अहंम भूमिका अदा करता है । मुख्य रूप से प्रथम पंक्ति प्रदर्शन अग्रिम पंक्ति प्रदर्शन, प्रशिक्षणों प्रदर्शनों आदि के माध्यम से कृषकों के खेती करने के ढ़ंग में परिवर्तन करना इसका अध्ययन म.प्र. के आदिवासी बहुल जिलों

Table 3. Relationship of socio-personal characteristics of tribal farmers with their adoption

Factors	Correlation Coefficient	
	Beneficiaries	Non-Beneficiaries
Age	-0.214*	-0.278*
Education	0.213**	0.388**
Occupation	0.240*	0.797*
Annual income	0.284**	0.350**
Land Holding	0.379**	0.704**
Farming Experience	0.312*	0.371*

Table 4. Association between independent variables with their adoption

Variables	Productivity			
	Beneficiaries		Non-Beneficiaries	
	χ^2	Degree of freedom	χ^2	Degree of freedom
Age	1.628*NS	5	0.456**NS	2
Education	29.152**	6	8.229*	3
Occupation	23.077*	6	8.996*	3
Annual income	30.799**	6	27.129**	3
Land Holding	28.916**	6	25.695**	2
Farming Experience	12.364*	4	11.363**	2

मण्डला, डिंडौरी, शहडोल के 12 गॉव तथा 300 कृषकों का का तकनीकी हस्तातंरण कृषि विज्ञान केन्द्र द्वारा अंगीकृत व गैर अंगीकृत कृषकों के बीच तकनीकी अंगीकरण का तुलनात्मक अध्ययन किया गया जिसमें अदिवासी कृषकों का स्तर अच्छा पाया गया ।

References

Anonymous, Planning Commission (2011) Government of India, Planning Commission steering committee report available at http://www.planningcommission.org.in

Annual Progress Report (2008-2012) of Krishi Vigyan Kendra Mandla, Dindori, Shahdol, JNKVV, Jabalpur

Chauhan PS, Dangi KL, Meena DK (2013). Impact of front line demonstration on the farmers in adoption of scientific technologies of soybean cultivation. Environment and Ecology 31 (3) 1419-1423

Dubey AK, Srivastava JP (2008). Effect of Training Programme on Knowledge and Adoption Behaviour of Farmers on Wheat Production Technologies. Indian Res J Ext Edu 8 (2&3) 60-61

Dubey MK, Chauhan HS, Khare NK, Tiwari SG (2010). Factor Associated with Adoption of Cotton Production Technology by Tribal Farmers. Madhya J Ext Edu 9: 92-94

Mehta PC (2000). Tribal Development in 20th century, Durga Taldar Shiva Publisher, Udaipur p 7

Sharma AK, Kumar V, Jha SK, Sachan RC (2011). Frontline Demonstration on Indian Mustard: An Impact Assessment. Indian Res J Ext Edu 11 (3) 25-31

Sharma P, Singh GP, Jha SK (2013). Impact of Training Programme on Knowledge and Adoption of Preservation Technologies among Farm women. A Comparative Study Indian Res J Ext Edu 13 (1) 96-100

Singh M, Choudhary AK (1997). Predictors of change in symbolic adoption of pulse growers. J International Academician 1(4) 354-357

(Manuscript Receivd : 05.04.2014; Accepted :10.08.2014)

JNKVV Res J 48(2): 217-219 (2014)

Constraints in adoption of improved production technology by soybean growers

S. Raghuwanshi, Abha Tiwari and **S.K. Agrawal**
Department of Extension Education
Jawaharlal Nehru Krishi Vishwa Vidyalaya
Jabalpur 482004 (MP)
Email : sidu.raghuwanshi@gmail.com

Abstract

The study was carried in one block i.e. Seonimalwa block of Hoshangabad district of Madhya Pradesh, which was selected purposively for the study on the basis of large area and low productivity. The total sample size was 120 soybean growing farmers selected from 12 villages. Result showed that important constraints reported by the soybean growers in adoption of improved soybean production technology were electricity problem(100%), irregular visits of RAEOs(100%) and lack of availability of technical information from extension personnel(100%), lack of training regarding production technology(82.5%), high cost of seed, fertilizers, insecticides and lack of soil testing facilities(100%).

Keywords: Soybean, Constraints, Adoption

Soybean has emerged as one of the most important oil seed crop of India, particularly in central part of India. Madhya Pradesh has its major share in area and production in India, hence designated as "Soya State" of India.

In Madhya Pradesh the soybean area is increasing continuously, but the productivity of crop has registered stagnation or a decreasing trend. The basic problem continues to be low productivity and is practiced as a way of life. The traditional method of crop-raising still dominates the agriculture. The time has come when agriculture is to be viewed and practiced as business. In doing so, many new inputs are to be employed. One of the most supporting input is the technical knowledge arising out of the research. The yield per hectare is far from satisfactory, thereby leading to a wide gap. Hence, the production of soybean can be increased by the farmers become progressive. Obviously, the reason which could be the attributes to low yield as against expected yield may be due to technological knowledge regarding cultivation of soybean crop and non-adoption of improved production practices recommended for soybean crop. Under such circumstances, the prime need is to enhance the productivity in farmers' field. Thus, there seems to be no other alternative than to adopt the recommended technology for increasing production.

Soybean production in Madhya Pradesh is 3.5 - 4.5 million tones (http://mpkrishi.org) in which the major soybean producing agro-climatic regions of Madhya Pradesh are Central Narmada Valley, Satpura Plateau, Malwa Plateau and Vindhyan Plateau.

The average yield of soybean in India is1046 kg/ha against the world average of 2270 kg/ha. The area and production of soybean in our country is increasing, but the yield had not achieved a desired increase. To find out the answer of low production present study was undertaken.

Material and methods

The study was carried out in Seonimalwa block of Hoshangabad district of Madhya Pradesh in 2010-2011. The district is situated on the"Narmada valley region". It lies in latitude 21° 53" to 22° 59" North and longitude 76° 47" ti 78° 44" East, and elevation of 302 Meters above mean sea level (MSL). This was selected purposively for the study on the basis of large area and low productivity. The total sample size was 120 soybean growing farmers selected from 12 villages. Ten respondents from each village were selected to comprise a sample of 120 respondents. The respondents were personally interviewed. The responses of soybean growers on these possible constraints were obtained on a two point continuum

namely "yes" or "no". The frequencies and percentage were calculated to find out the degree of constraints as expressed by the soybean growers for participation in adoption behavior.

Results and discussion

The constraints reported by the soybean growers in adoption of improved production technology are presented in Table. It is evident from the data that the major constraints as expressed by the soybean growers were inadequate supply of electricity, irregular visits of RAEOs and lack of availability of technical information from extension personnel, followed by minimum support price by the government, lack of training of improved soybean production technology (95.83%), RAEOs contact only big farmers (87.50%), lack of knowledge about insects and diseases (85%), lack of training programme on soybean production technology (85.50%), whereas 79.19 per cent soybean growers reported high cost of seed, fertilizer, insecticides, followed by lack of knowledge about seed treatment and its importance and their doses (76.66%), lack of demonstration at farmers' field by RAEOs (72.50%), lack of technical information in local language (70%), lack of information about varieties of soybean (69.16%), lack of technical guidance from RAEOs at grass root level.This finding finds support from Dalvi et al 2004, Dwivedi 2007.

Other constraints reported by the soybean growers in adoption of improved production technology were lack of soil testing facilities (100%), high labour charges (55.83%), lack of money to purchase useful agricultural inputs (54.16%), co-operative societies should not provide fertilizers and seed timely (16.66%). Thus, overall soybean growers were reported the constraints which they faced in adoption of improved production technology viz., lack of training and irregular visit of RAEOs and lack of knowledge about diseases and insects which minimized the adoption of improved

Table 1. Constraints reported by soybean growers in adoption of improved production technology

	Constraints	Respondents N = 120		
		Frequency	%	Rank
(A)	Economic constraints :			
	Lack of money to purchase useful agricultural inputs	65	54.16	XI
	High cost of seed, fertilizers, insecticides and implements	95	79.16	VI
	High labour charges	67	55.83	X
(B)	Technical constraints :			
	Lack of information about improved varieties of soybean	20	16.66	XII(a)
	Lack of knowledge about seed treatment with fungicides and bio-fertilizers	98	81.66	IV
	Lack of knowledge about insects and diseases of soybean	97	80.08	V
	Lack of knowledge of doses of fertilizers in soybean crop	110	91.66	II
	Lack of knowledge about soil testing	120	100.00	I(a)
(C)	Extension constraints :			
	Lack of technical guidance from RAEOs	77	64.16	IX
	Lack of information available in local language	84	70.00	VIII
	Irregular visit of RAEOs	120	100.00	I(b)
	Lack of demonstration of farmers' field by RAEOs	87	72.50	VII
	Lack of trainings provided on soybean production technology	99	82.50	III
(D)	Institutional constraints :			
	Co-operative societies are not providing fertilizers and seeds timely	20	16.66	XII(a)
	Lack of agriculture related technical information from Gram Panchayat	120	100.00	I(c)
(E)	Situational constraints :			
	Electricity problem	120	100.00	I(d)

soybean production technology. This finding finds support from Ahirwar et al 2005.

Conclusion

The major constraints reported by the soybean growers in adoption of improved soybean production technology were electricity problem, irregular visits of RAEOs and lack of availability of technical information from extension personnel, minimum support price by the government, high cost of seed, fertilizers, insecticides and lack of soil testing facilities, lack of training of improved soybean production technology, RAEOs contact only big farmers, lack of knowledge about seed treatment, insects and diseases, higher cost of inputs (fertilizer, seed, insecticides) and lack of demonstration at farmers' field were the major constraints and these constraints may be overcome with the help of education, training, dissemination of information through different communication methods and extension personnel.

यह अध्ययन मध्यप्रदेश के होशंगाबाद जिले के सिवनी मालवा विकासखण्ड में सोयाबीन के उत्पादन, भंडारण, परिवहन एवं विपणन में आने वाली बाधाओं की जानकारी प्राप्त करने हेतु किया गया। यह अध्ययन दर्शाता है कि सोयाबीन उत्पादन में प्रमुख रुप से तकनीकी ज्ञान की उपलब्धता की कमी, ग्रामीण कृषि विस्तार अधिकारियों से कम संपर्क, बिजली की समस्या, सरकार द्वारा न्यूनतम समर्थन मूल्य निर्धारण में कमी, बीज, खाद, उर्वरक और कीटनाशकों की अधिक कीमत, मृदा परीक्षण की सुविधा की कमी और सोयाबीन उत्पादन की उन्नत तकनीकों के कम प्रशिक्षण की समस्या को प्रमुख रुप से सोयाबीन उत्पादकों द्वारा अनुभव किया गया। किसानों की इन प्रमुख समस्याओं के निवारण को शिक्षा, प्रशिक्षण और तकनीकी ज्ञान की उपलब्धता के द्वारा कम किया जा सकता है।

References

Ahirwar RF, Sharma HO, Mishra PK (2005) Constraints of soybean marketing in Malwa Plateau of Madhya Pradesh. J Extn Edu 8

Dalvi ST, Mahajan BS, Wake PK, Shinde SV, Sukase KA and Kadam AS (2004) Constraints faced by farmers in adoption of improved cultivation of soybean in Marathwada region, MAU, Parbhani. India J Soils & Crops 14 (1) : 55-57

Dwivedi N (2007) A study on factors affecting the adoption level of different categories of soybean growers of Saikheda block of Narsinghpur district (MP) M Sc (Ag) Thesis, JNKVV, Jabalpur : 76-79

Soni Satyanarayan, Kurmvanshi SM Soni SN (2000) Technologies status of soybean cultivation in district Sagar (MP) Crop Res, Hissar 18 (1) : 150-154

(Manuscript Receivd : 16.04.2014; Accepted : 30.08.2014)

JNKVV Res J 48(2): 220-223 (2014)

Utilization pattern of Kisan Credit Card among tribal farmers for agricultural development in Umaria District Madhya Pradesh

Mahesh K. Nargave, R. A. Sathwane, Kinjulck C. Singh* and **Chandrajiit Singh***
Department of Extension Education
College of Agriculture
Rewa 486 001 (MP)
*Jawaharlal Nehru Krishi Vishwa Vidyalaya
Jabalpur 482 004 (MP)
Email : kinsinghla@gmail.com

Abstract

Credit is essential for adoption of agricultural technology from purchase of modern inputs, implements, to development and purchase of live stock, raw materiel etc. For this study Umaria district was selected purposively since the district is having tribal farmers dominated farming community with maximum number of Kisan Credit Card holders. The present study reveals that majority (50.83 per cent) of the tribal farmers utilized the credit to the low extent. Hence to equip them with proper understanding and utility of the Kisan Credit Card through mass campaigning is required So that the Kisan Credit Card utilization may be enhanced and benefits can be availed among tribal community. Constraints perceived by tribal farmers suggest that knowledge regarding credit utilization and repayment should be imparted and a proper linkage between the agricultural experts and beneficiaries should be established.

Keywords: Credit utilization, Kisan Credit Card, Tribal community

The emergence of Green revolution in India in the last sixties has radically changed the farmers to replace the traditional farm practices with scientific and modern practices, which is reflected by the inputs use like high yielding varieties seed, fertilizers, pesticides, irrigation, machineries and equipments etc. It requires heavy financial investments, which the majority of the farmers can not afford from their own savings only. The farmers in the under developed countries can not expect their capital needs to be fulfilled from savings only. Credit is essential for adoption of agricultural technology, and also for non-productive requirements including expenses on marriage, death, serious illness and other social happenings in the family.

In view of necessity of linkage of farmers with simplified credit delivery mechanism with more flexibility the Kisan Credit Card (KCC) was introduced during 1998-99 by Government of India. It is believed that tribal community is a slow adopter in comparison to the other farming communities. To assess the utilization pattern of Kisan Credit among the tribal farmers the present study was undertaken with the objectives: To determine the extent of utilization of Kisan credit card among the beneficiaries of tribal community; To find out the association between utilization pattern of Kisan Credit Card and socio economic & psychological profile of beneficiaries; To study the constraints perceived by the tribal beneficiaries in availing the benefits of Kisan credit Card.

Material and methods

The Umaria district of Madhya Pradesh was selected purposively since the district is having tribal farmers dominated farming community. Out of three blocks in the district namely Karkeli, Pali, and Manpur; Manpur block was selected purposively because the number of Kisan Credit Cards holder of tribal community is highest in Manpur block. Further, eight villages namely Semra, Kolar, Pipritola, Navgava, Balhod, Mala, Sarvania, Parasi, were selected purposively on the basis of maximum number of tribal farmers having Kisan Credit Card of State Bank of India. From each village the tribal farmers having Kisan Credit Card were selected to make

a sample size of 120 by using proportionate method of random sampling.

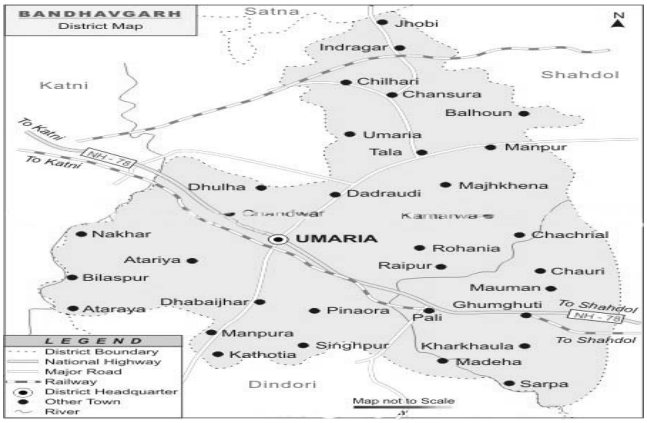


Fig 1. District Map of Umaria

Result and discussion

Kisan Credit card helped in Increasing Saving (Rank I, Score 235) followed by timely conduct of various agricultural activities (Rank II and score 229) and increase in income through Kisan Credit Card (Rank III and score 209) (Table 1).

Out of other effect of Kisan Credit Cards, it was observed that use of KCC helped in increase of crop production. This may be due to the timely conduct of agricultural operations. Actually these effects are so closely interrelated that they seems to be consequence rather than effect.

Table 1. Effect of Kisan Credit Card utilization by tribal farmers (N= 120)

Component	Score	Rank
Credit helped in quality input purchase	185	VI
Credit helped in input purchase on time	198	V
Helped in timely conduct of agril operations	229	II
Helped in increase of production	203	IV
Increase in income	209	III
Increase in saving	235	I
Helped to change the cropping pattern through credit utilization	198	V

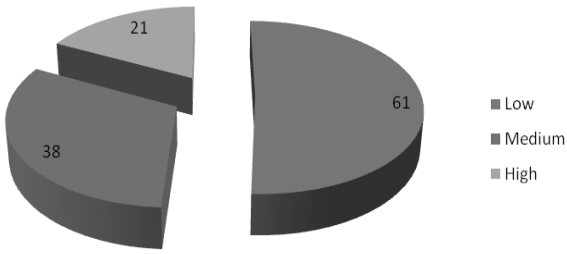


Fig 2. Frequency distribution of the respondents in relation to extent of utilization of Kisan credit card N=120

Extent of Credit Utilization

Majority of the respondents i.e. 50.83 per cent (61) of the beneficiaries of Kisan Credit Card scheme belonged to low extent of credit utilization group followed by 31.67 per cent (38) who belonged to medium extent of credit utilization group. It was found that only 17.50 per cent (21) beneficiaries utilizing the Kisan Credit Card to high extent. This may be due to small sized land holdings of the beneficiaries which require less credit facility.

Age, caste, size of family, social participation and contact with development agency were found to be non significant with the extent of utilization pattern of Kisan Credit Card (Table 2). This finding is in line with the results obtained by the Singh (2001) in case of social participation.

Table 2. Association between socio-economic attributes & extent of utilization pattern of Kisan credit card

Characteristics	χ^2 Value
Age	5.59
Education	11.15*
Caste	0.24
Size of land holding	13.37*
Size of family	1.48
Social participation	3.31
Occupation	10.86*
Personal experience of utilization pattern	9.37*
Risk Orientation	13.19*
Contact witch development agency	8.90
Mass media exposure	16.21*
Economic motivation	15.97*

*Significant at 5% level of significance with 4 d.f/6d.f.

It was observed that education, size of land holding, occupation, personal experience of utilization pattern, risk orientation, mass media exposure and economic motivation had significant association with extent of utilization pattern of Kisan Credit Card. This finding is in line with the results obtained by Puthussery (1999), Srinu and Reddy (1999) in case of education.

Constraints as perceived by the tribal beneficiaries in availing the benefits of Kisan Credit Card

Lack of proper information about operation & utility of K.C.C. (55.0per cent) and exploitation of mediators and brokers (43.33%) were the major personal constraints as perceived by the beneficiaries of Kisan Credit Card. As regards the natural/ social constraints expenses on social events and other contingent work from credit (54.17%) and poor soil fertility status (50.0 per cent) were recorded as the major constraints.

As far as technical constraints were concerned lack of technological skill and knowledge (59.17%) and lack of proper linkage with agriculture experts /officers as needed (39.17%) were the serious constraints faced by the beneficiaries of Kisan Credit Card. In case of administrative constraints, difficulties in obtaining land records (58.33%) and complicated loaning procedure (46.67%) were observed the major constraints.

Lastly lack of Govt. agencies for information and advice near by village (60.83%) and unavailability of irrigation & electricity at critical time (57.50%) were found as infrastructures constraints perceived by the beneficiaries of Kisan Credit Card. This finding supported to Virk et al. (2003), Chaudhary & Mohamad (2003), Singh & Sekhon (2005) and Singh & Shakya (2007).

Table 3. Constraints as perceived by the tribal beneficiaries in availing the benefits of Kisan Credit Card

Constraints	No. of beneficiaries	Percentage	Rank
Personal			
Illiteracy	33	27.50	XVII
Lack of sufficient knowledge about the scheme	48	40.00	XIII
Lack of proper information about operation & utility of Kisan Credit Card	66	55.00	IV
Exploitation of mediators and brokers	52	43.33	XI
Natural / social			
Crop failure due to natural calamities	57	47.50	VII
Poor soil fertility status	60	50.00	VI
Fragmented land holdings	43	35.83	XV
Expenses on social events and other contingent work from credit	65	54.17	V
Technological			
Non adoption of improved agricultural technology	39	32.50	XVI
Lack of technological skill and knowledge	71	59.17	II
Administrative problem			
Lack of co operation & guidance from concerning bank officers	53	44.17	X
Complicated loaning procedure	56	46.67	VIII
Recovery procedure is Stringent	49	40.83	XII
Difficulties in obtaining land records	70	58.33	III
High interest rate in delay Repayment of credit	32	26.67	XVII
Infrastructural constraints			
Lack of marketing & storage facilities	53	44.17	IX
Un availability of irrigation and electricity at critical time	69	57.50	IV
Lack of Government agencies for information and advice near by village	73	60.83	I

Implications

On the basis of constraints perceived by the tribal farmers the study suggests that Knowledge regarding credit utilization and repayment should be imparted, there should be proper linkage between the agricultural experts and beneficiaries, Bank & other institutions should provide crop insurance facilities, Awareness camp should be organized for dissemination of improved agricultural technologies, Irrigation and electric facilities should be improved, Land record should be given in a particular needed time, Premium of repayment should be minimum, Repayment and recovery procedure should be flexible, Interest rates should be low as possible, and Loaning procedure should be easier.

आधुनिक यंत्र एवम् आदानों की खरीद, पशुधन के विस्तार और देखरेख एवम् खेती की अन्य छोटी-बड़ी आवश्यकताओं हेतु लागत की जरूरत होती है । आदिवासी किसानों के मध्य सर्वाधिक किसान क्रेडिट कार्ड धरकों की संख्या को ध्यान में रखते हुये इस अध्ययन हेतु उमरिया जिले का चयन किया गया । इस अध्ययन से ज्ञात होता है कि लगभग 50 प्रतिशत (50.83%) आदिवासी, किसान ऋण का उपयोग न्यूनतम सीमा में करते है । अतः किसान क्रेडिट कार्ड की उपयोगिता एवम् समझ बढ़ाने हेतु रूप से प्रचार-प्रसार की आवश्यकता है ताकि किसान क्रेडिट कार्ड का इस्तेमाल बढ़ सके तथा आदिवासी किसान समुदाय लाभांवित हो सके । आदिवासी कृषकों द्वारा प्रत्यक्षीकृत बाधायें दर्शाती है कि उन्हें ऋण के उपयोग एवम् ऋण-वापसी सम्बंधी ज्ञान प्रदाय किया जाना चाहिये । साथ ही कृषि विशेषज्ञों एवम् लाभर्थियों के मध्य तारतम्य स्थपित किया जाना चाहिये ।

References

Chaudhary M Ali, Mohammad Ishfaq (2003) Credit worthiness of rural borrowers of Pakistan. J Socio Econo 32(6) 674-68

Singh Harpreet, Sekhon M K (2005) Cash in benefits of the Kisan Credit Card scheme. Indian J Agril Eco 60 (3):319-334

Singh Surendra, Shakya Deepak (2007) Role of institutional credit in agriculture in case of marginal and small framers. 4th National Seminar on Extension Education. Society of Extn Edu Agra

Virk G S, Kalra R K. Hansra B S (2003) Agricultural credit repayment behaviour of Punjab farmers. Indian J Extn Edu 39 (1&2) 12-17

Pathussery J (1999) Socio-economic characteristics and nature of dealt : A study of Primary Agriculture and Rural development Bank in Kerala. Land Bank J 38 : 7-15

Srinu A V, Reddy M Veeraghav (1999) Awareness of farmers in getting short term loans from primary agriculture co-operative society J Ext Edu 10(4): 2581-2585

Singh R K (2001) Performance of soybean production technology assessed by resource-rich and resource-poor farmers in different micro-farming situation of Chhindwara district Madhya Pradesh Ph D thesis JNKVV Jabalpur pp128-135

(Manuscript Receivd :22.12.2012; Accepted : 05.06.2013)

JNKVV Res J 48(2): 224-231 (2014)

Characteristics of beetroot (*Beta vulgaris* L.) drying under different drying methods

Mohammad Azam, B.M.Khandelwal, S.K.Garg* and **Sheela Pandey**
Department of Post-Harvest Process and Food Engineering
College of Agricultural Engineering
Jawaharlal Nehru Krishi Vishwa Vidyalaya
Jabalpur 482004 (MP)
*College of Agriculture Ganjbasoda (MP)
Email : mazam226@gmail.com

Abstract

Beetroot is a biennial root crop, rich in antioxidants and nutrients including magnesium, sodium, potassium and vitamin C. Beetroot powder also finds application as a natural colorant in many food items. The drying characteristics of sliced beetroots were studied under natural convection in solar cabinet with and without direct exposure to the sun (OSC and UCSC), direct open sun (SUN) and shade (SHD) drying methods at an average temperature of 62°C, 33°C and 36°C and RH of 15.5%, 33.5% and 28% respectively. In forced convection drying was carried out under hot air tray dryer (HAT) at three levels of air temperature 40, 50 and 60°C and average RH of 16%, 14% and 12% respectively with an air velocity of 1.8±0.1m/s. The highest overall drying rate of 213.56 (%db/h) and lowest final moisture level of 5.16 (%db) was recorded in HAT_{60}. The HAT, OSC, UCSC, SUN and SHD drying of beetroot showed decreasing trend of overall drying rate (%db loss/h) i.e. 213.56, 157.36, 135.90, 99.66, 93.43, 78.68 and 55.36 and increasing trend of final moisture levels, i.e. 5.61, 7.75, 10.53, 5.57, 5.06,12.02 and 20.64 (%db) respectively. The increase in drying air temperature adversely affected the major quality parameters viz. colour, rehydration ratio and mass shrinkage ratio. The microbial load was found maximum in SHD and SUN dried roots and minimum in HAT dried root.

Keywords: Beetroot, Different drying methods, Drying characteristics, Quality parameters and Slices

Vegetables are highly perishable, seasonal and available in plenty at a particular area bringing complexity in its post harvest processing. In peak season, prices fall steeply and producers have to sell at throw away prices. Glut leads to sharp fall in market prices, enormous deterioration in quality as well as quantity of vegetables. It is estimated that only 1.8% of production of vegetables goes for food processing industry (Parthasarathi 1997). Beetroot is a biennial root crop and cultivated in loam, sandy loam, and clay loam soils. The yield of beetroots varies from 5000 to 7000 kg per acre. Beetroot is consumed as salad and cooked with other vegetables. It has high medicinal value (Das 2005). Beetroots are a rich source of potent antioxidants and nutrients, including magnesium, sodium, potassium and vitamin C, and Betaine, which is important for cardiovascular health. Beetroot powder has a natural red colour and can be used as food colouring agent and substitute for artificial red colour. Its powder can be used as colour in fruit salads, jams, jellies, deserts, ice creams, beverages and many nutraceutical products (en.wikipedia.org).

Drying process plays an important role in the preservation of agricultural products (Waewsak et al. 2006). It enhances the shelf life and reduces water activity (Doymaz and Pala 2003). The post harvest losses of fruits and vegetables are estimated to be 30-40% of the production (Azharul Karim and Hawlader 2006). Therefore, in many countries, large quantities of food products are dried to improve shelf life, reduce packaging costs, lower weights, enhance appearance, retain original flavour and maintain nutritional value (Baysal et al. 2003). Drying is generally evaluated experimentally by measuring the weight of a drying sample as a function of time. Drying curves may be represented in different ways; averaged moisture content versus time, drying rate versus time, or drying rate versus averaged moisture content (Coumans 2000). The survey of literature on processing of beetroot revealed that very limited work has been done on beetroot drying and there is strong need to enhance the shelf life and availability throughout the year, the

objective of this study was (1) to study the drying characteristics of beet root slices under four popular methods viz. sun (SUN) drying; shade (SHD) drying; solar cabinet (OSC and UCSC) and hot air tray (HAT) drying, (2) to study the effect of different drying methods on quality of dried beetroot.

Material and methods

The research work carried out in Post Harvest Process and Food Engineering laboratory of Department of Post Harvest Process and Food Engineering, College of Agricultural Engineering, JNKVV, Jabalpur (MP) during 2011.

Sample preparations

Fresh beetroots procured from local market of Jabalpur were used in the study. Samples were stored in refrigerator at 4±0.5°C prior to the drying experiment. At the start of each experiment, beetroot of uniform size were selected cleaned, washed and moisture on the wet root surface was removed with tissue paper. The roots were then peeled and sliced into transverse section of approximate 2 mm thickness using a kitchen slicer. The sample size was kept constant at 200g for all runs. The initial moisture content of beetroot samples was determined by standard AOAC 930.15 method (AOAC 1990).

Drying methods

Sun and shade drying

In SUN and SHD drying perforated aluminium trays of 75×60 cm size were used to facilitate drying of beetroot slices in a single layer and placed 10 cm above the concrete floor on the roof of the laboratory building in direct sun light during the month of April and May. In SHD drying, slices of beetroot were spread over same trays and placed in the shade 10 cm above the concrete floor inside the laboratory hall.

Solar cabinet drying

Natural convection multi-rack solar cabinet dryer developed by PAU, Ludhiana was used. The drying of beetroot slices in solar cabinet dryer was performed in two methods. First method slices were placed in direct exposure of sun (OSC) and in second method slices were covered with black plate (UCSC) and placed in direct sun light.

Table 1. Specification of solar cabinet dryer

Particulars	Dimensions
Aperture area	0.36 m^2
Number of trays	Three
External dimensions	620×620×350mm
Weight of dryers	Approximately 17 kg
Inclination of the dryer	
Variable	30° /45° & 15° /30°
Fixed	45° for north & 30° for South India

Hot air tray drying

Hot air tray dryer consisted of heating unit, drying chamber and centrifugal fan for providing air flow. Fresh air enters the cabinet by the fan through screens filter and heater coils, and is then blown across the trays to exhaust. The trays used were perforated from bottom in order to permit vertical movement of hot air. All four trays were assembled in a column inside the hot air tray dryer. The HAT drying was performed in three temperature levels i.e. 40±2 °C, 50±2 °C and 60±2°C which denoted by HAT_{40}, HAT_{50} and HAT_{60} with air velocity of 1.8±0.1m/s.

Test parameters

Test parameters for SUN and SHD drying were average temperature of the day, average RH of the day, weight of drying material at 30 min time interval; for OSC and UCSC drying average temperature of the day, average RH of the dryer, weight of the drying material at 30 min time interval, outlet air temperature of dryer and for HAT drying average temperature of dryer, average RH of hot air, weight of the drying material at 15 min time interval. All drying experiment was performed in three replication R_1, R_2 and R_3.

Drying characteristics

Moisture content

The dry basis (%) moisture content (Haque and Langrish 2005, Saeed et al. 2006, Ceylon et al. 2007, Upadhyay et al. 2008) and on wet basis (%) moisture content (Hall

1980, Simpson 1991, Rodrigues and Fernandes 2007) were calculated as follows

$$MCdb(\%) = \frac{Ww}{Wd} \times 100 \quad ...(1)$$

$$MCwb(\%) = \frac{Ww}{(Ww+Wd)} \times 100 \quad ...(2)$$

Moisture Ratio (MR)

MR is the ratio of the moisture content at any given time to the initial moisture content (both relative to the equilibrium moisture content). It can be calculated as (Ozbek and Dadali 2007, Shivhare et al. 2000, Thakor et al. 1999)

$$MR = \frac{(M-Me)}{(Mo-Me)} \quad ...(3)$$

Drying rate

Drying rate (g of water per minute per 100 g of bone dry material) was calculated (Chakraverty 2005) as following

$$\text{Drying rate} = \frac{\text{Amount of moisture removed (g)}}{\text{Time taken (min) x Total Bone dry weight of sample in g/100g}} \quad ...(4)$$

Quality parameters of beetroot

Rehydration ratio (RR)

Weigh 10 g of the dry material. Placed it in 500 ml beakers, 80 to 150 ml of distilled water was added, cover each with a watch glass, bring to a boil within 3 minutes on an electric heater and boiled for 5 minutes. The precise amount of water varied with the material, time and rate of boiling; excessive amounts of water was not be used. Remove it from the heater and place it into a 7.5cm Buchner funnel which is covered with a

Table 2. Extent of beetroot drying under different drying methods (Initial moisture content of beetroot 88.20%wb, or 747.46%db, bone dry wt -11.8 g and sample wt-200 g)

Drying methods	Drying air temp. range (°C)	Average air temp (°C)	Average Air vel. (m/s)	RH(%) Range of drying air	Final MC attained (%db)	Drying time(h)	Overall drying rate (moisture removed %dh)	Final MR
SUN	30-40	36	-	21-35	12.02	9.5	78.68	0.0166
SHD	29-36	33	-	30-37	20.64	13.5	55.36	0.027
OSC	53-72	62	-	13-18	5.06	7.5	99.66	0.006
UCSC	53-72	62	-	13-18	5.57	8.0	93.43	0.007
HAT_{40}	-	40±1	1.8±0.1	14-18	10.53	5.50	135.90	0.014
HAT_{50}	-	50±1	1.8±0.1	12-17	7.75	4.75	157.36	0.010
HAT_{60}	-	60±1	1.8±0.1	10-15	5.61	3.50	213.56	0.007

coarsely porous Whatman No. 4 filter paper. Apply gentle suction and drain out water with careful stirring for half to 1 minute until the drip from the funnel and weigh. Set the drained sample aside for quality tests. This test was repeated and then rehydrate six other 10 g samples, boiling two samples for 10 min, two for 20 min, and two for 30 min. It will be necessary to use 20 to 30 ml more of water for the last two tests. Only small pieces will rehydrate in 5 min (Ranganna 1986).

Calculation - calculate the result in terms of "rehydrate ratio" as :

If the weight of the dehydrated sample used for the test is a and drained weight of the rehydrated sample is b, then

$$\text{Rehydration ratio (RR)} = b/a \qquad ...(5)$$

Mass Shrinkage Ratio (MSR)

The most important structural variation appeared on vegetables, due to the weight loss, is the mass shrinkage ratio (MSR), which can be given as (Midilli 2001, Shanmugama and Natarajan 2006)

$$MSR = Wt/Wo \qquad ...(6)$$

Colour Measurement

Colour is an important quality parameter for the dried beetroot. It was analyzed by measuring the reflectance. A Hunter Colour Colorimeter at 65% 10° was used as the light source. The colorimeter was calibrated against standard white plate (L= 91.78, a = -0.28, b= 0.07) before the colour measurement of sample. A glass cylinder containing fresh/dried beetroot was placed above the light source and covered with a lid. Three Hunter parameters, namely L (lightness), a (redness/ greenness), and b (yellowness/blueness) were measured.

Microbial Load Study

To determine the microbial count a stock solution (1:1000) of beetroot powder (dried under different drying methods) with Potato Dextrose Auger (media) were prepared. 1 ml of stock solution was mixed with media and 2 h autoclaving were carried out to sterilize it. Then it was poured in sterilized petri dish inside the isolation chamber. After 2-3 days petri dish were kept out from isolation chamber and it was kept in colony counter to count the bacterial colonies (Frazier and Westhoff 1983).

Results and discussion

Effect of different drying methods on moisture depletion of beetroot

The initial moisture content of beetroot was found as 88.20% (wb), or 747.46% (db). The experimental data were summarized (Table 2). The final moisture content attained by beetroot slices under all drying methods was determined under the prevailing drying conditions of respective methods. It was observed that lowest moisture content was observed in HAT_{60} experiment as compared to other methods (Table 2). This may be due to the high temperature of air which reduces the RH of drying chamber and promotes the moisture removal rate. Highest level of moisture content was observed in SHD drying method. This was due to the less amount of moisture removal. It may be due to the lower temperature of atmosphere during drying experiment. The Fig.1 showed the moisture depletion pattern of beetroot under different drying methods and it was observed that HAT drying is superior (in terms of moisture removal rate) followed by SUN, SHD, OSC and UCSC which shows the decreasing trend in MR with increase in drying temperature.

Effect of different drying methods on moisture ratio of beetroot

The variations of MR with drying time at different drying methods. The drying curves typically demonstrated smooth diffusion-controlled drying behaviour under all drying conditions (Fig. 2). The samples dried more slowly at average 33°C under SHD drying condition. In general, the time required to reduce the MR to any given level was dependent on the drying condition, being the longest at average 33oC under SHD drying and shortest at 60oC under HAT_{60} drying condition.

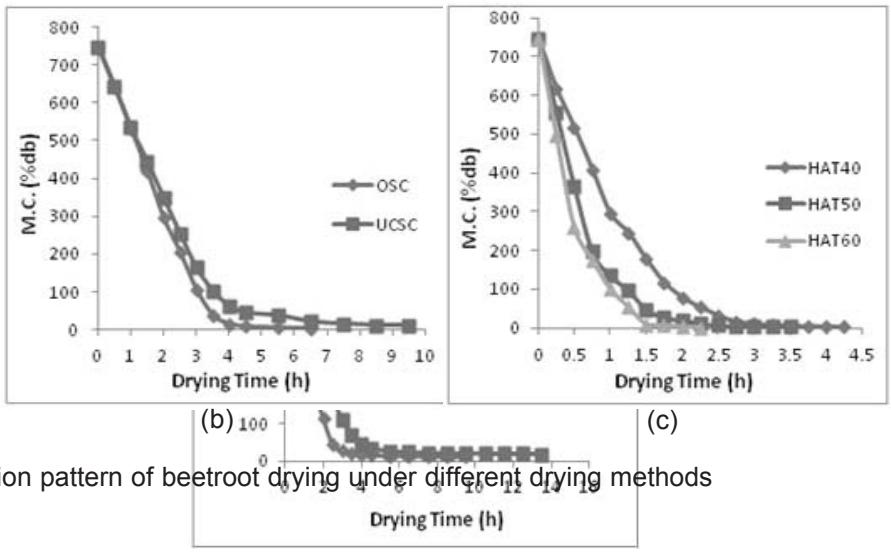
Effect of different drying methods on drying rates of beetroot

HAT drying experiments showed higher overall drying rates and drying levels than other drying methods (Table

2). The effect of drying air temperature on drying rate is clear (Fig. 4). The increase in drying air temperature increased the drying rate and also the drying level in all methods. The effect of drying methods on overall drying rate was significant and clearly depleted in bar chart (Fig. 3). The increase in drying rate with increase in air temperature could be due the fact that drying at high temperature led to high moisture diffusitivity and also provided a larger pressure deficit which is one of the driving forces for drying.

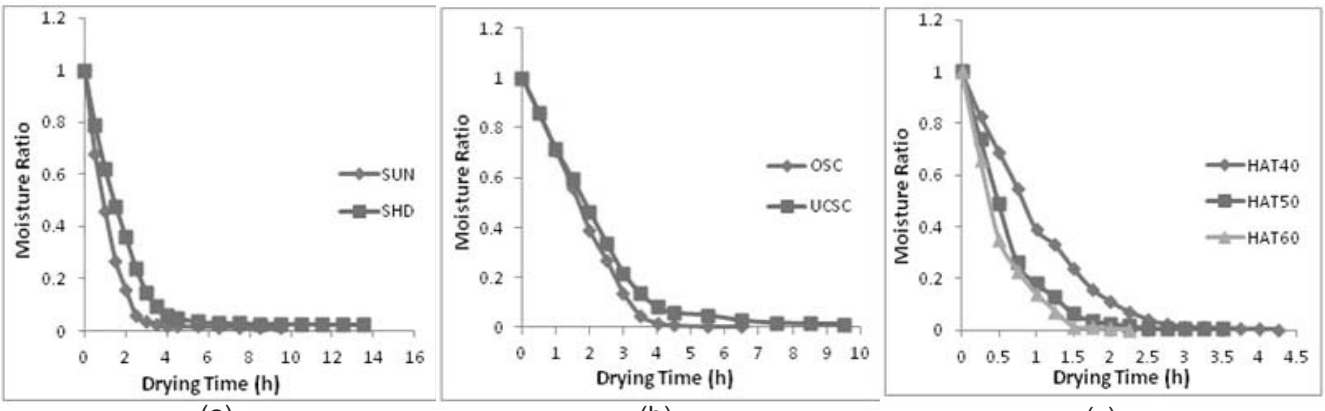
The drying rate curves of beetroot drying under different drying methods (Fig. 4), falling rate regime were observed in SUN and SHD drying. It is noted that the beetroot slices dried at a very high rate and later decreased at a lower drying rate. It also indicated that at first falling rate period water evaporated due to surface diffusion and when the drying process entered the second falling rate period the water slowly and gradually diffuse from the interior of the beetroot to the surface. In this region the drying rate controlled by diffusion from the inside to the surface. As drying proceeded the rate of internal movement of moisture decreased. The rate of drying falls even more rapidly at early stage and continues to drop until the moisture content reached its equilibrium value for the prevailing air humidity and drying stops. According to Fig. 4(b) and (c), observed constant rate drying period initially in HAT, OSC and UCSC drying. The period of constant rate was very short and remaining drying process followed by falling rate period.

In SUN drying the first falling rate period terminated after 2.5h and second falling rate period was observed at 2.5 to 9.5h {Fig. 4(a)}. In SHD drying method the first falling rate period terminated after 3.5h and second falling rate period was observed at 3.5 to 13.5h. Fig. 4(b) depicted the drying behaviour of beetroot slices



(a) (b) (c)

Fig 1. Moisture depletion pattern of beetroot drying under different drying methods



(a) (b) (c)

Fig 2. Drying curves of beetroot drying under different drying methods

in OSC and UCSC drying. It was observed the two drying periods i.e. constant rate and falling rate drying period. The constant rate drying period was observed at 0 - 3h and falling rate period was observed at 3 - 7.5h in OSC drying method. Similarly in UCSC drying method the constant rate drying period was observed at 0 - 1h and first falling rate period was observed at 1 - 3.5h and second falling rate period was observed at 3.5 - 8h. Fig. 4(c) showed the drying behaviour of beetroot under HAT drying method. In HAT_{40} treatment the constant rate period was observed very short at 0.5 - 1h and remaining portion of drying was followed by falling rate period. Drying curve of HAT_{50} the constant rate drying period was very short 0 - 0.5h and falling rate period was observed between 0.5 - 3.5h. In HAT_{60} drying curve the constant rate drying period was very short at 0 - 0.5h and there was two falling rate periods first at 0.5 - 1.5h and second at 1.5 - 2.25h were observed.

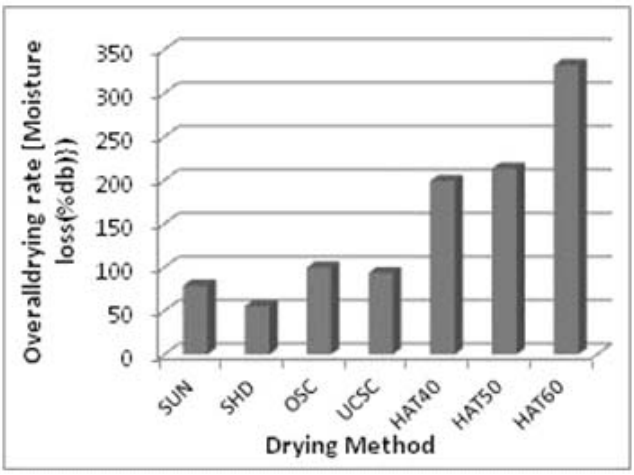
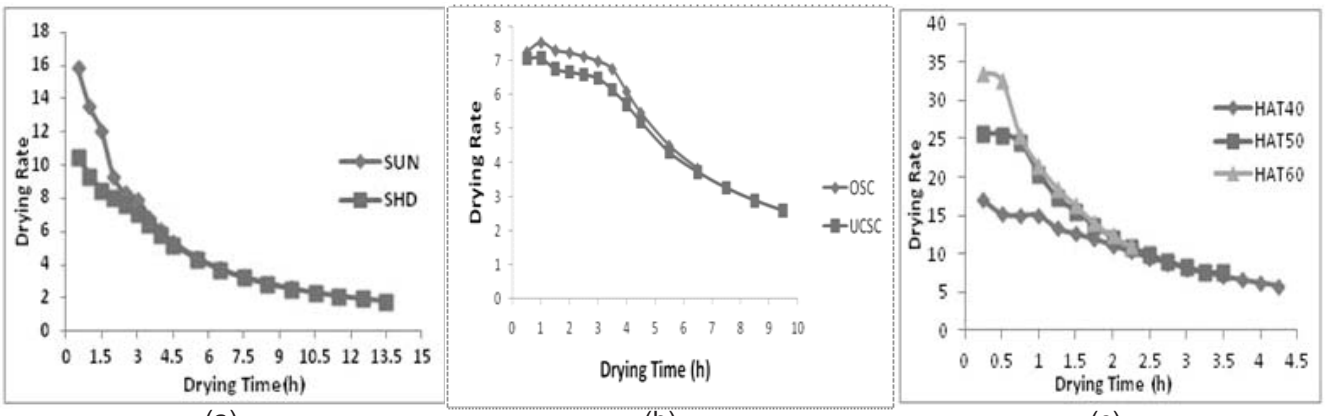


Fig 3. Effect of different drying methods on overall drying rate of beetroot

Effect of different drying methods on quality parameter

RR for dried beetroot under SUN, SHD, OSC, UCSC, HAT_{40}, HAT_{50} and HAT_{60} drying were found as 4.792, 4.574, 5.252, 5.021, 5.231, 5.391 and 5.650 respectively which shows the increasing trend as the drying air temperature increases. It may be due to the differences in moisture absorbing capacity of dried beetroot under different drying methods. MSR for beetroot under SUN, SHD, OSC, UCSC, HAT_{40}, HAT_{50} and HAT_{60} drying were found as 0.132, 0.142, 0.123, 0.124, 0.130, 0.127 and 0.124 respectively. This shows the increasing trend with decrease in drying temperature. It may be due to the differences in weight loss due to differences in drying temperature. Initial colour value of fresh beetroot was found as 18.57, 17.49 and 4.27 for L, a and b respectively. The colour values for dried beetroot under SUN, SHD, OSC, UCSC, HAT_{40}, HAT_{50} and HAT_{60} were found as 16.49, 15.72, 17.98, 17.49, 16.77, 16.89 and 17.52 for L; 4.16, 4.59, 4.26, 4.88, 6.99, 5.86 and 5.37 for a and 1.97, 1.24, 2.63, 2.48, 1.22, 1.34 and 1.38 for b respectively. According to results the colour values of dried beetroot was affected by sun light and temperature. In HAT drying the value a of dried beetroot is inversely proportional to temperature while the values L and b are directly proportional to temperature. In other drying methods was found good colour retention in SHD and UCSC methods than SUN and OSC respectively. The number of bacterial colonies per 100 g dried beetroot powder under SUN, SHD, OSC, UCSC, HAT_{40}, HAT_{50} and HAT_{60} were observed as 6×105, 7×105, 5×105, 4×105, 3×105, 2×105 and 2×105 respectively. Maximum number of bacterial colonies was observed in SUN and SHD dried beetroot powder. It may be due to lower temperature of drying and long time exposure



(a) (b) (c)

Fig 4. Drying rate curves of beetroot drying under different drying method

of sample in atmosphere, while the minimum number of colonies was observed in HAT dried beetroot powder due to higher temperature and short period of drying as compared to other drying conditions.

Conclusions

One important aim of drying of agricultural produce is reduction in crop losses and improvement in the quality of dried products. HAT drying is superior (in terms of moisture removal rate) followed by SUN, SHD, OSC, and UCSC which shows the decreasing trend in MR with increase in drying temperature. HAT drying experiment showed higher overall drying rates and drying levels than other drying methods. The drying curves typically demonstrated smooth diffusion-controlled drying behaviour under all drying conditions. The increase in drying air temperature increased the drying rate and also the drying level in all methods. The effect of temperature on overall drying rate was significant and increased linearly. The increase in drying rate with increase in air temperature could be due the fact that drying at high temperature led to high moisture diffusitivity and also provided a larger pressure deficit which is one of the driving forces for drying. In SUN and SHD drying methods the whole drying process was followed under falling rate period, while in HAT, OSC and UCSC drying initially the constant drying rate period was observed. The period of constant rate was very short and remaining drying process followed by falling rate period. The RR shows the increasing trend as the drying air temperature increases due to the differences in moisture absorbing capacity of dried beetroot under different drying methods. The MSR shows the increasing trend with decrease in drying temperature due to the differences in weight loss due to differences in drying temperature. The colour values of dried beetroot were affected by sun light, temperature and duration of drying. The microbes were detected more in open atmosphere drying methods such as SUN and SHD drying in comparison solar cabinet and HAT drying methods and the growth of microbes was depended on the presence of moisture level.

चुकंदर एक द्विवार्षिक जड़ मूल फसल है, जिसमें एंटी ऑक्सीडेन्ट तथा मैग्नीशियम, पोटेशियम, सोडियम और बिटामिन सी जैसे पोषक तत्व प्रचुर मात्रा में पाये जाते हैं। चुकंदर चूर्ण कई खाद्य पदार्थो में एक प्रा. तिक रंग के रुप में उपयोग किया जाता है। फांक के रुप में कटे हुये चुकंदर के टुकड़ो का विभिन्न सुखाने की विधियों जैसे सोलर केबिनेट ड्रायर में प्रा.तिक संवहन द्वारा सीधी सूर्य की रोशनी में और बिना सूर्य की रोशनी (OSC और UCSC) द्वारा, प्रत्यक्ष खुले सूर्य की रोशनी में (SUN) और छाया (SHD) द्वारा औसत तापमान क्रमशः 62, 33 और 36 डि.से. तथा औसत सापेक्ष आर्द्रता क्रमशः 15.5, 33.5 और 28 प्रतिशत में सुखाने की अभिलक्षणिकताओं का अध्ययन किया गया। होट एयर ट्रे ड्रायर में बलपूर्ण सुखाने की विधि द्वारा विभिन्न तीन स्तरों पर हवा के तापमान 40, 50 और 60 डि.से. तथा सापेक्ष अर्द्धता क्रमशः 16, 14 तथा 12 प्रतिशत और 1.80, 0.1 मीटर प्रति सेकन्ड के वेग के साथ अध्ययन किया गया। सर्वोच्च कुल सुखाने की दर 213. 56 (% db/h) तथा न्यूनतम अंतिम नमी स्तर 5.16 (% db) HAT_{60} विधि में दर्ज की गई थी। चुकंदर सुखाने की HAT_{60}, HAT_{50}, HAT_{40}, OSC, UCSC, SUN तथा SHD विधियों द्वारा समग्र सुखाने की दर (% db loss /h) को घटती प्रवृत्ति में क्रमशः 213.56, 157. 36, 135.90, 99.66, 96.43, 78.68 तथा 55.36 पाया गया। अंतिम नमी का स्तर (%db) को बढ़ती प्रवृत्ति में क्रमशः 5.61, 7. 75, 10.53, 5.57, 5.06, 12.02 तथा 20.64 पाया गया। सुखाने के लिये प्रयुक्त हवा का तापमान बढ़ाने पर प्रमुख गुणवत्ता के मानक रंग, पुनर्जलीकरण अनुपात और जन संकोचन अनुपात पर प्रतिकुल प्रभाव देखा गया। अधिकतम माइक्रोबियल लोड SHD और SUN तथा न्यूनतम HAT विधि में पाया गया।

References

Azharul Karim M, Hawlader MNA (2006) Performance evaluation of a v-groove solar air collector for drying applications. Appl Therm Eng 26: 121-130

AOAC (1990) Official method of analysis. Association of Official Analytical Chemists (No. 934.06), Arlington, VA

Baysal T, Ic-ier F, Ersus S, Yildiz H (2003) Effects of microwave and infrared drying on the quality of carrot and garlic. Eur Food Res Technol 218:68-73

Ceylan I, Aktas M, Dog an H (2007) Mathematical modeling of drying characteristics of tropical fruits. Appl Therm Eng 27: 1931-1936

Chakraverty A (2005) Post Harvest Technology of cereals, Pulses and oilseeds, 3rd Edition, oxford and IBH Publishing Co Pvt Ltd, New Delhi 54-55

Coumans WJ (2000) Models for drying kinetics based on drying curves of slabs. Chem Eng Process 39: 53-68

Das PC (2005) Root crops. Vegetable crops of India. Kalyani Piblisher. Ludhiana123-127

Doymaz I, Pala M (2003) The thin-layer drying characteristics of corn. J Food Eng 60 (2): 125-130

Frazier WC, Westhoff DC (1983) Food Microbiology. Tata McGraw Hill Publishing Company Limited New Delhi

Hall CW (1980) Drying and storage of agricultural crops. The AVI Publishing Company Connecticut USA: 1-15

Haque MN, Langrish TAG (2005) Assessment of the actual performance of an industrial solar kiln for drying timber. Dry Technol 23: 1541-1553

Ozbek B, Dadali G (2007) Thin-layer drying characteristics and modelling of mint leaves undergoing microwave treatment. J Food Eng 83: 541-549

Parthasarathi A (1997) Raw materials for food processing industries. Indian Fd Packer 51(6): 20-23

Ranganna S (1986) Handbook of Analysis and Quality Control for Fruits and Vegetables Products. 2nd Edition. Tata McGraw Hill Publishing Company Limited, New Delhi

Rodrigues S, Fernandes FAN (2007) Dehydration of melons in a ternary system followed by air-drying. J Food Eng 80: 678-687

Saeed IE, Sopian K, Zainol Abidin Z (2006) Drying kinetics of Roselle (*Hibiscus sabdariffa* L.): dried in constant temperature and humidity chamber.Proc. SPS 2006. Edited by Muchtar. 29th-30th August. Permata, Bangi S D E, Malaysia 143-148

Shanmugama V, Natarajan E (2006) Experimental investigation of forced convection and desiccant integrated solar dryer. Renew Energ 31: 1239-1251

Shivhare US, Gupta A, Bawa AS, Gupta P (2000) Drying Characteristics and Product Quality of Okra. Dry Technol 18(1-2): 409-419

Simpson WT (1991) Dry Kiln Operator's Manual. Agriculture Handbook 188. Edited by Simpson, W.T. United State Department of Agriculture Wisconsin USA: 07-09

Thakor NJ, Sokhansanj S, Sosulski FW, Yannacopoulos S (1999) Mass and dimensional changes of single canola kernels during drying. J Food Eng 40: 153-160

Upadhyay A, Sharma HK, Sarkar BC, (2008) Characterization and Dehydration Kinetics of Carrot Pomace, Agricultural Engineering International: The CIGR E journal. Manuscript FP 07 35. (10):31-35

Waewsak J, Chindaruksa S, Punlek C. (2006) A mathematical modeling study of hot air drying for some agricultural products. Thammasat Int J Sci Tech 11(1): 14-20

Wikipedia Foundation, Wikipedia, en.wikipedia.org. 27-04-2011

(Manuscript Receivd : 30.10.2013; Accepted : 07.03.2014)

JNKVV Res J 48(2): 232-244 (2014)

Physical characteristics and mathematical modeling of drying of beetroot (*Beta vulgaris* L.)

Mohammad Azam, B.M.Khandelwal, S.K.Garg* and **Sheela Pandey**
Department of Post-Harvest Process and Food Engineering
College of Agricultural Engineering
Jawaharlal Nehru Krishi Vishwa Vidyalaya
Jabalpur (MP)
*College of Agriculture
Ganjbasoda (MP)
Email : mazam226@gmail.com

Abstract

Some physical characteristics of beetroot such as shape, length, width, thickness, GMD, AMD, EMD, sphericity, surface area, aspect ratio, bulk density, true density, peel thickness, angle of repose and packing coefficient were determined. Exponential and Page model were tested for their goodness of fit through regression analysis. The experiment shows that exponential model fit best for HAT_{50}, SUN, UCSC and HAT_{60} methods of drying with R^2 value of 0.9911, 0.9839, 0.9786 and 0.9703 respectively. Page model fit best for HAT_{40}, HAT_{50}, HAT_{60}, OSC and UCSC methods of drying with R^2 value of 0.9975, 0.9973, 0.9963, 0.9922 and 0.9929 respectively. The average apparent moisture diffusivity was measured as 8.51962×10^{-09} m^2s^{-1} with standard deviation 5.51259×10^{-09} m^2s^{-1}.

Keywords: Beetroot, Physical properties, Mathematical modeling, Moisture diffusivity, Slices

One of the vegetables with proved pro-health properties is beetroot (*Beta vulgaris* L.). Beetroot commonly known as chukander, is mainly cultivated in India for its juice and vegetable value. It is a member of the flowering plant family Chenopodiaceae. The green leafy part of the beetroots is also of nutritional value, containing beta-carotene and other carotenoids. The nutritional benefits of beetroot are very well known. They are loaded with vitamins A, B1, B2, B6 and C. The greens have a higher content of iron compared to spinach. They are also an excellent source of calcium, magnesium, copper, phosphorus, sodium and iron. Beetroot coupled with carrot juice, the excellent cleansing virtues are exceptional for curing ailments (Grubben and Denton 2004). It contains high amounts of boron, which is directly related to the production of human sex hormones (Socaciu 2008). These findings suggest that beetroot ingestion can be a useful means to prevent development and progression of cancer. Extracts of beetroot also showed some antimicrobial activity on Staphylococcus aureus and on Escherichia coli and also antiviral effect was observed (Rauha et al. 2000). This nutrient is valuable for the health of the cardiovascular system (Anonymous 2002). The interest of the food industry in betalains has grown since they were identified as natural antioxidants (Escribano et al. 1998) which may have positive health effects on humans (Tesoriere et al. 2004).

Physical characteristics of agricultural products are the most important parameters to determine the proper standards of design of grading, conveying, processing and packaging systems (Tabatabaeefar and Rajabipour 2005). Among these physical characteristics, mass, volume, sphericity are the most important ones in determining sizing systems (Khodabandehloo 1999). Information regarding dimensional attributes is used in describing fruit shape which is often necessary in horticultural research for a range of differing purposes including cultivar descriptions in applications for plant variety rights or cultivar registers (Schmidt et al. 1995; Beyer et al. 2002).

Modeling of drying processes and kinetics is a tool for process control and necessary to choose suitable method of drying for a specific product. The developed models are used for designing new drying systems as well as selection of optimum drying conditions and for accurate prediction of simultaneous heat and mass transfer phenomena during drying

process. It also leads to produce the high quality product and increases the energy efficiency of drying system. Thin-layer drying models have been used to describe the drying process of several agricultural products, such as apple (Sacilik and Elicin 2006; Okyay and Ertekin 2006), raw mango slices (Goyal et al. 2006), grape (Yaldiz et al. 2001), pistachio (Midilli and Kucuk 2003), eggplant (Ertekin and Yaldiz 2004). These models are categorized as theoretical, semi-theoretical and empirical models (Khazaei and Daneshmandi 2007). The solution of Fick's second law was used widely as a theoretical model in thin layer drying of food products such as wheat (Gaston et al. 2004) and pistachio nuts (Kashaninejad et al. 2007). Therefore, the objectives of the current studies were: (i) to study the physical characteristics of beetroot, (ii) to develop the models for beetroot drying under selected drying methods.

Material and methods

The research work carried out in Post-Harvest Process and Food Engineering laboratory of Department of Post-Harvest Process and Food Engineering, College of Agricultural Engineering, JNKVV, Jabalpur (MP).

Preparation of sample

Fresh beetroots were procured from the local market Jabalpur. Fresh and healthy roots were selected and washed with tap water to remove the dust and dirt over the surface. 100 beetroots were selected for determination of physical properties.

Physical parameters of fresh beetroot

Measurement of axial dimension

To determine the average size of the fruits, three linear dimensions, namely length (L); equivalent distance of the stem (top) to the calyx (bottom), width (W); the longest dimension perpendicular to L, and thickness (T); the longest dimension perpendicular to L and W, were measured by using a Aerospace digital vernier caliper. The mass of beetroots were determined with an electronic balance (Make-Citizen, Model No: CY-3600) of 0.001 g accuracy.

Diameter

The diameter was calculated by considering Eqs (1), (2), and (3), respectively (Mohesnin 1986)

$$Dg = (LWT)^{1/3} \quad ...(1)$$

$$Dp = \left[L \frac{(W+T)^2}{4} \right]^{1/3} \quad ...(2)$$

$$Da = \frac{(L+W+T)}{3} \quad ...(3)$$

Where: Dg - geometric diameter, Dp - equivalent diameter, Da - arithmetic diameter (all in cm).

Sphericity

The sphericity, Sp (%) defined as the ratio of surface area of a sphere having the same volume as that of fruit to the surface area of the fruit, was determined using the following formula (Mohsenin 1986)

$$S_p = \frac{\sqrt[3]{(LWT)}}{L} \quad ...(4)$$

Surface area

The surface area of the fruit was calculated by using the following formula (Mohsenin 1986)

$$S = \Pi (Dg)^2 \quad ...(5)$$

Aspect ratio

The aspect ratio, Ra was calculated by using the following formula (Omobuwajo et al. 1999)

$$R_a = W/L \quad ...(6)$$

Packing coefficient

Packing coefficient was defined by the ratio of the volume of fruit packed to the total and calculated by the following formula (Topuz et al. 2004)

$$\lambda = V/Vo \quad ...(7)$$

where: λ = packing coefficient
V = true volume of fruit
Vo = volume of the box containing fruits

Bulk density

The bulk density is the mass of group of individual particle divided by the space occupied by the entire mass, (Mohsenin 1980) including the air space and was determined using following relationship. It was measured by a 500ml flask. Beet roots were poured inside the flask and shaked 10 times manually to fill the pore spaces.

$$\text{Bulk Density} = \frac{\text{Mass of sample (g)}}{\text{Volume of flask occupied by the sample (cm}^3\text{)}} \quad ...(8)$$

True density

The True density is defined as the ratio between the mass of material and the true volume of it, was determined using the toluene (C_7H_8) displacement method. 500ml Toluene was used in place of water, because it is not absorbed by crop material. The volume of toluene displaced was found by immersing beetroot root of known mass in the toluene. (Mohsenin 1986)

$$\text{True density (g/cm}^3\text{)} = \frac{\text{Weight of sample}}{\text{Volume displaced}} \quad ...(9)$$

Angle of repose

Angle of repose of beetroot is the maximum angle by which root heap can be made, it was measured by making the heap of 2 kg beetroot with hollow cylinder and it is measured by drawing tangent to slope and the horizontal line. Beyond this angle root have tendency to slide (Mohsenin 1986).

$$\text{Angle of repose } \theta = \tan^{-1} (2h/D) \quad ...(10)$$

Where, h = the height of pile and

D = the base (dia)

Drying Methods

Sample preparations

Fresh beetroots procured from local market of Jabalpur were used in the study. Samples were stored in refrigerator at 4±0.5oC prior to the drying experiment. At the start of each experiment, beetroot of uniform size were selected cleaned, washed and moisture on the wet root surface was removed with tissue paper. The roots were then peeled and sliced into transverse section of approximate 2 mm thickness using a kitchen slicer. The sample size was kept constant at 200g for all runs. The initial moisture content of beetroot samples was determined by standard AOAC 930.15 method (AOAC 1990).

Sun and Shade drying

In sun and shade drying, perforated aluminium trays of 75X60 cm size were used to facilitate drying of beetroot slices in a single layer and placed 10 cm above the concrete floor on the roof of the laboratory building in direct sun light. In shade drying, slices of beetroot were spread over perforated trays and placed in the shade10 cm above the concrete floor inside the laboratory hall.

Solar Cabinet Drying

Multi-rack solar dryer developed by PAU Ludhiana centre of All India Cordinated Research Project. It does not require electrical energy or any other fuel and works on all sunny or partly cloudy days during summer as well winter. The drying of beetroot slices in solar cabinet dryer was performed by two methods. In first method slices were placed in direct exposure of sun (OSC) and in second method slices were covered with black plate (UCSC) and placed in direct sun light.

Hot air tray drying

Hot air tray dryer consisted of heating unit, drying chamber and centrifugal fan for providing air flow. Fresh air enters the cabinet by the fan through screen filters and heater coils, and is then blown across the trays to exhaust. The trays used were perforated from bottom in order to permit vertical movement of hot air. All four trays were assembled in a column inside the Hot air tray dryer

Moisture content

The dry basis (%) moisture content (Haque and Langrish 2005, Saeed et al. 2006, Ceylon et al. 2007, Upadhyay et al. 2008) and on wet basis (%) moisture content (Hall

1980, Simpson 1991, Rodrigues and Fernandes 2007) were calculated as follows

$$MCdb(\%) = Ww/Wd \times 100 \quad ...(11)$$

$$MCwb(\%) = Ww/(Ww+Wd) \times 100 \quad ...(12)$$

Moisture Ratio (MR)

MR is the ratio of the moisture content at any given time to the initial moisture content (both relative to the equilibrium moisture content). It can be calculated as (Ozbek and Dadali 2007, Shivhare et al. 2000, Thakor et al. 1999)

$$MR = (M-Me)/(Mo-Me) \quad ...(13)$$

Drying Models

Modeling the drying process is important for characterizing the processes with different drying methods and conditions. Two models, the exponential and Page models were chosen to describe the drying process since they have been widely used in expressing drying behaviour of biological materials. Model curves were fitted to the experimental data and the performance of the model was determined by the correlation coefficient (R^2).

Exponential model

One of the most basic models used to describe moisture loss during the drying process is a simple exponential model (Sun and Woods 1994):

$$MR =(M-Me)/(Mo-Me) = A \exp(-kt) \quad ...(14)$$

where MR is the moisture ratio; M is the moisture content (% db) at any given time during drying; M0 is the initial moisture content; Me is the equilibrium moisture content; k is the drying constant (min^{-1}); and t is time in min. The exponential model was linearized to form of straight line equation (Y = mx + c) which is following:

$$\ln(MR) = \ln(A) + (-Kt) \quad ...(15)$$

This model assumes negligible internal resistance and considers only the resistance concentrated at the surface of the material (Afzal and Abe 1997). The exponential model, equation (15), is a simple lumped model often used to describe mass transfer in thin layer drying (Wang 2002). This model was used because of its simplicity, high correlation to most drying data, and common use in literature. Drying constant, k (min^{-1}), can be calculated by using the model.

Page model

Page (1949) modified the exponential model to include and additional exponent:

$$MR = \exp(-KtN) \quad ...(16)$$

where K is an empirical drying constant (min^{-1}); and N is an empirical drying exponent. It has been used extensively in thin layer drying of paddy rice and other grains and can be used in many thin-layer drying applications (Afzal and Abe 1997). The model was used in the study because of its simplicity and frequent use in literature.

The Page equation can be adapted from equation (16) as follows:

$$MR = \frac{(M-Me)}{(Mo-Me)} = \exp(-Kt^N) = y(t) \quad ...(17)$$

This may then be rearranged to read:

$$\ln[-\ln MR] = \ln(K)+ N \ln(t) \quad ...(18)$$

The slope of linear curve of a plot of ln[-lnMR)] versus ln(t) was the value N and the exponential of the y intercept as the value of K (Singh and Erdogdu 2004). Correlation coefficients, means, and standard deviations were also calculated for all drying conditions.

Determination of apparent moisture diffusivity

A single-term solution of the diffusion equation for an infinite slab is a common method to calculate the drying rate of fruits and vegetables in the falling rate period (Saravacos and Charm 1962). This simplified solution is mathematically represented as:

$$MR = \frac{(M-Me)}{(Mo-Me)} = (8/\Pi^2)\exp(-\Pi^2 Dt/4L^2) \quad ...(19)$$

Where,

((M-Me))/((Mo-Me)) = Moisture ratio

M = moisture content at any time (dry basis)

Me = equilibrium moisture content (dry basis)

Mo = initial moisture content (dry basis)

D = diffusion coefficient (m^2/s)

L = the half thickness of the slices (m).

An exponential model, which is analogous to Newton's law of cooling, can also be used to predict the general characteristics of thin layer drying of many products. It assumes that the rate of moisture removal is proportional to difference between products being dried and its equilibrium moisture content and all the resistance to moisture transfer is at the outer surface of products. It is mathematically expressed as:

$$dM/dt = -Ko(M-Me) \quad ...(20)$$

where Ko is the drying constant(s^{-1}). The solution of this equation is:

$$MR = ((M-Me)/(Mo-Me)) = \exp(-Kot) \quad ...(21)$$

An empirically modified form of this equation is:

$$MR = ((M-Me)/(Mo-Me)) = A\exp(-Kt) \quad ...(22)$$

where K is drying constant (s^{-1}), and A is a constant.

From equation (3.22), the drying constant (K) in equation (3.25) is related to diffusion coefficient by:

$$K = (\Pi^2 D/4L^2) \quad ...(23)$$

where D is the diffusivity (m^2/s), and L is the half-thickness of the sample (m). In this experiment the thickness of slice is 1mm.

Goodness of fit statistics

Coefficient of determination (R^2)

In statistics, the coefficient of determination R^2 is used in the context of statistical models whose main purpose is the prediction of future outcomes on the basis of other related information. It is the proportion of variability in a data set that is accounted for by the statistical model. It provides a measure of how well future outcomes are likely to be predicted by the model. This is equivalent to the ratio of the regression sum of squares (SSR) to the total sum of squares (SST), which explains the proportion of variance accounted for in the dependent variable by the model. It evaluates how well the model fits the data. A data set has values y_i, each of which has an associated modeled value fi (also sometimes referred to as $\hat{y}_i$). Here, the values y_i are called the observed values and the modeled values f_i are sometimes called the predicted values. It can be calculated from the following formulae:

Regression sum of squares:

$$SS_{reg} = \sum_i (f_i - \bar{y})^2 \quad ...(24)$$

The total sum of squares:

$$SS_{tot} = \sum_i (y_i - \bar{y})^2 \quad ...(25)$$

Sum of squares of residuals

$$SS_{err} = \sum_i (y_i - f_i)^2 \quad ...(26)$$

Now, coefficient of determination,

$$R^2 = \frac{SS_{reg}}{SS_{tot}} \quad ...(27)$$

or

$$R^2 = 1 - \frac{SS_{err}}{SS_{tot}} \quad ...(28)$$

Root Mean Square Error

Root-mean-square error (RMSE) is a frequently used measure of the differences between values predicted by a model or an estimator and the values

actually observed from the thing being modeled or estimated. RMSE is a good measure of precision. These individual differences are also called residuals, and the RMSE serves to aggregate them into a single measure of predictive power. It's signifying the noise in the data (Demir et al. 2004; Doymaz 2005; Wang et al. 2007).

$$RMSE = \sqrt{\frac{\sum_{i-1}^{N} (MR_{exp,i} - MR_{cal,i})^2}{N}} \quad ...(29)$$

Where,

MRcal,i= simulated value of MRexp,i

MRexp,i =experimental value

Results and discussion

Physical characteristics of beetroot

The initial moisture content of beetroot was found as 88.20% (wb), or 747.46% (db). Shape of beetroot was found like spherical and ellipsoidal. The physical properties of beetroot such as length, width, thickness, geometric mean diameter, arithmetic mean diameter, equivalent mean diameter, sphericity, surface area, mass, volume, aspect ratio, angle of repose, peel thickness; true density, bulk density and packing coefficient were measured. The 100 beetroot were taken for length, width, thickness, geometric mean diameter, arithmetic mean diameter, equivalent mean diameter, sphericity, surface area, mass, volume and true density. The 10 beetroots were taken to measure peel ratio and bulk density was measured by six replication of beetroots sample.

The statistical analysis of various physical properties was summarized in Table 1. According to the results of the dimensional properties of beetroot the mean length, width, and thickness were respectively 6.03, 5.60 and 5.14 cm with SD of 0.65, 0.57 and 055 cm. The geometric, Dg, equivalent, Dp, and arithmetic mean diameter, Da, of beetroots were different at 5.57, 5.57 and 5.59 cm with SD of 0.56, 0.55 and 0.56 cm respectively. The mean value of true density and bulk density of beetroots were 1.00 and 0.52 g/cm3 with SD of 0.04 and 0.02 g/cm3 respectively. The packaging coefficient, mass and volume were 0.55, 85.33 g and 84.75 cm3 with SD of 0.03, 11.85 g and 11.92 cm3. The mean values of sphericity and surface area were found 0.92 and 98.22 cm2 with SD of 0.04 and 19.84 cm2 respectively. The average values of aspect ratio, peel thickness and angle of repose were found 0.93, 1.06 mm and 40.67o with SD of 0.05, 0.13 mm and 2.51o respectively.

Selection of drying models and statistical analysis

Moisture ratio data obtained for single layer drying of beetroot under SUN, SHD, OSC, UCSC, HAT_{40}, HAT_{50}

Table 1. Physical characteristics of beetroot at 88.20 % (wb) moisture content

Properties	No. of observation	Specification			
		Mean	Max	Min	SD
Length (cm)	100	6.03	7.65	4.92	0.65
Width (cm)	100	5.59	6.93	4.58	0.57
Thickness (cm)	100	5.14	6.51	4.21	0.56
GMD, Dg (cm)	100	5.57	6.99	4.62	0.56
AMD, Da (cm)	100	5.59	7.02	4.64	0.56
EMD, Dp (cm)	100	5.57	6.99	4.63	0.55
Sphericity, Sp	100	0.92	0.98	0.79	0.04
Surface Area (cm^2)	100	98.22	153.59	67.12	19.84
Aspect Ratio	100	0.93	0.99	0.74	0.05
Mass(g)	100	85.33	111.25	60.62	11.85
Volume (cm^3)	100	84.75	109.0	56.0	11.92
True Density (g/cm^3)	100	1.01	1.08	0.94	0.04
Bulk Density (g/cm^3)	6	0.52	0.54	0.51	0.02
Peel Thickness (mm)	10	1.06	1.23	0.89	0.13
Packing Coefficient, λ	6	0.55	0.57	0.52	0.03
Angle of repose ($degree^0$)	6	40.67	43	38	2.51

and HAT_{60} methods are presented in Table 4.2. These data were fitted into both the page model (Fig 1-7) and exponential model (Fig 8-14).

Page model

The page model was linearized to form the following equation:

$$\ln(-\ln MR) = \ln K + N \ln t$$

The regression coefficient and constant value of page model under different drying methods of beetroot drying. The R^2 value for beetroot drying of page model (Fig.4.11-4.17) under SUN, SHD, OSC, UCSC, HAT_{40}, HAT_{50} and HAT_{60} drying method was observed 0.881, 0.9087, 0.9815, 0.9798, 0.9942, 0.9918 and 0.9901. Result shows that this model is best fit for HAT_{40}, HAT_{50} and HAT_{60}, moderately fit for OSC and UCSC drying methods and poor fit for SUN and SHD drying methods (Table 2).

The value of constant 'N' for page model was observed 0.8214, 0.8413, 1.5324, 1.2106, 1.2783, 1.1439 and 1.2408 for SUN, SHD, OSC, UCSC, HAT_{40}, HAT_{50} and HAT_{60} drying respectively. Maximum value of N was observed in OSC drying and minimum value was observed in SUN drying methods. The values of constant 'K' for SUN, SHD, OSC, UCSC, HAT_{40}, HAT_{50} and HAT_{60} methods were calculated as 0.0331, 0.0190, 0.0006, 0.0025, 0.0050, 0.0149 and 0.0137 respectively. The highest value of K was observed for SUN drying and minimum for OSC drying methods.

Root mean square error (RMSE) for page model were computed as 0.0436, 0.0459, 0.03007, 0.0297, 0.0163, 0.01607 and 0.0196 under SUN, SHD, OSC, UCSC, HAT_{40}, HAT_{50} and HAT_{60} methods for beetroot drying. Fig. (4.25-4.31) shows the validity of page model. R^2 value of SUN, SHD, OSC, UCSC, HAT_{40}, HAT_{50} and HAT_{60} methods of beetroot were observed 0.9839, 0.9777, 0.9933, 0.9929, 0.9975, 0.9973 and 0.9963 respectively. The page model best fit for HAT_{40}, HAT_{50}, HAT_{60}, OSC and UCSC drying methods and moderately fit for SUN and SHD drying methods.

The regression of coefficient value between observed and predicted moisture ratio shows the good agreement between observed and predicted moisture ratio for page model.

Table 2. Constants, Regression coefficients and Root mean square error for drying models

Methods of drying	Page model			Exponential model			RMSE (Page model)	R^2 for Page model	RMSE exponential model	R^2 for exponential model
	R^2	N	K	R^2	A	K				
SUN	0.8881	0.8214	0.0331	0.9271	0.8246	0.0141	0.0434	0.9839	0.2067	0.9005
SHD	0.9087	0.8413	0.0190	0.9087	0.7739	0.008	0.0459	0.9777	0.1857	0.8887
OSC	0.9815	1.5324	0.0006	0.9485	1.7125	0.0162	0.0300	0.9933	0.2260	0.8646
UCSC	0.9798	1.2106	0.0025	0.9632	0.9948	0.0085	0.0297	0.9929	0.2979	0.9786
HAT_{40}	0.9942	1.2783	0.0050	0.9856	1.5335	0.0243	0.0163	0.9975	0.1411	0.9458
HAT_{50}	0.9918	1.1439	0.0149	0.9901	1.0566	0.03	0.0160	0.9973	0.1844	0.9911
HAT_{60}	0.9901	1.2408	0.0137	0.9919	1.3346	0.0459	0.0196	0.9963	0.1384	0.9703

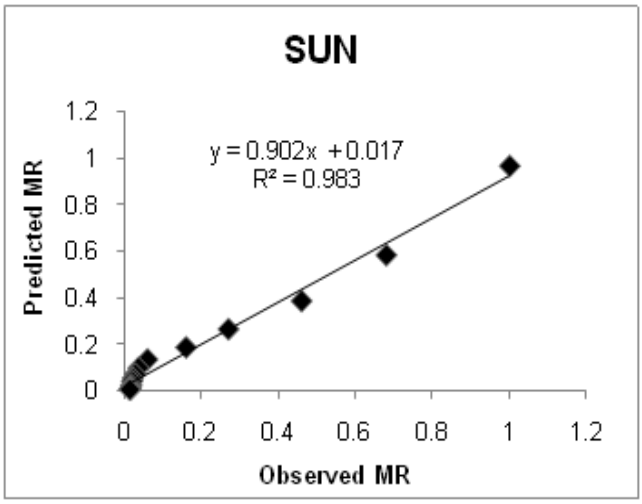


Fig 1. Comparison of experimental and predicted moisture ratio by the page model under SUN drying

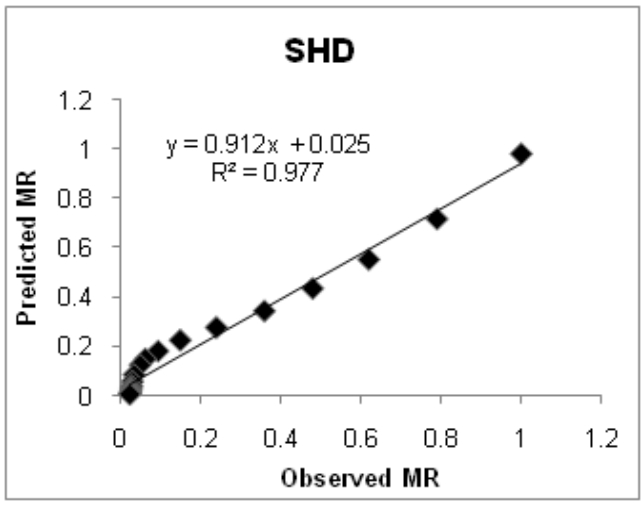


Fig 2. Comparison of experimental and predicted moisture ratio by the page model under SHD drying

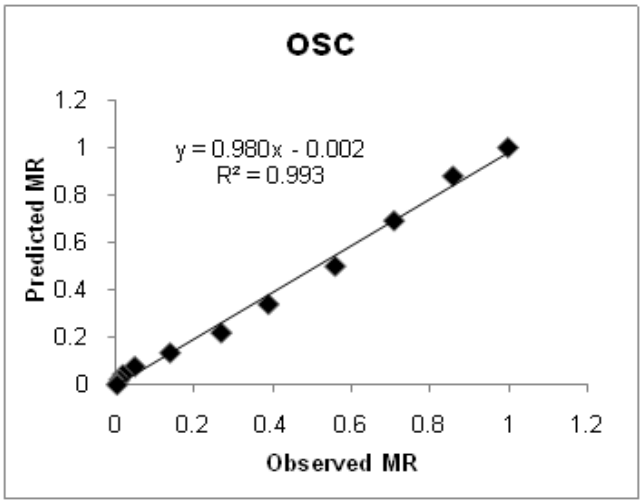


Fig 3. Comparison of experimental and predicted moisture ratio by the page model under OSC drying

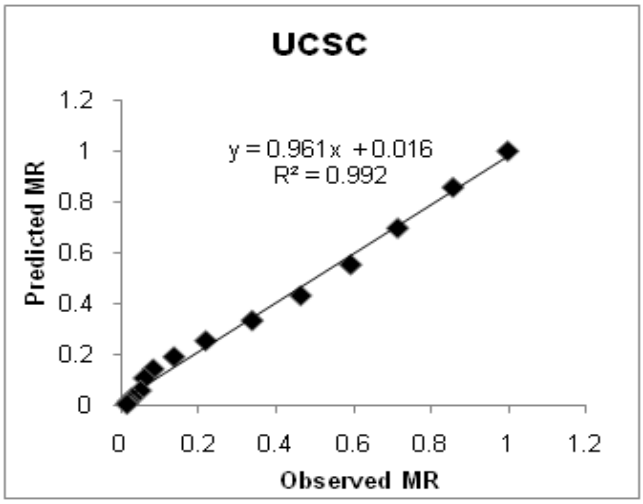


Fig 4. Comparison of experimental and predicted moisture ratio by the page model under UCSC drying

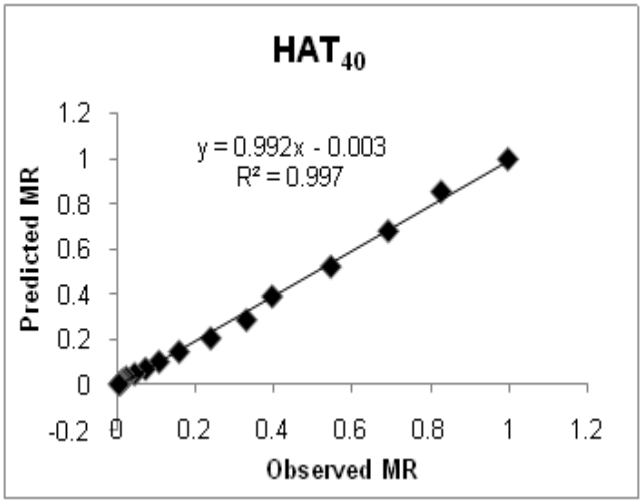


Fig 5. Comparison of experimental and predicted moisture ratio by the page model under HAT_{40} drying

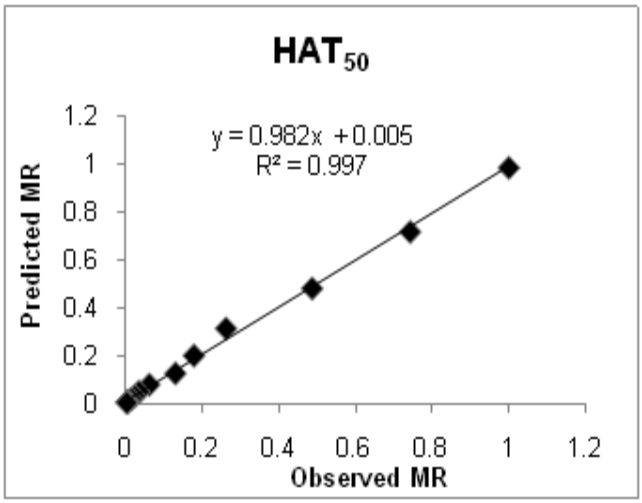


Fig 6. Comparison of experimental and predicted moisture ratio by the page model under HAT_{50} drying

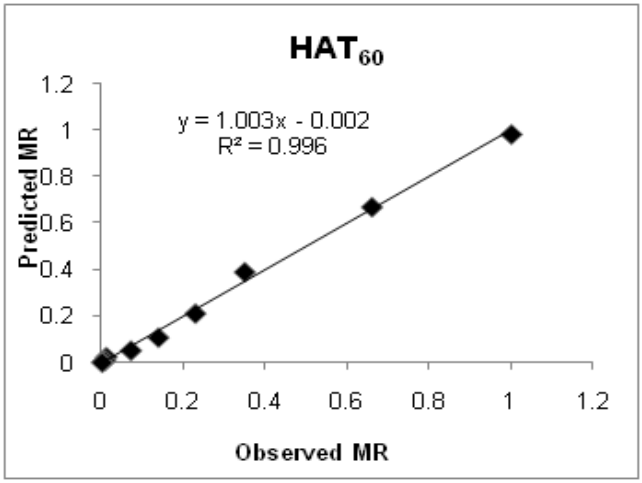


Fig 7. Comparison of experimental and predicted moisture ratio by the page model under HAT_{60} drying

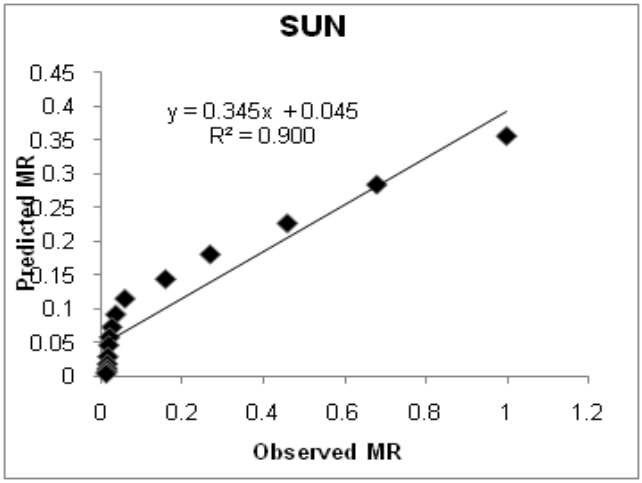


Fig 8. Comparison of observed and predicted moisture ratio by the exponential model under SUN drying method

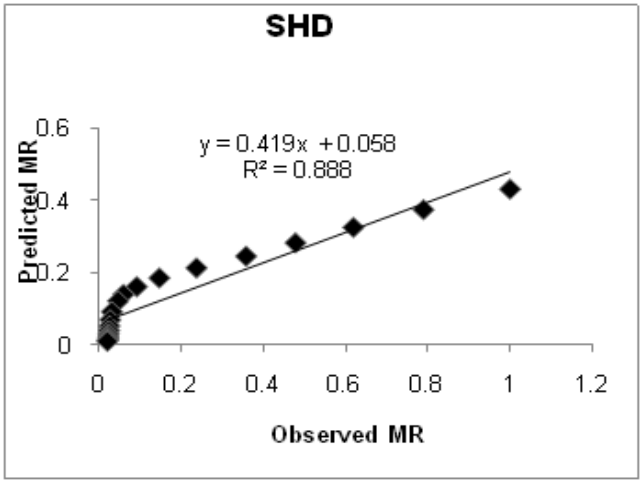


Fig 9. Comparison of observed and predicted moisture ratio by the exponential model under SHD drying method

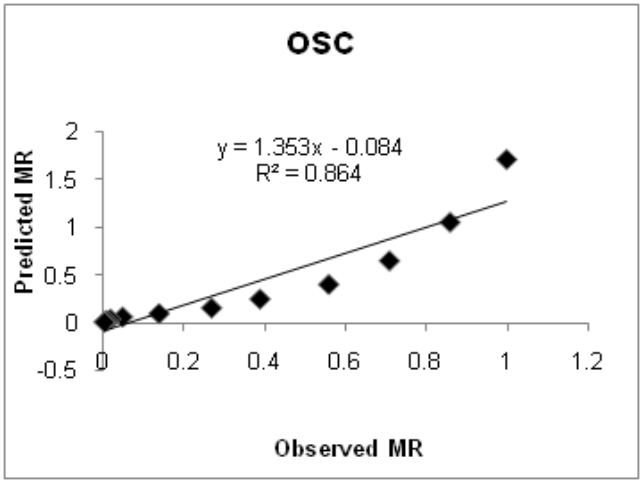


Fig 10. Comparison of observed and predicted moisture ratio by the exponential model under OSC drying method

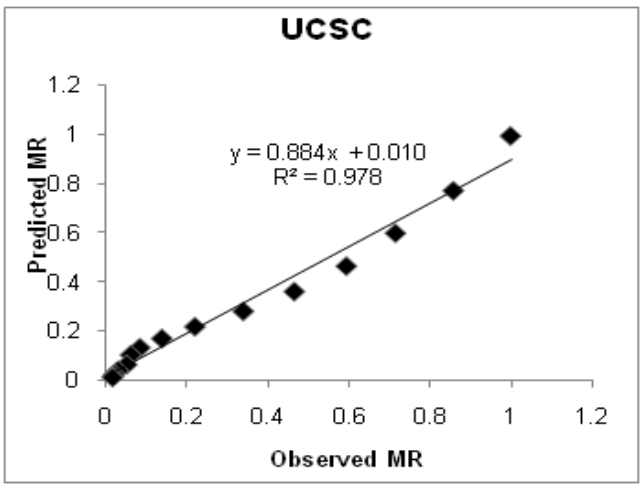


Fig 11. Comparison of observed and predicted moisture ratio by the exponential model under UCSC drying method

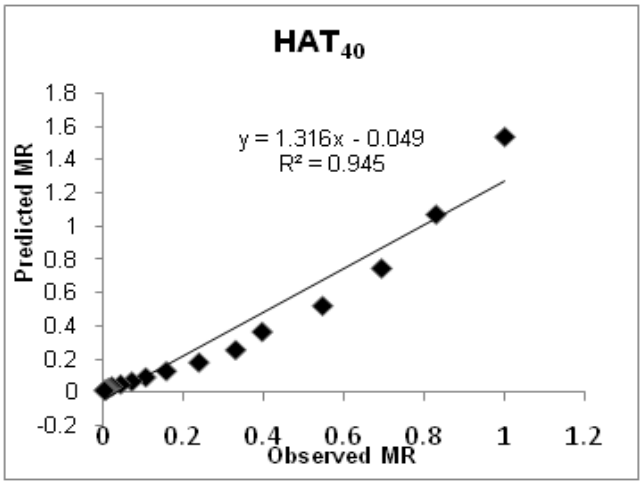


Fig 12. Comparison of observed and predicted moisture ratio by the exponential model under HAT_{40} drying method

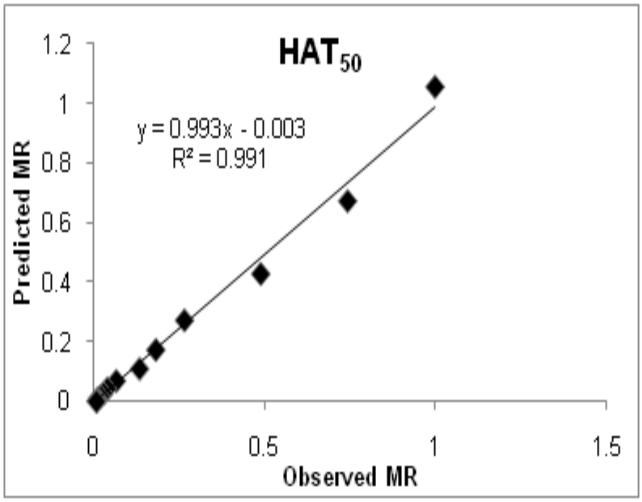


Fig 13. Comparison of observed and predicted moisture ratio by the exponential model under HAT_{50} drying method

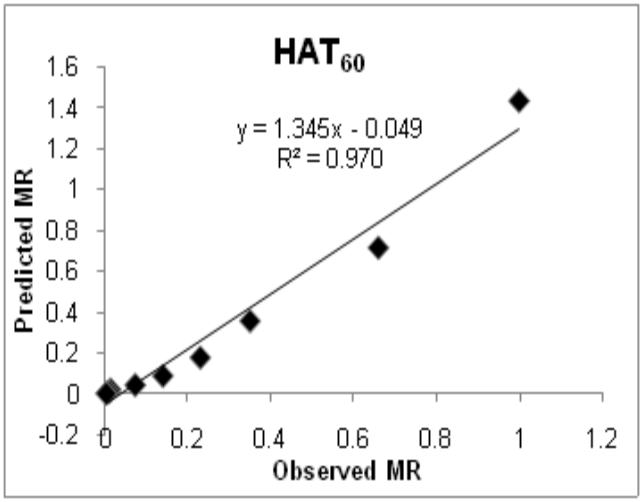


Fig 14. Comparison of observed and predicted moisture ratio by the exponential model under HAT_{60} drying method

Exponential model

From the result of this study, the exponential model (MR =A exp (-Kt) was linearized in the form of following straight line (Y=mx +C) equation.

$$\ln MR=(-Kt)+\ln(A)$$

The constants and regression coefficients for single layer drying of intact and Beetroot under different methods are presented in Table 2. Table presents the model validation and root mean square error of exponential model.

In the study the constant "A" was used as a shape factor. The Value of coefficient of determination R^2 (Table 2) for exponential model under SUN, SHD, OSC, UCSC, HAT_{40}, HAT_{50} and HAT_{60} drying methods were observed as 0.9271, 0.9087, 0.9485, 0.9632, 0.9856, 0.9901 and 0.9919 respectively. According to the coefficient of determination R^2 the exponential model was best fit for HAT_{50} and HAT_{60}. While in others it provides poorly fit.

The value of constants "A" for exponential model was observed 0.8246, 0.7739, 1.7125, 0.9948, 1.5335, 1.0566 and 1.3346 for SUN, SHD, OSC, UCSC, HAT_{40}, HAT_{50} and HAT_{60} drying methods respectively. The value of constant "K" under SUN, SHD, OSC, UCSC, HAT_{40}, HAT_{50} and HAT_{60} methods for beetroot drying were calculated as 0.0141, 0.008, 0.0162, 0.0085, 0.0243, 0.03 and 0.0459 respectively.

The value of constant K shows the general decreasing trend with decrease in drying temperature. While value of A shows the variable trend which was observed maximum (1.7125) in OSC drying of beetroot and minimum (0.7739) in SHD drying of beetroot (Table 2). These value shows that the K value is dependent on temperature. RMSE (root mean square error) for exponential model SUN, SHD, OSC, UCSC, HAT_{40}, HAT_{50} and HAT_{60} experiment were calculated as 0.206723, 0.18571, 0.226003, 0.029796, 0.141151, 0.028443 and 0.138498 respectively. R^2 values of exponential model validation were observed 0.9005, 0.8887, 0.8646, 0.9786, 0.9458, 0.9911 and 0.9703 respectively (Fig. 8-14).

The Table 2 shows that exponential model fit best for HAT_{50}, moderately fit for UCSC, HAT_{60} and HAT_{40} methods of drying while it is poorly fit for SUN, SHD and OSC drying methods.

Determination of apparent moisture diffusivity

Mathematical models have proved to be very useful in the design and analysis of drying operations. Simulation or designing the air drying operation requires the mathematical description of food moisture evolution during the process, known as drying kinetics (Bruce and Giner, 1993). Significant amounts of moisture removal from a food product will occur due to diffusion of liquid and/or water vapour through the product structure (Singh and Heldman, 1993). The exact mechanism of

moisture movement is still unclear. However the existing theory which is most accepted is diffusion due to concentration gradients. This has been successfully used in modeling the drying of many foods (Simal et al., 2005). Literature, regarding the diffusivity of various food stuffs is very limited and they vary considerably because of the complex structure of foods and the lack of a standard method for determination of diffusivity (Rao et al., 2005).

A quantitative measurement of the rate at which a diffusion process occurs is usually expressed in terms of a diffusion coefficient (diffusivity) and is often treated as an adjustable parameter. Therefore most models depend largely on experimental measurements of diffusivity. The moisture diffusivity of a food material characterizes its intrinsic moisture mass transport property which includes molecular diffusion, vapour diffusion, liquid diffusion etc. Generally apparent moisture diffusivity is used due to limited information on the mechanism of moisture movement during drying and complexity of the process.

The average apparent moisture diffusivity was calculated as $8.52X10^{-9}$ m^2s^{-1} with standard deviation $5.51X10^{-9}$ m^2s^{-1}. The highest value of moisture diffusivity recorded as 1.86X10-9 of HAT_{60} drying method and lowest value of $3.25X10^{-9}$ of SHD drying method.

Table 3. Apparent moisture diffusivity for beetroot slices under various conditions

Drying methods	Drying constant $K(s^{-1})$	Apparent diffusivity (m^2s^{-1})
SUN	0.0141	$5.72x10^{-9}$
SHD	0.008	$3.25X10^{-9}$
OSC	0.0162	$6.57X10^{-9}$
UCSC	0.0085	$3.45X10^{-9}$
HAT_{40}	0.0243	$9.86X10^{-9}$
HAT_{50}	0.030	$1.22X10^{-8}$
HAT_{60}	0.0459	$1.86X10^{-8}$
	Average diffusivity	$8.52X10^{-9}$
	Standard Deviation	$5.51X10^{-9}$

Conclusions

The shape of beetroot was found like spherical and ellipsoid. The mean value of length, width and thickness were measured as 6.03, 5.59 and 5.14cm with standard deviation of 0.65, 0.57 and 0.56cm respectively. The mean value of geometric mean diameter, arithmetic mean diameter and equivalent mean diameter were measured as 5.57, 5.59 and 5.57cm with standard deviation of 0.56, 0.56 and 0.55cm. The mean values of sphericity and surface area were found as 0.92 and 98.22 cm^2 with S.D. of 0.04 and 19.84cm^2 respectively. The mean value of aspect ratio was found as 0.93 with SD of 0.05. Mean values of true density and bulk density were measured as 1.01 and 0.52 g/cm^3 with standard deviation of 0.038 and 0.0185 g/cm^3 respectively. The mean values of peel thickness and packing coefficient were measured as 1.06mm and 0.55 with S.D. of 0.13mm and 0.03. Average angle of repose was measured as 40.67^o with SD of 2.51^o.

The experiments show that exponential model fit best for HAT_{50}, SUN, UCSC and HAT_{60} methods of drying with R2 value of 0.9911, 0.9839, 9786 and 0.9703 respectively. Page model fit best for HAT_{40}, HAT_{50}, HAT_{60}, OSC and UCSC methods of drying with R2 value of 0.9975, 0.9973, 0.9963, 0.9922 and 0.9929 respectively. The average apparent moisture diffusivity was measured as $8.52X10^{-9}$ m^2s^{-1} with standard deviation of $5.51X10^{-9}$ m^2s^{-1}. The highest value of moisture diffusivity was recorded as $1.86X10^{-9}$ of HAT_{60} drying method and lowest value of $3.25X10^{-9}$ of SHD drying method.

चुकंदर के कुछ भौतिक अभिलाक्षणिक गुणों जैसे कि लंबाई, चौड़ाई, मोटाई, GMD, AMD, EMD, गोलाई, सतह क्षेत्र, ऐस्पेक्ट अनुपाज, बल्क घनत्व, ट्र घनत्व, छील मोटाई, रिपोज़ कोण और पैकिंग गुणांक का अध्ययन किया गया । दो मॉडल एक्स्पोनेन्शल और पेज मॉडल का उपयोग सूखने के व्यवहार को व्यक्त करने में उपयोग किया गया । प्रयोग सिद्ध करता है कि एक्स्पोनेन्शल मॉडल HAT_{50}, SUN, UCSC और HAT_{60} विधियों के लिए R^2 के मान क्रमशः 0.9975, 0.9973, 0.9963, 0.9922 और 0.9929 के साथ उत्कृष्ट है । औसत अपेरन्ट मॉइस्चर डिफ्युसिविटी का मान 5.51259 x 10^{-09} m^2s^{-1} मानक विचलन के साथ 8.51962 x $10^{-09}m^2s^{-1}$ मापा गया ।

References

Afzal TM, Abe T (1997) Modeling for infrared drying of rough rice. J Microwave Power EE 32(2):80-86

Anonymous (2002) Betaine University of Maryland Medical Center (UMMC). Retrieved September 6: 2007

Beyer M, Hahn R, Peschel S, Harz M, Knoche A (2002) Analyzing fruit shape in sweet cherry (*Prunus avium* L.). Sci Horticulture J 96:139-150

Bruce DM, Giner SA (1993) Mathematical modeling of grain drying in counter-?ow beds: Investigation of cross-over of air and grain temperatures. J Agr Eng Res 55:143-161

Ceylan I, Aktas M, Dog an H (2007) Mathematical modeling of drying characteristics of tropical fruits. Appl Therm Eng 27:1931-1936

Demir V, Gunhan T, Yagcioglu AK, Degirmencioglu A (2004) Mathematical modeling and the determination of some quality parameters of air-dried bay leaves. Biosyst Eng 88(3):325-335

Doymaz I (2005) Sun drying of figs: an experimental study. J Food Eng 71:403-407

Ertekin C, Yaldiz E, (2004) Drying of eggplant and selection of a suitable thin layer drying model. J Food Eng 63:349-359

Escribano J, Pedreno MA, García-Carmona F, Muñoz R (1998) Characterization of the antiradical activity of betalains from Beta vulgaris L. roots. Phytochem Annal 9: 124-7

Gaston AL, Abalone RM, Giner SA, Bruce DM (2004) Effect of modeling assumptions on the effective water diffusivity in wheat. Biosyst Eng 88:175-185

Goyal RK, Kingsly ARP, Manikantanl MR, Ilyas SM (2006) Thin-layer drying kinetics of raw mango slices. Biosyst Eng 95:43-49

Grubben GJH, Denton OA (2004) Plant Resources of Tropical Africa 2. Vegetables. PROTA Foundation, Wageningen; Backhuys, Leiden; CTA, Wageningen

Hall CW (1980) Drying and storage of agricultural crops. The AVI Publishing Company Connecticut USA: 1-15

Haque MN, Langrish TAG (2005) Assessment of the actual performance of an industrial solar kiln for drying timber. Dry Technol 23:1541-1553

Kashaninejad M, Mortazavi A, Safekordi A, Tabil LG (2007) Thin layer drying characteristics and modeling of pistachio nuts. J Food Eng 78:98-108.

Khazaei J, Daneshmandi S, (2007) Modeling of thin-layer drying kinetics of sesame seed: mathematical and neural networks modeling. Int Agrophysics 21:335-348

Khodabandehloo H (1999) Physical Properties of Iranian Export Apples. M.S. Thesis, University of Tehran, Karaj, Iran

Midilli A, Kucuk H (2003) Mathematical modeling of thin layer drying of pistachio by using solar energy. Energ Convers Manage 44:1111-1122

Mohsenin NN (1986) Physical Properties of Plant and Animal Materials. Second Edn. Gordon and Breach Science Publishers, New York

Mohsenin NN (1980) Physical Properties of Plant and Animal Materials. Gordon and Breach Science. Publishing, New York

Okyay Menges H, Ertekin C (2006) Mathematical modeling of thin layer drying of golden apples. J Food Eng 77:119-125

Omobuwajo OT, Akande AE, Sanni AL (1999) Selected physical, mechanical and aerodynamic properties African breadfruit (Treculia Africana) seeds. J Food Eng 40:241-244

Ozbek B, Dadali G (2007) Thin-layer drying characteristics and modelling of mint leaves undergoing microwave treatment. J Food Eng 83:541-549

Roa MA, Rizvi Syed SH, Datta AK, Ahmed J (2005) Engineering properties of foods. CRC Press, USA

Rauha JP, Remes S, Heinonen M, Hopia A, Kahkonen M (2000) Antimicrobial effects of Finnish plant extracts containing flavonoids and other phenolic compounds. Intl. J Food Microbiol 25: 3-12

Rodrigues S, Fernandes FAN (2007) Dehydration of melons in a ternary system followed by air-drying. J Food Eng 80:678-687

Sacilik K, Elicin AK (2006) The thin layer drying characteristics of organic apple slices. J Food Eng 73:281-289

Saeed IE, Sopian K, Zainol Abidin Z (2006) Drying kinetics of Roselle (*Hibiscus sabdariffa* L.): dried in constant temperature and humidity chamber.Proc. SPS 2006. Edited by Muchtar. 29th-30th August. Permata, Bangi S D E, Malaysia 143-148

Saravacos GD, Charm SE (1962) A study of the mechanism of fruit and vegetable dehydration. Food Technol16:78-81

Schmidt H, Vittrup Christensen J,Watkins R, Smith RA. (1995) Cherry descriptors. ECSC, EEC, EAEC, Brussels, Lux and Int Board. Plant Gen Res, Rome, Italy p:23

Shivhare US, Gupta A, Bawa AS, Gupta P (2000) Drying Characteristics and Product Quality of Okra. Dry Technol 18(1-2):409-419

Simal S, Femenia A, Garau MC, Rosella C (2005) Use of exponential, Page's and diffusional models to simulate the drying kinetics of kiwi fruit. J Food Eng 66(3):1-12

Simpson WT (1991) Dry Kiln Operator's Manual. Agriculture Handbook 188. Edited by Simpson, W.T. United State Department of Agriculture Wisconsin USA: 07-09

Singh RP, Heldman DR (1993) Introduction to food engineering. Academic. San Diego

Socaciu C (2008) Food colorants: chemical and functional properties. Washington, DC: Taylor & Francis: 169

Sun D, Woods JL (1994) Low-Temperature Moisture Transfer Characteristics of Barley: Thin-Layer Modelsand

Equilibrium Isotherms. J Agric Engg Res 59:273-283

Tabatabaeefar A (2002) Size and shape of potato tubers. Int Agrophys 16: 301-305

Tesoriere L, Mario A, Daniela B, Maria A, Livrea (2004) Absorption, excretion, and distribution of dietary antioxidant betalains in LDLs: potential health effects of betalains in humans. Am J Clin Nutr 80(4): 941-5

Topuz A, Topakci M, Canakci M, Akinci I, Ozdemir F (2004) Physical and nutritional properties of four orange varieties. J Food Eng 66:519-523

Upadhyay A, Sharma HK, Sarkar BC, (2008) Characterization and Dehydration Kinetics of Carrot Pomace, Agricultural Engineering International: The CIGR E journal. Manuscript FP 07 35(10):31-35

Wang J (2002) A single-layered model for far-infrared radiation drying of onion slices. Dry Technol 20(10):1941-1953

Wang Z, Sun J, Liao X, Chen F, Zhao G, Wu J, Hu X (2007) Mathematical modeling on hot air drying of thin layer apple pomace. Food Res Int 40:39-46

Yaldiz O, Ertekin C, Uzun HI (2001) Mathematical modeling of thin layer solar drying of Sultana grapes. Energy 26(5):457-465

(Manuscript Receivd : 30.10.2013; Accepted :07.03.2014)