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Studies on Insect Pests of Malvaceous Medicinal Plants, *Abelmoschus* Spp Under Southern West Bengal Condition

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Abstract

Species of insect pests that injured the Muskdana, *Abelmoschus moschatus* (L.) and Aibaika or Bele, *Abelmoschus manihot* were investigated in a field at Kalyani, West Bengal during 2012 and 2013. The total insect pests recorded at Kalyani on Muskdana attained twelve species. They belong to three insect Orders viz., Lepidoptera (four species), Hemiptera (five species) and Coleoptera (three species). One mite species *Tetranychus urticae* (Tetranychidae: Prostigmata) was also recorded. Among these, leaf roller *Sylepta derogate* during vegetative stage and *Earias vitella*, *Dysdercus koenigii* and *Mylabris pastulata* during reproductive stage caused substantial damage to *Abelmoschus* spp. One pyrrhocoid bug *Antilochus coquebert* (Fab.) (Heteroptera: Pyrrhocoridae) was found to prey upon *Dysdercus koenigii*.

Key words: *Abelmoschus,* insect pest, seasonal, incidence, damage

Introduction

India's use of plants in traditional systems of medicines such as Ayurveda, Siddha, Unani and Folk (tribal) medicines dates back close to 5000 years. And traditional medicaments are now yielding their secrets and finding important roles in modern medicine. For the steady supply of raw materials for pharmaceuticals and herbal medicine, and also to conserve the natural population of endangered plant species in natural habitat, the cultivation of medicinal plants has been practiced nowadays. Like other agricultural crops, medicinal plants are subject to attack by insect pests. To identify the pest management problems, the records of incidence of different insect pests on different medicinal plants are very much necessary. During March, 2012 to July, 2013, studies have been made on insect pests of two important malvaceous medicinal plants in the medicinal plant garden of AICRP on Medicinal and Aromatic Plants & Betelvine at Kalyani, Nadia, West Bengal. These plants are Muskdana *Abelmoschus moschatus* (L.) Medik. and Aibaika or Bele *Abelmoschus manihot* Medik.

Materials and Methods

Recording and accounting the seasonality and biology of lepidopteran pests of the above mentioned medicinal plants as well as damage cause by them have been studied. The laboratory experiments were carried out in the Medicinal and Aromatic Plant Research Laboratory at Kalyani of Bidhan Chandra Krishi Viswavidyalaya, Nadia, and West Bengal. Pre-soaked seeds of Aibika or Bele, *Abelmoschus manihot* were sown with a spacing of 60 cm. in both ways. The seeds were sown in 29th March, 2012. Normal agronomic practices were followed like weeding, irrigation as and when required. Only oilcake was used as manure. No chemical fertilizer and pesticide was applied during the crop growth stage.

Some seeds of crop were also planted in earthen pots to study the biology of different insects in the laboratory. In the laboratory, the plants were kept in open space and maintained. First instar larvae of lepidopteran insect pests were collected from the field, and after that the larvae were provided with the leaves of host plant and kept in the petri-dish individually. Every day the fresh leaves were given. The observation were taken daily on the duration of different immature stages, as well on the morphology of different stages. In the laboratory larvae were allowed for pupation separately. After pupa is formed, they were kept in glass jar for adult rearing. The longevity of adults was observed by keeping the freshly emerged adults in large glass jar. Different stages were observed under stereo-microscope and external morphological characters were studied and measurements were taken from both freshly killed and preserved specimens. The measurement of feeding of flea beetle has also been noted in the laboratory. The adult beetle were collected from the field and kept in the large glass jar. Every day the fresh leaves were given. The observations of measurement of feeding were taken daily.

In the field, direct observations were made on seasonal occurrence, feeding, nature and symptoms of damage and other behaviours of the insects.

Results and Discussion

Insect and mite pests of Abelmoschus moschatus and A. manihot

During the study period the following insect and mite pests were recorded on both the species of *Abelmoschus*. Among them four from Lepidoptera i.e. Cotton Leaf roller, *Sylepta derogata* (Family: Pyralidae), Cotton green semilooper, *Anomis flava* (Noctuidae), Spotted bollworm, *Earias vittella* (Fab.) (Noctuidae), Unidentified semilooper (Noctuidae), three from Coleoptera i.e.Flea beetle, *Podagrica* sp. (Chrysomelidae), Grey weevil, *Myllocerus discolor* (Curculionidae), Blister beetle, *Mylabris pastulata* **(Meloidae),** three from Hemiptera i.e. *Aphis gossypii* (Aphididae), Mealybug, *Phenococcus solenopsis* (Pseudococcidae), Red cotton bug, *Dysdercus koenigii* (Pyrrhocoridae) and one from Acarina i.e. *Tetranychus urticae* (Tetranychidae: Prostigmata). Besides these, whitefly *Bemisia tabaci* (Aleurodidae: Hemiptera) and jassid *Amrasca sp.* (Cicadellidae: Hemiptera) were also found on these two malvaceous plants. Incidence and faunistic composition of insect pests of *Abelmoschus moschatus* and *A. manihot* at Kalyani were found more or less same. The above listed insect pests also occur in other related economic crops like bhendi (*A. esculenta*) and cotton (*Gossypium* spp.). *A. esculenta* belongs to same genus and cotton to the same family. It is quite obvious, that there might be some similarity in the insect pests. The detail study on the above insects with regard to their seasonality, behaviour and biology were done. These are described here under.

Cotton Leaf roller, Sylepta derogata F. (Pyralidae: Lepidoptera):

Larva: The larvae are shiny green in colour and more or less transparent. One black spot on dorso-lateral (both side) position on the prothorax. Head is shiny black in colour. One pair long setae present on the posterior region of the body. Body is with simple sitae of various lengths over the head and trunk region. Both basal and distal part of the setae is whitish. Spiracles are present on the prothorax and abdominal segments 1-8. Prothoracic shield is shiny black in colour and sclerotization is complete but divided at middle**.** Thoracic legs are black. They become pinkish before pupation. Fully-grown larva measures 22-30 mm. The larval period was 15-18 days. Before pupation it becomes pinkish.

Pupa: Stout, reddish brown in colour, 16-17 mm in length, obtect type. Pupation takes place mostly on the folded leaves but sometimes in fallen leaves on the ground. Prepupal and Pupal periods were 2-3 days and 7-8 days respectively.

Adult: Moth is medium sized yellowish with both the fore and hind wings having series of brown wavy or zigzag lines markings, abdomen is whitish in colour, 12.5 mm long and wing span 25mm. Head and thorax are dotted black. Adult longevity was 10-12 days.

Nature and Symptoms of Damage in Abelmoschus moschatus

The larvae feed on the lower surface of leaves when they are young and as they grow, they feed on the edges of leaves and cut a part of the leaf up to the midrib and roll inwards and fastened by means of silken thread into a trumpet or conical shape roll which is seen hanging from the main leaf. The larvae feed on the leaves from within the rolls. More than one caterpillar may be found in a single leaf roll initially with faecal materials inside the folds, but later they disperse and attack more and more leaves. Major portion of an attacked leaf is eaten up entirely and in the .remaining portion it eats by creating big holes. Severe infestation results in complete defoliation of the plant. Leaves at the bottoms of the canopy show symptoms at low infestation levels. Defoliation of the whole plant is seen under severe infestations. Infestations spread to neighbouring plants and hence the symptoms of the pests are patchy. Bhagat (2003) reported that cotton leaf roller attacked at vegetative and flowering stage of *A. moschatus* in Jammu and Kahsmir, India. Yadav *et al*. (2005) conducted an experiment on the seasonal incidence of *S. derogata* on *A. moschata* in Jabalpur, Madhya Pradesh, India. Misra *et al*. (1995) recorded the *E. vittella* on *A. moschatus* in Lucknow, India.

Cotton green semilooper, Anomis flava F. (Noctuidae: Lepidoptera):

Larva: The larva is a semilooper with three pairs of prolegs on the 5th, 6th and 10th abdominal segments Full grown larvae are long, slender pale green with five white lines running longitudinally on the dorsal surface and six pairs of prominent light yellowish spots on the back. The young larvae feed on the leaf making small holes on it. The grown up larvae feed voraciously leaving only midrib and veins.

Adult: The moth is light reddish brown with forewings slightly speckled with red and traversed by two dark zigzag bands, hind wings are pale brown**.** The pest was not found serious in this locality on *Abelmoschus* spp.

A. flava is a polyphagous pest. Larval host plants of *A. flava* include cotton, okra, *Abutilon*, tomato (Anonymous, 1978) and *A. moschatus* (Mehta *et al*., 2008). *A. flava* is one of the most widely distributed species in the world. It is known to occur in Africa, Asia and Australia (Deguine, 1991); Southeast Asia (Waterhouse, 1998).

Flea beetle, Podagrica sp. (Chrysomelidae: Coleoptera):

One flea beetle species, *Podagrica* sp. was found feeding on leaves. They (adults) feed on leaves creating many, small holes and as a consequence, reduce the photosynthetic area of the plant. The damage was found severe. The adult beetles are about 4 mm long, head and thorax are brownish orange and elytra being shinny black and can be found mostly on upper side of the leaves. They also found mating on leaf surface. Five wild beetles were given fresh leaves of *A. moschatus* every day to record their daily food consumption. In Table 1 the daily consumption for consecutive eight days were given. On an average 22 – 37.68 mm^2 leaf area were consumed by one adult per day. In Himachal Pradesh, Mehta *et al*. (2008) observed flea beetle, (*Podagrica bowringi*) attacking musk mallow, *A. moschatus*. *P. basselae* Bryant and *P. obliterate* Jac. are important pests of aibica (*A. manihot*) in Paua New Guinea (Dori, 1998). In West Bengal, Pandit and Chakravorty (1985) recorded *Nisotra* (=*Podagrica*) *orbiculata* on mesta (*Hibiscuss sabdariffa*). Two Chrysomelids viz., *Podagrica sjostedti* and *Podagrica uniformis* are important pests of *A. esculenta* in African countries. These two species of *Podagrica* have been observed to commence their infestation on okra plants from the stage of germination throughout all stages of its growth. (Van Epenhuijsen, 1974 ; Osisanya and Tayo, 1981).

Grey weevil, Myllocerus discolor (Curculionidae: Coleoptera):

Adult is brown with grey and white spots on elytra. The adult weevils feed on the foliage. They nibble the leaf from the margin and also eat away patches creating small to medium holes on the leaf lamina. In early stage of the plant, this insect can cause severe damage with a population of two insects per plant and thus checking the growth of the plant.

Cotton aphid, Aphis gossypii (Aphididae: Hemiptera):

A. gossypii was found attacking both the upper and lower surfaces of leaf. *A. gossypii* is distributed throughout the world and it is a polyphagous pest of a wide range of crops. (Petrovic-Obradovic *et al.*, 2005). It is a common pest of cotton. Bhagat (2003) reported that cotton aphid attacked at seedling and vegetative stage of *A. moschatus* in Jammu and Kahsmir, India.

Two spotted Mite, Tetranychus urticae (Tetranychidae: Prostigmata):

The mite was found on lower surfaces of leaf. The occurrence of the mite was sporadic in nature. It is also a polyphagous pest and known to attack a wide range of vegetable and field crops**.** The damage occurred in dry season. The mite form colonies breed and feed on the underside of the leaves.

Mealybug, Phenococcus solenopsis (Pseudococcidae: Hemiptera):

The mealy bug attacked the leaves and stems of these plants. The occurrence of this sucking pest was sporadic in nature. However in old plant some plants were severely infested. The whole apical stems, leaf petiole were covered by the colony of *P. solenopsis*. The young flower buds were also infested. The mealybug *P. solenopsis* has a wide geographical distribution (Fuchs *et al*. 1991; Williams and Granara de Willink, 1992) *P. Solenopsis* has been described as a serious and invasive pest of cotton in Pakistan and India (Hodgson *et al*., 2008) and on *Hibiscus rosa-sinensis* in Nigeria (Akintola and Ande, 2008). Latest report on the invasiveness of *P. solenopsis* has been from the Eastern region of Sri Lanka (Prishanthini and Laxmi, 2009) on ornamentals, vegetable crops, and weeds, and in China (Wang *et al*., 2009; Wu and Zhang, 2009) on cotton.

Blister beetle, Mylabris pastulata (Meloidae: Coleoptera):

The large blister beetle was found to feed voraciously on the corolla of flowers. They also damaged style and stamen of the flower severely affecting the fruit setting. During peak flowering stage, most of the flowers of *Abelmoschus moschatus* and *A. manihot* present in the field were damaged by this beetle. When open flower was not present, they also fed unopen flower bud.

Fruit borer, spotted bollworm Earias vittella (Fab.) (Noctuidae: Lepidoptera):

After fruit setting, the single insect, spotted bollworms *Earias vittella* was the limiting factor for fruit and seed production. The larva is blackish with irregular white spots on dorsum; a number of small fleshy projections (scoli) are present on the body. The insect bored into the young and maturing fruits and fed on the inner content including seeds. If mature fruit is bored by the early instar larva, the late larva was found to feed on the dry seeds within the dry fruit. The fruits of *A. manihot* were heavily infested much (35%). The insect pupate within the damaged fruit in cocoon. The pupa is reddish brown. *E. vittella* is a polyphagous pest. The larval host plants of *E. vitella* include okra (*Abelmoschus esculantus* L), cotton (*Gossypium hirsutum* L.), china rose (*Hibiscus rosa-sinensis* L), *Abutilon indicum* G. Den. (Syed *et al*., 2011) and *A. moschatus* (Misra *et al*., 1995; Bhagat, 2003; Yadav *et al*., 2009). Raut and Sonone (1979) screened one wild accession of *A. manihot* with 25 okra varieties for resistance to shoot and fruit damage by *E. vittella*. Shoots of *A. manihot* were immune to

TABLE 1. Daily food consumption by the adult of flea beetle (*Podagrica* spp.) (Sq. mm)

Beetle No.	1st day	2nd day	3rd day	4th day	5th day	6th day	7th day	8th day	Average (per day) (Sq. mm)
B 1	24.5	2	27	39.5	8.5	25	3	46.5	**22**
B 2	28	26.5	X	31	12.5	29	34	21	**22.75**
B 3	32	6	X	71	21	32	23	14	**24.87**
B 4	19.5	37	3.5	102	36.5	28.5	18.5	56	**37.68**
B 5	20	30	11	60.5	X	33.5	15	20.5	**23.81**

attack by *E. vittella* on shoot, but fruits were highly susceptible.

Red cotton bug, Dysdercus koenigii (Pyrrhocoridae: Hemiptera):

The nymphs and adults of *Dysdercus koenigii* (Pyrrhocoridae: Hemiptera) were found to suck the sap from developing and mature fruits. During vegetative stage of the plant, a few bugs were also seen on the plants. They were found in mass in the fruit and in mating condition. As the seed is important product of *Abelmoschus moschatus*, this pest may be considered as an important pest. *Dysdercus* spp are polyphagous pests. Saha and Mukhopadhyay (1993) recorded D. *koenigii* on four natural host seeds, *A. esculentus*, *Gossypium hirsutum*, *Hibiscus cannabinus* and *Bombax ceiba.* The muskdana *A. moschatus* also harbours *D. koenigii* (Bhagat, 2003) and *D. cingulatus* (Yadav *et al*., 2005).

Pyrrhocoid bug, Antilochus coquebert (Fab.), promising predator of Dysdercus koenigii:

The Pyrrhocorid Cotton stainers (*Dysdercus cingulatus* and *D. cingulatus*) are important insect pests of cotton plants and bhindi. At Kalyani *Dysdercus koenigii* was recorded on *Abelmoschus moschatus* and *A. manihot*. A pyrrhocoid bug *Antilochus coquebert* (Fab.) (Heteroptera: Pyrrhocoridae) was found to prey upon *Dysdercus koenigii*. The bug is very bright in colour and resembling *Dysdercus* spp. The size is same or slightly larger, the abdomen is broader and the rostrum is smaller than those of that its victim.

Seasonal occurrence of insect and mite pests of Abelmoschus spp. (A. moschatus & A. manihot):

During vegetative stage, defoliator insects namely leaf roller *Sylepta derogata*, cotton semilooper *Anomis flava*, flea beetle *Podagrica* sp. and grey weevil, *Myllocerus discolor* caused substancial damage to the crops. Among these, grey weevil *Myllocerus discolor* can check early growth of plants if early vegetavive stages are attacked. Leaf roller *Sylepta derogata* occurred during July-Nov with high populations and seriously damage the crops. And sucking pests like aphid *Aphis gossypii,* mealybug *Phenococcus solenopsis*, jassid, *Amrasca* sp. and mite species *Tetranychus urticae* were found attacking *Abelmoschus* spp. at Kalyani. These insects and mite were sporadic in nature. During reproductive stage, fruit borer *Earias vitella* and red cotton bug *Dysdercus koenigii* were found to damage fruits, and blister beetle *Mylabris pastulata* to damage flowers. These three insects were found very important and directly hampered the production of fruits and seeds (Table 2).

Conclusion

The works on the insect pests of malvacious medicinal plants are meager, so, the database on pests of these plants is also weak. The nature of interactions between medicinal plants and their insect herbivores are not completely known. This is urgent for formulation of specific pest control strategies in medicinal plants. For production of *A. moschatus* and *A. manihot*, the limiting insect pests factors are leaf roller *Sylepta derogate* during vegetative stage and *Earias vitella*, *Dysdercus koenigii* and *Mylabris pastulata* in reproductive stage.

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Table 2. Seasonal occurrence of different insect and mite pests of *Abelmoschus* spp. (*A. moschatus* & *A. manihot*)

Name of Insects and mite		Period of occurrence			Remarks (Importance at Kalyani)
Common name	Scientific Name	Crop stage	Months	Peak Period	
Jassid	*Amrasca* sp.	EV-V	May-Aug	June	
Cotton Aphid	*Aphis gossypii*	Fl- F-M	Oct- Dec	Nov	
Mite	*Tetranychus urticae*	V	July- Sept	August	
Mealybug	*Phenococcus solenopsis*	V- F	May- Dec	October	
Cotton Leaf roller	*Sylepta derogata*	V- F	July-Nov	Sept- Oct	**havoc damage,Max. Popln. 10 larvae plant
Cotton semilooper	*Anomis flava*	V- F	July-Oct	Sept	
Unknown semilooper	Noctuidae	V- F	July-Oct	Sept	
Leaf Beetle	*Podagrica* sp.	V- Early Fl	Aug –Oct	August	
Grey weevil	*Myllocerus discolor*	EV- V- Fl	May- Oct	May	*Check early growth of plants(1/pl)
Cottan bug	*Dysdercus koenigii*	V- Fl- F- M	Aug –Jan	Dec	**Important as seeds are damaged, (Max= 3/pl)
Blister beetle	*Mylabris pastulata*	Fl- F	Oct- Dec	Nov-Dec	*Lower the fruit setting (Max=2/plant)
Spotted boll worm	*Earias vittella*	Fl- F-M	Nov- Jan	Dec	**All seeds are damaged in an infested fruit (about cumulative 35% fruits damaged in *A. manihot*)

V= vegetative, EV= Early vegetative, Fl= Flowering, F= Fruiting, M= Fruit Maturing

* = important, ** = very important and needs control

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Production, Consumption, Marketing and Constraints in Rice Cultivation in Kaimur District of Bihar

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Abstract

Kaimur district of Bihar was the bowl of Rice and hence a study was done to know the contribution of its economy in the district as well as its impact on farmers' income. Various secondary from the district and primary data from farmers were collected and analyzed. Farmers lost their income more than 80 crores due to non-procurement of total marketed surplus of Rice (in paddy form, Grade-B)) at support price Rs. 1410/Qtl., declared by Govt. of India for the year 2015-16. APMC, and e-NAM could help for better income from paddy marketing on village level in the district.

Keywords : Production, Consumption, Marketed surplus, Marketing channel and place and Constraints.

Introduction

Kaimur district of Bihar was the bowel of fine rice and non –fine rice due to irrigation supported by canal with lower taxation of Rs.88 per acre and marketing supported by different agencies such as Food Corporation of India (FCI), State Food Corporation (SFC), Bihar, Primary Agricultural Credit Society (PACS), Rice millers, Wholesalers and Local traders etc. from time to time. In Kaimur district, 33.78% area (80678 acre) was covered by fine rice followed by non- fine rice, mostly MTU-7029/Nati Mansuri 69% (181471 acre) in total rice production area 262149 acre on the basis of mean data of six years (from 2010-11 to 2015-16). 31% fine rice area contributed 23.19% production (129550718 Kg.) while non-fine rice contributed 429019387 Kg (76.81%) with 69.22% area in total district production 558570105 Kg. Average fine rice productivity was 1592 Kg/ha and 2358 Kg/ha in non-fine rice while as a whole productivity was calculated 2123 Kg/ha in Kaimur district in the year 2015-16 (Source: District Agriculture Office, Kaimur, Analyzed by researcher). Sometimes bonus on procurement was given by Bihar Govt. Subsidy on diesel purchasing for irrigation was also given to famers. There were no APMC, e-markets (e-mandis) in the district.

The specific objectives of the study were as followed.

1. To examine the status of production, consumption and marketing in the district.

2. To know the marketing channels and place for paddy and Rice in the district and study area.

3. To estimate the profit and loss for marketing of Rice in the district.

4. To analyze the constraints faced by farmers.

5. To suggest the policy makers for farmers' welfare.

Materials and Methods

Primary and secondary data were collected to achieve the objectives. Primary data were collected from sampled farmers interviewing them personally by the researcher with pre-tested/ pre-structured schedules during the crop year 2015-16. Secondary data were collected from District Statistics Office, Kaimur, District Agriculture Office, Kaimur and District Cooperative Office, Kaimur. Two villages – Mokari and Betari at Bhabua block and two villages - Parauti as well as Kaser villages at Bhagwanpur block, Daharak and Deohalia from Ramgarh block, Bharkhar, Ahinaura at Mohania block and Nathopur, Dihra villages at Kura were selected randomly. Thus 10 villages were taken under study. Thereafter, 20 farmers from each selected village were taken randomly in the sample for detailed survey and thus 200 farmers (Rice growers) were selected. Over and above two sub-divisions, 05 blocks, 10 villages and 200 farmers were included in the sample for detailed investigation. Apart from that 5 Wholesalers, 5 Rice millers, 5 Brokers and 10 Retailers were surveyed primarily.

Tools of Analysis:

Production = (Consumption for food + Wage payment +Marketed surplus)

Mean data of production was used. 6 years production data (from 2010-11 to 2015-16) from District Agriculture Office, Kaimur and two years data from District Statistics Office, Kaimur were collected which were available for only Paddy (Grade-B). Mean data of Paddy (Grade-A) was calculated on the basis of primary data.

Consumption for food = Production – (Marketed surplus + Wage payment)

Marketed surplus = Production – (Consumption for food + Wage payment)

Value/Income = Quantity □Rate

Results and Discussion

In Kaimur district, there were 38450 (35%) marginal farmers (who had less than 1 ha cultivable land), 34042 (31%) small farmers (who had cultivable land 1-2 ha) and 37550 (34%) large farmers (who had more than 2 ha cultivable land) and thus total farmers were found 110042 (100%) as per available data analyzed and estimated. Table 1 revealed that out of total paddy production 558570105 Kg, 1503564419 Kg (26.92%) paddy was utilized for food consumption, 37550000 Kg. (6.72%) used for wage payment and balance quantity 370663664 Kg. (66.36%) was marketed surplus for marketing.

Table 1 also indicated that all size groups of farmer prioritized their paddy production to utilize in consumption, payment for wage and last for marketing. We found that marginal farmers consumed their produced paddy in food only and they had no surplus paddy for labor payment and marketing according to their food quantity as per calorie requirement. Small farmers had surplus paddy for marketing but not for wage payment. Total marketed surplus was 11608251 Kg by small farm size group whereas 359055413Kg

TABLE 1. Production, consumption and marketed Surplus of rice (paddy form) in different groups (farm size) in Kaimur district (2015-16)

Category of farmers	Production (Kg.)	Food consumption (Kg.)	Wage as a payment (Kg.)	Marketed surplus (Kg.)	Remarks
Marginal	34406041 (06.16)	34406041	0	0	Base for food consumption:
Small	52458651 (9.39)	40850400	0	11608251	Random sampling 200 families, 153
Large	471705413 (84.45)	75100000	37550000	359055413	gram rice per capita per family per day
Total	**558570105 (100)**	**1503564419 (26.92)**	**37550000 (6.72)**	**370663664 (66.36)**	(Avg. 5 members/ family), Total district population approx. 16 lakh (Census 2011)

Source : Estimated/ Calculated by researcher, (Figures in parenthesis showed percentage in round) by large farmers. No fine rice was distributed as wage by small and large farmers except non-fine rice.

Rice Marketing and Income realization in Kaimur district

Table 2 revealed that out of total marketed surplus of paddy 370663.67 Ton, 347181.02 Ton (93.66%) was found only Grade-B (MTU-7029) and balance Grade-A 23482.65 Ton (6.34%). PACS (Primary Agricultural Credit Society) was the main source of paddy (non fine mainly Nati Mansuri/MTU-7029 under grade B). Out of total marketed surplus paddy Grade-B 347181.02 Ton, PACS procured 40.26% (124433.43 Ton) paddy from Panchayat level and Block level for the year 2015-16. Balance Grade-B and total Grade-A (246630.24 Ton) was sold/procured by other agencies rather than PACS. Producers (Farmers) could be gained income Rs. in 489.52crores if total paddy grade-B could be procured by PACS at the support price Rs. 14100/Ton but only value in Rs 147.45crores realized by procurement. Balance paddy Grade-B, 222747.59 (59.74%) sold farmers to Millers, Wholesalers and Retailers at the rate of Rs 11500/ Ton and therefore they were in a loss of Rs 57.91crores. Mostly surveyed farmers told that they had been gotten the value of Grade-B paddy at the rate of Rs 13000/Ton by PACS due to bag and bagging as well as transportation charges by PACS agents and thus they had lost Rs 13.69crores whereas cost of production was in a range between Rs 12000/Ton and Rs 13500/Ton. Total loss was calculated Rs 82.74crores for farmers. Grade-A paddy sale rate was found generally Rs 15000/ Ton except Govindbhog paddy whereas cost of production was calculated Rs 15000 to Rs 21000/ Ton. Cost of production of Govindbhog paddy was calculated Rs 25000 to Rs 28000/Ton whereas market rate was Rs 20000 to Rs 22000/Ton in the 2015-16. Calculation was done for Grade-A paddy at the average rate of Rs 18000/Ton including Govindbhog superfine and aromatic variety. Table 2 indicated that total value/income was found Rs 42.27crores by marketing of Grade-A fine paddy.

Marketing Channels of Paddy and Rice

Table 3 revealed that two main channels for paddy marketing were functioning in Kaimur district 1: Farmers (Producers) - Rice Millers/Wholesalers and 2: Farmers - PACS (Primary Agricultural Credit Society) - Rice Millers whereas main marketing channels for rice were 1: Millers – Brokers and 2: Millers - Wholesalers (Gola) –Retailers – Consumers. PACS purchased only paddy grade ‘B’ that was MTU - 7029 from farmers and supply to rice millers for processing with 67% rice recovery. Milling charge had been fixed Rs. 10 /Qtl of paddy by PACS in the year 2015-16. As per Marothia, Dinesh.K. et al.,(2007) who conducted a Case Study in Nagri Block of the Dhamtari District and Bilha Block of the Bilaspur District in Chhattisgarh, found that there were two main marketing channels, channel-I (Producers- traders/ shopkeepers) and channel- II (Producers- Millers). Zala Y.C. and Gondalia V.K., (2011) also found during the investigation that the most common marketing channel was” Producer’ wholesaler of paddy’ Rice miller’ wholesaler of rice’ Retailer’ Consumer”. Producer’s share in consumer’s price in paddy marketing was 66.25 per cent and price spread was 33.75 per cent in the middle Gujarat.

Export of Paddy and Rice from Kaimur district

Table 4 revealed that both the paddy and rice (fine and non-fine) were being exported within the state and outside the state with mode of transportation based on demand. Fine paddy like Sonam and Rupali were supplied to outside the state- Andhra Pradesh and Ahmadabad by truck whereas non-fine paddy MTU-7029 (Nati Mansuri) was marketed outside the state like Gujrat, Rajasthan, Karnataka, Andhra Pradesh and Chhattisgarh. Mode of transportation was train only for Karnataka and other states by truck. Direct truck could not reach to marketing place Rajamundari in Karnataka so that approx. 40 wagons paddy (var-Nati) were loaded at Varun railway station in Dehari (Bihar).Non-fine paddy like hybrid-6444 and others were supplied to Ranchi (Jharkhand) and Ahmadabad by truck. Non-fine rice of MTU-7029(Nati Mansuri) were marketed within the state for Gaya, Patna, Bhagalpur and Aurangabad whereas outside the state

Table 2. Marketed surplus and value realization through marketing of paddy by different agencies (2015-16)

S.No	Particulars	Fine (Grade-A)	Non-Fine/Coarse/ B-Grade (Mainly MTU-7029)	Total	Remarks
1	Total Marketed Paddy (in Ton)	23482.65 (6.34%)	347181.02 (93.66%)	370663.67 (100.00%)	Grade-A included- Govindbhog, R . Sweta, Sonam, Rupali and Krishna etc.
2	Rice form (Ton)	14089.58	208308.61	222398.19	60% Rice recovery from paddy
3.a	Value/Income of paddy (Rs. in crores) at Govt. procurement price	–	489.52	489.52	Govt. Procurement rate (Rs. 14100/Ton) for Grade-B, Cost of production (12000 13500/Ton)
3.b	Value/Income of paddy Grade-A (Rs. in crores) at market price by non-Govt. agencies)	42.27	–	42.27	Grade-A, Range (Rs. 15000-21000/Ton), Avg.Rs.18000/Ton
	Sub-total	42.27	489.52	531.79	
4	Procurement of paddy by Govt. (Ton)	-	124433.43	124433.43	Procured by PACS, Kaimur, 40.26%
5	Value/Income (Rs. in crores) procured paddy by Govt.	-	175.45	175.45	Procurement price (Rs.14100/Ton)
6	Balance paddy Grade-B (Ton) sold to other agencies (1-4) from threshing floor.	-	222747.59	256.16	Rs. 11000-12000/Ton, Avg. Rs. 11500/Ton, 59.74%
7	Farmers lost (Rs.in crores) based on Procurement rate 3.a – (5+6)	-	-	57.91	If balance paddy sold/ procured by Govt. @Rs.14100/Ton
8	Farmers lost Rs. crores (175.45-161.76) from Grade-B	-	-	13.69	Farmers gained @Rs.13000/Ton by PACS, based on survey
9	Farmers lost (Rs.in crores) due to non-received cost of production)	-	-	11.14	Grade-B paddy, minimum cost of production was Rs 12000/Ton
10.	Total loss (7-9)	-	-	82.74	

Source: Farmers', and PACS interview

TABLE 3. Marketing Channels of Paddy and Rice

Year: 2015-16

Channels	From	To
Paddy		
1.	Farmers (Producers)	Rice Millers/Wholesalers
2.	Farmers (Producers)	Local traders - Rice Millers/Wholesalers
3.	Farmers (Producers)	PACS (Primary Agricultural Credit Society) - Rice Millers
Rice		
1.	Farmers (Producers)	Rice Millers/Wholesalers (Gola) – Commission agents (Brokers)
2.	Rice Millers	Wholesalers (Gola) –Retailers – Consumers
3.	Rice Millers	Brokers
4.	Farmers (Producers)	Local traders (Retailer) - Consumers
5.	Rice Millers	BSFC (Bihar State Food Corporation) Ltd.under Food and Civil Supply Deptt.

Source: Farmers', Rice Millers', Brokers' and PACS interview

TABLE 4. Export of Paddy and Rice from Kaimur district

Particulars	Varieties	Within the state	Outside the state	Transported by
Paddy	Non-Fine 1.MTU-7029 (Nati Mansuri)	-	Gujarat, Rajasthan, Karnataka, Andhra Pradesh and Chhattisgarh	Truck, Train
	2.Hybrid 6444 and others	-	Gujarat (Ahmedabad) and Jharkhand (Ranchi)	Truck
	Fine Sonam, Rupal	-	Andhra Pradesh and Gujarat (Ahmedabad)	Truck
Rice	Non- Fine MTU-7029 (Nati Mansuri)	Gaya, Patna, Bhagalpur and Aurangabad.	Madhya Pradesh, Punjab, Haryana, Uttar Pradesh, Maharashtra and Gujarat.	Truck
	Fine 1. Govindbhog	Patna and Bhagalpur.	Bardhman (Kolkata)	Truck
	2.Krishna, Katarni		Andhra Pradesh	Truck
	3.Sonam, Sonachur	Darbhanga, Motihari, Madhubani, Samastipur, Teghra (Begusarai) and Mokama.	–	Truck

Source: Rice Millers'and Brokers' interview

Madhya Pradesh, Punjab, Haryana, Uttar Pradesh, Maharashtra and Gujarat by truck. Fine rice Govindbhog was supplied to almost Patna and Bhagalpur whereas 80 to 90% at Vardman in Kolkata. Other fine rice like Krishna and Katarni were marketed to Andhra Pradesh whereas Sonam and Sonachur were supplied to Darbhanga, Motihari, Madhubani, Samastipur, Teghra (Begusarai) and Mokama in the state as per information reflected in the table 4 in year 2015-16.

Marketing of paddy by sample households

Table 5 showed that out of 200 sampled farmers, maximum 58.50% (117 farmers) sold their paddy to millers/wholesalers followed by local traders 15% and PACS 14%. Mostly millers also were wholesalers in Kaimur district. 6% sampled large farmers were registered under Bihar Rajya Beej Nigam (BRBN) Kudra, they got quality seed from Nigam and produced total seed were purchased by Nigam with remunerative rate. 6.5% sampled farmers sold their paddy to millers as well as PACS in the year 2015-16.

Table 6 indicated that mostly sampled farmers were faced constraints with respect to marketing of fine rice. 88.00% farmers responded that they did not get remunerative price of their produce whereas 80.50% producers faced problems for selling marketable quantity and they were in a stress to sell their paddy at lower rate. There was no regulated market at all to control price and only 29.50% sampled farmers were satisfied with the present method of sale and purchase of produce prevailed in Kaimur district. Government did not procure Grade-A paddy

Table 5. Paddy sold to different agents by sample households: Year 2015-16

Agents	No. of household	Percentage
1.Millers/Wholesalers	117	58.50
2.Local traders	30	15.00
3.Rice Mill+ PACS	13	6.50
4.PACS	28	14.00
5.BRBN, Kudra	12	6.00
Total	**200**	**100.00**

Source: Households'survey

Table 6. Marketing constraints in rice for sampled 200 farmers (Year-2015-16)

Particulars	**Percentage of farmers responded**	
	Yes	**No**
Did they get remunerative price of your product?	12.00	88.00
Did they face problems regarding transportation?	38.50	62.50
Was there regulated market by APMC/other agency?	00.00	100.00
Did marketable quantity created any problems in selling their product?	80.50	19.50
Were there sufficient No. of buyers of your product?	34.50	65.50
Did they depend on middle-men for disposal/sale of their produce?	80.00	20.00
Were they satisfied with the present method of sale & purchase of produce prevailed in Kaimur district?	29.50	70.50
Was there any kind of malpractices prevailed for the marketing of fine rice?.	40.00	60.00
Did Govt. procure Grade-A (fine/medium fine) in the district	0.00	100.00
Had farmer storage facility to create time utility for better price?	8.50	91.50

Source: Households'survey

at all. Tiwari Kumar Sudhir and Singh P.K. (2015) also found that price information and communication, delayed payments, high cost of transportation and lack of storage facilities were the major problems faced by the rice producers in marketing of produce.

Conclusion

Marketing of surplus paddy is not sufficient to raise farmers' income in the Kaimur district of Bihar. Government must assure to procure the quantity of paddy as per farmers' desire because loss was occurred due to non- procurement of total marketed surplus of Grade-B paddy in 2015-16. Generally cost of production was found higher than prevailed market price. Quantity of paddy should not be restricted and Grade-A also must be procured by Govt. APMC, e-market and e- NAM should be promoted on village basis so that farmers can achieve better price from paddy**.** *Reddy Amarender A (2016), also found positive impact in his study that in Karnataka there was 128% increase in average prices* in e-markets compared to only 88% in non-e-markets for groundnut between 2007 and 2015.Farmers of sampled households were also suggested to change their cropping pattern or reduce paddy area and to increase sugarcane area in canal belt. Over supply of paddy on demand created lower price in marketing.

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Evaluation of IPM Models in Managing Stem Borer and Leaf Folder of Rice and Aphid of Mustard

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Abstract

Rice and mustard are the most important field crops of West Bengal. Both the crops suffer a lot due to infestation of biotic stress; thus both are exposed to pesticide load in havoc. Aim was given to evaluate the IPM models against stem borer and leaf folder of rice and mustard aphid. Evaluated result showed that IPM field was recorded as most significant pest management option for the fore said crops in managing the fore said insects. In rice, IPM was found superior over other treatments in respect of all the parameters recorded in both of the year viz. dead heart (3.25% and 2.50%), white ear head incidence (3.33% and 2.75%), hibernating larvae of stem borer per stubble (1.38 and 1.10 nos.), infested leaf by leaf folder larvae (2.15 and 2.45 nos.), leaf folder larvae per hill (2.15 and 2.75 nos.). Grain yield was also recorded highest (3.86 and 4.25 t/ha) with highest benefit cost ratio (1.50 and 1.98). In similar way in case of mustard the per cent aphid infestation and nos. of aphid per 10 cm shoot during 2015-16 and 2016-17 was 10.5% and 11.9 nos., 5.25% and 3.50 nos. respectively followed by technology option II (sowing of mustard seeds in 2nd week of November and installation of yellow sticky traps @ 25/ha at 30 DAS). Field under IPM yielded maximum seed yield (11.1 q and 11.09 q per ha). Installation of yellow sticky trap along with seed sowing within 2nd week of november documented 63.68% and 80.84% less infestation of aphid (per 10 cm shoot) over farmers practice. Seed sown within 2nd week of november recorded 1.14 q and 1.06 q increased yield over late sown crop during 2nd or 3rd week of December and onwards.

Key words: Aphid, IPM, Leaf folder, Mustard, Rice, Stem borer

Introduction

Rice is the main staple food and contributed major share in food security. Rice cultivation is the principal activity and source of income for more than 100 million households in developing countries in Asia, Africa and Latin America. On the other hand mustard is the main oilseed crop widely cultivated throughout the globe. Cultivation of these two crops are though age old practice but due to climate change and global warming issues a pattern shift of biotic stress been occurred. Herbivorous insects are said to be responsible for destroying one fifth of the world's total crop production annually. Several species of insect pest been reported to infest rice and mustard and thereby limiting the production. About 128 species of insects have been addressed to wreak havoc on the rice field of which only 15 to 20 insect are regarded as economically obnoxious species (Kalode 2005). Stem borers (SBs) and leaf folder (in recent days) are an important group of insect pests of rice. Among the borers, yellow stem borer (YSB), *Scirpophaga incertulas* Walker (Lepidoptera: Pyralidae), distributed all over India, is considered as the most destructive species (Ooi *et al.* 1994). YRSB shares about 89.50% of the total borer population in the northern parts of West Bengal (Biswas, 2006). On the other hand among the various production restrictions of mustard, incidence of insect pests are the major limiting factors responsible for low yield. In India about 43 insect species have been recorded infesting this crop (Khan *et al.* 2013) and among these mustard aphid *Lipaphis erysimi Kalt.* is the most important one contributing 9 to 96% yield loss (Singh and Sharma, 2002) and 15% oil reduction (Verma and Singh, 1987).

Global population is increasing in a rapid rate whereas the cultivable area is decreasing day by day. To feed the huge population vertical expansion of agriculture is being followed. Use of key agricultural inputs like chemical fertilizer, pesticides brings a tremendous revolution in world agriculture (Anonymous, 1996; Warren, 1998). None can deny the overwhelming impact of chemical pesticide in food security by managing the insect pest infestation. Webster *et al*. (1999) stated that "considerable economic losses" would be suffered without pesticide use and quantified the significant increases in yield and economic margin that result from pesticide use. But in recent days environmental as well as biological issues like soil and water pollution, residue, pest resistance, secondary pest outbreak and resurgence comes out (Howell *et al.* 1998; Murphy 2005). Non-target organisms can also be impacted by pesticides. In some cases, a pest insect that is controlled by a beneficial predator or parasite can flourish should an insecticide application kill both pest and beneficial populations. Considering the fact of both beneficial and hazardous impact of chemical pesticides attempt been made to reduce the load of pesticide by exploiting the available pest management resources which is being termed as Integrated Pest Management. The present author feels the urged to evaluate the IPM practices in rice and mustard in reducing the specific key pest found to be associated with the said crops.

Materials and Methods

Experiments being carried out in farmers field of different blocks of South 24 Parganas district of West Bengal during rabi season of 2015-16 and 2016-17. In case of rice (var. lalat) the yield attributing characters were considered along with infestation of yellow rice stem borer (*Scirpophaga incertulus*) and leaf folder (*Cnaphalocrosis medinalis*) influence by the treatments which comprises farmers practices (application of carbofuran 3 G, 10 round spray the crop with triazophos 40 EC @ 2.5 ml/lt, chlorpyriphos 50% + cypermethrin 5% EC 2 ml/lt, cypermethrin 25 EC @ 2 ml/lt in rotation or even in cocktail), technology option I (application of recommended dose of granular insecticides cartap hydrochloride 4 G @ 6 kg/acre in nursery bed & 4 round spray of new generation insecticides like chlorantraniliprole 18.5% SC @ 03 ml/lt and emamectin benzoate 5 SG @ 0.5 g/lt in rotation starting from 15 DAT at an interval of 15 days) and technology option-II (IPM: seed treatment with carbendazim 12% + mancozeb 63% WP, seedling root dip in carbendazim 12% + mancozeb 63% WP, application of chlorantraniliprole 0.4% GR @ 4kg/acre at 15-30 DAT, 2 rows skip transplanting after 10 rows, installation of scirpolure pheromone trap for yellow rice tem borer @ 12/ha, erection of bird percher and structure for spider population build up, need based spot application of fipronil @ 0.5 ml/l). On the other hand in case of mustard (var. B-9) we mull over the infestation of aphid (*L. erysimi*) (%), here also we adopted two technological intervention which comprises (technology option-I: seed sowing within 2nd week of november along with spraying the crop with oxydemeton-methyl 25 EC @ 2 ml/lit, technology option-II: sowing of mustard seeds in 2nd week of november and installation of yellow sticky traps @ 25/ha at 30 DAS; technology option-III: seed sowing within 2nd week of november, installation of yellow sticky traps @ 25/ha at 30 DAS + 2 round need based spraying the crop with acephate 75 SP @ 0.75 g/lt and thiametoxam 25 WG @ 0.2 g/lt) along with a farmers conventional practices (seed sowing at 2nd to 3rd week of December and onwards, spraying the crop with oxydemeton-methyl 25 EC @ 2 ml/lit).

Observation was taken on per cent infestation of dead heart, white ear head, mean leaf folder population per hill, mean hibernating larvae of stem borer per stubble, infested leaf by leaf folder per hill, no of active tiller, panicle length, grains per panicle, filled grain per panicle, 100 seed weight (seed index) and yield in paddy; whereas in mustard the mean per cent pest infestation along with aphid population per 10 cm shoot was enumerated. Collected data were subjected to analysis after necessary transformation (angular transformation for per cent data and square root transformation for numerical value) in randomised block design. Benefit cost ratio was also calculated to assess the feasibility of the technology.

Results and Discussion

It is obvious from the presented data that during 2015-16 and 2016-17 IPM was found as most useful technologies over conventional practice practiced by the farmers; even noted better result over sole use of new generation chemical treatment. The occurrence of dead heart infestation at vegetative stage, white ear head at reproductive stage, hibernating larvae per stubble, infested leaf by leaf folder per hill, leaf folder larvae per hill and active tiller per hill showed significant variation over the treatment evaluated in both experimental year (table 1,3). IPM plot was considered as most significant pest management option for rice stem borer and leaf folder. During 2015-16; 18.21% dead heart infestation, 22.15% white ear head occurrence, 8.33 nos. infested leaf by leaf folder larvae was recorded in farmers own practiced plot (local check), whereas, the infestation of the said parameters was only to the tune of 7.33%, 8.20% and 4.67 nos. in technology option-I (new generation chemical treatment) and 3.25%, 3.33% and 2.15 nos. respectively in IPM plots (technology option-II) recoded. The hibernating larvae of stem borer was also enumerated from the stubbles after harvesting the crop; it was found that only 1.38 nos. of hibernating larvae of stem borer were recorded per stubble in IPM, 5.25 nos. in chemical treatment and 13.42 nos. in local check. The larvae of leaf folder per hill (*Cnaphalocrocis medinalis*) was also lowest in IPM (2.15 nos.) followed by chemical treatment (3.75 nos.) and local check (5.60 nos.). It is prominent from the experimental result that the active tiller per hill was also recorded as highest in IPM field (19.21 nos.). The yield attributing characters like panicle length, number of grain per panicle, filled grains per panicle and seed index showed non significant variation over treatments. The grain yield was also recorded highest in IPM field (3.86 t/ha) (table-1). During the next experimental year (2016-17) similar trend was followed; IPM found to be superior over other treatments in respect of all the parameters recorded viz. dead heart (2.50%), white ear head incidence (2.75%), hibernating larvae of stem borer per stubble (1.10 nos.), infested leaf by leaf folder larvae (2.45 nos.), leaf folder larvae per hill (2.75 nos.) and active tiller (21.5 nos.); grain yield was also recorded as highest (4.25 t/ha). No significant variation was noted in yield attributing parameters though the values indicated higher trend in all the case except the seed weight, highest seed index was recorded in chemical management option (2.75 g). The treatment wise benefit cost ratio showed that IPM offers highest benefit (B:C as 1.50 and 1.98 respectively in both experimental year) over sole chemical treatment as well as of local check (table 2, 4).

Mustard:

The impact of IPM on green peach aphid (*L. erysimi*) population in mustard during the experimental work carried out is presented in table 5 and 6. It is apparent from the tabulated result that technology option III (IPM: seed sowing within 2nd week of november. installation of yellow sticky traps @ 25/ha at 30 DAS + 2 round spraying the crop with acephate 75 SP @ 0.75 g/lt and thiametoxam 25 WG @ 0.2 g/lt) recorded as best treatment and provided better profit over local check. Per cent aphid infestation and nos. of aphid per 10 cm shoot recorded during 2015-16 and 2016-17 was 10.50% and 11.9 nos., 5.25% and 3.50 nos. respectively followed by technology option II (sowing of mustard seeds in 2nd week of november and installation of yellow sticky traps @ 25/ha at 30 DAS) (15.25% and 29.60 nos., 9.50% and 12.50 nos. respectively) and technology option I (seed sowing within 2nd week of november along with spraying the crop with oxydemeton-methyl 25 EC @ 2 ml/lit) (17.50% and 42.25 nos., 19.25 and 39.75 nos. respectively); whereas in farmers conventional practices the per cent aphid infestation was to the tune of 39.50% and 38.50%; the aphid infestation per 10 cm shoot was also highest (81.5 nos. and 65.25 nos. respectively). Only adjusting the sowing time during 2nd week of november found very effective in reduction of aphid population (in respect of per 10 cm shoot); which was recorded to be 48.15% and 39.08% in both of the experimental year over farmers conventional practices. Installation of yellow sticky trap along with seed sowing within 2nd week of

Table 1. Effect of different treatments on stem borer, leaf folder and yield attributing characters of paddy in 2015-16

Technology options	No. of trials	Dead heart (%)	White ear head (%)	Stem borer (nos./ stubble)	Infested Leaf by leaf folder/ hill	Leaf folder larvae/ hill	No of active tiller/ hill	Panicle length (cm)	No. of grains / panicle	No of filled grain/ panicle	100 seed wt. (g)	Grain Yield (t/ha)
Farmers' practice	10	18.21 (25.18)	22.15 (28.04)	13.42 (3.66)	8.33 (2.88)	5.6 (2.36)	13.10 (3.61)	16.91 (4.11)	95.25 (9.75)	85.46 (9.24)	2.71 (1.64)	3.15 (1.77)
Technology Option-I		7.33 (15.68)	8.20 (16.64)	5.25 (2.29)	4.67 (2.16)	3.75 (1.93)	14.35 (3.78)	16.86 (4.10)	96.10 (9.80)	87.33 (9.34)	2.68 (1.63)	3.65 (1.91)
Technology Option-II		3.25 (10.30)	3.33 (10.47)	1.38 (1.17)	2.15 (1.46)	2.15 (1.46)	19.21 (4.38)	16.84 (4.10)	95.18 (9.75)	88.15 (9.38)	2.90 (1.70)	3.86 (1.96)
CD (P=0.05)		1.21	1.87	1.09	0.04	0.39	0.7	NS	NS	NS	NS	0.02

Table 2. Effect of different treatments on benefit cost ratio during 2015-16

Technology options	Cost of cultivation (Rs./ha)	Gross return (Rs./ha)	Net return (Rs./ha)	B:C. Ratio
Farmers' practice	33778.00	42000.00	8222.00	1.24
Technology Option-I	34278.00	48666.67	14388.67	1.41
Technology Option-II	34100.00	51466.67	17366.00	1.50

(*Selling price: Rs. 1333/- per quintal; figure in parenthesis in angular transformed value for per cent data and square root transformed value for numeric)

Table 3. Effect of different treatments on stem borer, leaf folder and yield attributing characters of paddy in 2016-17

Technology options	No. of trials	Dead heart (%)	White ear head (%)	Stem borer in stubble (nos./ hill)	Infested Leaf by leaf folder/ hill	Leaf folder larvae/ hill	No of active tiller/ hill	Panicle length (cm)	No. of grains / panicle	No of filled grain/ panicle	100 seed wt. (g)	Grain Yield (t/ha)
Farmers' practice	10	12.50 (20.70)	15.30 (23.03)	11.45 (3.38)	7.50 (2.73)	6.50 (2.54)	16.50 (4.06)	17.00 (4.12)	94.50 (9.72)	85.45 (9.24)	2.50 (1.58)	3.20 (1.78)
Technology Option-I		8.25 (16.74)	5.25 (13.31)	3.25 (1.80)	4.25 (2.06)	3.25 (1.80)	17.25 (4.15)	16.75 (4.09)	94.30 (9.71)	87.60 (9.35)	2.75 (1.65)	4.01 (2.00)
Technology Option-II		2.50 (9.10)	2.75 (9.63)	1.10 (1.04)	2.45 (1.56)	2.75 (1.65)	21.50 (4.63)	17.25 (4.15)	95.25 (9.75)	89.05 (9.43)	2.65 (1.62)	4.25 (2.06)
CD (*P*=0.05)		0.75	0.90	0.08	0.13	0.10	0.17	NS	NS	NS	NS	0.05

Table 4. Effect of different treatments on benefit cost ratio during 2016-17

Technology options	Cost of cultivation (Rs./ha)	Gross return (Rs./ha)	Net return (Rs./ha)	B:C. Ratio
Farmers' practice	32705.00	47680.00	14975.00	1.45
Technology Option-I	32800.00	59749.00	26949.00	1.82
Technology Option-II	31900.00	63325.00	31425.00	1.98

(*Selling price: Rs. 1490/- per quintal; figure in parenthesis in angular transformed value for per cent data and square root transformed value for numeric) november documented notable result even over sole chemical treatment with oxydemeton-methyl 25 EC; it was recorded that 63.68% and 80.84% less infestation of aphid (on the basis of per 10 cm shoot) was noted over local check. Field adopted under IPM yielded maximum seed yield (11.10 q and 11.09 q per ha) and B:C ratio (3.24 and 3.22) followed by technology option II (5.90 q and 6.75 q). Seed sown at 2nd week of november recorded 1.14 q and 1.06 q increased yield over late sown crop.

The concept of integrated pest management includes a threshold concept for the application of pest control measures and reduction in the amount/ frequency of pesticides applied to an economically and ecologically acceptable level. Being a holistic approach it is more environment and crop ecosystem friendly approach to combat pest problem. Satpathi *et al.* (2005) from the southern part of Bengal have reported substantial increase of grain production following the adoption of rice-IPM protocol. Chakraborty (2012) recorded less infestation of dead heat (%), white ear head (%), higher naturally occurring predators, maximum grain yield, highest net return by adopting IPM module in rice field is in support of the present authors report. The combine effect of the module is being inflected in the present output. It is well documented that skip row transplanting allows more penetration of light and ventilation rendering difficult to hide and propagate for the insects, application of ryanodine receptor blocker chlorantraniliprole at tillering stage prevent the infestation of stem borer and leaf folder, installation of pheromone trap for mass trapping of male adults during active tillering stage restrict the further infestation via reduction of fertilized egg laid, whereas erection of bird percher for intrusion of insectivorous bird and spider population build up structure erection allows to take care of the plant biologically. Need based spot application of new generation insecticides fipronil of phenylpyrazole chemical family restricted the perpetuation of the rest population.

In case of mustard the present result shows that early sowing of mustard within 2nd week of november along with installation of yellow sticky trap and need based spot application of neonicotinoids make the crop free from aphid infestation. As the aphid have a close positive relation with the temperature, adjustment of sowing date coinciding winter season with the flowering stage of mustard make the plant free from aphid infestation. Yellow sticky trap is a simple tools applied as physical control method for the aphid management pronounced huge catch of alate aphid for multiplication. As the mother aphid have the ability to reproduce both via parthenogenesis and viviparous it would be a great tool to attract the alate aphid to be trapped. Neonicotinoid spot application except clothianidin or acephate at recommended dose may take care of the crop without rendering pronounced effect on bees. Thus holistically the crop can be managed without giving major insecticide load to the environment. Singh *et al.* 2003 reported advantageous effect of integration of eco-friendly pest management strategies supported the outcomes of the present study. Studies on the efficacy on some biocontrol based IPM modules against the important insect pests of mustard were carried out by Nayak *et al.* (2014) reported similar result prescribed earlier, who reported that significantly lower incidence of mustard aphid, saw fly, painted bug and cabbage webber were observed in a IPM modules in comparison to the farmers' practice of scheduled based insecticide application.

Conclusion

IPM was the most efficient cost effective option rather to depend on sole chemical management. Being a holistic approach of pest management strategy it is environment safe. It is prominent from the detailed result that seed treatment with carbendazim 12% + mancozeb 63% WP, seedling root dip in carbendazim 12% + mancozeb 63% WP, application of chlorantraniliprole 0.4% GR @ 4 kg/acre at 15-30 DAT, 2 rows skip transplanting after 10 rows, installation of scirpolure pheromone trap for yellow rice tem borer @ 12/ha, erection of bird percher and structure for spider population build up, need based spot application of fipronil @ 0.5 ml/l can be the best model of pest management for rice. In case of mustard from the present result it can be concluded that sowing of mustard within 2nd week of november can reduce the

Table 5. Effect of different treatment modules on mustard aphid on mustard during 2015-16

Technology options	No. of trials	Aphid incidence (%)	No. of aphids/10 cm shoot	Yield (q/ha)	Cost of cultivation (Rs./ha)	Gross return (Rs./ha)	Net return (Rs./ha)	B:C. Ratio
Farmers' practice	7	39.50 (38.94)	81.5 (9.02)	8.95 (2.99)	9790.00	26850.00	17060.00	2.74
Technology option I		17.50 (24.73)	42.25 (6.50)	10.09 (3.17)	9790.00	30270.00	20480.00	3.09
Technology option II		15.25 (23.03)	29.60 (5.46)	10.20 (3.19)	9975.00	30600.00	20625.00	3.06
Technology option III		10.50 (18.91)	11.90 (3.44)	11.10 (3.33)	10250.00	33300.00	23050.00	3.24
CD (P=0.05)		0.97	1.23	0.115	-	-	-	-

Table 6. Effect of different treatment modules on mustard aphid on mustard during 2016-17

Technology options	No. of trials	Aphid incidence (%)	No. of aphids/10 cm shoot	Yield (q/ha)	Cost of cultivation (Rs./ha)	Gross return (Rs./ha)	Net return (Rs./ha)	B:C. Ratio
Farmers' practice	7	38.50 (38.35)	65.25 (8.77)	9.01 (3.00)	9840.00	27030.00	17190.00	2.74
Technology option I		19.25 (26.06)	39.75 (6.30)	10.07 (3.17)	9840.00	30210.00	20370.00	3.07
Technology option II		9.50 (17.95)	12.50 (3.53)	10.11 (3.17)	10020.00	30300.00	20280.00	3.02
Technology option III		5.25 (13.31)	3.50 (1.87)	11.09 (3.33)	10320.00	33270.00	22950.00	3.22
CD (P=0.05)		0.94	1.05	0.112	-	-	-	-

(*Selling price Rs. 30.00/- per kg; figure in parenthesis in angular transformed value for per cent data and square root transformed value for numeric) aphid population in substantial amount and its combination with installation of yellow sticky traps @ 25/ha at 30 DAS + 2 round need based spot spraying of acephate 75 SP @ 0.75 g/lt and thiametoxam 25 WG @ 0.2 g/lt will be best model for aphid management.

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Effect of Different Date of Sowing and Chickpea (*Cicer Arietinum* L.) Varieties in New Alluvial Zone of West Bengal

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Abstract

A field experiment was conducted during *rabi* season of 2015-16 and 2016-17 at the AB-Block Farm (Seed Farm) Bidhan Chandra Krishi Viswavidyalaya, Kalyani (22º99¹ North latitude and 88º42¹ East Longitude) to study on effect of different date of sowing and Chickpea (*Cicer arietinum* L.) varieties in new alluvial zone of West Bengal. The experiment was factorial Randomized Block Design with three date of sowing i.e. early (20th November), medium (5th December) and late (20th December) and seven different chickpea varieties i.e. ICCV-10, Rajas, Vaibhav, Avrodhi, GCP-105, Phule G-12 and RUSJK-4-102 replicated with three. The experimental soil was clay loam with pH 6.3. Early sown chickpea crop recorded maximum yield (1106.52 q/ha) over two years followed by second date of sowing (984.71 kg/ha) and minimum yield (885.19 q/ha) was recorded in late sown crop. Among the chickpea variety vaibhav gave significantly highest (1205.67 kg/ha) economic yield (grain yield) which was followed by avrodhi (1129.67 kg/ha). Minimum (816.55 kg/ha) grain yield was observed in GCP-105 which was statistically at par with Rajas (867.22 kg/ha). The increasing trend was also observed in Vaibhav variety from medium sown crop. In late sown conditions crop was under terminal heat stress, yet this variety performed well with maximum yield compare to other varieties. In rice fallow conditions of New Alluvial zone of West Bengal, these varieties are very much essential where rice is harvested in late and all late sown chickpea varieties does not performed well. Some varieties are performed well in terminal heat stress conditions.

Keywords : Chickpea, Sowing date, Varieties, Terminal heat stress, Yield

Introduction

Chickpea (*Cicer arietinum* L.) is an important and widely grown pulse crop in India since ancient time. Chickpea is popularly known as Bengal Gram or Chana or Gram in India. Chickpea is consumed as leafy vegetable, chana dal, flour (Besan) as well as fodder. Variety of snacks, sweets and dishes can be made out of chickpea flour. It contains around 25% proteins and 60% carbohydrates. Chickpea is broadly classified into two viz. Brown or Bengal gram and white or Kabuli gram. The Desi type chickpea contribute to around 80% and the Kabuli type around 20% of the total production. India is the largest producer of this pulse contributing to around 70% of the world's total production. In India, Chickpea production was 7170 thousand tons in 2015-16 whereas in 2013-14 it was 9530 thousand tones. For higher chickpea production and productivity location specific suitable variety are important besides this quality seed production. In West Bengal, a substantial amount of land remains fallow (11.59 lakh ha) after *kharif* rice (winter rice) cultivation. Chickpea production also fluctuates year to year because of adverse weather during crop season and recorded a sharp decline over years. In West Bengal chickpea was cultivated in an area of 155.1 thousand ha in 1970-71 with a productivity of 666 kg/ha which has come down to only 27.0 thousand ha with a productivity of 1185 kg/ha in 2014-15. In this context the experiment was conducted with six genotypes including four varieties released for the Eastern Region and two new genotypes for studying growth and yield performance in the rice fallow situation of gangetic new alluvial plains of West Bengal (Hedayetullah *et al.*, 2017).

Materials and Methods

A field experiment was conducted during *rabi* season of 2015-16 and 2016-17 at the AB-Block Farm (Seed Farm) Bidhan Chandra Krishi Viswavidyalaya, Kalyani (22º99¹ North latitude and 88º42¹ East Longitude) to study on effect of different date of sowing and Chickpea (*Cicer arietinum* L.) varieties in new alluvial zone of West Bengal. The experiment was factorial Randomized Block Design with three date of sowing i.e. early (20th November), medium (5th December) and late (20th December) and seven different chickpea varieties i.e. ICCV-10, Rajas, Vaibhav, Avrodhi, GCP-105, Phule G-12 and RUSJK-4-102 replicated with three. The experimental soil was clay loam with pH 6.3. Five plant samples were selected randomly from each plot under different treatments to determine the growth attributes like plant height, primary branch, secondary branch, pod per plant, number of seed per pod and yield at harvest. Plant height was recorded from the base above the ground to the tip of the stem at maturity. Number of primary and secondary branch was recorded by counting the total number of primary and secondary branch per plant. The seed yield of each plot was converted to yield ha^{-1} (Kg).

Results and Discussion

Plant height (cm)

Significantly highest plant height (50.62 cm) was observed in first date of sowing followed by second date of sowing (D_2) and minimum plant height was in third date of sowing (41.00 cm). Among the chickpea varieties highest plant height (48.65 cm) was attained avrodhi (V_4) followed by Rajas (48.17 cm) and minimum plant height was recorded in RUSJK-04-102 (43.21 cm). Significantly plant height at maturity was also varied from variety to variety). Chickpea crop is very much sensitive to weather. Late sown chickpea received short winter for their growth and subsequently height of plant showed minimum compare to the medium and early sown chickpea (Table-1).

Number of primary branch

The number of primary branch (PB) was observed maximum (2.17) in early sown chickpea crop followed by medium sown crop. Minimum number (1.70) of primary branch was recorded in late sown chickpea during pooled over two years i.e. 2015-16 and 2016-17. Vaibhav and GCP-105 varieties also recorded maximum number (2.06) of primary branch followed by Rajas (1.97). Chaitanya and Chandrika (2006) was also recoded similar primary branch (PB) number. The minimum primary branch (1.71) was observed in RUSJK-04-102 (Table 1).

Secondary branch

At early sown (D_1) chickpea crop recoded maximum number (4.10) of secondary branch (SB). The trend of decrease in number is same in other growth parameter also in date of sowing. Minimum secondary branch was observed in late sown chickpea (3.17) during 2015-16 and 2016-17 polled over two years. Among the variety avrodhi recoded maximum number of secondary branch (5.81) at maturity stage. Nagarajaiah *et al.* (2005) and Munirathnam *et al.*, 2013 also recorded 5 to 10 secondary branch at maturity stage. The minimum secondary branch (2.4) was recorded in RUSJK-04-102 variety at harvest (Table 1). Chaitanya and Chandrika (2006) was also recoded similar secondary branch (SB) number.

Pod per Plant

First date of sowing crop (D_1) recoded maximum pod per plant (18.66) which was followed by medium sown crop (16.85) and minimum pod per plant was recorded in D_3 treatment (14.47). Impact of variety is important for their yield means pod bearing capability. Among the variety avrodhi was recorded maximum (19.78) pod per plant at harvest during pooled over two years i.e. 2015-16 and 2016-17 (Table 1). Chaitanya and Chandrika (2006) was also recorded similar trend in pod per plant.

TABLE 1. Effect of brown chickpea varieties on plant heights, number of Primary branch, number of Secondary branch and pod per plant during pooled over two years (2015-16 and 2016-17)

Treatments	Plant Heights (cm) at harvest	Number of Primary branch	Number of Secondary branch	Pod per Plant	No of seed per pod
Date of sowing					
D_1	50.62	2.17	4.10	18.66	1.45
D_2	46.07	1.98	3.65	16.85	1.32
D_3	41.00	1.70	3.17	14.47	1.23
SEM (±)	**0.52**	**0.04**	**0.21**	**0.72**	**0.04**
CD (5%)	**1.49**	**0.115**	**0.61**	**2.05**	**0.12**
Varieties					
V_1	44.00	1.87	3.27	14.33	1.16
V_2	48.17	1.97	3.56	17.78	1.64
V_3	46.36	2.06	3.63	18.44	1.2
V_4	48.65	1.97	5.81	19.78	1.58
V_5	46.48	2.06	3.63	15.88	1.38
V_6	44.42	1.96	3.18	14.66	1.23
V_7	43.21	1.71	2.40	15.77	1.16
SEM (±)	**0.79**	**0.06**	**0.32**	**1.09**	**0.06**
CD (5%)	**2.28**	**0.17**	**0.93**	**3.13**	**0.18**

D_1 = 20th November, D_2 = 5th December, D_3 = 20th December, V_1 = ICCV-10, V_2 =Rajas, V_3 = Vaibhav, V_4 = Avrodhi, V_5 =GCP-105, V_6=Phule G-12 and V_7 = RUSJK-4-102, SEM= Standard error of mean; CD= critical difference; cm- centimeter

Number of Seed per pod

Maximum seed (1.45) per pod was recorded in first date of sowing followed by second date of sowing. Minimum seed per pod was recorded in third date of sowing (1.23). Rajas variety showed maximum seed (1.64) per pod followed by avrodhi (1.58) variety at harvest (Table 1). Munirathnamm *et al*. (2013) also recorded similar results at harvest stage in of brown chickpea varieties.

Grain yield

Early sown chickpea crop recorded maximum yield (1106.52 q/ha) over two years followed by second date of sowing (984.71 kg/ha) and minimum yield (885.19 q/ha) was recorded in late sown crop (Fig 1). At late sown chickpea crop survive under terminal heat stress results in low yield. Among the chickpea variety vaibhav gave significantly highest (1205.67 kg/ha) economic yield (grain yield) which was followed by avrodhi (1129.67 kg/ha) (Sekhar *et al*. 2015 Munirathnam *et al*., 2013). Minimum (816.55 kg/ha) grain yield was observed in GCP-105 which was statistically at par with Rajas (867.22 kg/ha). Chaitanya and Chandrika (2006) was also recorded similar results trend in yield (Fig 2). In rice fallow conditions of New Alluvial zone of West Bengal,

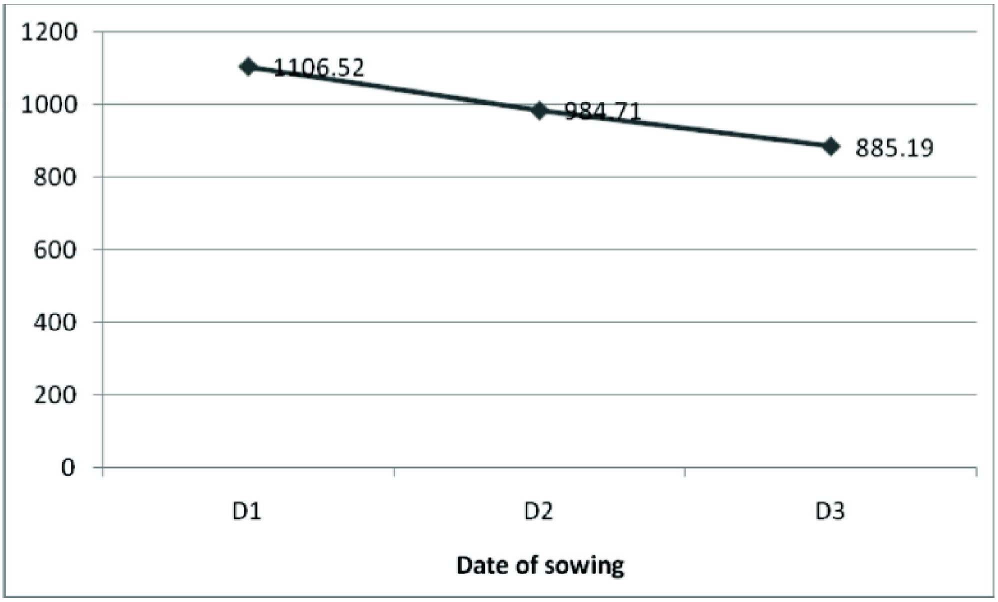

Fig. 1 Effect of different date of sowing on yield (kg/ha) during pooled over two years (2015-16 and 2016-17)

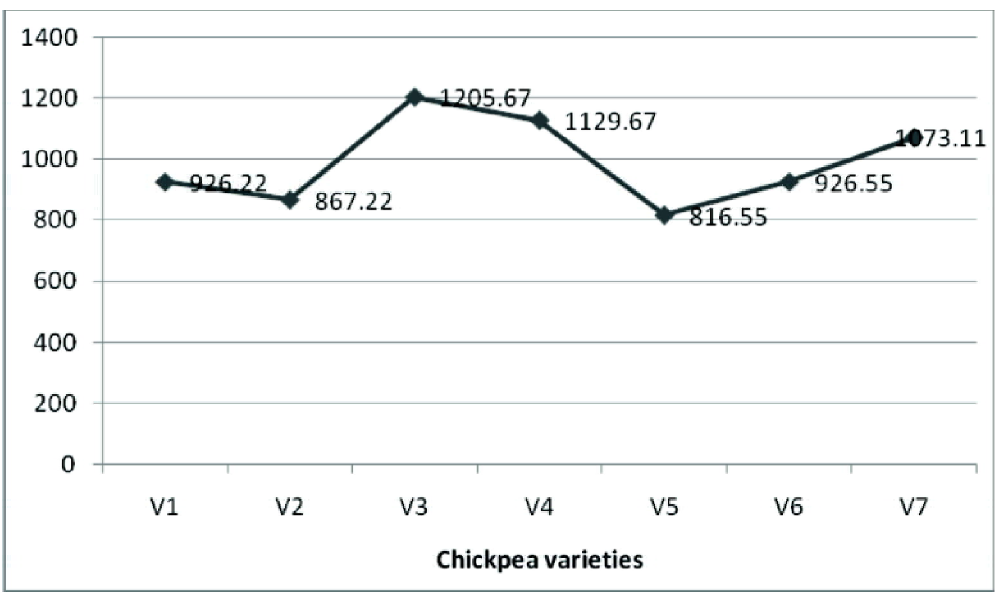

Fig. 2 Effect of brown chickpea varieties on yield (kg/ha) during pooled over two years (2015-16 and 2016-17)

these varieties are very much essential where rice is harvested in late and all late sown chickpea varieties does not performed well. Some varieties are performed well in terminal heat stress conditions.

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Economics of Paddy Production (Variety- Govindbhog) in Kaimur District of Bihar

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Abstract

A case study was done in 2015-16 to know the cost of cultivation/production with cost concept, net return, family labor income, farm business income, farm investment income and marketing for Govindbhog Rice in Kaimur district of Bihar. Forty famers in four villages of two blocks under two sub-division of Kaimur district were selected randomly due to massive cultivation of aromatic superfine rice variety "Govindbhog". Out of four villages (Mokari, Betari, Daharak and Deohalia), Mokari village was famous for Govindbhog Rice due to their good cooking quality, taste and pleasant aroma. Total cost of cultivation was calculated Rs.31560 and return over variable cost was found Rs.7841. Return over total cost was found in a loss of Rs.7173/ Acre. Cost of production on the basis of variable cost was Rs 14.68/Kg while on the basis of total cost was found Rs.28.00 per kg. Gross return was Rs.24387. Cost-Benefit Ratio over variable cost and over total cost were found 1.41 and 0.77 respectively. Per acre CostA1, CostB and CostC were found Rs.16560, Rs. 30060 and Rs. 31560 respectively.

Keywords : Cost concept (CostA_1, CostB and CostC), Gross income, Net return, Family labor income, Farm business income, and Farm investment income.

Introduction

Rice was the most important and second largest food grown after wheat in the World. It was the staple food of more than 60 percent of the world population and provided 20% of the world's dietary energy supply, while wheat supplies 19% and maize (corn) 5%.

In Bihar, from 2013-14 to 2014-15 area, production and productivity had been increased. Area, production and productivity were increased 3.57%, 23.94% and 19.67% respectively in 2014-15 over 2013-14. 3150.81thousand hectare area, 6649.59 thousand tones production and 2110Kg/ha productivity were found in 2013-14 whereas 2014-15 the area, production and productivity were found 3263.37 thousand hectare, 8241.62 thousand ton and 2525 Kg/ha respectively in Bihar. Out of 38 district Rohtas district ranked first in productivity 3937Kg/ha with 6.3% area 197.15 thousand hectare and 11.7% production 776.2 thousand tones and third rank was got by Kaimur district with 3296 Kg/ha productivity, 115.42 thousand hectare area (3.7%) and 380.46 thousand tones in Bihar in the year 2013-14. In the year 2014-15, Kaimur district was ranked 5th with productivity 2753kg/ha.

That variety was grown for family consumption and marketing for income raising. That was being exported to most part of other states of the country and also some countries of the world. Massive cultivation/ production of aromatic fine rice "Govindbhog" in Kaimur district of Bihar from the last two decades this study was proposed to be conducted in Kaimur with objectives as under :

1 To examine the status of Aromatic Fine Rice (Govindbhog) cultivation/production in the area under study.
2. To analyze the economics of Govindbhog cultivation/production on the sample farms of the study.

3. To suggest the prospects of further enhancement in the profitability of cultivation/ production of "Goovindbhog" Aromatic Fine Rice in the area under study.

Materials and Methods

Primary and secondary data were collected to achieve the objectives. Primary data were collected from sampled farmers interviewing them personally by the researcher with pre-tested/ pre-structured schedules during the crop year 2015-16. Secondary data were collected from District Statistics Office, Kaimur. At the first stage of sampling two sub-divisions of Kaimur District i.e., Bhabua and Mohania were selected purposively. At the second stage out of 11 blocks (six in Bhabua sub-division and five in Mohania sub-division) two blocks were taken in the sample randomly for this study on the basis of greater area coverage under above export quality aromatic fine rice variety. Bhabua block at Bhabua Sub-Division and Ramgarh block at Mohania Sub-Division were selected. At the third stage of sampling, two villages – Mokari and Betari at Bhabua block as well as two villages – Daharak and Deohalia from Ramgarh block were selected. Thus four villages were taken under study. At the ultimate stage of sampling ten farmers from each selected village were taken randomly in the sample for detailed survey and thus forty farmers (Govindbhog growers) were selected for detailed investigation.

Tools of Analysis:

Cost Concept

Cost A_1

1. Value of hired human labour (permanent and casual)

2. Value of owned bullock labour

3. Value of hired bullock labour

4. Value of owned machinery

5. Hired machinery charge

6. Value of fertilizers

7. Value of manure (owned and purchased)

8. Value of seed (both farm produced and purchased)

9. Value of insecticides and pesticides

10. Irrigation charges (both owned and hired machines)

11. Canal water charges

12. Land revenue, cesses and other taxes

13. Depreciation of farm implements (both bullock- drawn and used by human labour)

14. Depreciation on farm buildings, farm machinery and irrigation structure

15. Interest on working capital

16. Miscellaneous expenses (artisans, ropes and repairs to small farm implements)

Cost A_2= Cost A_1 +17. Rent Paid for leased in land

Cost B= Cost A_2 plus

18. Imputed rental value of own land (less land revenue paid thereon)

19. Imputed interest of fixed capital (excluding land)

Cost C= CostB plus

20. Imputed value of family labour = Cost of cultivation

Results and Discussion

Status of area and production of Govindbhog Rice (paddy form) on sample farms

Table 1 revealed that out of total land 2325.87 acres 1687.55 acres were under cultivation in which 1662.75 acres (98.53%) area was covered by rice (paddy form) in kharif season in the year 2015-16. Total area of Rice under sampled farms was 580.80 acres in which Govindbhog covered 107.00 acres (18.42%) alone. As per table 1 overall area 107 acres, production 1205.89 Qtls and productivity 11.27 Qtl/ acre were found of rice Govindbhog Overall avg. production per farmer was 30.15 Qtl whereas highest

TABLE 1. Status of area and production of Govindbhog Rice (paddy form) on sample farms

Sl.No.	Village	No of selected farmer	Total land	Cultivable land	Irrigated land	Total Rice cultivated area	Area of Rice under sampled farms	Area covered by Govindbhog Rice in sampled farms	Production of Govindbhog on sample farms
			Area (in Acre),						Production (Qtl)
1	Mokari	10	658.39	586.96	583.50	582.00	141.00	32.80	376.22
2	Betari	10	456.47	326.56	321.85	321.20	155.55	36.50	414.27
3	Daharak	10	737.89	512.35	505.87	504.25	134.65	20.40	226.44
4	Deohaliya	10	473.12	261.68	257.60	255.30	149.60	17.30	188.96
	Total	**40**	**2325.87**	**1687.55**	**1668.82**	**1662.75**	**580.80**	**107.00**	**1205.89**

TABLE 2. Per acre costs, returns and cost of production of Govindbhog Rice (Year 2015-16) on sample farms

S. No	Particulars	Physical Unit	Value (Rs.)
I. Variable Cost			
1.	Human Labour	36 Mandays	6501 (20.70)
	a.Family/ Owned	8 Mandays	1500
	b.Hired	28 Mandays	5001
2.	Seed	4 Kg	322 (1.02)
3.	FYM/Compost	125 Kg	400 (1.37)
4.	Chemical fertilizer	116 Kg	1826 (5.86)
	a.DAP	44 Kg	1060
	b.Urea	62 Kg	500
	c. MOP	10 Kg	140
	d. Others (micronutrients)	4 Kg	126
5.	Plant protection	2 Litres	700 (2.22)
6.	Irrigation charges	10 Hrs	1983 (6.28)
7.	Machinery charges	5 Hrs	2172 (6.88)
8.	Total(1-7)		14014
9.	Interest on working capital @ 8 per cent per annum for 6 month	6 Month	532 (1.69)
10.	Harvesting, threshing and winnowing	10 Mandays/ Harvester	2000 (6.41)
11.	Total Variable Cost (TVC), 8-10=I		16546
II. Fixed Cost			
12.	Depreciation	6 Month	1000 (3.17)
13.	Land Revenue	1 Acre	14 (0.04)
14.	Rental value of land	6 Month	8000 (25.35)
15.	Interest on fixed capital @11 per cent per annum for 6 month	6 Month	5500 (17.43)
16.	Crop insurance(Premium charges)@ 2 per cent	Rs 25000	500 (1.58)

17.	Total fixed cost (TFC,12-16)=II		15014
18.	Total cost(I+II)=11+17		31560 (100.00)
Output/ Return			
19.	Main product (Paddy)	1127 Kg	23260
	By product (Paddy straw)	1127 Kg	1127
20.	Gross Return (Main product+By product)		24387
21.	Return over variable cost		7841
22.	Return over total cost		-7173
23.	Benefit-Cost Ratio overA.	variable cost	1.41
B.	Total cost		0.77
24.	Cost of production (Rs./ kg.) overA.	variable cost	14.68
	B. Total cost		28.00

Source: Primary data analyzed Figures in brackets showed percentage

TABLE 3. Per acre cost of cultivation according to cost concept (Variety- Govindbhog) on sample farms

Cost concept	In (Rs.)
1. Hired human labour	5001 (15.85)
2. Machinery charges	2172 (6.88)
3. Seed	322 (1.02)
4. Manures(FYM)	400 (1.27)
5. Fertilizers	1826 (5.79)
6. Plant protection chemicals	700 (2.21)
7. Irrigation charges	2093 (6.64)
8. Harvesting, threshing and winnowing	2000 (6.33)
9. Depriciation	1000 (3.16)
10. Land revenue	14 (0.04)
11. Crop insurance (premium charge)	500 (1.58)
12. Interest on working capital	532 (1.69)
Total CostA_1	16560
1. CostA_1	16560
2. Rental value of land	8000 (25.36)
3. Interest of fixed capital	5500 (17.43)
Total Cost B	30060
1.Cost B	30060
2.Imputed value of family labour	1500 (4.75)
Cost C=Cost of cultivation	31560 (100.00)

Source: Farmers survey (Calculated primary data), Figures in parenthesis showed percentage avg. production per farmer was found 41.43 Qtls at Betari village due to coverage of maximum area. Maximum productivity 11.47 Qtls/Acre was achieved by the farmers of Mokari village while minimum productivity 10.92 Qtls/Acre was found at Deohalia village. Prevailed market rate were in a range of Rs. 2000 to Rs. 2060 per Qtl.

Table 2 revealed the per acre variable cost, fixed cost and total cost under cost of cultivation of fine rice variety (Govindbhog) It included yield (in kg.), gross value of yield (Rs.), return (profit) over variable and total cost. Table 5 also covered the benefit-cost ratio and cost of production. Cost was found on human labour Rs.6501 in which 77% cost was incurred for hired labor as well as 23% for family labor. Yield was achieved 1127Kg. Total cost of cultivation was calculated Rs.31560 and return over variable cost was found Rs.7841. It was evident from table 2 that return over total cost was found in a loss of Rs.7173/ Acre. Cost of production on the basis of variable cost was Rs 14.68/Kg while on the basis of total cost was found Rs.28.00 per kg. Gross return was Rs.24387. Cost-Benefit Ratio over variable cost and over total cost were found 1.41 and 0.77 respectively. Tiwari Kumar Sudhir and Singh P.K. (2015) studied and found that coarse variety-MTU-7029 and Swarna Sub-1, per acre cost of cultivation was Rs25500 to 26700/Acre and Gross Return was Rs 35000 to Rs 40500/acre in the Nokha block of Rohtas district in Bihar.

Cost of cultivation according to cost concept

Table 3 indicated that in Govindbhog rice cultivation, Cost concept covered CostA_1, CostB and CostC were studied in which hired human labor, machinery charges, seed, manures and fertilizers, plant protection chemicals, irrigation charges, harvesting, threshing and winnowing, depreciation, land revenue, crop insurance and interest on working capital were included in CostA_1. CostB included CostA_1 plus rental value of land and interest of fixed capital . CostC was equal to cost of cultivation covered CostB plus imputed value of family labor. Table 3 revealed that CostA_1 was Rs16560, CostB was Rs30060 and CostC was Rs31560. Maximum cost 25.36% was found for rental value of land followed by interest on fixed capital 17.43% and human labor cost 15.85% as indicated in table 3**.** Cost of cultivation could be reduced by using more implements instead of labor. Kadiri, F. A. *et.al* (2014 also told that labor saving equipment was also important in reducing inefficiencies in paddy production through reduction in labor cost.

Measures of farm profit/income per acre on sampled farm size- groups

Table 4 showed that for cultivation/production of Govindbhog rice, net income per acre was in loss of Rs 7173 and per acre family labor was also in loss Rs 5673. Farm business income was found Rs. 6327.

Conclusion

Cost of cultivation was found Rs.31560/acre while per acre gross income was only Rs. 24387 and thus net income was calculated in a loss of Rs.7173/ acre on sample farms. Sampled farmers were suggested to use fertilizers on the basis of soil test. Use of sulphur, zinc, boron and molybdenum may increase the yield of Govindhog Rice. Prevailed market rate was found lower (Rs.2000-2100/Qtl) than cost

TABLE 4. Measures of farm profit/income per acre on sampled farm size- groups Variety: Govindbhog

Measures of farm profit	Rs.
1. Net income/return	-7173
2. Family labour income/income	-5673
3. Farm business income	7827
4. Farm investment return/ income	6327

Source: Farmers survey (Calculated primary data) of production Rs.2800-Rs.3000/Qtl) in the year 2015-16. After harvesting, sampled farmers sold their Govinbhog paddy at the lower rate than cost of production due to storage problem.

Future Prospects for further enhancement in the profitability of production of "Goovindbhog Paddy"

Sampled farmers would increase their area, production and income from Super fine Aromatic Rice "Govindbhog" if they would be provided better procurement price/market rate at least cost of production by Govt. and other agencies. No procurement was done by Government only purchased by millers and other agencies. Declared MSP Grade-A, did not support superfine aromatic -Govindbhog. Foreign money would be earned more through export because of demand by other countries. Yield maximization and cost minimization through new coming effective technology like- use of bio- fertilizers, fertilizers and micronutrients on the basis of soil test would enhance net return from Super fine rice. Mostly sampled farmers were using their own seed of Govindbhog because they believed that there were no true seed supply in the market by any agencies.. E-Marketing, e-NAM and SEZ (Special Economic Zone) would help to increase the income from Govindbhog rice. As per **Kaur Parminder, *et.al.* (2014),** The Punjab Mandi Board has been established to guide supervise and control the market committees of the state for better and efficient marketing of farm produce Bihar Govt. also must follow the same. Crop insurance would help the sampled households to cover the loss/ risk from flood, natural fire, lightning, storm, hailstorm, cyclone, drought, dry spell and pests/diseases etc during sowing to threshing period. Govt. must help in storage facilities for grains so that sampled farmers would get better rate to sell their produce in off season. To provide farm machinery and implements with subsidized rate by Govt. would help to minimize the cost and time in cultivation as well as to fulfill labor shortage in agriculture.

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Morphological Variability and Tuber Productivity in Sweet Potato *(Ipomoea Batatas* (L.) Lam.) Genotypes Under Andhra Pradesh

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Abstract

A replicated field experiment was carried out by using 18 sweet potato genotypes selected at random from the germplasm collection of diverse sources. The germplasm accessions were characterized for 10 morphological traits like plant type, vine pigmentation, abaxial leaf vein pigmentation, type of leaf lobes, number of leaf lobes, mature leaf colour, petiole pigmentation, root shape, root skin colour, root flesh colour as per descriptors for the characterization and evaluation of sweet potato genetic resources and 5 quantitative traits like number of roots per plant, root length (cm), root girth (cm), root yield per plant (g), and root yield (t/ha). Wide ranges of variations were recorded for most of the traits. Based on quantitative characters Pusa Safed was found to be elite for the characters like number of roots per plant (5.00), root yield per plant (567.3 g) and total root yield (24.8 t/ha). The frequency distribution of genotypes for variability in each morphological and quantitative trait was calculated.

Key words : Tuber yield, Variability, Morphology, Sweet potato.

Introduction

Sweet potato (*Ipomoea batatas* (L) Lam), an important food cum vegetable crop is grown in the tropics, subtropics and warm temperate regions of the world for its edible storage roots. It is a cross-pollinated and hexaploid (2n=6x) crop with 90 chromosomes (Jones, 1965). The roots are used as a source of carbohydrate and dietary fibre. The crop is also a rich source of provitamin A, vitamin B1 (Thiamin) and vitamin C. Dietary fibre has the potential to reduce the incidence of a variety of diseases in man including colon cancer, diabetes, heart diseases and digestive disturbances (Pavio and Russel, 1999). In sweet potato the major carotenoid present is β -carotene. Carotenoids have been linked with the enhancement of immune system and decreased risk of degenerative diseases such as cardiovascular problems, age-related macular degeneration and cataract formation (Byers and Perry, 1992).

Sweet Potato is a highly heterozygous cross pollinated crop in which many of the traits show continuous variation. There is considerable genetic variation with regard to leaf lobbing pattern, leaf shape and colour, root shape and colour and root flesh among indigenous material (Jones *et al.,* 1986). Hence evaluation and characterisation of the genotype is necessary to know their performance in terms of morphological character and yield and other yield attributing characters as well as resistant to major pest and diseases.

Materials and Methods

A field experiment was carried out with 18 genotypes of sweet potato during *kharif* season (July-

December) 2013 at Horticultural College and Research Institute working under Dr. YSR Horticultural University, Venkataramannagudem, West Godavari district, Andhra Pradesh, India. The location is at 16°83'N latitude, 81°50'E longitude, and 34 m above mean sea level. The soil was a red sandy loam. The experiment was conducted in a randomized complete block design with three replications in 3.0 × 2.4 m plots. Seven-week-old cuttings of 18 genotypes (Table 1) having 20–30 cm length with three to four nodes were transplanted manually on the ridges at a spacing of 60 × 20 cm. The vines were planted in 5 cm deep in the field as per recommendations of Nedunchezhiyan *et al.* (2008). Plots were kept free from weeds by regular hand-weeding. Fertilizer N–P–K @ 50:25:60 kg/ha was applied as urea (108.6 kg/ha), single superphosphate (156.2 kg/ha), and muriate of potash (83.3 kg/ha). The single superphosphate was applied prior to planting and urea and muriate of potash were applied by side-dressings 1 month after planting.

10 morphological characters like plant type, vine pigmentation, abaxial leaf vein pigmentation, type of leaf lobes, number of leaf lobes, mature leaf colour, petiole pigmentation, root shape, root skin colour and root flesh colour were recorded at the time of harvest (120 days after planting) as per IBPGR descriptor by Huaman (1991) and all the 5 quantitative observations of tuber characters like number of roots per plant, root length (cm), root girth (cm), root yield per plant (g), and root yield (t/ha) were recorded from 6 plants / replication.

Results and Discussion

Morphological characterization has been used for various purposes including identification of duplicates, variability patterns and correlation with characteristics of agronomic importance (CIAT, 1993). Here, the 18 sweet potato germplasm exhibited high morphological variability for the shoot and storage root characters which have been summarized in Table 2 and 3.

Plant type

The germplasm consisted of 3 classes of plant types (Table 2). The spreading plant type was predominant which was found in nine genotypes (Pol.4-9, 82/16, S-30, RNSP-5, OP-219, 90-10-11, S-30/25, S-30/17, 362-9, Sree Bhadra, Sree Nandini and Pusa Safed) followed by four genotypes (Pol.13-4, 90/704, 90-10-17 and S-30/11) exhibited semi compact plant type and remaining two genotypes (Pol.21-1 and A-14) exhibited extremely spreading plant type.

Vine pigmentation

Overall, six types of vine pigmentation were recorded (Table 2). Green colour vine pigmentation was predominant and were found in nine genotypes (Pol.13-4, 90/704, A-14, 82/16, RNSP-5, 90-10-11, S-30/17, Sree Nandini and Pusa Safed) followed by three genotypes (S-30/11, 362-9 and Sree Bhadra) exhibited Green with few purple spots. Three genotypes (Pol.4-9, 90-10-17 and S-30/25) showed mostly dark purple colour and rest three genotypes viz. OP-219, Pol.21-1and S-30 were exhibited green with many dark purple spots, totally purple colour spot and totally dark purple spot respectively.

Abaxial leaf vein pigmentation

Four patterns of abaxial leaf vein pigmentation were observed (Table 2). The majority i.e., nine genotypes (90/704, Pol.21-1, A-14, 82/16, 90-10-11, S-30/17, S-30/11, 362-9 and Sree Nandini) showed green colour where as five genotypes (RNSP-5, OP-219, 90-10-17, S-30/25 and Sree Bhadra) showed partially purple colour at abaxial leaf vein. Remaining Leaf veins of two genotypes (Pol.4-9 and S-30) were purple in colour and (Pol.13-4 and Pusa Safed) had purple spot at base of the main rib. Daros *et al.* (2002) observed high morphological variation in abaxial leaf vein pigmentation.

Type of leaf lobes

The germplasm consisted of 5 types of leaf lobe (Table 2). The majority i.e., six genotypes (Pol.13-4, Pol.4-9, Pol.21-1, A-14, 82/16 and S-30/25) exhibited slight leaf lobe followed by four genotypes (S-30, RNSP-5, S-30/11 and Sree Bhadra) exhibited no lateral lobe. Moderate leaf lobbing pattern showed in three genotypes (90-10-11, S-30/17 and 362-9), deep

TABLE 1. Germplasm accessions of sweet potato

Treatment	Accession number	Source
T_1	Pol.13-4	CTCRI regional centre, Bhubaneswar, Odisha
T_2	90/704	CTCRI regional centre, Bhubaneswar, Odisha
T_3	Pol.4-9	CTCRI regional centre, Bhubaneswar, Odisha
T_4	Pol.21-1	CTCRI regional centre, Bhubaneswar, Odisha
T_5	A-14	AICRP on tuber crops, Rajendranagar, Hyderabad
T_6	82/16	AICRP on tuber crops, Rajendranagar, Hyderabad
T_7	S-30	CTCRI regional centre, Bhubaneswar, Odisha
T_8	RNSP-5	AICRP on tuber crops, Rajendranagar, Hyderabad
T_9	OP-219	AICRP on tuber crops, Rajendranagar, Hyderabad
T_{10}	90-10-17	AICRP on tuber crops, Rajendranagar, Hyderabad
T_{11}	90-10-11	AICRP on tuber crops Rajendranagar, Hyderabad
T_{12}	S-30/25	AICRP on tuber crops Rajendranagar, Hyderabad
T_{13}	S-30/17	AICRP on tuber crops, Rajendranagar, Hyderabad
T_{14}	S-30/11	AICRP on tuber crops, Rajendranagar, Hyderabad
T_{15}	362-9	AICRP on tuber crops, Rajendranagar, Hyderabad
T_{16}	Sree Bhadra	CTCRI regional centre, Bhubaneswar, Odisha
T_{17}	Sree Nandini	CTCRI regional centre, Bhubaneswar, Odisha
T_{18}	Pusa Safed	CTCRI regional centre, Bhubaneswar, Odisha

leaf lobbing pattern observed in three genotypes (90/704, OP-219 and 90-10-17) and two genotypes (Sree Nandini and Pusa Safed) had very slight leaf lobe.

Number of leaf lobes

Four patterns of number of leaf lobes were observed (Table 2). Six genotypes (90/704, A-14, OP-219, 90-10-17, 90-10-11 and 362-9) showed 5 leaf lobes where as another six genotypes (Pol.13-4, Pol.4-9, Pol.21-1, 82/16, S-30/25 and S-30/17) had three leaf lobes. One leaf lobes were observed in four genotypes (S-30, RNSP-5, S-30/11 and Sree Bhadra) and the genotype Pusa Safed had six and Sree Nandini had seven leaf lobes respectively.

Mature leaf colour

Overall, 3 types mature leaf colour were observed (Table 2). Mature leaf colour of eleven genotypes (Pol.13-4, Pol.21-1, A-14, 82/16, OP-219, 90-10-11, S-30/25, S-30/17, S-30/11, Sree Nandini and Pusa Safed) had green colour followed by four genotypes (Pol.4-9, S-30, RNSP-5 and 90-10-17) showed green with purple veins at lower surface. Green with purple colour was observed in three genotypes (90/704, 362-9 and Sree Bhadra).

Petiole pigmentation

The petiole pigmentation of ten genotypes (90/704, A-14, 82/16, RNSP-5, 90-10-11, S-30/25, S-30/17, S-30/11, 362-9 and Pusa Safed) had green colour (Table 2). Four genotypes (Pol.13-4, OP-219, Sree Bhadra and Sree Nandini) had green with purple spot near leaf. Three genotypes (Pol.4-9 and 90-10-17) had green with purple spot at both ends and petiole pigmentation of remaining genotypes had green with purple strips (Pol.21-1) and mostly purple (S-30) respectively.

Table 2. Variation in morphological traits of sweet potato genotypes

Genotypes \ Characters	Plant type	Vine pigmentation	Abaxial leaf Vein pigmentation	Type of leaf lobes	No. of leaf lobes	Mature leaf colour	Petiole pigmentation	Root shape	Root skin colour	Root Flesh colour
Pol.13-4	Semi compact	Green	Purple spot at base of the main rib	Slight	Three	Green	Green with purple Spot near leaf	Round elliptic	Purple red	Cream
90/704	Semi compact	Green	Green	Deep	Five	Green with purple edge	Green	Round Elliptic	Purple red	White
Pol.4-9	Spreading	Mostly dark purple	All veins mostly purple	Slight	Three	Green with purple veins at lower surface	Green with purpleSpot at both ends	Round elliptic	Purple red	Cream
Pol.21-1	Extremely Spreading	Totally purple	Green	Slight	Three	Green	Green with purple strips	Round	Cream	Cream
A-14	Extremely Spreading	Green	Green	Slight	Five	Green	Green	Longelliptic	Purple red	Cream
82/16	Spreading	Green	Green	Slight	Three	Green	Green	Round	Purple	Cream
S-30	Spreading	Totally dark purple	Al veins mostly purple	No lateral lobes	One	Green with purple veins at lower surface	Mostly purple	Round elliptic	White	Cream
RNSP-5	Spreading	Green	Main rib partially purple	No lateral lobes	One	Green with purple veins at lower surface	Green	Long elliptic	Purple	White
OP-219	Spreading	Green with many dark purple spots	Main rib partially purple	Deep	Five	Green	Green with purple Spot near leaf	Round elliptic	Purple	Cream
90-10-17	Semi compact	Mostly dark purple	Main rib partially purple	Deep	Five	Green with purple veins at lower surface	Green with purple Spot near leaf	Long elliptic	Purple	Cream
90-10-11	Spreading	Green	Green	Moderate	Five	Green	Green	Round	Purple red	White
S-30/25	Spreading	Mostly dark purple	Main rib partially purple	Slight	Three	Green	Green	Obovate	White	Cream
S-30/17	Spreading	Green	Green	Moderate	Three	Green	Green	Ovate	Purple	White
S-30/11	Semi compact	Green with few purple spots	Green	No lateral lobes	One	Green	Green	Round elliptic	Purple red	White
362-9	Spreading	Green with few purple spots	Green	Moderate	Five	Green with purple edge	Green	Long irregular	Dark purple	White
Sree Bhadra	Spreading	Green with few purple spots	Main rib part purple	No lateral lobes	One	Green with purple edge	Green with purple spot near leaf	Round	Light pink	Cream
Sree Nandini	Spreading	Green	Green	Very slight	Seven	Green	Green with purple spot near leaf	Cream Ovate	White	
Pusa Safed	Spreading	Green	Purple spot at base of the main rib	Very slight	Six	Green	Green	Round	White	White

Root shape

The germplasm consisted of 6 types of root shape (Table 2). The round elliptic root shape was predominant which was found in six genotypes (Pol.13-4, 90/704, Pol.4-9, S-30, OP-219 and S-30/11) followed by round root shape which was found in five genotypes (Pol.21-1, 82/16, 90-10-11, Sree Bhadra and Pusa Safed). Three genotypes (A-14, RNSP-5 and 90-10-17) had long elliptic roots where as two genotypes (S-30/17 and Sree Nandini) showed ovate shape. S-30/25 had obovate and 362-9 showed long irregular tuber shape.

Root skin colour

Overall, 6 types of root skin colour was observed (Table 2). Root skin colour in six genotypes (Pol.13-4, 90/704, Pol.4-9, A-14, 90-10-11 and S-30/11) had purple red root skin colour followed by five genotypes (82/16, RNSP-5, OP-219, 90-10-17 and S-30/17) showed purple colour. Two genotypes (Pol.21-1 and Sree Nandini) showed cream colour where as three genotypes (S-30, S-30/25 and Pusa Safed) showed white colour and remaining two genotypes had light pink (Sree Bhadra) and dark purple colour (362-9) root skin respectively. Similar results were reported by Hernandez *et al.* (1967).

Root flesh colour

Two types of flesh colour were observed (Table 2). Predominance of cream colour was observed in 10 genotypes (Pol.13-4, Pol.4-9, Pol.21-1, A-14, 82/16, S-30, OP-219, 90-10-17, S-30/25 and Sree Bhadra) followed by eight genotypes (90/704, RNSP-5, 90-10-11, S-30/17, S-30/11, 362-9, Sree Nandini and Pusa Safed) exhibited white colour flesh.

A genotype/variety is considered to be distinct if observations /measurements differ consistently from all others. Hence, the study is of significance in morphological characterization of genotypes. Daros *et al.* (2002) observed high morphological variation in abaxial leaf vein pigmentation and root shape. Hernandez *et al.* (1967), Vimala and Nair (1988), Vimala and Lakshmi (1990), Wilckens *et al.* (1993), Choudhary *et al.* (2001), Kaledzi *et al.* (2010), Sreekanth *et al.* (2011), Wadud *et al.* (2011), Vimala *et al.* (2011a), Vimala *et al.* (2012) and Richardson *et al.* (2012) reported that morphological characterization will be helpful in identification of genotypes with agronomic importance.

Number of roots per plant

Significant variation was observed with respect to number of roots per plant, which was ranged from 2.00 to 5.00 with a grand mean of 2.77 (Table 3). The genotype Pusa Safed recorded the maximum number of roots per plant (5.00) followed by Pol.4-9 (4.00). The minimum number of roots per plant (2.00) were recorded in Pol.21-1, RNSP-5,OP-219, 90-10-11, S-30/25 and S-30/17 respectively .

Root length (cm)

Significant variation was noticed among the genotypes with respect to root length which was ranged from 10.33 to 18.49 cm with a grand mean of 13.98 cm (Table 3). The genotype Sree bhadra recorded the maximum root length (18.49 cm) followed by S-30/11 (17.27 cm) and RNSP-5 (16.05 cm), while S-30/25 recorded the minimum root length (10.33 cm).

Root girth (cm)

The genotypes showed significant differences with respect to tuber girth (Table 3). The range obtained was from 11.52 to 22.43 cm with a grand mean of 17.49 cm. The genotype Pusa Safed recorded the maximum root girth (22.43 cm) followed by Pol.4-9 (21.95 cm) and 90-10-11 (21.63 cm). The minimum root length was recorded in 362-9 (11.52 cm).

Root yield per plant (g)

There was significant variation among the genotypes with respect to root yield per plant which was ranged from 111.91 to 567.30g with a grand mean of 273.73g (Table 3). The genotype Pusa Safed recorded the maximum root yield per plant (567.30g) followed by Pol.4-9 (452.43g) and OP-219 recorded the minimum root yield per plant (111.91g). Similar results were also reported by Byju and Ray (2002) for root yield per plant.

Total Root yield (t/ha)

Considerable variation was found for tuber yield per hectare among the genotypes (Table 3). It was ranged from 11.92 to 24.80 t/ha with a grand mean of 15.50 t/ha (Table 3). Highest tuber yield per hectare of 24.80 t/ha was recorded in the genotype Pusa Safed followed by Pol.4-9 (18.83 t/ha), where as the genotype S-30/25 recorded lowest tuber yield per hectare (11.92 t/ha). Similar results were also reported by (Kamalam, 1990; Wilckens *et al.,* 1993; Engida Tsegaye *et al.,* 2007; Vimala *et al.,* 2009; Binu *et al.,* 2011; Pushpalata *et al.,* 2011).

Characterization of 18 germplasm accessions for 10 morphological and 5 quantitative traits showed wide range of variation. Thus, the present work of frequency distribution of morphological traits in sweet potato reflects the spectrum of variation available for the traits considered. This will help in the efforts for identification of desirable plant type, their conservation and used in the crop improvement programme.

Considering all factors at a time, it could be concluded that the genetic stocks of sweet potato used in this investigation had wide range of variability, particularly for morphological, yield and yield

TABLE 3. Variation in quantitative traits of sweet potato genotypes

Accessions	No. of roots/ plant	Root length (cm)	Root girth (cm) (cm)	Root yield/ (g)	Plant Root yield (t/ha)
Pol.13-4	3.00	13.80	16.28	256.43	15.07
90/704	3.00	14.59	18.13	306.14	14.42
Pol.4-9	4.00	15.25	21.95	452.43	18.83
Pol.21-1	2.00	13.88	17.72	228.42	17.56
A-14	3.00	11.72	15.17	303.90	15.58
82/16	3.00	11.66	17.63	268.53	13.84
S-30	2.00	13.23	19.81	236.58	14.71
RNSP-5	2.00	16.05	17.57	332.44	17.17
OP-219	2.00	12.64	18.44	111.91	12.80
90-10-17	3.00	13.84	15.71	120.53	14.98
90-10-11	2.00	14.13	21.63	184.56	12.71
S-30/25	2.00	10.33	13.07	172.83	11.92
S-30/17	2.00	12.00	17.76	196.23	15.59
S-30/11	3.00	17.27	17.25	314.10	15.43
362-9	3.00	15.67	11.52	301.10	14.83
Sree Bhadra	3.00	18.49	16.50	351.14	15.81
Sree Nandini	3.00	12.75	16.29	222.67	13.06
Pusa Safed	5.00	14.35	22.43	567.30	24.80
Mean	2.77	13.98	17.49	273.73	15.50
SE m±	0.60	1.01	0.82	32.94	1.90
CD (*P*=0.05)	1.70	2.87	2.32	93.25	5.37

attributing characters. As such, there is enough scope of improvement of these characters by selection.

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Effect of Genotype, Method of Establishment and Intra-Row Sapcing on Yield and Economics of Peripheral Pigeonpea in Odisha

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Abstract

A field experiment was conducted over three years (2012-13, 2014-15 and 2015-16) at the Centre for Pulses Research, OUAT, Berhampur-761001, Odisha, under AICRP on Pigeonpea, with objectives to standardize the intra row spacing, method of establishment and genotype of pigeonpea. Altogether 12 treatment combinations comprising of two genotypes{improved genotype Manak (H-77-216) & Local-Kathikandula}; three intra-row spacing (20cm, 40cm & 60cm) and two methods of establishment (direct sowing and transplanting with 5 week old seedling) were laid out in factorial randomized block design (FRBD) with three replications. The results revealed that improved variety pigeonpea (Manak) was significantly superior than local cultivar (Kathi kandula) and recorded 237.41 g/RM or 3962.31 kg/ha grain yield (pooled) which was 66% higher than that of Kathi kandula (143.32g/RM or 2388.61 kg/ha). Improved variety Manak also recorded 5.6% higher plant height, 24.65 % more primary fruiting branches per plant, 52.14% more pods per plant and 32.96 % more seeds per pod as compared to local cultivar Kathikandula. Although individual plant performance was better under wider spacing, the productivity per running metre or unit area was higher at closer spacing due to higher plant population. Higher yield and total dry matter production were recorded with closer spacing and 20 cm plant to plant spacing with pooled grain yield of 231.26 g/RM or 3854.29 kg/ha was found to be the best as compared to wider spacing. Transplanted pigeonpea produced 23% higher grain (210.11g/RM) than that of direct sowing (170.61 g/RM). Though the treatment combination Manak transplanted in 20 cm intra-row spacing produced highest grain yield (302.82 g/RM or 5047 kg/ha), but considering the economics, direct sowing of Manak at 20 cm intra-row spacing was found better with at par grain yield (284 g/ RM or 4737.33 kg/ha) and maximum net return (Rs. 986/100RM or Rs.164407/ha) and B:C ratio(4.95) as compared to transplanting due to less investment.

Key words : Peripheral cropping, transplanted pigeonpea, running metre (RM), harvest index, net return, B:C ratio

Introduction

In developing populous country like India, the small holders, resource poor and dry land farmers could not afford to derive their protein requirement from animal sources. Pulses are considered as the cheapest sources of dietary protein for these resources poor people. The rapid stride in population growth further aggravate the situation coupled with decrease in arable up-land available for *kharif* pulses due to urbanisation, industrialization etc. Pulses are important for both soil and human health leading to sustainable future. Pigeonpea is one of the most ancient versatile permaculture plant, can be grown in wide range of soil and diverse agro-ecological condition. Pigeonpea is generally grown in *kharif* as rainfed crop and very often replaced by other high value, comparatively more remunerative shorter duration crops such as sweet corn, baby corn, hybrid maize, vegetables etc. per capita availability of pigeonpea is gradually declining due to mismatch in the growth of human population and production of protein rich pulses and bridging this gap is essential to maintain self sufficiency in pulses production (Saxena, K.B. 2006). Paddy is the most important *kharif* crop of Odisha covering approximately 39 lakh hectare and most of the field bunds are left unutilized. These areas covered with weeds; act as source of weed seed and harbour pests. Considering the new niche for horizontal expansion, rice bunds can be used successfully for growing pigeonpea and have a good yield by harvesting border effect due to zero inter-row competition & benefits of ridge method (Panda *et. al.,* 2016). Raising pigeonpea seedling and transplanting in the field on receipt of good rains would help in reaping the benefit of early sowing (Poornima, D. S. *et. al*. 2010). Standardization of agro-technologies for these peripheral cropping would have immense benefit for farming community and increase pigeonpea production.

Materials and Methods

A field experiment was conducted under AICRP on Pigeonpea, over three years (2012-13, 2014-15 and 2015-16) at the Centre for Pulses Research, OUAT, Berhampur-761001, Odisha, which comes under East and South Eastern Coastal Plain zone of Odisha with objectives to standardize plant to plant spacing, study the performance of transplanted against direct sown pigeonpea and evaluate the performance of improved versus local cultivar in peripheral cropping of pigeonpea. However, due to very severe cyclonic storm (VSCS), Phylin on 13th October 2013, the trial for 2013-14 was vitiated and not taken into account. Altogether 12 treatment combinations comprising of two genotypes (HYV- Manak (H-77-216) & Local- Kathi kandula magusuria); two methods of establishment (direct sowing and transplanting with 5 week old seedling) and three intra-row spacing (20cm, 40cm & 60cm) were laid out in factorial randomized block design (FRBD) with three replications. Meaning of Kathi kandula magusuria is narrow small poded pigeonpea matured in the month of Magusura(November) and this local cultivar is commonly used by farmers for bund planting. Dome shaped rice bunds of 0.9 metre average height with 0.5 to 0.75m width were selected for trial. Six running metre (RM) was considered as the gross plot and the net plot was 4.8 RM. Soil of bunds was sandy loam with pH 6.2, medium Organic Carbon (0.63 %), medium available Phosphorus (21.67kg/ha) and high Potassium (292kg/ha). Observations on plant height, yield attributes, grain yield, *bhusa* yield, stick yield were taken at harvest and analysed as per statistical procedure described by Panse and Sukhatme (1985). Economics of the treatment combinations were calculated and compared for economic feasibility.

Results & Discussion

Plant height: Data depicted in Table-1 revealed that improved variety Manak(H-77-216) has better growth and registered 5.6 % higher plant height (152.79cm) than local genotype (Kathikandula magusuria) of Pigeonpea (144.65cm), though the difference was not significant. But significant difference in plant height was observed due to method of establishment. Transplanted pigeonpea recorded 11.6% higher plant height (156.87cm) than that of direct sown crop (140.57cm). Closer the intra-row spacing, more the plant height and the maximum value was recorded with 20cm spacing (152.59cm), which might be due to more competition for light in closer spacing. However, the difference due to intra-row spacing was not significant. Nevertheless, significant variation was observed in plant height of pigeonpea with interaction effect of genotype, method of establishment and intra-row spacing and the maximum(167.64cm) being recorded with improved variety (Manak) transplanted at 20cm intra-row spacing (Table-2).

Yield attributes: Data on various yield attributes of pigeonpea were taken at harvest and placed in table-1 & 2. Number of primary fruiting branches per plant showed significant variation due to different genotypes, method of establishment and intra-row spacing. The highest number of fruiting branches per plant was recorded with improved variety Manak (14.31) which was 25% higher than local cultivar (Kathi kandula). Transplanted pigeonpea recorded significantly more branches per plant (13.90) in comparison to direct sown crop (11.39). Higher intra-row spacing induced more branching and the maximum branching (14.54) was recorded with 60cm intra-row spacing (Table-1). The variation on number of primary fruiting branches per plant due to interaction effect of genotypes, methods of establishment and intra-row spacing were found significant and the maximum branching per plant (17.74) was obtained from the treatment combination $V_1M_2S_3$ i:e: Manak transplanted

Table 1. Effect of genotypes, method of establishment and intra-row spacing on plant height, yield attributes and yield of peripheral pigeonpea (Pooled for 3 years)

	Treatment	Plant height (cm)	No. of branches /plant	No. of Pods /plant	No. of seeds /pod	Grain yield (g/RM)	Bhusa yield (g/RM)	Stick yield (g/RM)	TDMP (g/RM)	Grain yield (kg/ha)
V1	Manak	152.79	14.31	184.79	3.55	237.41	122.63	434.00	794.02	3962.31
V2	Kathikandula(magusuria)	144.65	11.48	121.46	2.67	143.32	94.54	299.30	525.83	2388.61
SEm±			0.69	7.64	0.14	9.78	4.86	14.81	26.22	142.36
CD (5%)		NS	2.02	22.41	0.41	28.68	14.25	43.44	76.90	417.54
M1	Direct sowing	140.57	11.89	146.04	3.07	170.61	97.89	320.43	588.94	2843.53
M2	Transplanting	156.87	13.90	160.21	3.15	210.11	119.26	401.53	731.24	3507.38
SEm±		3.51	0.64			9.61	4.74	14.36	24.68	138.16
CD (5%)		10.29	1.87	NS	NS	28.18	13.90	42.12	72.39	405.22
S1	Intra-row Spacing 20cm	152.59	11.29	123.38	2.98	231.26	127.60	421.87	780.73	3854.29
S2	Intra-row Spacing 40cm	147.90	12.85	158.84	3.09	184.20	103.18	352.55	639.93	3069.92
S3	Intra-row Spacing 60cm	145.68	14.54	177.15	3.26	156.13	94.95	308.53	559.61	2602.17
SEm±			0.72	9.71		10.19	5.14	16.31	29.64	161.62
CD (5%)		NS	2.11	28.48	NS	29.89	15.07	47.84	86.93	474.03

Table 2. Interaction effect of genotypes, method of establishment and intra-row spacing on plant height, yield attributes and yield of peripheral pigeonpea (Pooled for 3 years)

Treatment	Plant	Plant height (cm)	No. of branches /plant	No. of Pods /plant	No. of seeds /pod	Grain yield (g/RM)	Bhusa yield (g/RM)	Stick yield (g/RM)	TDMP (g/RM)	HI (%)	Grain yield (kg/ha)
T1	**Manak + DS + Spacing 20cm**	147.57	11.91	138.38	3.33	284.24	137.81	481.63	903.68	31.45	4737.33
T2	**Manak + DS + Spacing 40cm**	145.73	13.44	176.48	3.37	194.65	101.22	350.37	646.24	30.12	3244.17
T3	**Manak + DS + Spacing 60cm**	145.28	15.31	203.09	3.60	169.43	93.12	324.97	587.52	28.84	2823.83
T4	**Local + DS + Spacing 20cm**	136.41	9.52	92.86	2.63	150.20	98.13	300.36	548.69	27.37	2503.33
T5	**Local + DS + Spacing 40cm**	134.58	10.08	126.39	2.80	117.80	81.26	242.04	441.10	26.71	1963.33
T6	**Local + DS + Spacing 60cm**	133.87	11.10	139.04	2.70	107.35	75.82	223.23	406.40	26.41	1789.17
T7	**Manak + TP + Spacing 20cm**	167.64	12.57	160.64	3.37	302.82	156.83	537.48	997.13	30.37	5047.00
T8	**Manak + TP + Spacing 40cm**	158.41	14.91	202.88	3.70	263.90	136.83	489.02	889.75	29.66	4398.33
T9	**Manak + TP + Spacing 60cm**	152.11	17.74	227.25	3.93	211.39	119.92	410.50	741.81	28.50	3523.17
T10	**Local + TP + Spacing 20cm**	158.72	11.15	101.65	2.60	187.77	117.64	367.99	673.40	27.88	3129.50
T11	**Local + TP + Spacing 40cm**	152.87	12.98	129.61	2.47	160.43	103.42	318.77	582.62	27.54	2673.83
T12	**Local + TP + Spacing 60cm**	151.45	14.02	139.21	2.80	136.35	90.94	275.43	502.72	27.12	2272.50
SEm		6.08	0.98	13.88	0.21	14.89	7.14	25.31	42.64		241.62
CD (5%)		17.86	2.87	40.72	0.62	43.67	20.92	74.16	124.93		708.69

with 60 cm intra-row spacing.(Table-2) The number of pods per plant was taken at harvest and the maximum number of pods per plant was recorded with improved variety Manak (184.79) which was 52% higher than local cultivar (Kathi kandula) which recorded 121.46 pods per plant. Transplanted pigeonpea recorded more pods per plant (160.21) in comparison to direct sown crop (146.04). Significant variation was observed in number of pods per plant due to varying intra-row spacing which followed the same trend as that of fruiting branches. Higher the intra-row spacing, more the fruiting branches per plant and higher the number of pods per plant. The maximum pod per plant (177.15) was recorded with 60 cm intra-row spacing which was 11.5% and 43.6% higher than that of 40cm and 20 cm intra-row spacing (Table-1). The variation on number of pods per plant due to interaction effect of genotypes, methods of establishment and intra-row spacing were found significant and the maximum pods per plant (227.25) was obtained from the treatment combination $V_1M_2S_3$ ie. Manak transplanted with 60 cm intra-row spacing (Table-2). No significant variation was observed in number of seeds per pod due to different planting methods and intra-row spacing. However, more seeds per pod were recorded with transplanting (3.15) and 60 cm intra-row spacing (3.26). Nevertheless, improved variety Manak recorded significantly higher seeds per pod (3.55) than local cultivar Kathikandula (2.67). Significant variation on number of seeds per pod was found due to interaction effect of genotypes, methods of establishment and intra-row spacing and the maximum seeds per pod (3.93) was obtained from the treatment combination $V_1M_2S_3$ i.e., Manak transplanted with 60 cm intra-row spacing (Table-2).

Yield: Conspicuous variation in pigeonpea grain yield was observed for different genotypes, method of establishment and intra-row spacing (Table-1). Highest grain yield (237.41 g/RM or 3962.31 kg/ha) was obtained from improved genotype Manak which was significantly higher (66%)as compared to that obtained from local cultivar Kathikandula (143.32 g/RM or 2388.61 kg/ha). Among methods of establishment, transplanted pigeonpea performed better and recorded significantly higher grain yield (210.11 g/RM or 3507.38 kg/ha) as compared to direct sown crop (170.61g/ RM or 2843.53 kg/ha). Closer spacing recorded more grain yield and the maximum value (231.26 g/RM or 3854 kg/ha) was obtained from 20 cm intra-row spacing. *Bhusa* and stick yield followed the same trend as that of grain yield. Highest *bhusa* yield (122.63 g/RM, 119.26 g/RM & 127.60 g/RM) and stick yield (434 g/RM, 401.53 g/RM & 421.87 g/RM) were recorded with Manak, transplanting and 20 cm intra-row spacing respectively. Significant variation was observed in total dry matter production due to different genotypes, method of establishment and intra-row spacing. The maximum values were recorded with Manak (794.02 g/RM), transplanting (731.24 g/RM) and 20 cm intra-row spacing (780.73 g/RM). Grain yield, *bhusa* yield, stick yield and total dry matter production (TDMP) due to interaction effect of three components was also found significant (Table-2) and the maximum grain yield (302.82 g/RM or 5047 kg/ha) was recorded with Manak transplanted at 20 cm intra-row spacing ($V_1M_2S_1$) followed by $V_1M_1S_1$ ie., Manak direct sown at 20 cm intra-row spacing (284.24 g/RM or 4737.33 kg/ha). The maximum *bhusa* yield (156.83 g/RM), stick yield (537.48 g/RM) and total dry matter production (997.13 g/RM) were recorded with $V_1M_2S_1$ followed by $V_1M_1S_1$.

Harvest Index (HI): Harvest Index for each treatment combination was calculated on proportion of grain yield to biological yield i.e., total dry matter production of above ground parts on percentage basis to find out the dry matter partitioning to grain as influenced by different genotypes, method of establishment and intra-row spacing (Table-2). Maximum harvest index (31.45%) was recorded from variety Manak direct sown at 20 cm intra-row spacing ($V_1M_1S_1$) followed by $V_1M_2S_1$ (30.37).

Economics : Economics of all the treatment combinations were calculated and placed in Table-3. Despite the maximum grain yield obtained from T_7 (Manak transplanted at 20cm intra-row spacing), the highest net return (Rs. 986/100RM or 164407/ha) was registered with T_1(Manak direct sown at 20cm intra-row spacing), as compared to T_7 (Rs.667/100RM or 111212/ha). This might be due to high cost of

Table-3: Effect of genotypes, method of establishment and intra-row spacing on grain yield and economics of peripheral pigeonpea.

	Treatment	Grain yield (kg/ha)	Economics per hectare			Grain Yield (kg/100RM) (g/RM)	Economics per 100RM			B:C Ratio
			Gross Return (Rs)	Cost of Production (Rs)	Net Return (Rs)		Gross Return (Rs)	Cost of Production (Rs)	Net Return (Rs)	
T1	Manak+DS+Spacing 20cm	4737.33	206074	41667	164407	28.42	1236	250	986	4.95
T2	Manak+DS+Spacing 40cm	3244.17	141121	36667	104455	19.47	847	220	627	3.85
T3	Manak+DS+Spacing 60cm	2823.83	122837	33333	89503	16.94	737	200	537	3.69
T4	Local + DS + Spacing 20cm	2503.33	108895	41667	67228	15.02	653	250	403	2.61
T5	Local + DS + Spacing40cm	1963.33	85405	36667	48738	11.78	512	220	292	2.33
T6	Local + DS + Spacing 60cm	1789.17	77829	33333	44496	10.74	467	200	267	2.33
T7	Manak+TP+Spacing 20cm	5047.00	219545	108333	111212	30.28	1317	650	667	2.03
T8	Manak+TP+Spacing 40cm	4398.33	191327	70000	121327	26.39	1148	420	728	2.73
T9	Manak+TP+Spacing 60cm	3523.17	153258	55000	98258	21.14	920	330	590	2.79
T10	Local + TP + Spacing 20cm	3129.50	136133	108333	27800	18.78	817	650	167	1.26
T11	Local + TP + Spacing 40cm	2673.83	116312	70000	46312	16.04	698	420	278	1.66
T12	Local + TP + Spacing 60cm	2272.50	98854	55000	43854	13.64	593	330	263	1.80

Cost of pigeonpea grain is Rs.43.50 /kg. as per MSP;

Conversion factor: 100RM = 60sq.m=0.006ha (calculated on recommended row spacing of early duration pigeonpea ie. 60cm)

production for transplanting of pigeonpea. Maximum B:C ratio (4.95) was computed with T_1 (Manak direct sown at 20cm intra-row spacing). Considering both net return and B:C ratio T_1 was found most profitable among all treatment combinations.

Conclusion: The results revealed that improved genotype of pigeonpea (Manak) was significantly superior than local cultivar (Kathi kandula), recorded 237.41 g/RM grain yield (pooled) which was 66 % higher than that of Kathi kandula(143.32 g/RM). Transplanted pigeonpea produced 23% higher grain (210.11 g/RM) than that of direct sowing (170.61 g/ RM). Although the individual plant performance was better under wider spacing, the productivity per unit area or running metre was higher at closer spacing due to higher plant population. Higher yield was recorded with closer spacing and 20 cm intra-row spacing with pooled grain yield of 231.26 g/RM was found to be the best. However, considering the economics, direct sowing was better as compared to transplanting due to less investment. As a package recommendation, improved genotype (Manak) can be sown directly on rice bunds with 20cm plant to plant spacing for higher grain yield (284 g/ RM) with maximum net return (Rs. 986/ 100RM or 164407/ha) and B:C ratio (4.95).

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Different Levels of Nitrogen on Growth and Yield of BARI Tomato Varieties

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Abstract

A field experiment was conducted at Sher-e-Bangla Agricultural University Farm of Sher-e-Bangla Agricultural University, Dhaka during 2014-2015, to study the different levels of nitrogen on growth and yield of BARI tomato varieties. The experiment was laid out random complete block design with five levels of nitrogen; viz: N_0 – No nitrogen ha^{-1}, N_1– 80 kg nitrogen ha^{-1}, N_2-100 kg nitrogen, N_3- 120 kg nitrogen ha^{-1} and N_4-140 kg nitrogen ha^{-1} on two varieties of tomato (V_1- BARI tomato-2 and V_2- BARI tomato-14) replicated thrice. The experimental result showed that the growth, yield attributing characters and yield of both the varieties of tomato had significant influence. Between two varieties the growth, yield attributes and yield which plant height, number of cluster $plant^{-1}$, number of flowers $plant^{-1}$, number of fruits $plant^{-1}$, weight of fruits $plant^{-1}$ and yield were recorded highest in BARI tomato-14 as compared to BARI tomato-2. Similarly, levels of nitrogen shows the same trend on growth, yield attributing characters and yield of tomato and was recorded heights significant effect when nitrogen was applied 120 kg ha^{-1}. The combination of levels of nitrogen and varieties also exhibited significant variation in all yield components and yield. And the heights yield 47.83 tonnes ha^{-1} was recorded when 120 kg nitrogen was applied on BARI tomato-14.

Key words : Nitrogen levels, BARI tomato varieties and Yield.

Introduction

Tomato (*Solanum lycopersicum*) belonging to Solanaceae family is a vegetable crop grown in Bangladesh during winter. Its food value is very rich because of higher contents of vitamins A, B and C including calcium and carotene. It is much popular as salad in the raw state and is made into soups, juice, ketchup, pickles, sauces, conserved puree, paste, powder and other product.

In Bangladesh, there is a great possibility of increasing tomato yield per unit area with proper use of fertilizer. Tomato requires large quantity of readily available fertilizer nutrient. To get one ton fresh fruit, plant need to absorb on average 2.5-3 kg N. 0.2-0.3 kg P, and 3-3.5 kg K. In absence of other production constraints, nutrient uptake and yield are very closely related. Nitrogen has the positive response and essential for building up protoplasm and protein, which induce cell division and initial meristematic activity when applied in optimum quantity. Nitrogen has largest effect on yield and quality of tomato. It also promotes vegetation growth, flower and fruit set of tomato. It significantly increases the growth and yield of tomato. Nitrogen has a pronounced effect on growth and development of tomato. It promotes both vegetative and reproductive growth and impacts the characteristic deep green color of leaves. Nitrogen application resulted in greater values of plant height, leaf area, number of leaves and stem diameter of fodder maize, fresh and dry forage yield were also increased due to addition of nitrogen. Leaf to stem ratio was found also to be increased by nitrogen that the increase in leaf to stem ratio with nitrogen application is probably due to the increase in number of leaves and leaf area under nitrogen treatments, producing more and heavy leaves. Application of N-fertilizer to the soil produces high tomato fruit yield and improves fruit quality, whereas excessive application leads to luxuriant development of vegetative parts of the plant at the expense of reproductive growth. It has been reported that tomato can grow on a variety of soils except worst soils such as gravelly soils and water-logged soils but better yields were obtained from some soil types than others even with the same management practices and environmental conditions.

The specific dose of nitrogen may affect yield and storage behavior of tomato fruits.

Usually the farmers of Bangladesh cultivate tomato without pruning and even they do not maintain proper plant density. Where it has been reported that the single stem tomato plants gave early yield but closely planted plants produced higher yield.

The present study was undertaken in view of the following objectives:

- To find out the effect of different levels of nitrogen for higher growth and yield of tomato.
- To find out the suitable variety for higher yield.

Materials and Methods

This chapter deals with the materials and methods that were used in carrying out the experiment. It includes a short description of location of the experiment, characteristics of soil, climate, materials used, land preparation, manuring and fertilizing, transplanting and gap filling, staking, after care, harvesting and collection of data.

3.1 Location of the experiment field

The field experiment was conducted in the Sher-e-Bangla Agricultural University farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207 during the period from October 2014 to March 2015 to find out the effect of different doses of nitrogen on the growth and yield of bari tomato 2 and BARI tomato 14. The location of the experimental site is at 23.75 N latitude and 90.34 E longitudes with an elevation of 8.45 meter from the sea level.

3.2 Climate

The climate of the experimental area was subtropical in nature. It is characterized by heavy rainfall, high temperature, high humidity and relatively long day during kharif season (April to September) and a scanty rainfall associated with moderately low temperature, low humidity and short day period during rabi season (October to March).

3.3 Soil of the experimental field

Soil of the study site was silty clay loam in texture. The area represents the Agro- Ecological Zone of Madhupur tract (AEZ-28) with pH 5.8-6.5, ECE 25.28.

The analytical data of the soil sample collected from the experimental area were determined in the Soil Resources Development Institute (SRDI), Soil Testing Laboratory, Khamarbari, Dhaka.

3.4 Plant materials used

The tomato variety BARI Tomato-2 and BARI Tomato-14 were used in the experiment. These were high yielding, heat tolerant and semi-indeterminate type varieties, the seeds of which were collected from the Horticulture Research Centre, Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur.

3.5 Raising of seedlings

Tomato seedlings were raised in three seedbeds situated on a relatively high land at Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka. The size of the seedbed was 3 m x 1 m. The soil was well prepared with spade and made into loose friable and dried mass to obtain fine tilth. All weeds and stubbles were removed and 5 kg well rotten cowdung was applied during seedbed preparation. The seeds were sown on the seedbed on 25 October, 2011 to get 30 days old seedlings. Germination was visible 3 days after sowing of seeds. After sowing, seeds were covered with light soil to a depth of about 0.6 cm. Heptachlor 40 WP was applied @ 4 kg ha-1 around each seedbed as precautionary measure against ants and worm. The emergence of the seedlings took place within 5 to 6 days after sowing. Necessary shading by banana leaves was provided over the seedbed to protect the young seedlings from scorching sun.

3.6 Treatments of the experiment

The experiment consisted of two factors as follows:

Factor A: It is consisted of two varieties which are mentioned below with alphabetic symbol.

Varity	Alphabetic symbol
BARI Tomato 2	V_1
BARI Tomato 14	V_2

Factor B: The experiment consisted of three different level of nitrogen which are mentioned below with alphabetic symbol.

Doses of N (kg ha^{-1})	Alphabetic symbol
Control treatment (No N fertilizer)	N_0
80 kg N fertilizer	N_1
100 kg N fertilizer	N_2
120 kg N fertilizer	N_3
140 kg N fertilizer	N_4

Total 10 treatment combinations were as follows:

V_1N_0: BARI Tomato 2 + No N

V_1N_1: BARI Tomato 2 + 80kg N ha^{-1}

V_1N_2: BARI Tomato 2 + 100 kg N kg ha^{-1}

V_1N_3: BARI Tomato 2 + 120 kg N kg ha^{-1}

V_1N_4: BARI Tomato 2 + 140 kg N kg ha^{-1}

V_2N_0: BARI Tomato 14 + No N

V_2N_1: BARI Tomato 14 + 80kg N ha^{-1}

V_2N_2: BARI Tomato 14 + 100 kg N kg ha^{-1}

V_1N_3: BARI Tomato 14+ 120 kg N kg ha^{-1}

V_2N_4: BARI Tomato 14 + 140 kg N kg ha^{-1}

The experiment was laid out in Randomized complete Block Design (RCBD) having two factors with three replications. The treatment combinations were accommodated in the unit plots.

3.7 Layout of the experiment

An area of 31.5 m x 11.2 m was divided into three equal blocks. Each block consisted of 09 plots where 09 treatments were allotted randomly. There were 30 unit plots altogether in the experiment. The size of each plot was 2 m x 1.8 m. The distance between two blocks and two plots were l m and 0.5 m respectively. Seedlings were transplanted on the plots with 60 cm x 40 cm spacing (Appendix 5).

3.8 Cultivation procedure

3.8.1 Land preparation

The soil of the experiment field was first opened on 02 October, 2011 in order to get well prepare and good tilth for tomato crop production. The land of the experimental field was ploughed with a power tiller. Later on the land was ploughed three times followed by laddering to obtain untill desirable tilth. The corners of the land were spaded and larger clods were broken into smaller pieces. After ploughing and laddering, all the stubbles and uprooted weeds were removed. Finally, the unit plots were prepared as 15 cm raised beds. Fifteen pits were made in each plot with in row-to-row and plant to plant spacing of 60 cm X 40 cm.

3.8.2 Manuring and Fertilizing

Manure and fertilizers such as Cow dung, Urea, Triple Super Phosphate (TSP) and Muriate of Potash (MoP) were applied in the experimental field as per recommendation of BARI (1996).

The entire amount of well-decomposed cow dung was applied just after opening the land and the total Amount TSP was applied as basal dose during final land preparation. Urea and MoP were applied in two installments by the ring placement. The first ring placement was done three weeks after transplanting and the remaining was done two weeks after the first ring placement.

3.8.3 Transplanting of seedlings

Healthy and uniform 30 days old seedlings were uprooted separately from the seed bed and were transplanted in the experimental plots in the afternoon of 25 November, 2014 maintaining a spacing of 60 cm x 40 cm between the rows and plants respectively.

This allowed an accommodation of 15 plants in each plot. The seedbed was watered before uprooting the seedlings from the seedbed so as to minimize damage to the roots.

The seedlings were watered after transplanting. Shading was provided using banana leaf sheath for three days to protect the seedling from the hot sun and removed after seedlings were established. Seedlings were also planted around the border area of the experimental plots for gap filling.

3.8.4 Intercultural operations

After transplanting the seedlings, different intercultural operations were accomplished for better growth and development of the plants, which are as follows.

3.8.4.1 Weeding and mulching

Weeding was done whenever it was necessary. Mulching was also done to help in soil moisture conservation.

3.8.4.2 Gap filling

A few gap filling was done by healthy seedlings of the same stock where planted seedlings failed to survive. When the seedlings were well established, the soil around the base of each seedling was pulverized.

3.8.4.3 Irrigation

Light watering was given with watercan immediately after transplanting the seedlings and then flood irrigation was done as and when necessary throughout the growing period up to before 7 days of harvesting.

3.8.4.4 Plant protection

Insect pests: Melathion 57 EC was applied @ 2 ml L-1 of water against the insect pests like cut worm, leaf hopper, fruit borer and others. The insecticide application was made fortnightly after transplanting and stopped before second week of first harvest. Furadan lOG was also applied during final land preparation as soil insecticide.

Disease: During foggy weather precautionary measure against disease attack of tomato was taken by spraying Diathane M-45 fortnightly @ 2 gm per litre of water, at the early vegetative stage. Ridomil gold was also applied @ 2 g per litre of water against blight disease of tomato.

3.8.4.5 Harvesting

Fruits were harvested at 3-days interval during early ripe stage when they developed slightly red color. Harvesting was started from 28 February and was continued up to March, 2015.

3.9 Parameters assessed

Five plants were selected at random and uprooted carefully at the time of collecting data of root from each plot and mean data on the following parameters were recorded:-

- Plant height (cm)

- Number of flowers per plant
- Number of fruits per plant
- Length of fruit (cm)
- Diameter of fruit (cm)
- Yield per plant (kg)
- Yield per hectare (t ha-1)

3.10 Data collection

Five plants were selected randomly from each plot for data collection in such a way that the border effect could be avoided for the highest precision. Data on the following parameters were recorded from the sample plants during the period of experiment.

Plant height (cm):

The plant height was recorded at 14 days interval starting from 28 days of transplanting up to 70 days. Plant height was taken at 28, 42, 56 and 70 days after transplanting to record the growth rate of plants.

Number of flowers per plant:

Total number of flowers was counted from selected plants and their average was taken as the number of flowers per plant at the time.

Number of fruits per plant:

Total number of fruits was counted from selected plants and their average was taken as the number of fruits per plant at harvest.

Length of fruit (cm):

The length of fruit was measured with slide-calipers from the neck to the bottom of 5 selected marketable fruits and their average was taken in cm as the length of fruit

Yield per plant (kg):

The fruits were harvested from 5 sample plants and they were measured with the help of measuring balance and average was taken by following formula:

Yield per plant (kg) = Total weight of fruits in 5 sample plants (kg)

Yield per hectare (ton):

The yield per hectare was calculated out from per plot yield data.

3.11 Statistical analysis

The data in respect of growth and yield components were statistically analyzed to find out the significance of the experimental results. The means of all the treatments were calculated and the analysis of variance for each of the characters under study was performed by F test. The difference among the treatment means was evaluated by Least Significant Difference (LSD) test (Gomez and Gomez, 1984) at 5% level of probability.

Results and Discussion

The results of the experiment conducted under field conditions are presented in several Tables and Figures. The experiment was conducted to study the effect of different levels of Nitrogen on the performance of BARI Tomato 2 and BARI Tomato 14 in RCBD 2 factor. The results are presented and discussed under the following parameters.

4.1 Effect of varieties

4.1.1 Plant Height:

Plant height of the present study was significantly influenced due to the effect of varieties. The height were varied to 96.92 to 101.79 cm. between the varieties BARI Tomato 14 was found with taller plant height (101.79 cm) than BARI Tomato 2. Where BARI Tomato 2 produced shorter plant height (96.92 cm). Many scientist found such kinds of findings in their study. Due to significant variation, BARI Tomato 14 is better than BARI Tomato 2.

4.1.2 Flower Plant^{-1}

Significant response was observed in Flower Plant^{-1} due to effect of varieties. The Flowers Plant^{-1} were varied from 12.16 to 13.22. Between the varieties BARI Tomato 14 was found with highest Flower

Plant^{-1} (13.22) than BARI Tomato 2. Where BARI Tomato 2 produced shorter Flower Plant^{-1} (12.16). Many scientist found such kinds of findings in their study. Due to significant variation, BARI Tomato 14 is better than BARI Tomato 2 in case of flower plant^{-1}. Increasing the number of flower plant^{-1} illustrate the opportunity of yielding. As much increase the flower plant^{-1} as increase the higher yield. Similar result also found by Bhadoria *et. al.* 2007.

4.1.3 Fruit Plant^{-1}

Performance study of tomato varieties had significant effect on fruit Plant^{-1}. The fruit Plant^{-1} were varied from 14.672 to 15.648. Between the varieties BARI Tomato 14 was found with highest fruit Plant^{-1} (15.648) than BARI Tomato 2. Where BARI Tomato 2 produced lowest fruit Plant^{-1} (14.672). Many scientist found such kinds of findings in their study. Due to significant variation, BARI Tomato 14 is better than BARI Tomato 2 in case of fruit plant^{-1}.

4.1.4 Fruit Weight (kg/ Plant)

Significant response was observed in fruit weight (kg/ Plant) due to effect of varieties. The fruit weight (kg/ Plant) were varied from 2.23 to 2.79 . Between the varieties BARI Tomato 14 was found with higher fruit weight (2.79 kg/plant) than BARI Tomato 2. Where BARI Tomato 2 produced shorter plant height (2.23 kg/plant). Many scientist found such kinds of findings in their study. Due to significant variation, BARI Tomato 14 is better than BARI Tomato 2 in case of fruit weight (kg/ Plant).

4.1.5 Fruit Yield (t/ha)

Performance study of tomato varieties had significant effect on fruit yield (t/ha). The fruit yield (t/ha) were varied from 38.61 to 41.72 t/ha . Between the varieties BARI Tomato 14 was obtained higher yield (41.72 t/ha) than BARI Tomato 2. Where BARI Tomato 2 produced shorter (38.61 t/ha). Many scientist found such kinds of findings in their study. Due to significant variation, BARI Tomato 14 is better than BARI Tomato 2 in case of fruit yield (t/ha). So BARI Tomato 14 can be recommended for better result.

4.2 Effect of treatments

4.2.1 Plant Height:

Plant height of the present study was significantly influenced due to the effect of treatments. The height were varied to 78.29 to 111.7 cm. Among the treatments N_3 was found with tallest plant height (111.7 cm) than rest of treatments. Where N_0 treatment produced shorter plant height (78.29 cm). Many scientist found such kinds of findings in their study. Due to significant variation, N_3 treatment was found better than any other treatments. Similar findings by Badruddin *et. al.* 2004.

4.2.2 Flower Plant^{-1}

Significant response was observed in Flower Plant^{-1} due to effect of varieties. The Flowers Plant^{-1} were varied from 11.56 to 13.85 . Among the treatments N_3 was found with highest Flower Plant^{-1} (13.85) than rest of. Where N_0 produced lowest Flower Plant^{-1} (11.56). Many scientist found such kinds of findings in their study. Due to significant variation, N_3 treatment was found best than other treatments in case of flower plant^{-1}. Increasing the number of flower plant^{-1} illustrate the opportunity of yielding. As much increase the flower plant^{-1} as increase the higher yield.

4.2.3 Fruit Plant^{-1}

Performance study of Nitrogen treatments had significant effect on fruit Plant^{-1}. The fruit Plant^{-1} were varied from 12.43 to 17.21. Among the treatments N_3 was found with highest fruit Plant^{-1} (17.21) than other treatments. Where N_0 produced lowest fruit Plant^{-1} (12.43). Many scientist found such kinds of findings in their study. Due to significant variation, N_3 treatment was found suitable in case of fruit plant^{-1}. Similar findings by Ferriera *et.al.* 2010.

4.2.4 Fruit Weight (kg/ Plant)

Significant response was observed in fruit weight (kg/ Plant) due to effect of treatments. The fruit weight (kg/ Plant) were varied from 2.261 to 2.850 . Among the treatments N_3 was found with highest fruit weight (2.850 kg/plant) than any other treatments.

Where N_0 treatment produced lowest fruit weight (2.261 kg/plant). Many scientist found such kinds of findings in their study. Due to significant variation, N3 treatment was found better in case of fruit weight (kg/ Plant).

4.2.5 Fruit Yield (t/ha)

Performance study of treatments had significant effect on fruit yield (t/ha). The fruit yield (t/ha) were varied from 31.25to 46.45 t/ha. Among the treatments N_3 was obtained highest yield (46.45 t/ ha). Where N_0 was produced shorter (31.25 t/ha). Many scientist found such kinds of findings in their study. So N_3 treatment can be recommended for better result. Similar result were found by Ingole *et.al* 2005.

Variety	Treatment	Plant Height	No. of Flowers Plant^{-1}	No. of Fruits Plant^{-1}	Fruit Weight (Kg/ plant)	Fruit Yield (t/ ha)
V_1	N_0	74.95	10.96	11.96	2.021	**30.15**
	N_1	90.26	11.36	13.81	2.110	**33.75**
	N_2	100.0	12.41	14.34	2.251	**35.81**
	N_3	110.6	12.91	16.80	2.430	**46.91**
	N_4	108.8	13.15	16.45	2.326	**46.43**
V_2	N_0	82.53	12.07	13.09	2.516	**32.93**
	N_1	94.71	12.70	14.88	2.661	**39.13**
	N_2	105.2	13.03	15.23	2.782	**41.24**
	N_3	114.0	14.23	17.84	3.080	**47.83**
	N_4	112.5	14.06	17.20	2.935	**47.46**
LSD $_{(0.01)}$		2.165	1.024	1.550	0.05474	**0.1111**
CV (%)		**1.23**	**4.48**	**5.72**	**0.23**	**0.04**

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Impact Assessment of Front Line Demonstrations (Fld) on the Yield of Pulses

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Abstract

A field study was carried out during *kharif*, *rabi* and summer seasons in eight villages of Ganjam district of Odisha during 2013-14. Altogether 87 Front Line Demonstrations on green gram, black gram and pigeon pea crops were carried out in area of 38 ha by the active participation of farmers with the objective to demonstrate the package technologies of pulses production under AICRP on Pigeonpea and AICRP on MULLaRP operated at Centre for Pulses Research, OUAT, Berhampur, Odisha. The improved technologies consisting use of modern variety, seed innoculum with *rhizobium* and PSB culture, balanced fertilizer application and integrated pest management. FLD recorded higher yield as compared to farmer's local practice. The improved technology recorded higher yield of 600 kg/ha, 652 kg/ha and 1056 kg/ha in green gram, black gram and pigeon pea, respectively as compared to 420 kg/ha, 470 kg/ha and 761 kg/ha respectively in farmer's practice. The improved technology gave higher gross returns of Rs 30000/-, Rs 26080/- and Rs 41000/- as compared to farmer's practice of Rs 21000/-, Rs 18800/- and 29000/- respectively. The net returns were also higher i.e. Rs 18000/-, Rs 14080/- and Rs 21000/- per ha with the B:C ratios 2.50, 2.17 and 2.13 in case of improved practices for green gram, black gram and pigeon pea, respectively than the farmer's practice of Rs 11000/-, Rs 8800/- and Rs 13000/- with the B:C ratios 2.10, 1.88 and 1.83. In spite of increase in yield of pulses, technological yield gap, extension yield gap and technology index existed. The technology yield gap in the demonstration yield over potential yield were 400 kg/ha for green gram, 348 kg/ha for black gram and 944 kg/ha for pigeon pea. The highest extension yield gap of 295 kg/ha was recorded in pigeon pea followed by 182 kg//ha for black gram and the lowest 180 kg/ha in green gram. The technology indices were 40%, 34.8% and 47.2% for green gram, black gram and pigeon pea, respectively.

Key words : Pulses, Yield, Technology yield gap, Extension yield gap, Technology index

Introduction

India is the largest producer, consumer and importer of pulses. Pulses are a good and chief source of protein for a majority of the population in India. Pulses contain about 20-30% protein. Pulses contribute 11% of the total intake of proteins in India (Reddy, 2010). In India, frequency of pulses consumption is much higher than any other source of protein, which indicates the importance of pulses in our daily food habits. Keeping the cheapest source of protein, it is important to increase pulses production to increase balanced diet among the socially and economically backward classes.

India accounts for 33% of the world area and 22% of the world production of pulses. About 90% of the global pigeon pea and 45% of mungbean area falls in India(FAOSTAT, 2011). Although it is the world's largest pulses producer, India is importing 3-4 million tons (MT) of pulses every year to meet its domestic demand. However, during the last decade, growth in pulses production has increased significantly. The area under total pulses of the country during 2013-14 is 25.21 mha with production of 19.77 million tonnes and productivity 798 kg/ha. Mungbean is grown on about 3.38 mha in the country mainly in Rajastan, Maharastra, Andhra Pradesh, Karnataka, Odisha and Bihar. A phenomenal increase in area, production and productivity has occurred since 1964-65. The production has increased from 0.60 million tonnes in 1964-65 to 1.60 million tonnes in 2013-14. The productivity has also increased from 302 kg/ha to 474 kg/ha during the said period. Urdbean also occupies about 3.06 mha area in the country; the major urdbean growing states are Maharastra, Uttar Pradesh, Madhya Pradesh and Tamil Nadu. The total area under the crop has increased progressively from 1.98 mha to 3.06 mha in 2013-14. Similarly the production has increased from 0.64 million tonnes in 1964-65 to 1.70 million tonnes and the productivity increased from 321 kg/ha to 642kg/ha in 2012-13 and 555kg/ha in 2013-14 during the said period. Likewise, pigeonpea is grown in an area of 3.88 mha with with production of 3.17 million tonnes and productivity 817 kg/ha during 2013-14.

Even though pulses production increased significantly during the last decade but continuing the faster growth is a bigger challenge for researchers, extension agencies and policy makers to fulfill the domestic demand of its in India. The productivity of pulses in India (785 kg/ha) is lower than most of the major pulse producing countries. In Odisha, pulses are cultivated in an area of 2.04 mha with production of 1.04 million tonnes and productivity 508 kg/ha during the year 2012-13. Malnutrition in women and children is common problem in Ganjam district of Odisha. Therefore, this investigation was carried out in this area for popularizing high yielding pulse varieties to increase pulse production and productivity with objective of providing nutritive diet and increase in availability of pulse per capita.

Material and Methods

The present study was carried out by Centre for Pulses Research, OUAT, Berhampur under All India Coordinated Research Project on MULLaRP and All India Coordinated Research Project on Pigeon pea during *kharif, rabi* and summer seasons in the farmers fields of eight villages of Ganjam district during 2013-14. All 87 front line demonstrations in 38 ha area were conducted in different villages. Materials for the present study with respect to FLD was on following:

(i) Improved variety (Green gram-TARM-1, Black gram-Prasad, Pigeon pea-UPAS 120)

(ii) Seed treatment with *Trichoderma* 10 gm/ kg seed, *rhizobium* and PSB culture with 20 g/kg of seed (iii) Farm manure @ 5 ton/ha (iv) Fertilizers (N:P: K: S) 20:40 :20 : 20 kg/ha (v) Adoption of IPM.

The improved technology included modern varieties, seed treatment and maintenance of optimum plant population etc. The sowing was done during June-July in Pigeon pea and black gram, and Feb.-March in Green gram. The spacing was 60 x 20 cm, 30 x 10 cm and 30 x 10 cm in pigeon pea, black gram and green gram, respectively. The seed rate of pigeon pea, black gram and green gram were 20 kg/ha, 25 kg/ha and 25 kg/ha, respectively. The fertilizers were given as per improved practices as basal dose. Hand weeding within lines was done twice at 25-30 and 50-55 DAS in Pigeonpea and once at 21-25 DAS in mungbean and urdbean. The crops were harvested at perfect maturity stage in all pulses with suitable method.

In general, soils of the area under study were sandy loam with pH 5.6 to 6.2 with low fertility status. The average rainfall of this area was 1276 mm with 64 rainy days. In demonstration plots, critical inputs in the form of quality seed and treatment, farm manure, balanced fertilizers and agro-chemicals were provided by CPR, Berhampur. For the study, technology yield gap, extension yield gap and technology index were calculated as suggested by Samui*, et al* .(2000).

Technology yield gap = Potential yield - Demonstration yield

Extension yield gap = Demonstration yield - Farmers yield

$$\text{Technology index (\%)} = \frac{\text{Technology yield gap}}{\text{Potential yield}} \times 100$$

Results and Discussion

Yield

The average yield of pulses recorded in demonstration plots[Green gram (600 kg/ha, Black gram (652 kg/ha) and pigeon pea (1056 kg/ha)] were found much higher as compared to those obtained from farmers practices [Green gram (420 kg/ha), Black gram (470 kg/ha) and Pigeon pea (761 kg/ha)]. The average percentage increased in the yield over farmer's practices was 42.86, 38.72 and 38.76 for green gram, black gram and pigeon pea respectively. The results indicated that the front line demonstrations have given a good impact over the farming community of Ganjam district as they were motivated by the new agricultural technologies applied in the FLD plots (Table 1). This finding is in corroboration with the findings of Poonia and Pithia (2010).

Technology yield gap

The technology yield gap in the demonstration yield over potential yield were 400 kg/ha for green gram, 348 kg/ha for black gram and 944 kg/ha for pigeon pea. The technological yield gap may be attributed to the dissimilarity in the soil fertility status and weather conditions (Mukharjee, 2003) (Table 1).

Extension yield gap

The highest extension yield gap of 295 kg/ha was recorded in pigeon pea followed by 182 kg/ha for black gram and the lowest 180 kg/ha for green gram. This emphasized the need to educate the farmers through various means for the adoption of improved agricultural production technologies to bridge up the wide extension yield gap. More and more use of latest production technologies with high yielding variety will subsequently change this alarming trend of galloping extension yield gap. The new technologies will eventually lead to the farmers to discontinue the old technology and to adopt new technology (Table 1). This finding is in corroboration with the findings of Hiremath and Nagaraju, (2010).

Technology Index

The technology index shows the feasibility of the evolved technology at the farmer's fields and the lower the value of technology index more is the feasibility of the technology (Jeengar, *et al.*, 2006). The technology indices were 47.2 percent for pigeon pea, 40.0 percent for green gram and 34.8 percent for black gram (Table 1).

Economic return

The inputs and outputs prices of commodities prevailed during the study of demonstrations were taken for calculating gross return, cost of cultivation, net return and benefit: cost ratio (Table 2). The improved technology gave higher gross returns of Rs 30000/-, Rs 26080/- and Rs 41000/- than farmer's practice of Rs 21000/-, Rs 18800/- and 29000/-. The net returns were also higher i.e. Rs 18000/-, Rs 14080/- and Rs 21000/- per ha with the B:C ratios 2.50, 2.17 and 2.13 in case of improved practices for green gram, black gram and pigeon pea, respectively than the farmer's practice of Rs 11000/-, Rs 8800/- and Rs 13000/- with the B:C ratios 2.10, 1.88 and 1.83. The higher B:C ratio may be due to higher yields obtained under improved technologies compared to local check (farmers practice). This finding is in corroboration with the findings of Mokidue *et al*, (2011).

Reason of Low Yield of Pulses at Farmer's Field

Optimum sowing time is not followed due to non availability of quality seed. More than 90 per cent of farmer pulses seed sowing as broadcast method and most of situation the plant population at farmer's field is very high or two-three times high of the recommended stand. Lack of popularization of seed cum fertilizer drill for sowing and use of inadequate and imbalance dose of fertilizers especially the nitrogenous and phasphatic fertilizers by farmers does not make possible to fetch potential yield. Mechanical weed control is costly and chemical control is quit uncommon in this region.

Specific Constraints With Marginal/Sub Marginal Farmers

Small Holding: the adoption of well proven technology is constrained due to small size of holding and poor farm resources. Small and marginal farmers have less capability to take risk and do not dare to invest in the costly input due to high risk and the poor purchase capacity of small farmer.

Farm Implements and Tools: traditional implements and tools are still in practice due to small holding which have poor working efficiency. The lack

TABLE 1. Productivity, Technology gap, Extension gap and Technology index of pulses under FLDs

Name of the pulses	Area (ha)	No. of FLDs	No. of farmers	Potential	Yield (kg/ha) Improved technologies	Farmer's practice	% increase over local check	Technology yield gap (kg/ha)	Extension yield gap (kg/ha)	Technology Index (%)
Green gram	20	36	36	1000	600	420	42.86	400	180	40.0
Black gram	10	31	31	1000	652	470	38.72	348	182	34.8
Pigeon pea	8	20	20	2000	1056	761	38.76	944	295	47.2

TABLE 2. Gross return (Rs/ha), Cost of cultivation (Rs/ha), Net return (Rs/ha) and B:C ratio as affected by Improved and Local Technologies

Crop	Gross return(Rs/ha)		Cost of cultivation(Rs/ha)		Net return(Rs/ha)		B:C ratio	
	Improved technologies	Farmers practice	Improved technologies	Farmers practice	Improved technologies	Farmers practice	Improved technologies	Farmers practice
Green gram	30000	21000	12000	10000	18000	11000	2.50	2.10
Black gram	26080	18800	12000	10000	14080	8800	2.17	1.88
Pigeon pea	41000	29000	20000	16000	21000	13000	2.13	1.83

of simple modern tools for small holding also hinders the adoption of improved technology.

Thus, the cultivation of pulses with improved technologies has been found more productive and seed yield might be increased up to 40 per cent. Technological and extension yield gap extended which can be bridges by popularity package of practices with emphasis of improved variety, use of proper seed rate, balance nutrient application and proper use of plant protection measures. Replacement of local variety with the released high yielding variety of pulses would increase in the production and net income.

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Effect of In-Situ Moisture Conservation Practice in Castor Under Dryland Condition

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Abstract

A field experiment was conducted under NICRA project at village - Kalimati/Dholiya, districts - Banaskantha, Gujarat under care of All India Coordinated Research Project for Dryland Agriculture centre, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar during *kharif* 2011 to 2015 on Loamy sand to sandy clay loam soil to find out the effect of climate change on in-situ conservation of rain water at on-farm in participatory action research mode under dry land condition. The data indicated that the practice of compartmental bunding in pearl millet crop exerted their significant influence on grain and fodder yields of castor. On the basis of pooled results, the practice of compartmental bunding recorded significantly higher grain as well as fodder yields of pearl millet 1606 and 4238 kg/ha respectively as compared to farmers practice. Further, the higher net return (₹ 23324/ha) and benefit cost ratio (2.39) were secured with preparation of compartmental bund.

Key Words: Castor, Dryland, Ridge & Furrow and Rainwater harvesting

Introduction

About 70% of the total cultivable area in India is under rainfed agriculture. In Gujarat, nearly 56% of the area is under rainfed farming and 70% of the total number farmers in the state are depending on rainfed farming for their livelihood. Therefore, the potential for future growth in agriculture could be anticipated to a large extent from rainfed agriculture. The dryland area in Banaskantha district and surrounding dryland tracts are characterized by low and erratic distribution of rainfall, inherently poor soil fertility and frequent crop failures due to droughts. To improve the crop productivity and economic status of the farmers under such conditions, ICAR-CRIDA started the National Innovations in Climate Resilient Agriculture (NICRA) project at the All India Coordinated Research Project for Dryland Agriculture centre Sardarkrushinagar. During the last 36 years, the research center has come out with several practicable and highly useful recommendations for rainfed agriculture. The impact created and finally achieved were not encouraging as the piece meal approach hitherto followed for transfer of technology did not make a desired impact on the overall agricultural production in the state. Based on an on-farm testing approach, the improved practice of rainfed crop developed under this project have been tested under farmer's field conditions during the last five years. The on-farm testing of improved dryland technology was found beneficial for tackling the problems of the region on an integrated development basis. A statistical assessment of the superiority of improved practice i.e. ridge and furrow in castor crop compared to farmer's practice has been attempted in this research based on on-farm trials conducted during the years 2011 to 2015.

Materials and Methods

The field experiment was conducted to find out the effect of in-situ conservation of rain water on climate change effect at on-farm in participatory action research mode under dryland condition in the village - Kalimati/Dholiya, districts - Banaskantha under NICRA project of All India Coordinated Research Project for Dryland Agriculture centre, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar during *kharif* 2011 to *kharif* 2015. The soil was loamy sand to sandy clay loam in texture having available nitrogen 149 and 138 kg/ha (Jackson, 1978 Method) and available phosphorus 29.35 and 31.20 kg/ha (Olsen method, Jackson. 1978) from 15 and 30 cm depth, respectively. The soil was slightly saline in reaction (pH 7.2 - 7.7). The experiment comprised of two treatments i.e. T_1**:** ridge and furrow T_2**:** farmers practice were replicated thirteen times in randomized block design. The ridges were made by earthing-up on planting row while furrows made in between two rows of castor crop after 30 days of sowing of the seed to convenience the in-situ water conservation by storing, infiltration and percolation into the lower layers of soil. Recommended dose of nitrogen and phosphorus fertilizers (60:40 kg/ha) were applied to the crop through urea and diammonium phosphate. A uniform dose of nitrogen @ 30 kg/ha, phosphorus and farmyard manure were applied at the time of sowing of the crop. Remaining half dose of nitrogen @ 30 kg/ha was given in root zone of the plants at 40-50 days after sowing just after rainfall. The observations were recorded on grain and fodder yield of pearl millet at harvest.

Results and Discussion

The data presented in Table 1 indicated that in-situ water conservation practice of ridge and furrow exerted its significant persuade on seed and stalk yields of castor. The ridge and furrow making in castor crop recorded significantly the highest seed yields of 1312, 1350, 1352, 1190, 830 and 1207 kg/ha while stalk yields of 2269, 2398, 2414, 2340, 1625 and 2209 kg/ha for the years 2011-12, 2012-13, 2013-14, 2014-15, 2015-16 and pooled data, respectively as compared to farmers practice (flat bad). Further, the higher net return (₹29506/ha) and benefit cost ratio (2.34) were secured with practicing of ridge and furrow as compared to local practice (flat bed). The rain water use efficiency (RWUE) of castor crop was also recorded higher (1.35 kg/ha-mm) due to ridge and furrow. Similarly, Ramachandrappa, *et al*., (2014) also found that the increased yield and net returns accrued

Effect of in-situ moisture conservation practice on castor yields

Treatments	Castor yields (kg/ha)											
	2011-12		2012-13		2013-14		2014-15		2015-16		Pooled	
	Seed	Stalk	Seed	Stalk	Seed	Stalk	Seed	Stalk	Seed	Stalk	Seed	Stalk
T_1 : Ridge & furrow	1312	2269	1350	2398	1352	2414	1190	2340	830	1625	1207	2209
T_2 : Local practice	868	1476	810	1650	880	1888	823	1700	465	940	769	1531
SEm±	54.55	99.84	38.23	61.31	53.22	111.83	40.64	59.64	24.28	54.53	19.78	35.99
CD at 5%	168.18	307.80	117.86	189.00	164.09	344.76	125.29	183.88	74.86	168.10	55.93	101.79
CV %	18.04	19.22	12.76	10.92	17.20	18.74	14.56	10.65	13.52	15.33	15.92	15.61
Rainfall (mm)	1028.8		859.0		949.0		638.0		999.4		894.8	
Rainy days	34		22		37		24		22		28	

were associated with increased soil profile moisture as a result of conservation furrow.

The highest seed and stalk yields of castor were recorded in the year 2013-14 which might be due to comparatively optimum rainfall and higher rainy days. Whereas lowest grain and fodder yields were recorded in the year 2015 which might be due to lowest rainy days and two dry spells of long duration between seed formation to maturity of the crop. The yields obtained in the years 2011, 2012 and 2014 ranked at 3rd, 2nd and 4th, respectively. During drought situations, rainwater conservation technique of ridge and furrow conserved greater quantity of rainwater and increased soil moisture availability in root zone profile as compared to flat bad method in the period of water scarcity. Moreover, Vaidyanathan *et al.* (1998) conducted a study on the effect of moisture conservation practices on the yield of rainfed castor and the results revealed that sowing of castor in ridges and furrows has recorded higher yields by 17.69 per cent than the flat bed system. The same findings were observed by Bhatnagar, *et al.*, (1998) in pearl millet, Baskar, (2010) in cotton, Jat, *et al.*, (2010) and Patil, *et al.*, (2013) in sorghum.

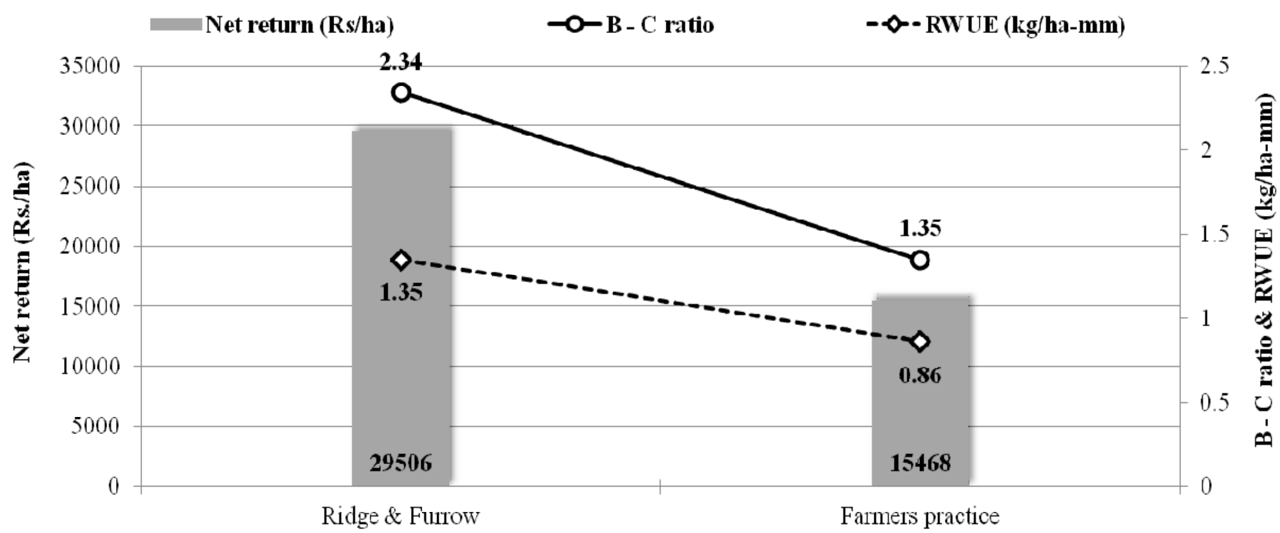

Fig.: Economic and RWUE as influenced by in-situ moisture conservation practices in castor

Conclusion

As a result based on the on-farm trials, the farmers of village Kalimati/Dholiya, (District – Banaskantha) were convinced to adopt the ridge and furrow method of sowing for rainfed castor as an improved technology of in-situ moisture conservation. The maximum yield and monetary returns were obtained from the improved practice of ridge and furrow in different years have also motivated other farmers in the villages for a large scale adoption in the semi-arid area of North Gujarat.

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Integrated Farming System – An Ecofriendly Approach for Sustainable Agricultural Environment

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Abstract

Sustainable development in agriculture must include integrated farming system (IFS) with efficient soil, water crop and pest management practices, which are environmentally friendly and cost effective. In IFS, the waste of one enterprise becomes the input of another for making better use of resources. In integrated crop livestock farming system, crop residues can be used for animal feed, while manure from livestock can enhance agricultural productivity. IFS also play an important role in improving the soil health by increasing the nitrogen, phosphorous, organic carbon and microbial count of soil and thus, reduces the use of chemical fertilizers. Moreover, IFS components are known to control the weed and regarded as an important element of integrated pest management and thus minimizes the use of weed killers as well as pesticides and thus protects the environment. The water use efficiency and water quality of IFS was better than conventional system.

Key words: environment, integrated farming system, nutrient regimes, pest control, weed control

Introduction

In the present scenario, it is hardly difficult to meet out the ever increasing requirement for the ever rising population in India. Unfortunately, In India the food producing enterprises like agriculture and its allied activities namely livestock farming, horticulture, floriculture, aquaculture etc. have been dominated by the small and marginal farmers. Hence, they are unable to invest more capital for doing intensive farming activities to produce more and meet the requirement. In this situation, Integrated Farming System (IFS) plays an imperial role for maximizing their profit and production to meet the nutritional requirement with food security with less investment. Further in IFS it is more advantageous that the farmers can able to produce more by using optimal resource utilization and recycling of waste materials and family labour employment.

The growth rate of agriculture in the recent past is very slow inspite of the rapid economic growth in India. According to the Economic Survey of India, 2008, the growth rate of food grain production decelerated to 1.2% during 1990-2007, lower than the population growth of 1.9%. It is projected that in our country population will touch 1370 million by 2030 and to 1600 million by 2050. To meet the demand, we have to produce 289 and 349 mt of food grains during the respective periods. The current scenario in the country indicates that area under cultivation may further dwindle and more than 20% of current cultivable area will be converted for non-agricultural purposes by 2030. The operational farm holding in India is declining and over 85 million out of 105 million are below the size of 1 ha. Due to ever increasing population and decline in per capita availability of land in the country, practically there is no scope for horizontal expansion of land for agriculture. Only vertical expansion is possible by integrating farming components requiring lesser space and time and ensuring reasonable returns to farm families. The Integrated Farming Systems (IFS) therefore assumes greater importance for sound management of farm resources to enhance the farm productivity and reduce the environmental degradation, improve the quality of life of resource poor farmers and maintain sustainability. In order to sustain a positive growth rate in agriculture, a holistic approach is the need of the hour. Farming system is a mix of farm enterprises in which farm families allocate resources for efficient utilization of the existing enterprises for enhancing productivity and profitability of the farm. These farm enterprises are crop, livestock, aquaculture, agro-forestry, agri-horticulture and sericulture. In such diversified farming, though crop and other enterprises coexist, the thrust is mainly to minimize the risk, while in IFS a judicious mix of one or more enterprises along with cropping there exist a complimentary effect through effective recycling of wastes and crop residues which encompasses additional source of income to farmer. IFS activity is focused around a few selected interdependent, inter-related and interlinking production system based on crops, animals and related subsidiary professions. Integrated farming system approach is not only a reliable way of obtaining fairly high productivity with considerable scope for resource recycling, but also concept of ecological soundness leading to sustainable agriculture. With increasing energy crisis due to shrinking of non-renewable fossil-fuel based sources, the fertilizer nutrient cost have increased steeply and with gradual withdrawal of fertilizer subsidy. It is expected to have further hike in the cost of fertilizers (Singh CB *et al.*). This will leave the farmers with no option but to fully explore the potential alternate sources of plant nutrients atleast for the partial substitution of the fertilizer nutrients for individual crops and in the cropping systems. Integrated farming has immense potentiality to emerge out as an effective tool for improvement of rural economy due to low investment and high profitability (Nanda and Bandopadhyay 2011).

Materials and Methods

The location of this study is in Baruipur block. The study employed primary data and secondary data. The survey was conducted to interview farmers as the respondends. The empowerment strategy is prioritized to some extent of 60 farmers who practiced for mainly paddy cultivation and to some extent horticultural crops. These selected strategies are determined by the Focus Group Discusion (FGD) and in-depth interviews with respondents and also the key-persons. The competent key-persons were selected for FGD to outline the strategy of empowerment for the stakeholders were composed by academician, government, and community. This was compared with the conventional monoculture of rice cultivation. The data were collected on economic parameters like expenditure, gross returns, net return, B:C ratio etc.

Results and Discussion

The data of results of integrated farming system applied at the farms of different farmers are presented in the Tables 1, 2 and 3.

Results discussed revealed that IFS enables the agricultural production system sustainable, profitable and productive. About 95 % of nutritional requirement of the system is self sustained through resource recycling. Balusamy et al. explained that rice + Azolla-cum-fish culture is one of the economical option in such type of area. As the number of enterprises are increased, the profit margin increases but simultaneously coupled with increase in cost of production and employment generation though the profit increase was marginal. Further, it is evident that profit margin varied with the ecosystem (rainfed/ irrigated), management skill, and socio-economic conditions. On an average profit margin on account of IFS varied from Rs 15,000 to Rs 1,50,000/ha/annum. Simultaneously it takes care of the food and nutritional security of the farming family. The study further revealed improvement in the net profit margin varying from 30-50 %. The resource characterization study reveled that improvement in profitability varied from Rs 20,000 to 25,000 under irrigated condition, resource recycling improve fertility led to 5 to 10 q/ha crop yield increase, generate 50-75 mandays/ family/ year and reduce the cost of production by Rs.500-1,000/ha. Therefore, there is an urgent need to promote the IFS concept under all agro-climatic conditions of the country.

TABLE 1. Economic viability of integrated farming system approach

Prevailing system	Net return	Integrated Farming System	Net returns
Rice-rice-blackgram	8,112	Rice-rice-cotton +maize	15,000
		Rice-rice-cotton +maize+poultry/fish	17,788
Rice-rice	14,299	Rice-rice-Azolla/Calotropis+Fish	17,419
Rice-rice-rice-fallow-pulses	12,790	Rice-rice-rice-fallow-cotton+maize+ duck cum fish	24,118
Cropping alone	36,150	Cropping+fish+poultry	97,777
		Cropping+fish+pigeon	98,790
		Cropping+fish+goat	13,1889
Rice	22,071	Rice+fish	28,560
		Rice+Azolla+fish	31,795
Maize	36,360	Coconut+forage +dairy	32,377
		Rice-brinjal (0.5 ha) + Rice-cowpea (0.5 ha)+mushroom +poultry	75,987
Arable farming	24,099	Mixed farming + 2 cow	37,980
		Dairy (2cows) +15 goats+10 poultry+10 duck+fish	44,089
Cotton (K) + Groundnut (S)	(-) 62	Blackgram(K) - Onion (R)-Maize +cowpea	1,308
		Crop+dairy+sericulture	3,509
		Crop + dairy	5,187
Crops (Sugarcane-wheat)	41,097	Crops (Sugarcane+wheat)+dairy	47,739
Rice-Rice system	21590	Rice-fish (pit at the center of the field) – poultry (reared separately)	62, 199
		Rice-fish (pit at one side of the field) – poultry (shed on fish pit)	49, 309

TABLE 2. Productivity and economic analysis of integrated farming system

Farming systems System	rice- equivalent yield (t/ha)	Net returns (Rs./ha)	B:C ratio	Per day return (Rupees)	Employment generation (mandays)
Cropping alone	12.5	37,109	2.33	170	398
Cropping + fish + poultry	28.6	98,886	3.12	409	510
Cropping + fish + pigeon	23.2	98,991	3.16	421	510
Cropping + fish + goat	31.7	1,31,590	3.46	567	590

TABLE 3. Economics of rice-*Azolla* fish integrated farming system

System	Gross income (Rs.)			Total expenditure	Net income
	Crop	Fish	Total	(Rs.)	(Rs.)
Rice	43,888	—	43,998	20,390	23,971
Rice + fish	39,879	11,487	50,898	22,000	28,069
Rice + azolla + fish	40,799	13,609	54,409	22,903	30,788

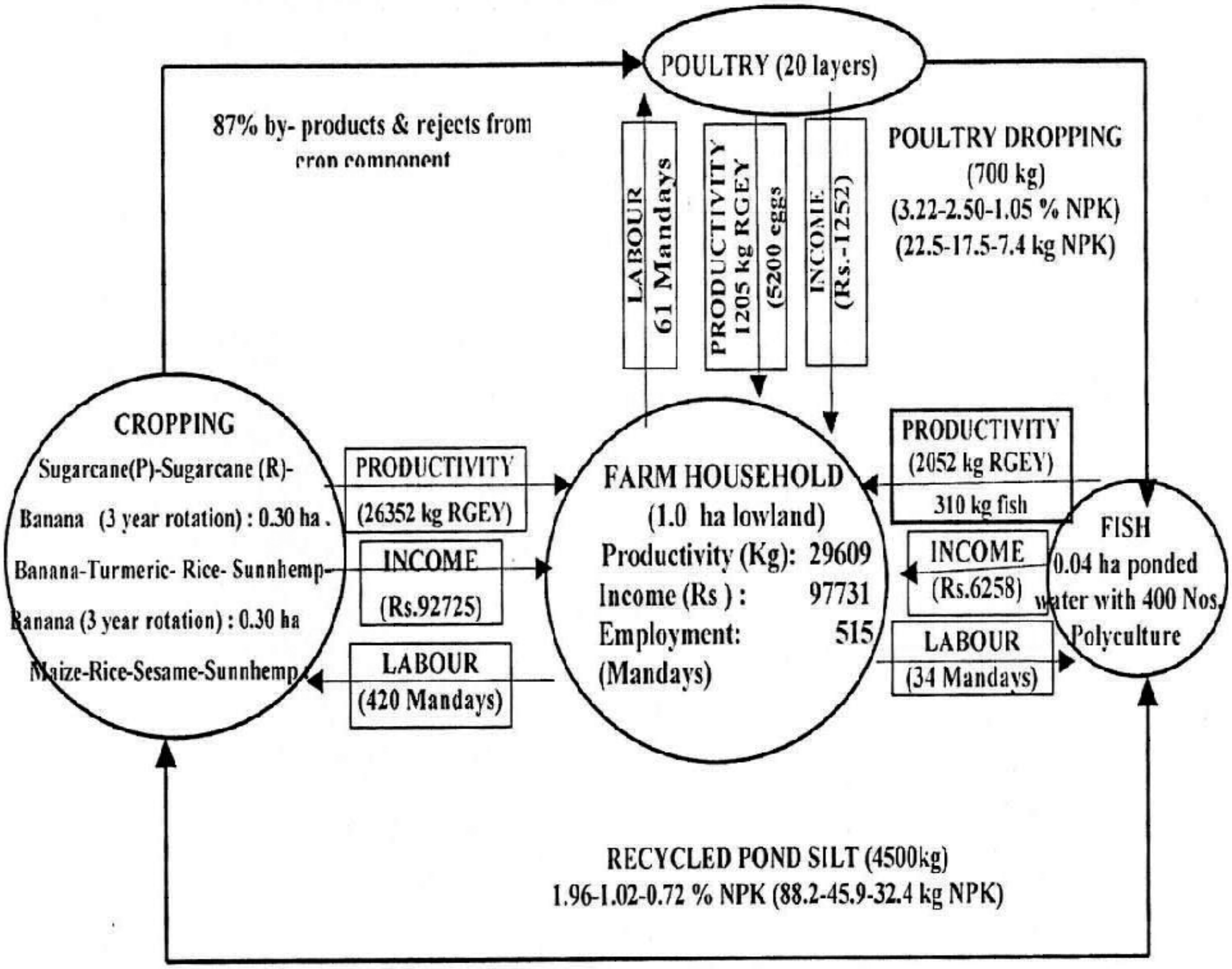

Fig. 1 Resource flow in crop + poultry + fish in integrated farming system (Source :Manjunatha S.B *et al,2014)*

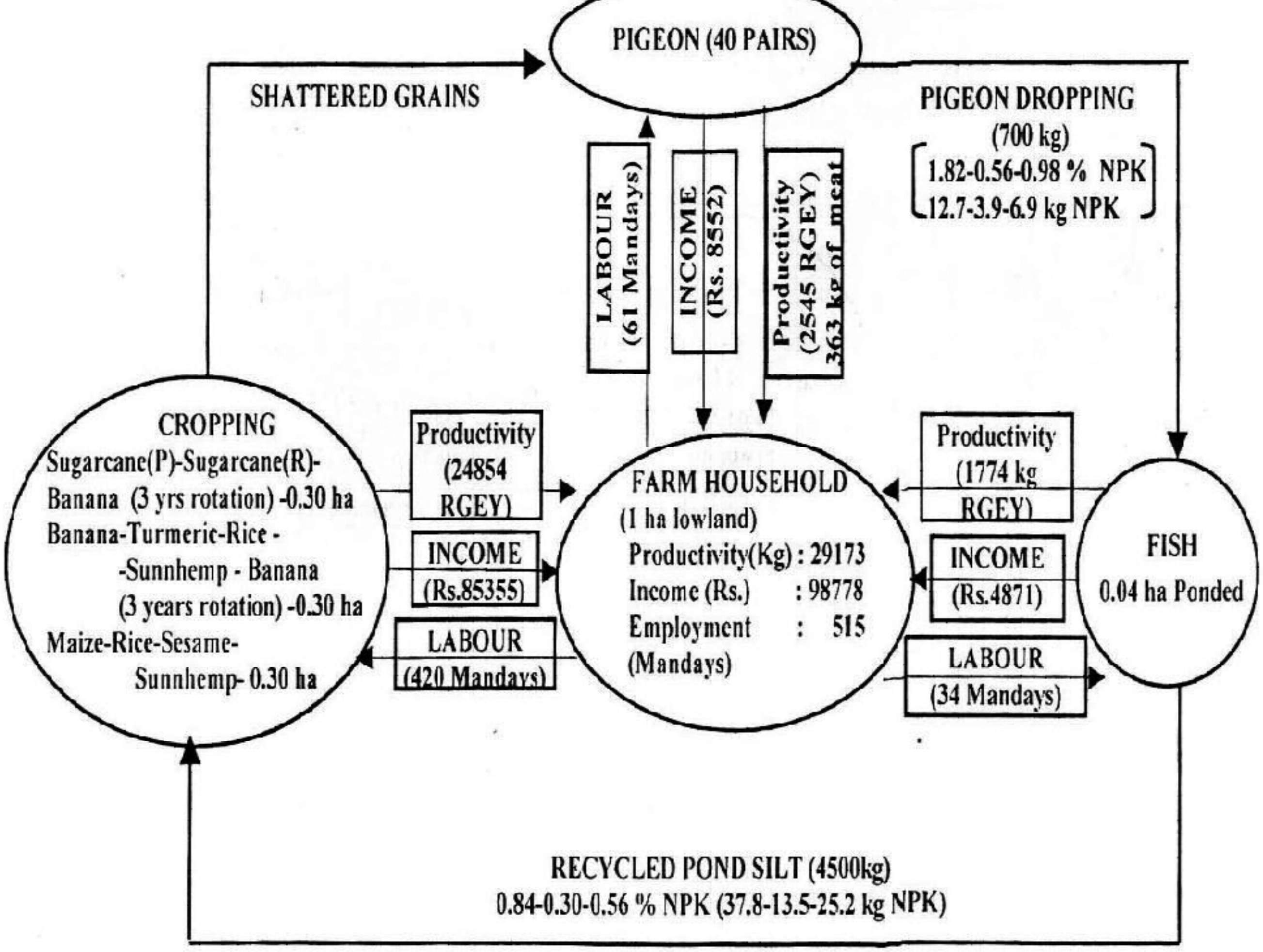

Fig. 2 Resource flow in crop + pigeon + fish in integrated farming system (Source :Manjunatha S.B *et al,2014)*.

Conclusion

An integrated farming system involving crop and non-crop components have been found economically more viable than the traditional cropping system. There are various options in integrated farming system but in the present scenario, integrated farming practice involving paddy and non-paddy based crops and other enterprises may be practised significantly, efficiently and economically by small and marginal farmers. Integrated farming approach enables the agricultural production system to be sustainable, profitable and productive. It not only enhances income and minimizes risk factors but also provides employment opportunities throughout the year. No single farm enterprise is likely to support the small and marginal farmers for generation of adequate income and gainful employment round the year. Small farming in resource poor areas must be sustainable, economical and intensive in order to provide long term support for livelihood and income to rural households. To achieve this, farmer must have access to sustainable technology suitable and available in agriculture and allied sectors. However, policies are required to harness and unleash the potential of small holder producers to build sustainable livelihoods while simultaneously helping the world to protect natural resource and mitigate climate change.

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Studies on Foliar Nutrients on Growth and Productivity of Sunflower (*Helianthus Annuus* L.) in Lower Gangetic Alluivial Soils of West Bengal

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Abstract

A field experiment was conducted at the Agricultural Experimental Farm of Calcutta University, Baruipur, South 24- Pargana, West Bengal, India to study the effect of foliar nutrients on spring hybrid sunflower (*Helianthus annuus* L.) in Gangetic alluvial soils of West Bengal in the year of 2014-15. The experiment comprised of ten different foliar treatments viz. water spray, K_2SO_4@ 0.75% KNO_3@ 0.75%, KCl @ 0.75%, NaCl@0.75%, Boron @0.20%, K_2SO_4+Boron@0.50%+0.20%, KNO_3+ Boron@0.50%+0.20%, KCl+Boron@0.50%+0.20% and NaCl+ Boron@0.50%+0.20% at 50% flowering stage. A recommended dose of fertilizers was applied @N: P_20_5:K_20-80:60:60 kg per hectare in the form of urea, SSP & MOP respectively. The variety of the crop was SIRI-333(hybrid variety). The crop was sown 5th December, 2014 and harvested on 27th March 2015. The experiment was conducted in randomized block design with three replications. The salient features of the findings are in general, application of spray salts at 50% flowering stage recorded better growth and yield attributing characters and seed yield of sunflower crop. The application of K_2SO_4+ Boron @ 0.50%+0.20% registered highest seed yield (47.76% higher over control) and which was closely followed by KCl + Boron (39.80% higher over control) and KNO_3 + Boron (36.32% higher over control). These three treatments recorded statistically on par result with respect to seed yield. Highest stover yield was recorded under KNO3+ Boron@0.50+0.20% and which was closely followed by spray of K_2SO_4+ Boron @ 0.50%+0.20%. Further it was observed that foliar nutrients when tank mixed with boron enhanced seed yield of sunflower significantly over their sole application without boron. It was worth to mention even spraying of NaCl could increase seed yield of sunflower significantly over control and some nutrients. Obviously significantly lowest grain yield was obtained by spraying of water only. Thus it could be concluded that during 50% flowering stage, foliar application of K_2SO_4+ Boron @ 0.50%+0.20% @ has capable of producing significantly higher yield of sunflower and could be suggested to the farmers from yield point of view.

Keywords : Foliar nutrients, Seed Yield, Sunflower, Late winter season

Introduction

In the southern part of West Bengal there is a vast tract of fallow areas about 0.35 million hectares of Gangetic alluvial land. Due to late harvest of traditional *aman* rice as well as due to late receding of water from low lying rice fields, sowing of important winter crops like potato, wheat, rape-seed & mustard is not practically possible on such rice fallow land. Sunflower a photo- and thermo-insensitive, short-duration, deep rooted, drought resistant, wide adaptable crop offers promise for its cultivation on those lands to wipe out shortage of oilseeds in the state of West Bengal when most of the fields are lying vacant after harvest of traditional long duration *aman* rice and before the sowing of the next *kharif* season rice crop.

Loss of N due to leaching and volatilization, P due to fixation and K due to leaching & fixation may not be available adequately at flowering and seed development stages of crop resulting in less number of flowers and poor seed development due to transient nutrient deficiency. Inactivation of the roots activity may be additional cause for this deficiency. Sunflower has a high nutrient requirement that must be applied throughout its growth. So to provide plant nutrients at critical period, foliar application is very important. Foliar fertilization is an effective way of quickly supplying plant nutrients during critical periods of flowering and seed development stages. There is a direct link between foliar feeding and the activities of the enzymatic systems of the plant. Foliar nutrition with N at later stage of crop growth delays the synthesis of abscisic acid and promotes cytokinin activity and causes high chlorophyll retention and thereby photosynthetic activity in effective leaves for supply of current photosynthates to the grains resulting in higher yield (Sarkar *et al.* 2007). Potassium on the other hand is essential for enzyme activation, protein synthesis and photosynthesis. It has proven to be effective in improvement of the cellular as well as the metabolic function of plant (Suryavanshi *et al.* 2016). Potassium nitrate (Bardhan *et al.* 2007) was reported to be effective for enhancing the productivity in wheat crop. Boron is the most widespread high-yield limiting micronutrient. The role of boron within the plant includes cell wall synthesis, sugar transport, cell division, differentiation, membrane functioning, root elongation, and regulation of plant hormone levels (Marschner, 1995, Romheld and Marschner 1991). Moreover, it is recognized as one of the most commonly deficient micronutrients in agriculture. Silberbush (2002) reported that foliar fertilization is widely used practice to correct nutritional deficiencies in plants caused by improper supply of nutrients to roots. Foliar applied fertilizers/nutrients often show a better efficacy which may help to reduce the required dose (Suryavanshi *et al.* 2016). Camberato *et al.* (2010) reported that if the micronutrient deficiencies do occur during the growing season, the most effective method for overcoming these deficiencies is through foliar fertilizer applications. This investigation was mainly done to find out the effects of supplemental foliar nutrients at 50% flowering stage on growth and seed yield under irrigated condition on hybrid sunflower in Gangetic alluvial soils of West Bengal.

Materials and Methods

The experiment was conducted at the Agricultural Experimental Farm of Institute of Agricultural Science of Calcutta University, situated in South 24-Parganas district; West Bengal is situated at 22°53‘N latitude and 88° 26‘E longitude at an altitude of about 6.4 m above mean sea level during late rabi season of 2014-15. The mean maximum temperature in June, which is the hottest month of the year, ranges from 40° to 45°C, while the mean minimum temperature in the coldest month of January is as low as 12.9°C. The mean annual rainfall is about 1582 mm, of which nearly 80 per cent is received during the monsoon period from June to September and the rest during the period between October and May. The field experiment was conducted during late winter season of 2014-15 consist of ten different foliar treatments viz. water spray at 50%flowering stage viz. T_1-Water spray,T_2-K_2SO_4@ 0.75% ,T_3- KNO_3 @ 0.75%, T_4 -KCl @ 0.75% , T_5-NaCl @ 0.75%, T6- Boron @0.20%, T7-K_2SO_4+Boron@0.50%+0.20%,T8-KNO_3+Boron@0.50%+0.20%, T9 KCl+Boron @ 0.50% + 0.20%, T10NaCl+Boron @0.50%+0.20%. A fertilizer dose of 60 kg/ha N, 80 kg/ha P2O5 and 80 kg/ha K2O was applied of which half of N, entire quantity of P and K were applied at the time of final land preparation and rest of N at the time of first irrigation as top dressing.

The variety used for this experiment was SIRI-333. This variety was a medium tall, early maturing (100-120 days) and robust plant type with excellent uniformity of plant height and heads (capitulum). Capitulum is fully convex, mono head, uniformly big size. The sowing of winter sunflower was done by dibbling method with row spacing of 60 cm and plant to plant spacing of 30 cm. Extra plants in the rows were thinned to maintain a plant to plant spacing of 30 cm on 15th day after sowing. The weeds were controlled by pre-emergence spray of pendimethalin @ 0.5 kg a.i. /ha. Three irrigations one each as bud formation, flowering and seed filling stages were applied in the crop field.

Results and Discussion

Data on plant height presented in table-1 clearly revealed that all the foliar nutrient treatments significantly improved plant height over control (only water spray). Highest plant height was obtained by foliar feeding with KNO_3 + Boron (195.04cm). This beneficial effect may be due to NO_3 (Suryavanshi *et al.* 2016) as it induced the improvement in photosynthesis by increasing chlorophyll content counteracted oxidative damage by decreasing the generation of ROS and increase the uptake of nutrient elements. Besma *et al.* (2011) also reported on the similar finding. Many researchers have reported that foliar fertilization treatments significantly increase plant height (El-Abady *et al.* 2008, Yildirim *et al.* 2008)

Data pertaining to yield attributes viz. capitulum diameter, number of seeds/capitulum, test weight (1000-seed weight), and yields (seed and stover yield) as influenced by various foliar treatments were recorded and analysed statistically (table-1). The perusal of data clearly reveals that all the foliar nutrient treatments significantly improved yield attributes viz. capitulum diameter, number of seeds/capitulum and test weight over control (only water spray). The increased yield attributes might be due to enhanced partitioning efficiency and correction of transient nutrient deficiency during flowering and seed filling stages when nutrient demand is at its peak but supply from root may not be sufficient to meet the demand. The data of number of seeds/capitulum (table-1) clearly revealed that all the foliar nutrient treatments significantly improved number of seeds per capitulum over control. Maximum number of seeds/capitulum (1364.67) was registered under KCL+Boron @0.50+0.20% followed by K_2SO_4 + Boron@0.50+0.20% (1346.00). Highest capitulum diameter (23.10 cm) was recorded under the foliar feeding with K_2SO_4+ Boron (23.10cm) and which was closely followed by KCl + Boron (22.89) and KNO_3 + Boron (22.88). These three treatments were found statistically on par. In case of test weight of sunflower seed, highest test weight (59 g) was recorded under the foliar feeding with KNO3 + Boron which was closely followed by K_2SO_4+ Boron (58 g) and KNO3 (56.50 g) while lowest test weigh was registered in case of only water sprayed treatment. The probable reason of highest yield attributing characters may be due to the foliar application of nutrient salts met the N/P/K requirement of the crop during flowering periods resulting in greater availability; absorption of nutrient and efficient translocation of assimilates to reproductive parts which eventually contribute to the high yield attributes. Spraying foliar nutrients at 50% flowering stage might have helped the plants better absorption and consequent assimilation of nutrients supplied through foliar application resulting in optimum growth and development which led to higher dry matter and consequently improved yield attributes and subsequently higher seed yield in sunflower. These results are in close conformity with the findings of Mallick and Das (2017), Sarkar *et al.* (2007) in sunflower and Mallick and Mallick (2017) in greengram.

Highest seed yield was recorded under the supplemental foliar feeding with K_2SO_4+ Boron @ 0.50%+0.20% (47.76% higher over control) and which was closely followed by KCl + Boron (39.80% higher over control) and KNO_3 + Boron (36.32% higher over control). All the tested foliar nutrients treatments enhanced seed yield when they were tank mixed with foliar Boron except NaCl+ Boron. Among the sole application of foliar nutrients like K_2SO_4@ 0.75%, KNO_3@ 0.75%, KCl @ 0.75%, NaCl @ 0.75% and Boron @0.20%, highest seed yield was noticed with K2SO4 @ 0.75% which was closely followed by NaCl @ 0.75%. These two treatments were found statistically at par. It was also observed from investigation that even application of NaCl@0.5% could increase the seed yield significantly in comparison to control and it was found statistically at par with some other foliar nutrient treatments like K_2SO_4@0.5%, KCL@0.5% and KNO_3@0.5%. It is worth to mention here only NaCl@0.75% at 50% flowering stage could increased yield by 29.85% over water spray treatment and foliar boron application at 50% flowering stage could increased yield by 26.37%.

It is evident from the results data that the biological yield under the spray of K_2SO_4+Boron @ 0.50+0.20% (9.75t/ha) was higher than that of other foliar treatments which was closely followed by

TABLE 1. Effect of foliar nutrients on yield attributes & yields of sunflower

Foliar spray	Plant height	No of Seeds/Head	Capitulum Diameter	Test weight	Seed yield (t/ha)	Stover yield (t/ha)	Biological yield (t/ha)	Harvest Index
T1 Water spray	169.85	1103.67	19.20	45.33	2.01	6.06	8.07	26.33
T2 K_2SO_4@ 0.75%	173.65	1270.00	20.03	51.00	2.73	6.70	9.43	28.92
T3 KNO_3@ 0.75%	179.55	1249.67	19.87	56.50	2.48	6.38	8.86	28.04
T4 KCL @ 0.75%	179.62	1267.00	20.30	56.00	2.45	6.48	8.93	27.53
T5 NaCl @ 0.75%	195.11	1281.67	22.35	54.33	2.61	6.47	8.80	29.71
T6 Boron @0.20%	182.58	1211.67	21.11	51.00	2.54	6.41	9.25	27.53
T7 K_2SO_4+Boron@ 0.50+0.02%	192.18	1346.00	23.10	58.00	2.97	6.78	9.75	28.63
T8 KNO_3 +Boron @0.50+0.20%	195.04	1309.67	22.88	59.00	2.74	6.80	9.54	28.54
T9 KCL+Boron @0.50+0.20%	190.48	1364.67	22.89	55.00	2.81	6.75	9.56	29.85
T10 NaCl+Boron @0.50+0.20%	181.07	1201.33	22.45	54.67	2.53	6.60	9.13	27.63
SEm± (0.05)	2.99	65.31	0.63	2.87	0.13	0.13	0.286	1.19
CD	6.12	133.76	1.30	5.87	0.27	0.27	0.868	3.60

KNO_3+ Boron@0.50%+0.20% and KCl+Boron @0.50%+0.20%. Harvest index of tested sunflower crop was also shown significant variation under different sprayed treatments and highest harvest index (29.85) was observed under KCl + Boron @ 0.50% + 0.20%.

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Impact of Agricultural Mechanization on Small Holding Rural Population

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Abstract

India is currently at its GTP II program implementation years. In these years, the country is expected to undergo transformation of its economy. The rural India is expected to transform itself in many ways including but not limited to demography, farm power, intensification, employment reduction, diversification of livelihoods and most importantly increased productivity. In this aspect, the contribution of appropriate agricultural mechanization cannot be relegated given the research and actual evidences from within and other developing countries. Hence, utilization of appropriate agricultural mechanization is expected to enhance the transformation of rural India and lead to a middle income country by 2025. Therefore, this review of literature was undertaken to bring to light the various opportunities of appropriate agricultural mechanization as an input for transformation. It tries to link the different effects of mechanization under a developing economy. Mechanization once implemented with great ambition and ultimate failure has resulted in unfitness to the Indian condition. In addition to land holding and other institutional issues, demography resulted in the idea and conclusion by most Indians that mechanization will not work in India at all. The great deviation in assuming the contribution of mechanization to the development process as a whole is intensified by the poor perception of people about it. Most people declare mechanization only refers to tractor and combine harvester. However, mechanization includes the different small and medium agricultural implements used in the production, processing and transporting of agricultural produces. Generally Indian experience shows that mechanization has a positive overall effect on the development of rural areas. With certain opportunity costs especially little displacement of human labor, mechanization having a response coefficient of 0.45 bears an important part of the agricultural production system. However, owing to the land conditions of Indian smallholder what is most important is selective use of mechanization technologies that could increase the technical efficiency of the smallholder through increasing the labor and land productivity. So from the review it is possible to conclude that mechanization of agriculture bears undisputed truth for improving food security, creating employment opportunities, increasing productivity, reducing loss and promoting economic gender empowerment while maintaining environmental degradation to lower levels.

Keywords : Developing Economy, Empowerment, Employment, Environment, Mechanization, Productivity, Rural India, Transformation.

Introduction

One of the major problems of India for the last four decades is the inability of its agricultural population to produce enough to feed the population and/ or the inability of land areas forced the inclusion of more and more marginal lands for agriculture. However, the increased production from these lands has not been significant that food shortage has become ordinary in the country. As a result one of the major challenges to rural development in the country is how to promote food production to meet the ever increasing demand of the growing population. It becomes very much relevant given the conditions prevailing of high population growth, low labor productivity, recurrent drought and similar dreadful situations the country has been experiencing. Several methodologies have been devised and applied including the use of improved varieties of crops for improving food production in the country. However, the situation is still dire to a significant part of the population and the whole of the population in general dependent on subsistence oriented farming system. Generally, methods of increasing production are farm area expansion, use of external inputs, use of improved seeds, better seed bed preparation and use of other improved farm implements (for increasing farming area or improving technical efficiency). In the Indian context, except in the low land areas expansion of farm lands is over due to obvious reasons of slope and marginality. Though use of improved varieties is going it is solely use and this requires harmony with improving the technical capacity of farmers. The government has devised a policy that centers the development of rural areas and transfers to industrialization and urbanization. This is due to reasons of resource availability in agriculture and insignificant industrial base of the country. The policy has formulated several strategies to achieve the development agenda. The strategy stresses on commercialization and intensification through use of other external inputs as a means to ensure food security locally as a means to combat the problem. Up until now, the problem has continued with scanty success stories. Several scholars pointed out that the problem of low production could largely be related to low technical efficiency. This is due to the time old implements and operation systems that are being used in using new crop technologies also. The problem of Indian agriculture cannot be primarily explained by natural endowments . By any measure, India is well endowed at least in part with a fertile soil, abundant water resources and good climatic conditions until recently. What needs careful analysis is why Indian farmers continue to practice essentially the same farming methods with very little technical or management improvement for so long. The low productivity level of Indian farmers even compared to African standards could largely be traced to low technical efficiency along with the decrease in fertility of soil. Recently for example, a preliminary research result by Melkasa research centered proved that traditional 'Mofer' attached Moald Board Plow has helped increase productivity of haricot bean on average by 23% compared to seed bed prepared using local 'Maresha' alone. In line BBM has been useful in increasing productivity at vertisols. The methods of improving technical efficiency are through improving the management activities. This could largely be achieved through utilization of appropriate agricultural implements. However, the government and smallholders including other stakeholders has given little attention to use of agricultural implements (mechanization technologies). Lack of interest for mechanization is largely blamed for land conditions like fragmentation and small size. However, search for and utilization of appropriate mechanization technologies should be part of the strategy for increasing production and productivity. In this aspect recently the government has drafted a national mechanization strategy. The aim of the strategy is to 'increase national food production and security through enhanced and sustainable use of agricultural mechanization technologies in order to support India's middle-income status by 2025'. Hence experiences should be re-reviewed and mechanization like the other technologies and inputs of agriculture should be promoted at a highest priority levels. The rationale is due to several reasons accompanying increased productivity and as a means to create alternative livelihoods for the majority of the population. Statement of the problem Despite the fact that smallholders exert optimum efforts to increase productivity of crops, the improvement seen is insignificant in relation to the plowed crop land, trend of population growth and input use. In all parts of the country, the problem of food deficit is not solved. Increasing the technical efficiency, way of increasing productivity by appropriate management, could help in the way forward. More over, introduction of medium or low level mechanization implements and technologies enables lighten burden of women who contribute most of the labor for agricultural production in India. It is because it releases labor to be used for other on, off and non-farm activities, which are the strategies to increase resilience and productivity in the smallholder context in general. The current Indian development policy stresses on development push from agriculture to industry based on use of all means's of increasing productivity and production. Hence it adheres to growth and development primarily from agriculture. One of the means's of development of agriculture is intensification of labor. Labor intensive refers both to employment of all available working labor and maximizing its output. In agriculture this can be done through use of management intensive operations and increasing the working labors productivity through mechanization. Mechanization is a multi-dimensional concept and includes social, economical bases, technical and agricultural engineering, agricultural machinery engineering, programming and more importantly management. Farm mechanization has been helpful to bring about a significant improvement in agricultural productivity. Thus, there is strong need for mechanization of agricultural operations. Even thou mechanization is part of the Indian research and extension system, it is sufficient to witness its recognition by the government and other stakeholders only by taking the representation of one research centre in Amhara region where more than 33% of the country's agricultural production takes place and the insignificant attention given at the low administration and agricultural bureaus except in campaign like activities. The factors that justify the strengthening of farm mechanization in the country can be numerous. The timeliness of operations has assumed greater significance in obtaining optimal yields from different crops that has been possible by way of mechanization. Extremely scanty information about local experience affected for full exploitation of the learning experience. Thus the objectives of this assessment are to review the experiences of countries with smallholder farming system and scientific studies done to extrapolate to India and to enable people look alternative ways of agricultural development strategies. This review is directed to provide information for decision makers, researchers and extension workers so that to encourage them invest optimum efforts for wider promotion of mechanization technologies and create overall awareness about favorable environments for rapid adoption of mechanization technologies. Farm Mechanization defined: Agricultural mechanization embraces the use of tools, implements and machines for agricultural land development, crop production, harvesting, preparation for storage, storage, and on-farm processing. Others defined mechanization as application of suitable machines, recognition of technologies and applying suitable methods for production, processing of agricultural products, continuous increase of productivity as the result of the reducing the cost of production, reduction of the losses and increase of efficiency and increase of income . Generally both refer to better farm power input to agriculture. Farm power consists of manual labor, agricultural tools, draught animals, tractors, implements, equipment, and machinery as an essential farm input. In almost any agricultural production system the annual expenditure on farm power, whether on labor, draft animals, or fuel and depreciation of machines, largely exceeds the costs of other inputs such as agro-chemicals and seeds. In many developing countries, agricultural production and food security are adversely affected because of insufficient use of farm power, low labor productivity and/or labor scarcity . The need to improve agricultural labor productivity is increasingly recognized. In the case such as pump sets for irrigation, the need for machinery is undisputed. Rather than agricultural mechanization, it would be preferable to use the term farm power or labor productivity enhancing technology, to recognize not only the importance of manual labor and hand tools, draft animals, and mechanical power, but also other issues related to labor scarcity, such as cropping and farming systems . The term mechanization is unfortunately often very narrowly perceived while its real purpose, namely, enhancing productivity of land and labor is often not well understood. In fact an agricultural mechanization strategy ought to be part of an agricultural technology or development strategy. In this context, three principal purposes of mechanization may be summarized . The first is increase in labor productivity. The introduction of machinery to substitute for labor ("labor saving") is a common phenomenon associated with the release of labor for employment in other sectors of the economy or to facilitate cultivation of a larger area with the same labor force. The other principal purpose is increase in land productivity enabling production of more output from the existing land. Machinery is a complementary input, required to achieve higher land productivity, for example, through the introduction of pump sets, or faster turn-around-times to achieve higher cropping intensity. However, in labor surplus economies, net labor displacement or replacement should be avoided. The third purpose is decreasing the cost of production. Introduction of a machine may lower production costs or offset increased.

2. Benefits of Agricultural Mechanization

2.1. Agricultural Production and Productivity

The factors that justify the strengthening of farm mechanization can be numerous. The timeliness of operations has assumed greater significant in obtaining optimal yields from different crops, which has been possible by way of mechanization. For instance, the sowing of wheat in Punjab is done up to the first fortnight of November. A delay beyond this period by every one week leads to about 1.50 quintals per acre decrease in the yield. However mechanization facilitates timely sowing and thus avoids loss that could be incurred. Farm mechanization is regarded as sine-qua-non to reduce the human drudgery and enhance the agricultural productivity. During the post-green revolution period of India, the impact of farm mechanization on agricultural production and productivity has been well recognized. Post harvest grain loss of 6% in harvesting and threshing with traditional methods, and 2-4% with combines. The linear regression function to examine the effect of important inputs on crop productivity for the State of Punjab showed high for mechanization. Standardized regression coefficients were calculated for relative efficiency of different inputs. The elasticity of productivity for fertilizer, irrigation and farm power was reported to be significant in the production function. Relative efficiency of farm power was higher followed by fertilizer and irrigation. The coefficient for relative efficiency and standardized regression coefficient for fertilizer, irrigation and farm power was reported to be 0.23, 0.35 and 0.45, respectively. The effect of farm power, however, showed decreasing effect beyond 3.24 kW/ha. Tractorization resulted in a positive correlation for area sown with variables such as percent of double cropped area, percentage area irrigated, percentage area under high-yielding varieties, percentage area of holding with more than twenty hectares, wages of agricultural labor and annual growth rate of agricultural output. However, there was negative correlation of tractors with agricultural labor and working animals per 100 acres of net area sown. It was observed that tractorization was significantly associated with higher level of high-yielding varieties and HYV's were positively correlated with irrigation. Thus the interaction between tractors, high-yielding varieties and irrigation had led to the observed association between tractors and rate of growth of agricultural output. The quality and precision of the operations are equally significant for realizing higher yields. The various operations such as land leveling, irrigation, sowing and planting, use of fertilizers, plant protection, harvesting and threshing need a high degree of precision to increase the efficiency of the inputs and reduce the losses . In sum higher productivity of land and labor is the factor that clearly justifies use of farm mechanization. A study in India, According to field experiments conducted by agronomists over two seasons, a row planter (a simple animal drawn semi automatic row planter was developed at AIRIC) gave 30% more grain yield compared to manual placement of two seeds. The study also revealed as farmers reporting a 20 to 100% increase in yield by using moldboard plow, low level mechanization as it uses the traditional implement system.

2.2. Cropping Intensity

Agricultural mechanization has made significant contribution in enhancing cropping intensity. A study in India (on 162 farming households) concluded that the cropping intensity showed consistently positive relationship with tractorization. Within the given size groups, tractor-owning farms had higher cropping intensity as compared to tractor-using or animal operated farms. The time taken to perform sequence of operations is a factor determining the cropping intensity to ensure timeliness of various operations.

2.3. Employment of Human Labor

The problem of unemployment stems in part from the dominance of South Asia in the mechanization literature, but also from the low total number of hours in agricultural activities reported in many studies for

Africa. Almost certainly there is available labor that can and will respond to adequate incentives, as reflected yearly when family members and communities mobilize in order to meet peak season requirements. It is well known that the livelihood strategies of most African rural households are well diversified. In many areas, arable farming provides half or less of household incomes and in some, substantially less. Even in areas that are heavily reliant on crop farming, significant amounts of income are derived from beer-making, transport, small trading, brick-making and other activities, as well as wage employment and remittances. There are, in brief, many competing demands from other activities. Most of these other activities have low real wage rates, but unfortunately, returns to labor in agriculture are often even lower, except in peak periods when labor flows from other activities to agricultural ones. Displaced labor may be absorbed in the other alternatives created by the increased mechanization such as manufacturing, repair and service shops and the sale services. Thus, it only results in the shifting of the labor from one vocation to the other. The impact of farm mechanization on labor employment, particularly in a labor surplus country like India, has been a matter of concern and debate. The available evidences suggest that mechanization had helped in overall increase in employment of human labor. A study had showed that both tractor as well as non-tractor farms had on an average 8.2 persons per farm and the labor force at their disposal was neither surplus nor inadequate. GIPE concluded that tractorization generated greater demand for labor by facilitating more intensive cultivation. Thus, there was no significant displacement of human labor after tractorization. Mechanization accompanied by use of new seed technology and adoption of modern cultivation methods had a beneficial effect on employment. Kahlon reported that reduction in aggregate labor use on tractor-operated farms owning tube wells was only 1.3% as compared to bullock. The Indian Committee called Bhagwati on Unemployment concluded that mechanization of agricultural operations, by and large, displaced bullock labor and not human labor . In another study increased use of tractors was associated with marked rise in employment due to their effect on cropping intensity. AERC concluded that the use of tractors had, in most cases, displaced only one pair of bullocks. The overall human labor input for crop production per cultivated hectare was practically the same for both types of farms. The study reported that the technological displacement of labor associated with tractor use was compensated by the employment of labor owing to increased yield as a result of tractor use among farms characterized by partial tractorization. The net employment effect of tractor use turned out to be positive when its complementarity with other techniques was taken into account. Tractors replaced mainly family labor time on small farms and permanent labor time on large ones. Use of threshers displaced mainly family and casual labor time on small farms and family and permanent labor time on large ones. The combined effect of family labor time was increased in the use of permanent and casual labor time on farms of most size groups. With the addition of power threshers, these effects were lessened. Patil and Sirohi studied the employment per hectare of cropped area. The total labor employment was the highest on small farms and decreased as the farm size increased in respect of all categories of farms. The overall human labor employment was the highest for tractor operated farms followed by tractor plus bullock operated farms. The ratio of family labor to total labor employed per hectare decreased with an increase in farm size. On an average, the per hectare employment of hired labor and total labor was higher by 39 per cent and 24 per cent on tractor operated farms and by 43 per cent and 22 per cent on tractor plus bullock operated farms respectively than that of bullock operated farms. The higher percentage of hired labor employment with the increase in farm size, in general, and of tractor-owning farms in particular disproved the general opinion held regarding displacement of human labor by mechanized farming. Aggarwal and Mehra reported an estimated displacement of casual labor by cost of combine harvester to the extent of 9 man days per acre. Another study found that harvester combine displaces labor on a large scale and was costliest from social point of view. The use of harvester combine resulted in saving of about 15 man-days of unskilled labor per acre . Singh states that it is worth mentioning that it is wrong to say that all sorts of mechanization are unjustifiable. Thus, the question of farm mechanization and unemployment is basically concerned with the use of tractors, threshers, combine harvesters etc. However, these machines bring timeliness and remove drudgery for farm operations and reduce unit cost of production in improving competitiveness. Hence, medium size and improved low level mechanization that are currently in use by countries like china and South East and Far Asia should be recognized. Introduction of mechanization to address peak season labor constraints could consequently be expected to have two benefits leading to an increase in employment and wages. One is the substitution of capital for labor when meeting peak season labor constraints, thereby allowing household members to continue to engage in their other nonfarm activities that are put on hold during peak seasons though otherwise remunerative. The second and more important is the increase of labor demand in agriculture in the non-peak seasons through increases in scale and/or increases in land productivity because of more timely and high quality land preparation . Reduction of the extreme seasonality of labor in agriculture could lead to an increase in time devoted to agricultural production from 15 % up to 50 %. There was labor displacement in the area of plowing and transport. However, this was more than compensated by higher employment in other agricultural operations notably, fertilizing, weeding, inter culture, pest control, irrigation, harvesting, threshing etc. According to field tests by farmers, in Melkassa area by AIRIC, animal-drawn inter row weeder reduced the time and labor required for manual weeding, up to 18 fold. Thus, freeing labor for another employment opportunity and increasing productivity through timely operations. Generally, different studies conducted on mechanization indicated that net human labor displacement in agricultural operations was not significant and it was more than compensated by increased demand for human labor due to multiple cropping, greater intensity of cultivation and higher yields.

2.4. Subsidiary and Non-farm Employment

The demand for non-farm labor for manufacture, services, distribution, repair and maintenance as well as other complementary functions increased substantially and helped in relieving rural unemployment to some extent. Mechanization in agriculture provided indirect employment to skilled and unskilled persons engaged in operation, repair and maintenance of prime movers and farm equipment. Besides many subsidiary activities like dairying and poultry keeping got generated . Mechanization through provision of more free time helped in increasing the subsidiary activities that ultimately increase income of the farm household. Mechanization has generated many non-farming and subsidiary activities among the farming households. On one hand additional employment was created in the manufacture of farm machinery, distribution of the equipment and spare parts, repair and servicing etc. Tractorised farms reduced their draught animal stock and increased their milk stock . Tractor-owners and tractor-users had 82% and 25% more milk cattle's, respectively as compared to bullock farms [23, 24]. A tractor owner was able to increase his household income by undertaking supplementary activities such as dairying and provisions of custom-hiring. A tractor owner with a land holdings of 6.28 ha, had an average gross income of Rs. 47,534 which exceeded that of a bullock farm and tractor-user household by 285% and 132%, respectively.

2.5. Post-Harvest Technology

Post-harvest management is the handling, processing and preservation of crop produce at the time and after harvesting. The average post-harvest losses of food crops such as Teff, Sorghum, Wheat and Maize are 12-9%, 14.8%, 13.6% and 10.9% respectively . Thus, whether the gain in crop yield is marginal or significant, it could be nullified because of inappropriate or unreliable post- harvest management employed. In a country where production is much lower than the national demand and supplemented with the above stated level of post-harvest loss, shows how much effort is needed in the area of generating technology that minimizes this loss. One way to overcome this problem is to increase local value-added food products. The thrust of the post-harvest technology is to improve existing small and medium scale processing enterprises (both formal and informal) that produce a wide range of traditional basic food items that are so important for nutrition and food security in many areas of Africa. This includes the vibrant root crop processing sector in West Africa, as well as milling of basic grain staples in Southern Africa. The emphasis is on traditional products that are important in the basic diet of rural and urban people, and on the employment generated through the value added by such processing. Often, potential exists to make significant advances in value added (and thus the profitability of these enterprise) through relatively low cost interventions such as improved grading and packaging as well as storage and processing.

2.6. Contribution for Women's Economic Empowerment

Gender equality promotes poverty reduction and economic growth. In Kenya, one study estimated that giving women farmers the same level of agricultural inputs and extension services as men farmers could increase yields obtained by women farmers by more than 20%. Macro- and micro-level analyses of the links between gender inequality and growth show that gender-based asset inequality acts as a constraint to growth and poverty reduction in SSA. For example, gender inequality in education and in employment is estimated to have reduced SSA's per capita growth in the 1960-92 periods by 0.8% per year . Women prevent the poverty of the ultra-poor households from worsening. In post-transition Mongolia, if women's contributions were ignored, the rural Gini coefficient and household's poverty gap ratios would be 0.63 and 32%, respectively. But when women's income is taken into account, the ratios drop to 0.49 and 29% respectively. This means that for the ultra poor households, women are crucial in preventing their poverty from worsening. Strategies that consider how best to enhance women's economic contribution can in turn enhance their potential for reducing household poverty and promote gender equality and women empowerment as effective means to combat poverty. Mechanization may be a means of freeing women and children from agricultural work to more rewarding occupations and education . Women in rural areas spend 1-2 hours daily on domestic transport, carrying water, firewood and crops on their heads and traveling on foot. Studies in Ghana show that women contribute to 60-70% of the transportation time for crop productivity, harvesting and marketing. An African woman uses 13 hours to pound maize that is enough to feed a family for four to five days. She spends 4-5 hours every day to prepare the food her family eats. This is twice the time it takes the villagers to grow and gather food and cash crops . Throughout Africa, many small-scale food processing operations are undertaken mainly by women. Hence there is a need to lighten the burden on women as women are also key to the success of post-harvest operations as enterprises or businesses . Women's time burdens are an important time constraint on growth and development. For example, a study in Tanzania shows that reducing such constraints in a community of smallholder coffee and banana growers increased household cash incomes by 10%, labor productivity by 15% and capital productivity by 44% . Therefore mechanization technologies by easing the drudgery of farm work and providing more time for women enable to achieve the economic empowerment through other employment opportunities. Such action also helps achieve two of the four dimensions of gender sensitive poverty reduction strategies. These are; (i) the opportunity dimension where by among others reduction in women's travel and time burdens is a critical intervention , and (ii) provision of water and energy that could be facilitated by use of several pumping methods like rope-washer pump that is highly in use.

2.7. Contributions to Environment or Promoting Green Economy

Finding solutions to environmental problems in agriculture requires (improved) agricultural tools and machinery, for example for soil tillage and pesticide application, the latter also addressing health concerns. By largely avoiding use of pesticides, insecticides, and other chemicals it is possible to attain productivity levels through mechanization. This results in saving the natural biodiversity useful to the continuation of man-land nexus. Thus, it is now recognized that agricultural mechanization is crucial in the fight against hunger and poverty, and at the same time to address environmental and health concerns . Additionally the freed labor especially man could be directed for natural resource conservation and management works as being used currently in India. 2.8. Gross Farm Income and Net Return Farm mechanization has greatly helped the farming community in the overall economic upliftment. The studies conducted on impact of mechanization on farm income clearly support this view point. Studies revealed that the gross income was higher on mechanized farms than non-mechanized farms. The gross crop output per cultivated hectare was reported to be Rs.3144 for tractor operated farms as compared to value Rs.2677 for bullock operated farms. Tractor farms secured 21% more income per hectare of gross cultivated area compared to bullock farms. The net return per hectare of gross cropped area or net cultivated area was higher for tractorized farms than the non- tractorized farms as a result of better utilization of resources. Another study revealed that the tractor owners and users derived higher per hectare gross income compared to bullock farms. The gross income per hectare of an average tractor-owned house hold was 63% higher than that of a household using only bullock labor. The gross income per hectare of tractor-using households as a group exceeded that of the bullock farms by 31%. The average net return from a tractor-owning farm on a cropped hectare exceeded that of a bullock farm by 152%. A tractor using farm also derived a net additional income of 84% over a bullock farm. A tractor-owning farm spent 57% more than bullock users on material inputs and 62% more on human labor. An average tractor owner and user, in spite of spending more on cultivation expenses, derived higher net income on a cropped hectare compared to bullock farm. However, this should not be attributed entirely to tractor usage as other factors such as hybrid seeds, fertilizer and irrigation also contributed to it. A study confirmed that the gross return were higher by about 33 to 34% on tractor-owning farms than those on bullock operated farm . Net return per hectare from mechanized farms having tube wells and tractors and partially mechanized farms having only tube well were 49% and 29% higher respectively than that from non-mechanized farms.

3. Conceptual Framework

Generally, the household asset base of rural people lies at the heart of the farm power system. Household composition and group membership determine the labor available for farm work. The education, skills and off-farm employment experiences of the household head are often associated with specific power sources. The strength of the association between farm power and wealth suggests that the source of farm power may be taken as a proxy for a household's asset-based wealth within a given community. As a result farm power is central to productivity as indicated by the inefficiency of maize growers (that could have been increased by 22%) was attributed to, among others, labor. Similar studies showed the role of labor. The basic assumption is that Indian agricultural development could better be promoted by the use of appropriate mechanization technologies. Appropriate refers to research supported and lead trial and diffusion of technologies in which technology failure is minimized and appropriate places for each levels of mechanization are scientifically identified. Several inputs could be used for increasing productivity to feed the booming population, provide raw material for industries, facilitate empowerment of rural women that constitute the larger proportion of the rural poor through increasing the technical efficiency of farmers. Hence the contribution of mechanization that is highly disvalued in the country should be counted for. The idea is though mechanization, through cooperative farming, has been implemented during the Derg period with great ambition and with no such care of failurity and support from other stakeholders, the ultimate failure partly due to political reasons has resulted in mis-conception by many Indians that mechanization will not work in our country. Of course it is locally conceived mechanization referring to directly tractor and combine harvester, engine powered, that are being used by large farm owners. Rather mechanization includes the low levels, mechanically driven farm implements and small scale motorized machines suitable for smaller farms. As Singh put, there are good chances to reduce the cost of production if farm operations are mechanized as it saves labor, both human and bullock. In the absence of mechanization, the ever-increasing wage rate of human labor and cost of upkeep of draught animals could have increased the cost of production much higher. It also encompasses use of improved storage and processing methods that could minimize post harvest loss. An efficient post-harvest system aims to minimize losses and maintain the quality of the crop until it reaches the final consumer. When food losses are minimized, both food security and income increase, and this is vital for smallholders. From a socio-economic point of view, the implementation of an efficient post-harvest system in any community must provide equitable benefit to all those involved in the system . Similarly, machines are required to assist with post-harvest loss reduction and on-farm processing. As Singh stated as production increases with mechanization of the farm operations, it creates a good scope for commercialization of agriculture that is also India's national orientation. The following two reasons underlie the rational behind promotion of mechanization.

3.1. Farm Power as a Determinant of Livelihood Strategies and Food Security

There is no doubt that farm-power technologies other than a hoe offer considerable advantages in terms of area cultivated, total yields achieved, levels of drudgery, opportunities to redeploy family labor, and household food security. Households relying on family labor for all their farming needs survive at the margin of subsistence. Many do not even have sufficient essential hand tools for all household members, and they are extremely vulnerable to the loss of key household members. Their lives are a continual struggle and they race against time from the initial preparation of their land for planting through to harvest, and the untimely sale of produce to raise essential cash. The timeliness of their operations is often compromised by the need to hire out their labor to others at the busiest times of the year. Households headed by women tend to be overrepresented among this group, partly as a result of the loss of assets typically associated with widowhood, and they are often among the poorest in a community. The motivation to mechanize is primarily driven by a wish to increase a family's food security, increase household income, or improve the quality of life. There are significant economic and social benefits to be reaped from farm-power mechanization. These are economic and social. Economic benefit refers to increasing the efficiency of labor, reducing costs, increasing the area cultivated, undertaking more timely production, improving the quality of cultivation, increasing yields, adopting new crops, reducing harvest and post-harvest losses, and earning a rental income through hiring farm-power services to others. Social benefit refers to reducing drudgery and workloads (particularly for women), improving safety, gaining prestige. The other benefit is encouraging younger and more innovative people to remain in rural areas and work on the land.

3.2. Potential Role of Farm Power as a Lifeline in Communities Under Labor Stress

In the absence of the widespread adoption of alternative cropping systems and practices, tillage and weeding are the major labor bottlenecks. Improved access to farm power for primary tillage and subsequent cropping activities will be vital to overcome the constraints that are arising as a result of the impact of diseases and employment opportunities on the agricultural workforce. However, addressing the primary-tillage component alone will not bring substantial advantages in terms of household food security and other livelihood outcomes could be driven. Current migration of the youth from rural areas to urban centers in India also ticks an alarm signal to future labor availability and farming population who is willing to continue as a farmer. With household level agricultural productivity enhanced, the outcome will be a better rural population capable of resisting shocks, dependent on market oriented production, with diverse employment opportunities due to the increased productivity, better managed landscapes, healthy and capable of investing for better infrastructure, connected to industries for producing raw materials, research is within the reach of their hands, drudgery and burden are highly minimized, only selected activities are done manually or with small machines, external input use is minimized, the poor and landless are employed in other related areas, women are economically empowered and in general transformed rural areas from rudimentary farm tools and operations to more advanced and technological farm operations and living conditions. For households experiencing extreme labor stress, the opportunity to release labor from time-consuming and repetitive household tasks (such as fetching water or fuel wood) may be vital not only for generating sufficient capacity to work on their own farms but also to enable some household members to work for cash or food elsewhere (a crucial coping strategy for livelihoods security).

4. Conclusion

Broad-based poverty reduction in Africa, including India, simply will not occur with out a vibrant agricultural sector providing income, employment and affordably priced staple foods. What is more important is the contribution of mechanization should not be overlooked. A common finding that emerged from various studies was that tractorisation displaced mainly bullock labor, but its impact on man-power was much less. Various studies concluded that owing to this relatively low displacement of man power that was unavoidable, mechanization should not be viewed in isolation. Indeed, mechanization opened up new avenues for human employment such as managerial and supervisory jobs on the one hand and driving, servicing, maintenance and repair of the machines on the other. Therefore, they recommended selective mechanization in an increasing manner for farms as animal, mechanical and engine power work complemented each other. Majority of the studies done on impact of mechanization led to the following broad conclusions; (i) Farm mechanization led to increase in inputs on account of higher average cropping intensity and larger area and increased productivity of farm labor, (ii) It increased agricultural production and profitability on account of timeliness of operation, better quality of work done and more efficient utilization of inputs and (iii) It increases on- farm human labor marginally, whereas the increase in off- farm labor was much more and displaced animal power but resulted in lesser time for farm work. Generally, APO recognized time saved, freedom from over burdened work, improvement in social status, increase in overall production, timeliness of operations, reduction in cost, increase in the number of cropping and adoptions of inter-cropping as gains. Increased debt, cost of fuel and repair, unemployment, disparity in income were considered as losses due to farm mechanization (that is highest level). Ultimately, for farm power is to have a greater role in rural livelihoods, farmers will have to be informed, educated, skilled and financially empowered to purchase, repair and maintain farm-power resources.

Recommendations

The adoption process for mechanization (labor productivity enhancing technology) follows stages that our farmers should experience from low to high for better productivity and food security that ultimately enhances the development desired. Therefore, after reviewing these studies the researchers recommend selective use of mechanization technologies for better productivity. Promotion of mechanization should recognize undertaking a national survey using multi disciplinary team for delineation of land suitability for medium and higher level mechanization, devising a clear national agricultural mechanization strategy , delivering mechanization based extension services to farmers and undertake intensive land use and sustainable activities, strengthening the capacity of local actors in developing agricultural implements that could be modified locally and formulation and implementing supporting policy systems including production of highly calibrated professionals and researchers in both the physical and social sciences of this sector.

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Effect of Organic Matter and Lime Application on the Changes in Fertility of *Typic Haplaquents* Soil of Tea Garden

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Abstract

A laboratory experiment was conducted on typic haplaquents tea garden soil, (which was collected from Panbari tea estate) to study the changes in soil fertility and the quality using different combination of organic matter (0.5 and 1 % by weight of the soil) and liming materials (1/4th LR, 1/2th LR and Full LR) under 60% WHC for a period of 4 weeks in a completely randomised block design replicated thrice. The result further reveals that the mean changes in pH, organic carbon; available N, P_2O_5, K_2O and MBC have been found to be increased with the treatments over the initial amount in the soil. With the application of organic matter, the pH content of soil is decreased irrespective of treatment combinations. The amount of available N, P_2O_5, K_2O and MBC content have been found to be significantly increased with the organic matter application which was recorded further enhanced with the combined application of organic matter and liming materials. With regards to soil quality assessment, it was suggested that the microbial biomass carbon (MBC) contents of the tea garden soil has been proved superior as soil quality indicex based on the highest co-efficient of determination values(R^2= 0.99*)

Key words : lime, MBC, organic matter, soil fertility, tea garden.

Introduction

Long-term tea (mono) cropping has also been implicated for "soil sickness" caused by a combination of soil pathogens, mineral depletion, change in soil structure and accumulation of toxic substances, amongst others (Owuor, 1996). This may lead to physical, chemical and biological soil degradation and ultimately to a decline in yield of the older tea plantations (Kamau, 2007). For soils of the tropics regions, the OM may constitute an important source of potential acidity in the soil. Soil acidity within correct range is an important requirement for tea cultivation. The role of phosphorus in improving tea productivity did not receive adequate attention. Though regional responses were reported (Sen, 1964). Primary reason for variability in response of phosphorus may be attributed to the variation in the inorganic and reductant soluble phosphate as well as organic and total phosphate in the soil (Bhattacharya and Dey, 1978). Organic phosphate fraction in tea soil is a potential source of soil phosphate because of rapid mineralization of soil organic matter. The iron and aluminium fraction acid tea growing soil also make up the slowly available pool of soil phosphorus. The dynamics of organic matter in soil seems to play an important role in this regards (Sanyal, 2002).

Materials and Methods

Soil samples were collected from the surface layer (0-15 cm) of the Panbari tea garden of Dooars area, North Benagal.

Amount of soil for each treatment: 200 gm of soil were taken for each treatment.

Organic Matter: Farm Yard Manure (FYM).

Lime: Calcium Carbonate ($CaCO_3$).

Moisture: 60% of total WHC capacity of soil was maintain throughout the experimental period.

Incubation Period: Incubation period of total 28 days were conducted maintaining the 60 % of WHC the soil sample with above 6 different treatments. Each sample was collected at intervals of 7, 14, 21 and 28 days.

Results and Discussion

Changes in pH and Organic Carbon content in soil:

The results (Table 2) reveal that the change in soil pH with the application of organic matter at different levels was decreases. While that of the application of ¼thlime LR and combination of lime and organic matter, the pH of the soil increases which is obvious. The application of organic matter irrespective of their levels, however, decreased soil pH with the progress of incubation. The application of higher amount of organic matter which might be explained by the release of greater amount of organic acids in the soil solution resulting from the extensive decomposition of organic resource materials in tea garden soils.

Considering the effect of liming, it was found (Fig.1) that the soil pH has been found to be significantly increased, being highest increase with the combined application of full LR and organic matter at 0.5 % on soil weight basis.

The results (Table 3) shows that the amount of organic carbon content in soil has been to be increased initially and thereafter the amount of same gradually decreased with the progress of incubation irrespective of treatments, it was found that the mean organic carbon content was recorded highest (1.31 %) T3 and T5 (1.16 %) treatment where organic matter at 1% by weight of soils and lime at ½ LR coupled with 1 % organic matter were applied respectively. Such increased in organic carbon content in tea soil might be due to continuous improved agronomic managements as well as decomposition of pruning leaf materials in the soil (Sarwar *et. al.* 2011).

Changes in available content of N in soil:

The results (Table 4) reveals that the amount of available nitrogen content in soil has been found to be consistently increase initially with the progress of incubation period in all treatments except in the last progress of incubation period. The result further show that the application of organic matter increase the amount of available nitrogen content in soils, being greater magnitude with the application of organic matter 1% on soil weight basis. Considering the combined of liming and organic matter application it was found that the amount of available nitrogen has been found to significantly increase over that of the sole application of organic matter, however, the amount was recorded highest (169.46 kg/ha) in T5 treatments where combined application of lime was high of the LR & organic matter at 1% level, Such increase in amount of available nitrogen content due to the moderation of soil reaction as well as increased proliferation of microorganism.However the mean changes available nitrogen content in treated soil has been found to be increased in T6 treatment. Where the combined application of lime at his (full LR + 0.5 organic matter) did not show any significant variation in the soil. The mean percent changes in available nitrogen content of soil has been found to be increased in T3 (31.60), which might be explained by the application of organic matter to the soil released in greater amount of available nitrogen in respect soil.

Changes in available content of P_2O_5 in soil:

The results (Table 5) reveals that the amount of available phosphorus content in Panbari Tea Estate soil has also been found to be increased over that of initial content with progress incubation irrespective of treatments. The magnitude of such changes, however, varied with treatment being greater combination application of lime and organic matter. The highest amount of available phosphorus content was recorded as (100.60 kg/ha) in treatment T5 (1/2 LR + 1% organic matter) during 28 days of incubation. Such magnitude of increase might be due to the stimulating effect of applied lime and organic matter on phosphorus solubilisation resulting in an increase in available phosphorus content.

Changes in available K_2O content:

The results (Table 6) shows that the amount

TABLE 1. physico-chemical properties of experimental soil.

Taxonomic Name of soil	Name of Tea estate	pH	EC (µs/cm)	Org. Carbon (%)	WHC (%)	LR (t/ha)	BD (gm/cc)	Av. N (kg/ha)	Av. P_2O_5 (kg/ha)	Av. K_2O (kg/ha)
Typic Haplaquents	Panbari	5.84	5.54	0.82	59	9.14	1.29	78.54	14.18	97.44

The soil which collected from the tea garden was moderately acidic (pH= 5.84) in nature. The treatments were followed

Design of Experiments: completely Randomized design (CRD).

Treatments:

Treatment	Description
T1(control)	Control, no application of organic matter and lime
T2(0.5% OM)	Only organic matter applied @ 0.5 % on soil weight basis
T3(1% OM)	Only organic matter applied @ 1 % on soil weight basis
T4(1/4th LR)	Only lime applied @1/4th LR on soil weight basis
T5(1/2nd LR+ 1% OM)	Application of lime @1/2nd LR and organic matter @ 1 % on soil weight basis
T6(Full LR + 0.5%OM)	Application of lime @ full LR and organic matter @ 0.5 % on soil weight basis

TABLE 2. Periodic changes in pH of Panbari Tea Estate soil under 60% WHC moisture regime (Mean of three replications)

TREATMENT	Days after Incubation				Mean	% Increase or Decrease
	7	14	21	28		
T1(control)	5.56	5.20	5.06	4.70	5.13	
T2(0.5%OM)	5.91	5.10	4.98	5.00	5.25	2.29
T3(1%OM)	5.85	5.32	5.20	5.10	5.37	2.29
T4(1/4th LR)	6.10	5.98	5.70	5.36	5.79	7.78
T5(1/2nd LR + 1% OM)	6.36	6.20	5.90	5.70	6.04	4.41
T6(Full LR + 0.5% OM)	6.45	6.35	6.25	6.31	6.34	4.97
S.Em (±)	0.02	0.02	0.02	0.01		
C.D. (5%)	0.08	0.08	0.08	0.08		

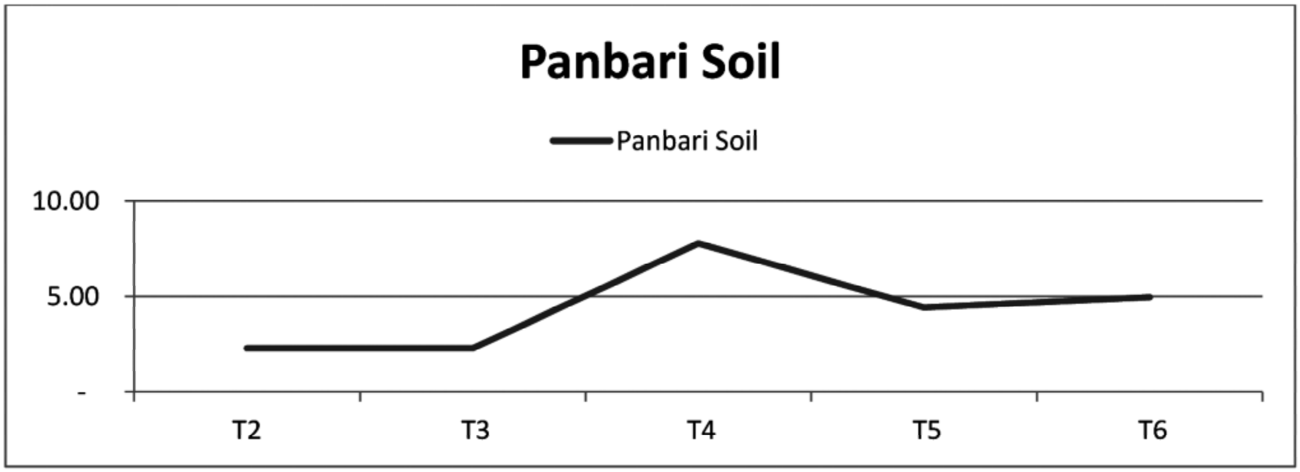

Fig. 1 Mean percent changes in pH of Panbari Tea Garden soil affected by different treatment

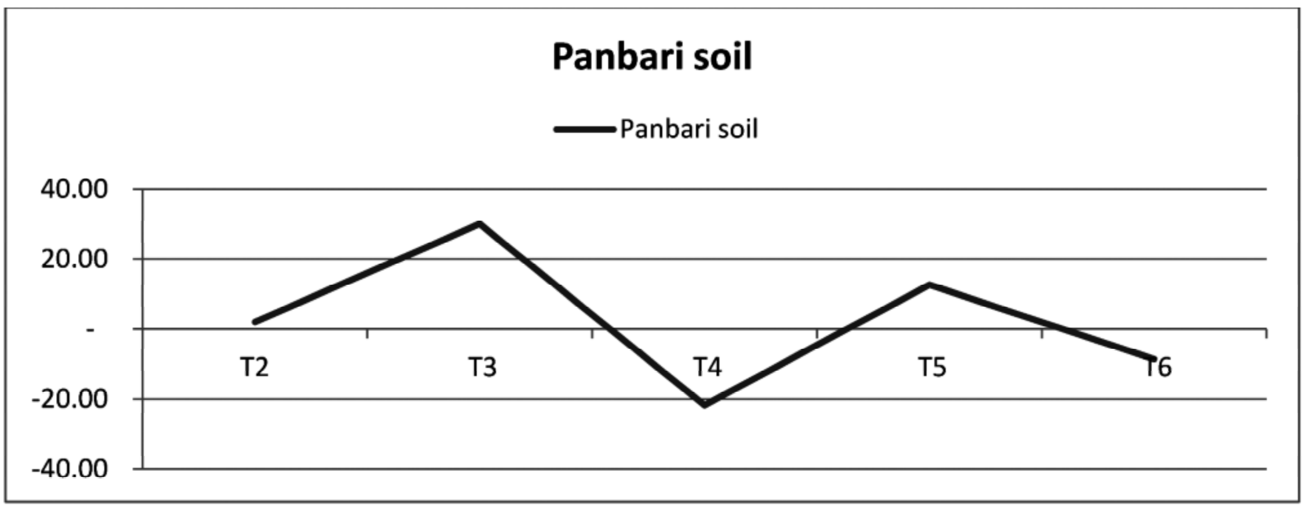

Fig. 2 Mean percent changes in organic Carbon of Panbari Tea Garden soil affected by different treatments

of available K_2O content in the Panbari tea garden soil has been found to be decreased progressively irrespective of treatments. The magnitude of such decrease has been found to be varied with treatments. However, the amount of available K_2O has been recorded a significant increase over control with the application of organic matter and liming material being highest mean increase (175.60 kg/ ha.) in the T5 treatment was recorded, such greater increase in available K_2O content due to the favourable effect of lime resulting in release of non-exchangeable form of K; specially planner-surface K.

Changes in MBC content in soil:

The result (Table 7) shows that the amount of microbial biomass carbon content has been found to be varied with treatments during the period of incubation. Magnitude of such variation has been found to be significantly varied with the combined application of lime and organic matter, being highest (169.49 µg/ gm) in Panbari Tea garden soil, such increased amount of MBC in soil might be ascribed to the combined effect of lime and organic matter which enhances the proliferation of soil microorganism resulting from the moderation of soil reaction in both the soil. The sole

TABLE 3. Periodic changes in organic carbon content (%) of Panbari Tea Estate soil under 60% WHC moisture regime (Mean of three replications)

TREATMENT	Days after Incubation				Mean	% Increase or Decrease
	7	14	21	28		
T1(control)	0.96	0.99	1.00	1.01	0.99	
T2(0.5%OM)	0.93	0.98	1.05	1.08	1.01	2.02
T3(1%OM)	1.20	1.26	1.49	1.30	1.31	29.95
T4(1/4th LR)	1.01	1.03	1.03	1.04	1.03	-21.71
T5(1/2nd LR + 1% OM)	1.35	1.14	1.14	1.00	1.16	12.65
T6(Full LR + 0.5% OM)	0.96	0.99	0.99	1.29	1.06	-8.64
S.Em (±)	0.013	0.015	0.011	0.011		
C.D. (5%)	NS	0.08	NS	NS		

TABLE 4. Periodic changes in Available Nitrogen (kg /ha) of Panbari Tea Estate soil under 60% WHC moisture regime (Mean of three replications)

TREATMENT	Days after Incubation				Mean	% Increase or Decrease
	7	14	21	28		
T1(control)	72.95	82.48	90.29	79.34	81.27	
T2(0.5%OM)	85.90	89.47	94.46	82.32	88.04	8.33
T3(1%OM)	98.22	126.36	121.38	117.48	115.86	31.60
T4(1/4th LR)	107.96	132.14	123.45	119.56	120.78	4.24
T5(1/2nd LR + 1% OM)	118.16	156.28	169.46	152.68	149.15	23.49
T6(Full LR + 0.5% OM)	122.16	159.59	166.43	159.77	151.99	1.91
S.Em (±)	1.159	1.176	1.283	1.126		
C.D. (5%)	5.50	5.58	6.08	5.34		

application of organic matter irrespective of their levels also showed a significant increase in the amount of MBC content of both soil but such increased effect has been found to be further enhanced with the combined application of lime and organic matter. Bishnu *et. al.,* (2011) also reported that the management system for the production of tea particularly due to organic matter application has a strong impact on microbial biomass and their activities.

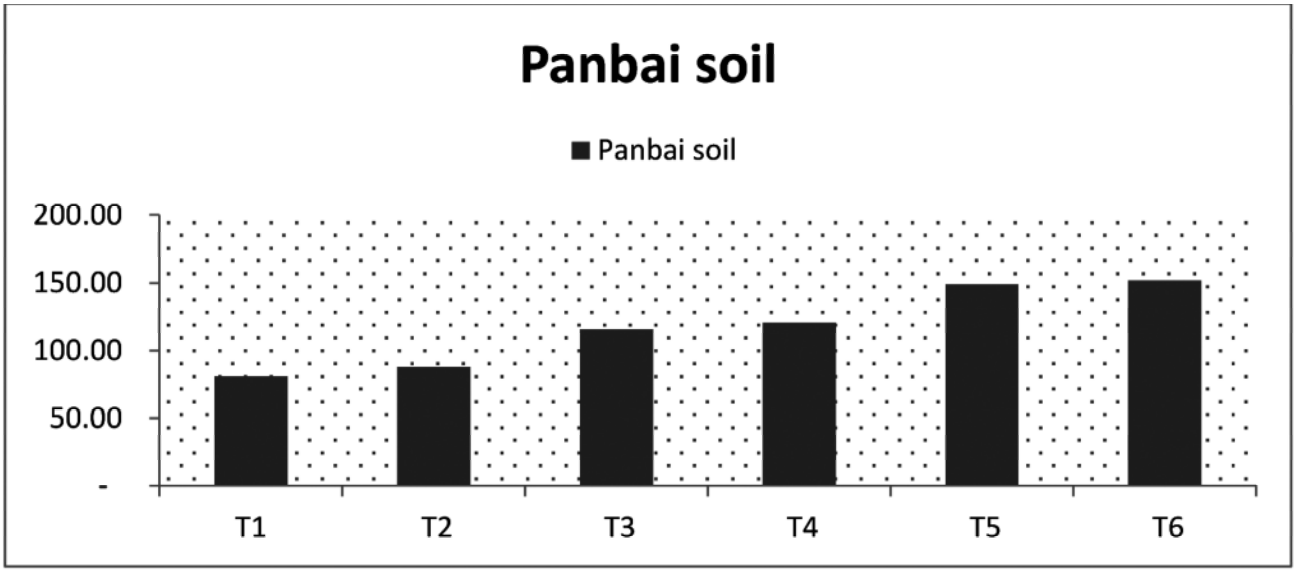

Fig. 3 Mean percent changes in available nitrogen content of Panbari Tea Garden soil affected by different treatments

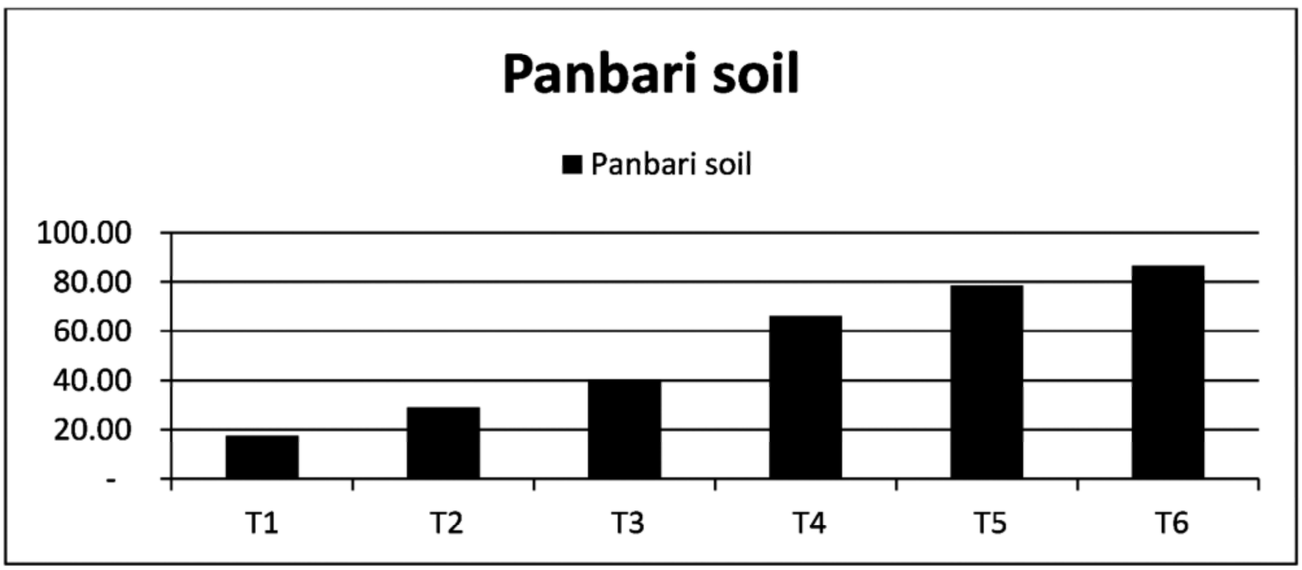

Fig. 4 Mean percent changes in available phosphorus content of Panbari Tea Garden soil affected by different treatments

The mean content of MBC was recorded height (151.94 µg /gm) in the treatment T6, where, lime at its full LR and 0.5 % organic matter was applied. Considering the percent changes in MBC content in soil, it was found that the percent increase was found highest (35.59) in the treatment T3 where only organic matter at 1% level was applied. Such increased MBC content in the tea garden soil might be explained by organic carbon contents resulting in an increase in the proliferation of soil micro-organisms which also confirms the results reported by Acharya (1955).

Evaluation of soil quality:

Soil quality indices namely pH, org C content, MBC content, available N, P_2O_5 and K_2O have been determined from the garden soil. Out

TABLE 5. Periodic changes in Available Phosphorus (kg /ha) of Panbari Tea Estate soil under 60% WHC moisture regime (Mean of three replications)

TREATMENT	Days after Incubation				Mean	% Increase or Decrease
	7	14	21	28		
T1(control)	17.19	13.08	17.65	22.22	17.54	
T2(0.5%OM)	28.49	15.64	22.45	49.78	29.09	65.90
T3(1%OM)	29.40	41.55	40.76	49.50	40.30	38.54
T4(1/4th LR)	34.48	63.45	75.29	91.58	66.20	64.26
T5(1/2nd LR + 1% OM)	39.36	82.28	92.18	100.60	78.61	18.74
T6(Full LR + 0.5% OM)	65.41	87.39	95.54	98.65	86.75	10.36
S.Em (±)	1.100	1.188	1.131	1.141		
C.D. (5%)	5.22	5.64	5.37	5.41		

TABLE 6. Periodic changes in Available K_2O (kg /ha) of Panbari Tea Estate soil under 60% WHC moisture regime (Mean of three replications)

TREATMENT	Days after Incubation				Mean	% Increase or Decrease
	7	14	21	28		
T1(control)	98.68	101.50	123.20	78.40	100.45	
T2(0.5%OM)	101.60	122.20	116.40	108.72	112.23	11.73
T3(1%OM)	184.00	156.30	139.00	131.48	152.70	36.06
T4(1/4th LR)	116.48	141.70	135.20	131.80	131.30	-14.01
T5(1/2nd LR + 1% OM)	192.80	180.20	172.60	156.80	175.60	33.74
T6(Full LR + 0.5% OM)	176.72	178.20	172.20	156.80	170.98	-2.63
S.Em (±)	1.15	1.14	1.17	1.16		
C.D. (5%)	5.44	5.41	5.57	5.53		

of all quality indices the co-efficient of determination (R^2) have been interpreted statistically with the help of multiple regression equation in the soil which are presented in the Table 8.

The results (Table 8) shows that the amount of organic carbon, available P_2O_5, available K_2O and MBC content of Panbari Tea Estate soil explained 99.3% of variability towards the change in pH, organic carbon content, available N, P_2O_5 and K_2O content of soil

Table 7. Periodic changes in Microbial Biomass Carbon (µg /gm) of Panbari Tea Estate soil under 60% WHC moisture regime (Mean of three replications)

TREATMENT	Days after Incubation				Mean	% Increase or Decrease
	7	14	21	28		
T1(control)	72.81	82.48	90.33	79.42	81.26	
T2(0.5%OM)	85.80	89.47	94.42	82.44	88.03	8.33
T3(1%OM)	98.22	126.36	121.32	117.48	115.85	31.59
T4(1/4th LR)	107.86	132.11	123.66	119.56	120.80	4.28
T5(1/2nd LR + 1% OM)	118.16	156.28	169.49	152.76	149.17	23.49
T6(Full LR + 0.5% OM)	122.16	159.59	166.20	159.82	151.94	1.86
S.Em (±)	1.166	1.194	1.156	1.199		
C.D. (5%)	5.53	5.66	5.48	5.69		

Table 8. Multiple regression equations showing relationship between different soil quality parameters of Panbari Tea Estate soil

Model summary	R^2
pH = 5.067 – 1.170 OC + 0.003 Av_P + 0.001 Av_K + 0.013 MBC	0.993
OC = 3.145 – 0.586 pH + 0.001 Av_P + 0.004 Av_K + 0.006 MBC	0.942
Av_N = - 2.625 + 0.535 pH – 0.389 OC – 0.003 Av_P + 0.001 Av_K + 0.993 MBC	0.999
Av_P = - 111.937 + 15.923 pH + 10.811 OC – 0.634 Av_K + 1.293 MBC	0.990
Av_K = - 78.538 + 6.608 pH + 38.907 OC - 0.724 Av_P + 1.507 MBC	0.990
MBC = 2.643 - 0.539 pH – 0.391 OC + 1.007 Av_N + 0.003 Av_P – 0.001 Av_K	0.999

contributed 99.9% of the variability towards MBC content in Panbari Tea garden soil. The pH, organic carbon content, Avail. N, Avail. P_20_5 and Avail. K_20 contents together contributed 99.9% of the variability

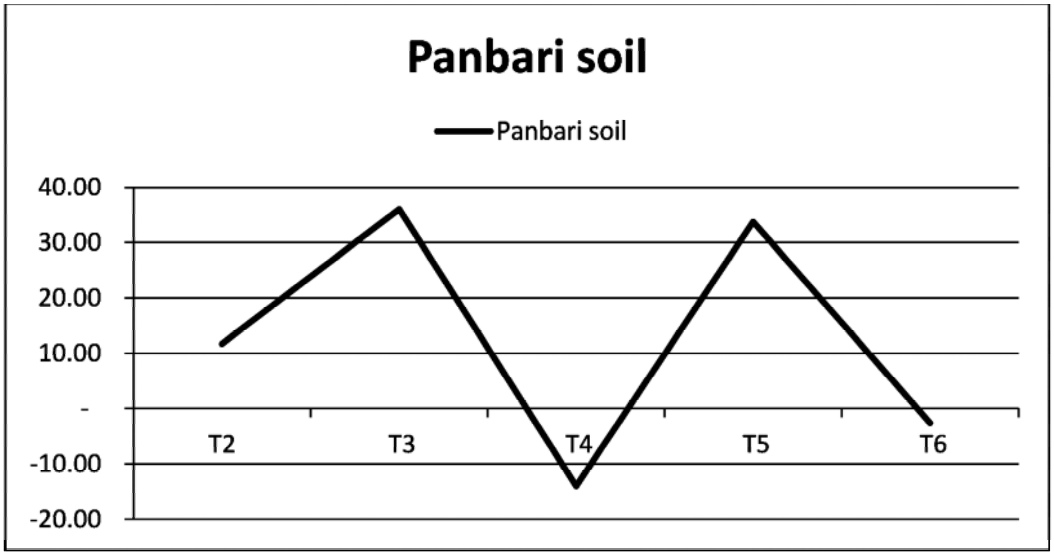

Fig. 5 Mean percent changes in available potassium content of Panbari Tea Garden soil affected by different treatments

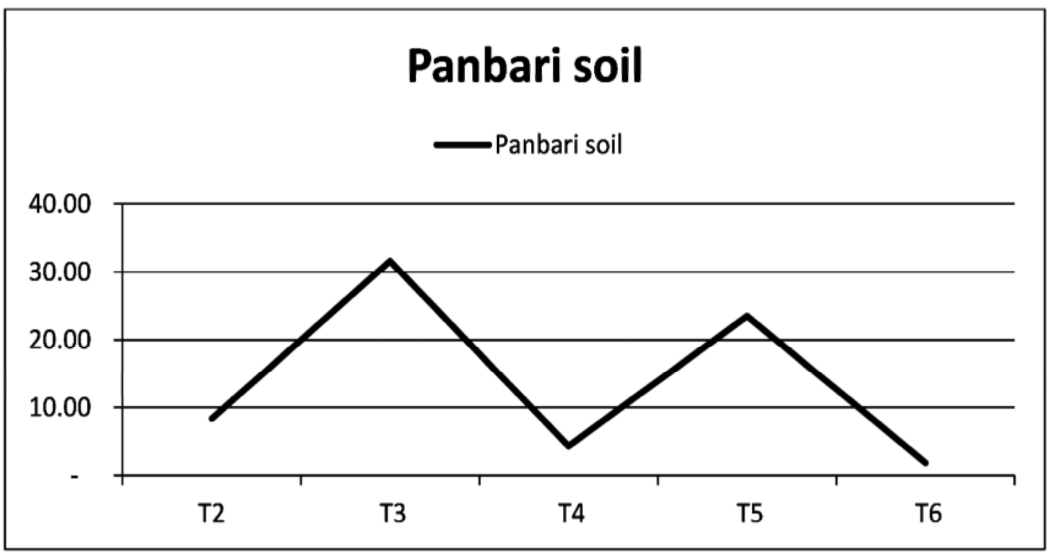

Fig. 6 Mean percent changes in Microbial Biomass Carbon (µg /gm) content of Panbari Tea Garden soil affected by different treatments

towards MBC content of the soil. Therefore, it may be suggested from the above results that organic carbon and microbial biomass carbon (MBC) contents of the tea garden soil have been proved good soil quality indices based on the highest co-efficient of determination values.

Conclusion

The overall results suggest that the combined application of organic matter (FYM) at 0.5 % and lime at its full lime requirement (LR) increased significant amount of available nitrogen, phosphorus, potassium, organic carbon and MBC contents in soil. The results further suggest that organic carbon and MBC were proved best indices with respect to maintaining quality of Panbari tea garden soil.

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