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Performance of Gravity Fed Drip Irrigation Model for Demonstration of Small Pomegranate Orchard

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Abstract

Gravity fed drip irrigation systems are a low cost and water use efficient technologies. Such systems run on gravity and do not require any electricity. They also require minimum manual inputs and maintenance. They can be used as a better water management alternate of irrigation for vegetable gardens and orchards in dryland environments where rainfall is low and erratic. In this study, gravity fed drip irrigation model is designed and developed for small demonstration plot of Pomegranate especially for small and marginal farmers at Regional Research and Technology Transfer Sub-Station, Kirei, Sundargargh, Odisha. The performance of gravity fed drip irrigation system was evaluated in terms of emission efficiency and discharge variation along the lateral length which is found to be more than 90 % and less than 20 % respectively which show better water resource management option. Also the model design shows effective reduction in the cost which is 18.8 % over conventional drip irrigation system.

Key words : *gravity fed drip, emission efficiency and discharge variation.*

Introduction

Drip irrigation allows for uniform distribution of water over the field at regular time intervals, averting adverse effects of under- (plant stress) or over-irrigation (leaching and water logging) in certain parts of the irrigated area. Water can be mixed with soluble fertilizer and is delivered directly to the root zone of the crop. As a result, drip irrigation generally increases both yield and water saving by about 50%, while using much less labour as compared with other systems (Sivanappan and Padmakumari, 1980). Drip irrigation is very well suited for water scarce areas and for areas where adequate land leveling is either undesirable, owing to less soil depth, or is uneconomical. A typical small farmer in India cultivates four to five plots ranging in size from one fifth of an acre to half an acre. Unlike other biological techniques such as seeds and fertilizers, the existing drip irrigation technology is not “divisible” i.e. it cannot be divided into very small functional units. Low cost drip irrigation systems developed by different research workers including pitcher irrigation, sip irrigation, siphon irrigation (Dadgi, 1993) and bucket kit (Naik, 2000) are too small to be adopted for commercial cultivation. The development of reliable low cost drip system that fits the needs of small farmers in developing countries has long been recognized as a critical need (Hillel, 1985; Saksena, 1995 and Nir, 1995). Drip kits that operate on small plots of 10 x 200m^2 have been successfully adopted by thousands of backyard farmers in Bangladesh, India and Nepal (Polak and Yoder, 2006). By keeping all above facts performance evaluation of gravity fed drip irrigation model developed for small demonstration plot of pomegranate orchard (under one year) at Regional Research and Technology Transfer Sub-Station, Kirei, Sundargargh, Odisha was carried out in terms of emission uniformity and quantity of discharge variation along the lateral length.

Methodology

The experiment was carried out at research farm of Regional Research and Technology Transfer Sub-Station, Kirei, Sundargargh, Odisha. The gravity fed drip irrigation model was designed and developed for demonstration plot of pomegranate orchard under one year m. Demonstration plot contains total 75 number of pomegranate trees having spacing 5 x 5 in to three rows. Layout of gravity fed drip irrigation system is shown in the Fig. 1. The experimental sets for head 1.5 m were developed. The plastic tank of 1000 liter capacity was installed over the cement concrete basement to develop the required head. The sub main of 50 mm was fitted with screen filter and the laterals of size 16 mm outer diameter (OD) and emitters of discharge capacity 4 and 8 lit hr^{-1} (LPH) were installed on laterals at predetermined spacing. The emitter discharges were recorded by using catch cans placed beneath the emitters. These observations were replicated thrice to minimize errors in observations. Elevations of field and storage tank were recorded by using the dumpy level. The pressure at inlet of sub-main and lateral was measured with manometer. Emitter discharges were recorded for different heads, lateral lengths and emitter spacing.

The emission uniformity and discharge variation along the length of lateral were determined for different heads and emitter spacing were determined using equation,

(1) $$E_u = \frac{Q_{\min}}{Q_{avg}} X100 \quad \ldots$$

(2) $$Q\,\mathrm{var} = \frac{Q_{\max} - Q_{\min} -}{Q_{\max}} X100 \quad \ldots$$

Where, E_u = Emission efficiency (%), Q_{min} = minimum discharge recorded Q_{max} = maximum discharge recorded and Q_{avg} = Average of observations recorded.

Results and Discussion

The experiment was carried out to check maximum permissible lengths of laterals having 16 mm outer diameter with 1.5 meter gravity head for drippers of 4 LPH and 8 LPH. The results found were as given in Table -1 and Table- 2 respectively.

From Table- 1and Table- 2, it is observed that, the emission uniformity was more than 90 percent and discharge variation was less than 20 percent for dripper capacity of 4 LPH and 8 LPH

Fig. 1 Layout of gravity fed drip irrigation model installed.

TABLE 1. Discharge variation and Emission Efficiency with 4 LPH drippers

	4 LPH Dripper				
	Discharge through Dripper (LPH)			Discharge	Emission Efficiency
	Min	Max	Avg	variation (%)	(EU)
Lateral 1	1.55	1.90	1.725	18.56	90.71
Lateral 1I	1.60	1.93	1.765	17.10	90.65
Lateral 1II	1.66	1.96	1.810	15.31	91.71

TABLE 2. Discharge variation and Emission Efficiency with 8 LPH drippers

	8 LPH Dripper				
	Discharge through Dripper (LPH)			Max. Discharge	Emission Efficiency
	Min	Max	Avg	variation (%)	(EU)
Lateral 1	3.11	3.75	3.430	17.07	90.67
Lateral 1I	3.21	3.82	3.515	15.97	91.32
Lateral 1II	3.31	3.90	3.605	15.13	91.82

TABLE 3. Cost of installation with comparison of pressurized drip irrigation system

Design Description	Pressurized Drip (Rs)	Gravity Drip(Rs)
PVC pipe 50mm x 6 kgf /2.5 kgf	20m x 40 = 800	20m x 30 = 600
Lateral 16mmx2.5 kgf/low pressure	225 m x 7.10 = 1597	225 m x 4.50 = 1012.5
Control valve	01x300=300	01x150=150
Dripper 4lph	45 x 2.50 = 112.5	45 x 2.50 = 112.5
Flush valve 50mm	01x80=80	01x80=80
Filter 25m^3/hr / small screen filter 25 mm	01x3000=3000	01x300 = 300
Drip fitting	50 x 3 = 150	50 x 3 = 150
Overhead Tank	——	2500
Total (Rs)	Rs. 6039.5 /-	Rs. 4905 /-
% Saving		18.8 %

respectively. The results indicated that lengths of laterals (75 m each) installed in the gravity fed irrigation system for small demonstration plot of pomegranate orchard (under one year) at Regional Research and Technology Transfer Sub-Station, Kirei, Sundargargh, Odisha were found permissible based on the Discharge variation and Emission Efficiencies.

Conclusion

Based on the results it can be concluded that gravity fed drip irrigation model for demonstration plot of pomegranate orchard (plantation under one year old) is best alternative to other traditional irrigation methods and pressurized drip irrigation system. The results obtained showed similar trends in emission efficiency for 4 LPH drippers and 8 LPH drippers respectively, however considering future demand of water requirements of pomegranate dripper having 8 LPH capacities were suggested to the farmers while installing gravity fed drip irrigation system for horticultural crops.

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Changes in Biochemical Composition of Stored Elephant Foot Yam (*Amorphophallus Paeoniifolius* Dennst- Nicolson) Corms

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Abstract

Elephant foot yam (*Amorphophallus paeoniifolius* Dennst- Nicholson) is a very popular vegetable due to its high productivity, nonirritant taste, and maximum monetary return within a short period of time. The present investigation of elephant foot yam was undertaken to access the performance of eleven cultivars (BCA-1, BCA-2, BCA-4, BCA-5, BCA-6, NDA-4, NDA-5, NDA-9, IGAM-1, AC-28 and Gajendra) nutritional changes during storage. The ranges of nutritional contents were found to be: dry weight 26.56-39.06%, total soluble solids (TSS) 7.35-10.07^{O}Brix, total sugar 1.35-3.66% and Titrable acidity 0.131-0.217% from harvesting to 90 days after storage. A significant increase was found in dry weight, total soluble solids, total sugar and titrable acidity at all stages at monthly intervals. This information will provide researchers with the ability to develop desirable types cultivars having better nutritional profile during storage of elephant foot yam.

Keywords: *Elephant foot yam, Cultivar, Quality, TSS, TS*

Introduction

Roots and tubers were critical components in the diet during the early evolution of mankind and the most important food crops of very ancient origin in the tropics and sub tropics, associate with human existence, survival and socioeconomic history (Asha and Nair, 2002; Behera *et al.,* 2009). Elephant foot yam is regarded as “King of tuber crops” due to its higher biological efficiency as a food producer and possesses higher productivity in a short growing season as well as confers high returns even in the years of droughts and flood (Mitra and Tarafdar, 2008; Nedunchezhiyan, 2014). It’s a cheap source of carbohydrates; rich in calcium, phosphorus and vitamins grown for corms (modified-stem), which are harvested after 7-9 months from planting and can be stored for 2-3 months in good condition. The corms are usually eaten as vegetable after boiling or baking and are rich in calcium (50 mg/g), phosphorus (34 mg/g), vitamin A (260 IU/g) vitamin B6, as well as with trace minerals like selenium, zinc and copper (Singh *et al.,* 2016). The leaves are used as a vegetable by local tribes in India because it contains high concentration of vitamin A (Rajyalakshmi *et al.,* 2001). With the development of high yielding, non-acrid, smooth corm type cultivars like Gajendra, Bidhan Kusum (BCA-1), the elephant foot yam has been now recognized as a highly remunerative and acceptable vegetable due to its higher productivity, non-irritant taste and excellent cooking quality (Mitra and Tarafdar, 2008). Due to high content of fiber it’s treated as slimming food, as it promotes weight loss and reduces the level of cholesterol in the body. Due to low level of glycemic index in elephant foot yam it’s considered as one of the good food source for diabetic patients. Vitamin B6 and B complex constituents help to increase the levels of estrogen hormone in women and provide relief from premenstrual syndrome.

Considering all the above aspects, in this study, an attempt has been taken with several experimental approaches to promote the cultivation of elephant foot yam throughout the India by identifying superior cultivars, their storage condition and suggesting suitable measures for improving the productivity and acceptability of the crop because elephant foot yam cultivars commonly consumed in India as well as in Asian country in her daily diet.

Materials and Methods

Collection of samples

The experiments were carried out in the Laboratory of Post Harvest Technology, Research Complex, Kalyani (Bidhan Chandra Krishi Viswavidyalaya), West Bengal during the consecutive year 2011-2013 with a view to analyze the physico-chemical characteristics of fresh harvested corms of elephant foot yam at monthly intervals. Eleven cultivars of elephant foot yam were procured from State Agricultural Universities and Research Institutes under the Indian Council of Agricultural Research, India and cultivated at Horticultural Research Station, Mondouri, BCKV, West Bengal, India and then stored at ambient temperature. Climatically the region located at 23.5^{O}N latitude and 89^{O}E longitudes with an altitude of 9.75m above mean sea level. The soil was a slightly acidic (pH 6.5) with sandy loam and climatic condition was tropical humid with rainfall of 0.00 to 264.00mm, temperature maximum 37.59^{O}C and minimum 9.62^{O}C along with RH (%) 96.87 to 36.74 (Annual average) by *AICRP on Agro Meteorology*, BCKV, Kalyani, Nadia West Bengal.

Physico-chemical analysis

The physico-chemical characteristics of elephant foot yam were recorded from 10 randomly selected corms from each cultivars in both year at monthly intervals during storage by mentioned methods *viz.,* total sugar (Moorthy and Padmaja, 2002), total soluble solids by Pocket Refractometer, titrable acidity by titration method (AOAC, 1990) and dry weight by total moisture content of fresh corms weighing 100g was calculated from loss in weight during drying at 70^{O}C for 48 hrs.

Statistical procedure

All the lab data were used to Complete Randomized Design (CRD) as suggested (Raghuramula *et al.,* 1983). The critical difference (CD) value at 5% level of probability was used for comparing the treatments and to find out the significant difference in between them. Each treatment was replicated for three times. The data analyzed with the help of statistical software from AGRES version 3.01 (Data Entry Module for AgRes Statistical Software <c> 1994 Pascal Intl software solution).

Results and Discussion

Dry Weight:

Dry weight content of corm was highly significant by cultivars during storage (Table 1). The cultivar AC-28 content highest (38.82 and 39.06%) and cv. NDA-5 content lowest dry matter (26.56 and 26.95%) at both stage 0 and 90 days after storage, respectively. The mean value of three storage stages was also varied significantly among the cultivars. Increase in dry weight content of corms with the advancement of maturity might be due higher accumulation of photosynthates to the corms. Similar observation on quantitative increase in dry matter content was also reported by Treche and Agbor-Egbe (1996) and Behera *et al.,* (2009) in yam tubers, Bonte *et al.,* (2000) in sweet potato, and Panja *et al.,* 2017 in elephant foot yam corms during storage.

Total soluble solids:

The results presented in Table 2 showed that total soluble solids (TSS ^{O}Brix) content of elephant foot yam corms increased throughout the storage condition in both the years. The highest TSS content in cultivar BCA-5 (8.85^{O}Brix) at 0 DAS, while, in cv. BCA-6 contents (10.07^{O}Brix) at 90 DAS. The cultivar AC-28 content lowest total soluble solids at both stage *viz.,* 0 and 90 DAS (7.35 and 8.29, respectively). The increase in TSS might be due to depletion of moisture in the

TABLE 1. Changes in Dry weight content (g) in elephant foot yam corms during storage

Cv.\DAS	**0** 2011-12	2012-13	Pooled	**30** 2011-12	2012-13	Pooled	**60** 2011-12	2012-13	Pooled	**90** 2011-12	2012-13	Pooled
BCA-1	37.03	36.37	36.70	37.41	36.54	36.98	37.54	36.65	37.10	37.59	36.72	37.16
BCA-2	27.76	28.05	27.90	28.07	28.21	28.14	28.18	28.34	28.26	28.25	28.42	28.34
BCA-4	29.90	31.72	30.81	30.17	31.92	31.05	30.30	32.01	31.16	30.35	32.08	31.22
BCA-5	31.95	34.54	33.24	32.08	34.66	33.37	32.20	34.75	33.48	32.27	34.81	33.54
BCA-6	28.68	29.98	29.33	28.83	30.12	29.48	28.96	30.23	29.60	29.01	30.30	29.66
NDA-4	34.83	36.17	35.50	34.94	36.34	35.64	35.04	36.45	35.75	35.11	36.51	35.81
NDA-5	24.72	28.40	26.56	24.92	28.59	26.76	25.05	28.73	26.89	25.10	28.80	26.95
NDA-9	34.18	35.27	34.73	34.26	35.44	34.85	34.35	35.55	34.95	34.42	35.61	35.02
AC-28	37.79	39.85	38.82	37.91	39.91	38.91	38.04	39.96	39.00	38.09	40.03	39.06
IGAM-1	33.29	35.30	34.29	33.45	35.43	34.44	33.56	35.53	34.55	33.63	35.59	34.61
Gajendra	28.69	30.79	29.74	28.86	30.86	29.86	28.99	30.97	29.98	29.04	31.04	30.04
Mean	31.71	33.31	32.51	31.90	33.46	32.68	32.02	33.56	32.79	32.08	33.63	32.85
	CD 0.05	**S Ed**		**CD 0.05**	**S Ed**		**CD 0.05**	**S Ed**		**CD 0.05**	**S Ed**	
C	1.862	0.924	**	1.728	0.857	**	1.665	0.826	**	1.658	0.823	**
Y	0.794	0.394	**	0.737	0.365	**	0.710	0.352	**	0.707	0.351	**
CY	2.633	1.306	NS	2.443	1.212	NS	2.355	1.168	NS	2.345	1.164	NS

C-Cv.- Cultivar; Y- Year; CD- Critical Difference at 5 %; S Ed- Standard Error of Deviation; DAS- Days After Storage; R- Replication (3); NS- Non Significant; **- Highly Significant; *- Significant

TABLE 2. Changes in Total Soluble Solids content (°Brix) in elephant foot yam corms during storage

Cv.\DAS	**0** 2011-12	2012-13	Pooled	**30** 2011-12	2012-13	Pooled	**60** 2011-12	2012-13	Pooled	**90** 2011-12	2012-13	Pooled
BCA-1	8.35	8.60	8.48	9.05	9.20	9.13	9.45	9.60	9.53	9.82	9.78	9.80
BCA-2	7.60	7.40	7.50	8.15	7.85	8.00	8.44	8.21	8.33	8.71	8.62	8.67
BCA-4	9.30	8.00	8.65	9.66	8.50	9.08	9.95	9.10	9.53	10.09	9.22	9.66
BCA-5	8.50	9.20	8.85	9.10	9.65	9.38	9.82	9.97	9.90	9.99	10.13	10.06
BCA-6	8.90	7.90	8.40	9.45	8.35	8.90	9.78	9.90	9.84	10.01	10.12	10.07
NDA-4	7.20	9.30	8.25	7.90	9.83	8.87	8.21	10.03	9.12	8.45	10.21	9.33
NDA-5	8.20	8.90	8.55	8.90	9.50	9.20	9.21	9.78	9.50	9.41	9.84	9.63
NDA-9	8.10	9.50	8.80	8.74	9.74	9.24	9.25	9.97	9.61	9.36	10.09	9.73
AC-28	6.80	7.90	7.35	7.50	8.35	7.93	7.78	8.62	8.20	7.86	8.71	8.29
IGAM-1	9.20	8.30	8.75	9.66	8.83	9.25	9.83	8.91	9.37	9.93	9.04	9.49
Gajendra	8.00	8.60	8.30	8.70	9.11	8.91	9.11	9.43	9.27	9.26	9.73	9.50
Mean	8.20	8.51	8.35	8.80	8.99	8.90	9.17	9.41	9.29	9.35	9.59	9.47
	CD 0.05	**S Ed**		**CD 0.05**	**S Ed**		**CD 0.05**	**S Ed**		**CD 0.05**	**S Ed**	
C	1.568	0.778	NS	1.089	0.540	NS	1.118	0.555	NS	1.240	0.615	NS
Y	0.669	0.332	NS	0.464	0.230	NS	0.476	0.237	NS	0.529	0.262	NS
CY	2.218	1.100	NS	1.540	0.764	NS	1.581	0.785	NS	1.753	0.870	NS

C-Cv.- Cultivar; Y- Year; CD- Critical Difference at 5 %; S Ed- Standard Error of Deviation; DAS- Days After Storage; R- Replication (3); NS- Non Significant; **- Highly Significant; *- Significant

TABLE 3. Changes in Total Sugar content (%) in elephant foot yam corms during storage

Cv.\DAS	0 2011-12	2012-13	Pooled	30 2011-12	2012-13	Pooled	60 2011-12	2012-13	Pooled	90 2011-12	2012-13	Pooled
BCA-1	1.60	1.55	1.58	2.62	2.45	2.54	3.31	2.99	3.15	3.61	3.23	3.42
BCA-2	1.72	1.65	1.69	2.82	2.63	2.73	3.41	3.26	3.34	3.60	3.51	3.56
BCA-4	1.65	1.62	1.64	2.75	2.43	2.59	3.45	3.11	3.28	3.64	3.42	3.53
BCA-5	1.60	1.52	1.56	2.75	2.42	2.58	3.15	2.89	3.02	3.45	2.99	3.22
BCA-6	1.55	1.60	1.58	2.68	2.50	2.59	3.11	3.03	3.07	3.44	3.28	3.36
NDA-4	1.58	1.44	1.51	2.71	2.33	2.52	3.19	2.93	3.06	3.47	3.30	3.39
NDA-5	1.45	1.25	1.35	2.55	2.25	2.40	2.99	2.88	2.94	3.24	3.19	3.22
NDA-9	1.54	1.81	1.67	2.69	2.71	2.70	3.34	3.41	3.38	3.62	3.69	3.66
AC-28	1.65	1.35	1.50	2.85	2.25	2.55	3.24	2.94	3.09	3.55	3.28	3.42
IGAM-1	1.25	1.55	1.40	2.44	2.49	2.47	3.07	2.87	2.97	3.36	3.09	3.23
Gajendra	1.60	1.65	1.63	2.82	2.61	2.72	3.12	2.95	3.04	3.39	3.27	3.33
Mean	1.56	1.54	1.55	2.70	2.46	2.58	3.22	3.02	3.12	3.49	3.30	3.39
	CD 0.05	**S Ed**		**CD 0.05**	**S Ed**		**CD 0.05**	**S Ed**		**CD 0.05**	**S Ed**	
C	0.471	0.234	NS	0.361	0.179	NS	0.382	0.189	NS	0.372	0.185	NS
Y	0.201	0.099	NS	0.154	0.076	**	0.163	0.081	*	0.159	0.078	*
CY	0.667	0.331	NS	0.511	0.254	NS	0.540	0.268	NS	0.527	0.261	NS

C-Cv.- Cultivar; Y- Year; CD- Critical Difference at 5 %; S Ed- Standard Error of Deviation; DAS- Days After Storage; R- Replication (3); NS- Non Significant; **- Highly Significant; *- Significant

form of water from elephant foot yam corms during growth and development stage. A similar finding was reported by Shirke *et al.,* (2002) in sweet potato.

Total sugar:

Total sugar showed a increasing trend during the storage condition and it was found that the highest total sugar content in cultivar BCA-2 (1.69%) at 0 DAS, while NDA-9 content (3.66%) at 90 DAS (Table 3). The lowest total sugar content was in cultivar NDA-5 at 0 DAS (1.35%), while, cv. BCA-5 and NDA-5 content lowest total sugar at 90 DAS (3.22% each). It could be due to hydrolysis of polysaccharides. The increase in total sugar was reported by Bonte *et al.,* (2000) in sweet potato; Treche and Agbor-Egbe (1996) in yam tubers and Panja *et al.,*2017 in elephant foot yam corms during storage.

Acidity:

It was found that there was a continuous increase in the titrable acidity in elephant foot yam corms during storage in both years (Table 4). The highest content of Titrable acidity was in cv. Gajendra (0.160%) at 0 DAS, while, in cv. BCA-6 (0.217%) at 90 DAS. The lowest content of titrable acidity was in cv. IGAM-1 and Gajendra at 0 and 90 DAS (0.131 and 0.187%, respectively). Similar findings were reported by Panja *et al.,* 2017 in elephant foot yam corms during storage and Shirke *et al.,* (2002) in sweet potato.

Conclusion

Dry weight, total soluble solids, total sugar and titrable acidity content increases during storage period and these less familiar vegetable cultivars having good content of nutrition may be used as a good alternative source of food to alleviate hunger and malnutrition, which are currently big problems in developing countries such as India. We hope that this study will help to propagate knowledge on compositional varietal variation in elephant foot yam corms during storage and their suitability for value addition *viz.,* powder, dried

TABLE 4. Changes in Titrable acidity content (%) in elephant foot yam corms during storage

Cv.\DAS	0 2011-12	2012-13	Pooled	30 2011-12	2012-13	Pooled	60 2011-12	2012-13	Pooled	90 2011-12	2012-13	Pooled
BCA-1	0.164	0.136	0.150	0.179	0.148	0.164	0.204	0.168	0.186	0.217	0.183	0.200
BCA-2	0.167	0.129	0.148	0.184	0.141	0.163	0.209	0.161	0.185	0.221	0.175	0.198
BCA-4	0.145	0.141	0.143	0.163	0.178	0.171	0.191	0.198	0.195	0.205	0.215	0.210
BCA-5	0.162	0.137	0.150	0.178	0.148	0.163	0.189	0.164	0.177	0.201	0.178	0.190
BCA-6	0.165	0.141	0.153	0.184	0.176	0.180	0.209	0.196	0.203	0.222	0.211	0.217
NDA-4	0.144	0.129	0.137	0.159	0.140	0.150	0.184	0.160	0.172	0.199	0.181	0.190
NDA-5	0.170	0.134	0.152	0.183	0.146	0.165	0.196	0.162	0.179	0.203	0.174	0.189
NDA-9	0.144	0.137	0.141	0.159	0.151	0.155	0.184	0.189	0.187	0.198	0.206	0.202
AC-28	0.168	0.135	0.152	0.181	0.147	0.164	0.192	0.163	0.178	0.205	0.178	0.192
IGAM-1	0.148	0.113	0.131	0.163	0.125	0.144	0.188	0.171	0.180	0.202	0.188	0.195
Gajendra	0.153	0.166	0.160	0.161	0.172	0.167	0.169	0.179	0.174	0.181	0.192	0.187
Mean	0.157	0.136	0.147	0.172	0.152	0.162	0.192	0.174	0.183	0.205	0.189	0.197
	CD 0.05	**S Ed**		**CD 0.05**	**S Ed**		**CD 0.05**	**S Ed**		**CD 0.05**	**S Ed**	
C	0.068	0.034	NS	0.065	0.032	NS	0.042	0.021	NS	0.031	0.015	NS
Y	0.029	0.014	NS	0.028	0.014	NS	0.017	0.008	NS	0.013	0.006	*
CY	0.096	0.048	NS	0.092	0.046	NS	0.059	0.029	NS	0.044	0.022	NS

C-Cv.- Cultivar; Y- Year; CD- Critical Difference at 5 %; S Ed- Standard Error of Deviation; DAS- Days After Storage; R- Replication (3); NS- Non Significant; **- Highly Significant; *- Significant

cubes, fry cubes and pickle can be selected for further improvement and stimulate activity to promote their production and utilization as valuable components of a well balanced diet.

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Study of Genetic Variability and Estimation of Genetic Parameters in Different YMV Tolerant Soybean Lines

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Abstract

The experiment was conducted at two locations *viz*. Ludhiana and Gurdaspur to assess the genetic variability and estimate the genetic parameters like genotypic coefficient of variance (GCV), phenotypic coefficient of variance (PCV), heritability (h^2) and genetic advance (GA) in $48_{F2.7}$ derived yellow mosaic virus tolerant soybean lines which were derived from a cross between SL 525 (Yellow mosaic disease resistant genotype) and JS 335(Stable but susceptible to YMD). Data were recorded for different agronomic and quality traits for this experiment. The traits like pods per plant, pods per node, seed yield per plant were highly variable one as well as having high GCV, PCV, heritability and genetic advance. So selection for these traits would be effective generation after generation.

Introduction

Soybean is an important grain legume as well as oil seed crop of the world in terms of total production and international trade. So selection is a prime criteria for improvement of grain yield. The efficiency of Selection from depends on amount of genetic variability present in the population. The mean performances of different characters provide the information about genetic variability to make the selection effective. Parameters of genotypic and phenotypic coefficient of variation are (GCV and PCV) are also useful in estimating the amount of variability present in the available genotypes. Heritability and genetic advance helps in determining the influence of environment in expression of characters and the extent to which improvement is possible after selection (Robinson *et al* 1949). Crop improvement depends on the magnitude of genetic variability and the extent to which the desirable characters are heritable. High heritability is not enough to make efficient selection in segregating generation, unless the information is accompanied with substantial amount of genetic advance (Johnson *et al* 1955). Heritability is the transmission of characters from one generation to next generation. To make an effective selection high heritable characters are selected.

Material and methods

Forty eight $F_{2.7}$ generation derived lines obtained from the cross between SL 525 and JS 335 were used as experimental material. The experiment was conducted during 2016 at two locations *viz*. Pulses Research area of Department of Plant Breeding and Genetics, Punjab Agricultural University, Ludhiana and Research Station, Gurdashpur.The cross was made during *kharif*, 2011 and F_1 was grown during winter 2011 at Indian Institute of Soybean Research (IISR), Indore. The F_2 generation was screened for yellow mosaic virus (YMV) resistance at Ludhiana, the hot spot for yellow mosaic. During rabi, 2012 generation was advanced at IISR, Indore and subsequent generation i.e F_3, F_4, F_5 and F_6 were grown at PAU Ludhiana and screened for YMV resistance and alternately 48 $F_{2:7}$ lines were retained for the present study. The material was sown at Ludhiana on 19th June and at Gurdaspur on 30th June. Genotypes were sown in with three replications having a row length of 2 meter, two rows per entry and spacing between and within rows of 45 cm and 5 cm, respectively at both the locations. The observations were recorded for nine agronomic traits viz. plant height at 60 DAS ,plant height at maturity, days to maturity, number of nodes per plant, number of pods per plant, seeds per pod, pods per node, 100-seed weight and seed yield per plant. Data were subjected to analysis of variance. Mean performance was evaluated for each trait. Genotypic coefficient of variation, phenotypic coefficient of variation, heritability and genetic advance were calculated for each trait.

Result and Discussion

Analysis of variance and mean performance was performed for both the locations. Significant variation was observed for all the traits except seeds per pod at Ludhiana. The mean performance of genotypes and range was evaluated for each character which indicated the presence of variability for the trait.

Mean performance for different traits

Plant height (60 DAS and at Maturity)

Mean performance was observed for different traits at both the locations. Plant height at 60 DAS and at maturity. At Ludhiana maximum plant height (90cm) and minimum plant height (54.5cm) at 60 DAS were observed for genotype SLJS 23-4 and SLJS 23-2 respectively. But at Gurdaspur maximum plant height was observed for genotype JS 335 (99.0cm) and minimum height (46.0cm) was observed for genotype SLJS 43-4. Regarding plant height at maturity, maximum plant height (107.0cm) for genotype SLJS 23-3 and (107.1cm), for genotype JS 335 were estimated at Ludhiana and Gurdaspur respectively. Minimum plant height at maturity were 39.9cm and 41.4cm for genotype JS 335 and SLJS 43-3-2 at Ludhiana and Gurdaspur respectively. Ganesamoorthy and Seshasdri (2002) and Gowande *et al* (2002) observed moderate variability within the soyabean genotypes for plant height but Karasu *et al.* (2009) and Prakash *et al.* (1966) concluded high variation of plant height from their experiment.

Days to flowering

The results for this trait differed significantly at both the locations. At Ludhiana, maximum value for this trait was obtained from genotype, SLJS 14-1 (64.3 days) followed by genotype, SLJS-41-2 (63 days). The genotype, SLJS-25-1 took minimum i.e 57 days to flower. The mean value for this character at Ludhiana

Table 1. Mean squares for different traits of soybean at Ludhiana (Ldh.) and Gurdaspur (Gsp.)

	Plant height at 60 DAS (cm)		Plant height at maturity (cm)		Days to maturity		Number of nodes per plant	
	Ldh	Gsp	Ldh	Gsp	Ldh	Gsp	Ldh	Gsp
Replication	70.60	78.89	67.36	58.68	3.58	8.01	5.71	8.01
Treatment	159.21**	377.71**	320.40**	355.04**	7.13**	23.45**	7.58**	23.45**
Error	21.31	47.79	27.35	20.79	0.19	0.91	2.37	0.91

Table 1Continued…

	pods per plant		Seeds per pod		Pods per node		100-seed weight (g)		Seed yield (g)	
	Ldh	Gsp	Ldh	Gsp	Ldh	Gsp	Ldh	Gsp	Ldh	Gsp
Replication	147.62	117.86	0.00	0.11	3.17	0.10	0.08	12.50	9.23	12.98
Treatment	1666.05**	319.21**	0.02	0.03**	6.99**	0.38**	2.23**	1.82**	100.80**	99.23**
Error	68.50	30.38	0.03	0.01	0.78	0.10	0.75	0.28	5.04	10.12

was 60.5 days. At Gurdaspur, mean value for 50% flowering was 59.3 days. Maximum days to flower (61.3 days) was taken by four genotypes *viz*. SLJS-4-3, SLJS 29-3, SLJS 29-1 and SLJS 43-3-2. Genotype, SLJS 25-3 took minimum days (57 days) for 50% flowering. Similar results were observed for days to 50% flowering from experiment conducted by Pushpendra and Ram (1987).

Days to maturity

At Ludhiana the genotype SL 958 took maximum (132.3days) to mature and minimum (124.7days) to mature was observed for genotype SLJS 26-2. At Gurdaspur maximum (119 days) and minimum (105.7 days) were observed by genotypes SLJS 29-3 and SLJS 9-2 respectively.

Pods per plant

Variation was observed for this trait at both the locations. At Ludhiana genotype SLJS 11-2 possessed maximum (126.8) number of pods per plant followed by genotype SLJS 4-1 (124.6) and genotype SLJS 26-2 (121.1). Minimum number of pods per plant was observed for the genotype JS 335 (18.6). At Gurdaspur, maximum number of pods per plant was possessed by the genotype, SLJS 1-1 (111.4) followed by genotype SLJS 29-2 (86.8). The minimum number of pods per plant was observed for genotype SLJS 11-2 (48.9). Similar findings were observed by Rajput *et al* (1987) and Jaylal (1994) in their earlier study on soybean genotype.

Pods per node

Ludhiana location, maximum value for pods per node (7.1) was observed for genotype, SLJS 11-2 and minimum number of pods per nodei.e 1.2 were recorded for genotype, JS335. At Gurdaspur, maximum value of pods per node i.e 4.4 was for genotype, SLJS 1-1and minimum value (2.4) by genotype SLJS 37-1-1.

Seeds per pod

At Ludhiana, maximum (2.7) and minimum (2.4) number of seeds per pod were possessed by genotype, SLJS 26-1 and JS335 whereas at Gurdaspur JS335 had maximum value of seeds per pod i.e 3.0 and minimum value of seeds per pod i.e 2.5 by genotype, SL525.

100-seed weight

At Ludhiana, the range for the trait was 10.7g to 6.7g. where 10.7g possessed by genotype SLJS 3-1 and 6.7g possessed by genotype SLJS 33-2. At Gurdaspur, maximum value *vi.z* 12.3g was observed in genotype, SLJS 23-4 and 12.2g for genotype, SLJS 26-2. Minimum value was obtained for genotype, SLJS 4-1 i.e 8.5g. These findings are supported by the observation given by Diaz *et al*. (1985) and Puspendra and Ram (1987) but it did not agree with report of Karasu (2009).

Seed yield per plant

At Ludhiana, maximum seed yield was obtained for genotype, SLJS 11-2 i.e 37.2g followed by genotypes SLJS 43-3-2 (36.2g), and SLJS 43-3-1 (42.0g). Lowest yield (4.7g) was obtained by genotype, JS335. The range for this character was 4.7-37.2g with the mean value of 25.0g. At Gurdaspur, maximum yield per plant (37.6g) and minimum value 14.6g were observed by genotype SLJS 43-2 and JS 335 respectively. Oritz *et al.* (2000) observed lot of variability for seed yield between 19 genotypes. Other workers like Resaily *et al.* (1986), Chaudhary and Singh (1987) also reported similar results for grain yield in soybean.

Protein content

The range for this trait varied from (34.9-39.1%) at Ludhiana. Maximum protein content was recorded for genotype, SLJS 43-7 i.e 39.1% followed by SLJS 25-1 (38.8%) and SLJS 23-2 (38.1%).The minimum value of protein content was observed in case of genotype, SLJS 37-1-1 (34.9%). At Gurdaspur, the maximum protein content was possessed by genotype, SLJS 25-1 i.e 38.9% and Minimum protein content (34.2%) was observed by genotype, SLJS 9-3. Zarkadas *et al.* (1999) observed variable range of protein (33.6-42.1%) in soybean genotypes. Brim and

Table 2. Mean performance of agronomic traits of different soyabean genotypes

Sl. No	Genotypes	Plant height at 60 DAS (cm)		Plant height at maturity (cm)		Days to flowering		Days to maturity		Pods per plant	
		Ldh	Gsp	Ldh	Gsp	Ldh	Gsp	Ldh	Gsp	Ldh	Gsp
1	SLJS 1-1	61.6	79.7	67.7	64.1	60.0	59.7	130.0	112.0	51.1	111.4
2	SLJS 1-2	57.3	54.3	62.5	58.0	60.3	59.0	128.3	110.3	69.9	72.0
3	SLJS 1-3	56.7	61.7	63.3	59.0	58.7	58.3	129.0	111.0	82.2	55.9
4	SLJS 2-1	60.6	68.3	69.2	59.7	58.0	59.7	129.7	110.3	62.6	56.2
5	SLJS 3-1	57.8	71.3	80.3	66.3	62.0	59.0	129.0	110.0	55.9	60.8
6	SLJS 3-2-1	69.4	79.7	74.5	65.4	62.7	58.7	130.0	107.7	74.1	78.5
7	SLJS 3-2-2	64.1	71.0	76.0	68.0	62.7	57.3	130.0	112.0	71.2	70.9
8	SLJS 3-3	57.2	82.7	58.5	63.3	60.0	60.7	126.3	107.3	70.1	56.4
9	SLJS 4-1	65.2	67.3	77.5	53.6	61.7	59.0	129.0	109.7	124.6	64.6
10	SLJS 4-2	63.2	81.0	76.5	66.1	61.0	60.0	126.7	108.0	65.9	63.9
11	SLJS 4-3	72.9	85.7	80.7	61.0	57.3	61.3	128.7	111.0	53.6	64.8
12	SLJS 9-1	63.3	79.0	73.2	70.4	58.0	59.3	128.7	106.7	80.5	79.4
13	SLJS 9-2	59.1	57.3	70.8	53.5	58.0	57.3	129.3	105.7	39.2	76.1
14	SLJS 9-3	64.4	68.0	67.7	44.5	60.3	59.3	130.0	108.0	86.0	68.8
15	SLJS 11-2	63.5	51.7	81.5	50.8	62.0	58.3	129.7	106.0	126.8	48.9
16	SLJS 13-1	64.8	63.0	79.2	57.3	62.7	59.0	129.7	107.0	85.5	72.9
17	SLJS 14-1	73.5	57.3	83.5	48.7	64.3	58.0	130.0	112.0	77.6	72.9
18	SLJS 14-2	56.3	63.3	67.3	67.1	60.7	59.0	126.7	110.7	90.0	76.1
19	SLJS 14-3	63.3	63.7	70.3	69.5	62.0	58.7	130.3	107.0	62.9	63.3
20	SLJS 23-2	54.5	62.0	79.7	54.0	58.3	58.3	129.7	111.0	87.3	69.0
21	SLJS 23-3	78.8	66.7	107.0	72.0	60.0	58.0	128.0	111.3	85.6	67.2
22	SLJS 23-4	90.0	86.3	98.8	78.8	61.3	58.3	126.3	110.0	105.9	82.8
23	SLJS 25-1	64.0	67.7	69.8	66.1	57.0	58.0	127.0	109.3	88.1	76.7
24	SLJS 25-2	58.0	75.7	80.5	82.4	59.0	58.0	128.7	108.3	60.1	75.9
25	SLJS 25-3	64.6	83.3	79.3	68.7	59.0	57.0	129.0	110.0	50.5	67.0
26	SLJS 25-4	56.4	73.3	57.8	77.0	62.7	58.7	128.7	109.7	98.7	58.3
27	SLJS 26-1	55.6	60.7	59.6	65.2	61.3	58.3	124.7	109.7	54.7	60.3
28	SLJS 26-2	73.6	64.7	76.6	52.4	60.0	58.7	124.7	113.0	121.1	73.7
29	SLJS 29-1	55.0	63.0	73.3	49.2	61.7	61.3	129.3	114.7	59.2	66.5
30	SLJS 29-2	70.1	56.7	78.5	59.7	62.7	60.7	127.0	112.7	97.7	86.8
31	SLJS 29-3	68.2	56.0	76.8	65.4	62.7	61.3	126.3	119.0	57.4	72.2
32	SLJS 29-4	65.0	90.7	70.3	73.1	61.3	59.0	126.7	116.0	87.2	74.8
33	SLJS 33-1	61.3	71.0	78.7	66.5	60.0	58.7	127.0	114.0	88.2	77.1
34	SLJS 33-2	63.2	70.3	69.0	54.9	58.0	57.7	129.0	115.0	78.2	80.4
35	SLJS 34-1	60.2	65.7	64.8	66.9	61.0	58.7	129.7	113.0	84.2	76.3
36	SLJS 37-1	62.9	62.7	65.2	52.7	60.0	59.3	130.0	113.0	76.3	74.1
37	SLJS 37-1-1	70.2	49.3	73.2	57.1	58.3	61.0	130.0	112.0	88.5	56.1

38	SLJS 41-1	66.4	65.3	78.0	63.6	62.7	60.0	130.0	110.3	35.3	57.4
39	SLJS 41-2	65.7	61.3	80.7	71.0	63.0	61.0	129.3	113.0	83.9	75.7
40	SLJS 43-1	57.0	77.3	74.2	65.1	61.0	60.7	129.7	112.0	88.9	71.5
41	SLJS 43-2	68.2	63.3	86.2	66.5	62.0	59.7	129.0	113.7	96.9	57.7
42	SLJS 43-3-1	60.2	57.3	63.3	56.9	60.3	60.0	129.3	112.7	78.5	84.5
43	SLJS 43-3-2	78.0	56.3	79.2	41.4	60.0	61.3	129.7	113.7	86.3	82.9
44	SLJS 43-4	58.7	46.0	77.5	47.5	60.0	60.0	129.3	112.7	82.9	73.3
45	SLJS 43-5	67.9	47.7	71.7	58.7	58.7	60.0	130.0	115.0	103.6	80.7
46	SLJS 43-6	65.6	71.3	70.5	63.2	61.0	58.7	128.7	113.0	76.9	67.5
47	SLJS 43-7	71.7	67.3	74.8	59.6	61.0	59.3	129.0	114.3	108.3	67.6
48	SLJS 43-8	55.7	78.3	73.3	75.7	60.3	58.0	130.0	110.0	72.3	73.0
49	SL 525	70.7	70.3	73.5	65.6	60.0	61.0	130.7	113.0	94.2	73.3
50	JS 335	61.0	99.0	39.9	107.1	59.3	61.0	130.3	115.0	18.6	76.8
51	SL 958	79.1	61.7	91.5	51.1	62.0	60.0	132.3	113.3	93.9	69.5
Mean		**64.5**	**67.7**	**74.0**	**62.8**	**60.5**	**59.3**	**128.8**	**111.3**	**78.8**	**71.0**
Range		**54.5 -90**	**46.0-99.0**	**39.9- 107.0**	**41.4- 107.1**	**57.0- 64.3**	**57.0- 61.3**	**124.7- 132.3**	**105.7- 119**	**18.6- 126.8**	**48.9- 111.4**
CD (5%)		**7.47**	**11.19**	**8.46**	**7.38**	**0.93**	**1.53**	**0.70**	**1.54**	**13.39**	**8.92**

Burton (1979) also observed this trait as a highly variable one.

Oil content

At Ludhiana, maximum oil content (22.7%) was possessed by genotype, SLJS 23-2 followed by 22.3 per cent by SLJS 43-1 and 22.1 per cent by SLJS 37-7-1. Minimum value i.e 18.8 per cent for oil content was observed for genotype, SLJS 43-3. At Gurdaspur, maximum oil content was possessed by genotype, SL525 i.e 22.1% and minimum oil content (18.8%) by genotype, SLJS 2-1. Clark and Synder (1989) observed significant differences of oil content in different soybean genotypes.

GCV, PCV, heritability and genetic advance

The estimated values of Genotypic Coefficient of Variance (GCV), Phenotypic Coefficient of Variance (PCV), Heritability (h^2) and Genetic Advance (GA) for Ludhiana and Gurdaspur are presented in table No 2. For most of the characters, the coefficient of phenotypic variation was more as compared to genotypic coefficient of variation which indicates the role of environment in expression of characters. Seed yield per plant exhibited highest GCV among total characters. The other characters which had high GCV values were pods per plant and pods per node. The characters which were having low GCV were days to flowering, days to maturity, number of seeds per pod, protein content and oil content at both the locations. At Ludhiana location the traits which had high heritability were days to flowering, days to maturity, number of pods per plant, seed yield per plant, protein content and oil content. But at Gurdaspur plant height at maturity, days to maturity had high heritability. Genetic advance was high for plant height at 60 days and at maturity, number of pods per plant and pods per node and seed yield per plant at both the locations.

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TABLE 3. Mean performance for different agronomic and biochemical traits of soybean genotypes

Sl. No	Genotypes	Pods per node		Seeds per pod		100 seed wt. (g)		Seed yield (g)		Protein content(%)		Oil content(%)	
		Ldh	Gsp	Ldh	Gsp	Ldh	Gsp	Ldh	Gsp	Ldh	Gsp	Ldh	Gsp
1	SLJS 1-1	3.3	4.4	2.6	2.7	10.0	10.5	30.4	28.2	36.8	35.6	20.8	19.7
2	SLJS 1-2	5.1	3.4	2.6	2.6	7.7	10.6	21.0	24.3	38.1	38.0	20.7	20.0
3	SLJS 1-3	6.0	3.0	2.5	2.6	8.7	11.0	23.6	33.3	35.8	34.4	20.1	20.0
4	SLJS 2-1	3.4	2.8	2.6	2.6	8.7	10.9	26.0	26.8	35.9	35.1	20.4	18.8
5	SLJS 3-1	1.8	2.6	2.7	2.8	10.7	11.0	29.2	33.8	35.5	35.3	20.3	21.3
6	SLJS 3-2-1	3.1	3.6	2.6	2.8	9.3	10.7	29.3	28.3	36.8	35.5	20.2	21.3
7	SLJS 3-2-2	3.8	3.1	2.5	2.6	10.0	10.9	22.9	34.2	37.5	37.1	19.8	19.9
8	SLJS 3-3	3.5	2.8	2.6	2.7	9.3	11.1	27.7	29.3	37.6	38.5	20.6	20.1
9	SLJS 4-1	6.1	3.1	2.6	2.7	7.7	8.5	27.9	27.0	35.8	35.1	21.4	19.0
10	SLJS 4-2	3.3	2.9	2.6	2.6	8.7	9.1	18.7	25.8	37.6	36.3	18.8	18.9
11	SLJS 4-3	3.1	3.7	2.5	2.6	8.7	11.1	20.2	23.5	37.4	36.5	21.0	19.6
12	SLJS 9-1	4.5	3.3	2.7	2.7	8.0	11.9	30.1	35.7	36.9	35.5	20.8	20.1
13	SLJS 9-2	2.6	3.4	2.5	2.7	9.7	10.3	25.5	25.3	36.3	35.1	19.9	19.9
14	SLJS 9-3	6.4	3.0	2.5	2.7	9.3	12.0	25.1	20.7	35.0	34.2	22.1	20.2
15	SLJS 11-2	7.1	2.6	2.5	2.8	8.0	8.9	37.2	32.6	36.8	35.6	20.2	20.4
16	SLJS 13-1	3.9	3.2	2.6	2.8	10.0	10.8	29.0	25.2	36.6	35.5	19.4	20.5
17	SLJS 14-1	4.0	3.5	2.5	2.7	8.7	10.2	26.7	21.0	37.9	37.4	20.4	20.0
18	SLJS 14-2	5.3	3.1	2.5	2.8	7.7	10.8	22.9	31.0	36.6	35.7	18.8	20.6
19	SLJS 14-3	3.1	2.8	2.6	2.7	9.3	11.9	32.0	26.7	37.2	36.6	19.2	19.0
20	SLJS 23-2	4.4	3.1	2.5	2.8	8.7	10.0	19.8	22.3	38.1	37.9	21.0	20.0
21	SLJS 23-3	4.1	2.8	2.5	2.8	7.3	10.8	30.4	33.5	36.3	36.3	21.2	18.9
22	SLJS 23-4	4.8	3.1	2.6	2.9	8.0	12.3	29.5	37.5	36.2	35.1	20.5	20.0
23	SLJS 25-1	4.3	3.2	2.5	2.7	8.7	11.7	26.4	32.3	38.8	38.9	21.0	19.8
24	SLJS 25-2	2.8	3.1	2.6	2.7	8.0	11.6	20.0	33.0	36.8	35.2	19.8	19.8
25	SLJS 25-3	2.3	2.9	2.5	2.7	8.0	10.4	20.4	25.6	36.8	35.4	21.2	21.7
26	SLJS 25-4	6.0	3.2	2.5	2.6	8.0	11.5	26.4	28.6	37.5	36.9	19.3	20.0
27	SLJS 26-1	2.5	3.4	2.7	2.7	8.7	10.2	20.7	22.3	37.1	35.7	20.1	19.7
28	SLJS 26-2	6.4	3.2	2.7	2.8	8.0	12.2	18.0	33.5	37.9	37.8	21.1	20.0
29	SLJS 29-1	2.8	3.0	2.5	2.8	8.7	11.5	20.2	26.5	37.2	35.7	21.3	20.0
30	SLJS 29-2	4.7	3.5	2.7	2.8	7.3	11.3	30.0	22.5	37.2	37.1	20.3	20.2
31	SLJS 29-3	2.9	3.1	2.4	2.9	7.3	11.7	17.4	35.5	36.6	35.9	20.3	19.8
32	SLJS 29-4	4.9	3.2	2.6	2.8	7.3	11.0	19.3	31.0	37.8	37.1	21.9	20.5
33	SLJS 33-1	5.4	2.8	2.4	2.8	7.3	11.8	17.6	35.3	36.5	36.0	21.4	20.8
34	SLJS 33-2	5.4	3.6	2.5	2.8	6.7	10.9	21.4	26.0	36.3	35.4	22.7	21.0
35	SLJS 34-1	4.7	3.1	2.5	2.7	8.0	10.9	23.3	21.2	36.6	35.8	21.8	21.0
36	SLJS 37-1	3.5	3.1	2.5	2.8	8.7	11.0	28.5	23.8	36.5	36.3	22.0	20.2
37	SLJS 37-1-1	4.4	2.4	2.7	2.8	10.0	11.0	27.3	20.9	34.9	34.9	22.1	20.6
38	SLJS 41-1	4.5	2.8	2.7	2.8	7.3	11.3	20.6	22.2	35.4	34.5	21.6	19.9
39	SLJS 41-2	4.2	3.8	2.6	2.9	8.7	10.2	26.5	37.6	37.1	37.3	21.2	20.9

40	SLJS 43-1	5.8	2.7	2.6	2.8	8.7	11.3	25.2	32.2	36.9	36.9	18.8	19.8
41	SLJS 43-2	5.8	2.8	2.7	2.9	8.0	11.1	21.9	20.2	38.0	38.1	21.1	21.2
42	SLJS 43-3-1	4.5	3.6	2.6	2.7	8.0	10.7	33.0	21.6	35.7	35.9	22.3	18.9
43	SLJS 43-3-2	4.9	3.9	2.6	2.6	8.3	11.3	36.5	21.4	35.4	35.2	20.3	19.9
44	SLJS 43-4	4.5	3.3	2.6	2.7	8.0	10.7	22.9	18.9	37.1	36.8	21.9	20.1
45	SLJS 43-5	6.3	3.3	2.7	2.7	8.0	10.8	30.3	21.0	37.1	37.2	20.5	20.4
46	SLJS 43-6	3.2	3.3	2.7	2.7	8.0	10.7	23.6	22.5	36.0	35.9	21.6	20.8
47	SLJS 43-7	6.1	3.0	2.7	2.7	9.3	11.7	32.0	32.8	39.1	38.8	20.3	19.8
48	SLJS 43-8	4.1	3.3	2.6	2.6	7.3	10.5	17.3	33.1	35.8	36.0	20.8	20.0
49	SL 525	3.4	2.9	2.6	2.5	8.0	12.1	27.3	32.7	36.9	37.3	21.0	22.1
50	JS 335	1.2	3.3	2.4	3.0	8.7	12.0	4.7	14.6	36.3	35.1	21.1	20.6
51	SL 958	2.5	3.0	2.6	2.7	8.0	10.6	32.7	36.3	37.7	38.5	20.6	21.4
	Mean	**4.2**	**3.2**	**2.6**	**2.7**	**8.4**	**11.0**	**25.0**	**27.7**	**36.8**	**36.3**	**20.7**	**20.2**
	Range	**1.2-7.1**	**2.4-4.4**	**2.4-2.7**	**2.5-3**	**6.7-10.7**	**8.5-12.3**	**4.7-37.2**	**14.6-37.6**	**34.9-39.1**	**34.2-38.9**	**18.8-22.7**	**18.8-22.1**
	CD (5%)	**1.43**	**0.51**	**0.26**	**0.18**	**1.40**	**0.85**	**3.63**	**5.15**	**0.60**	**1.04**	**0.61**	**0.92**

TABLE 4. GCV, PCV, Heritability and genetic advance of different agronomic traits of YMV tolerant soybean lines at Ludhiana and Gurdaspur

Genetic parameters	GCV		PCV		h^2		GA	
Agronomic and Bio-chemical observation	**Ldh**	**Gsp**	**Ldh**	**Gsp**	**Ldh**	**Gsp**	**Ldh**	**Gsp**
Plant height at 60 DAS	10.50	15.48	12.71	18.54	68.33	69.71	17.89	26.63
Plant height at maturity	13.36	16.82	15.14	18.32	78.13	84.27	24.32	31.80
Days to flowering	2.73	1.76	2.90	2.37	89.24	54.95	5.32	2.69
Days to maturity	1.18	2.46	1.23	2.61	92.46	89.24	2.34	4.79
Number of pods per plant	21.56	13.82	22.90	15.85	88.60	76.01	41.80	24.82
Number of seeds per pod	0.00	2.50	6.10	4.75	-1.32	27.71	-0.17	2.71
Number of pods per node	20.02	9.64	23.51	13.88	72.52	48.23	45.12	13.79
100-seed weight	8.36	6.54	13.27	8.11	39.67	64.90	10.84	10.85
Seed yield per plant	22.57	19.70	24.29	22.81	86.36	74.60	43.21	35.04
Protein content	2.41	3.12	2.61	3.54	84.97	75.69	4.58	5.60
Oil content	4.32	3.15	4.69	4.22	84.99	55.60	8.21	4.83

Note: GCV- Genotypic coefficient of variance, PCV- phenotypic coefficient of variance, h^2-Heritability, GA- Genetic Advance, Ldh- Ludhiana, Gsp- Gurdaspur

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Scaling Up of Sunflower (*Halianthus Annuus* L.) Productivity Through Improved Production Technologies in Nontraditional Belts of West Bengal Through Front Line Demonstration

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Abstract

The Front Line Demonstration (FLDs) were conducted in the nontraditional belts of West Bengal in the district of Bankura and Purulia in the *rabi – summer* season under DAC Programme to know the yield gaps between improved technology (IT/IP) and farmer's practice (FP) in sunflower crop. In the FLDs, the sunflower hybrid (LSFH-171,KBSH-53) used in the demonstration plot which were performed better in terms of seed yield, in all two years of demonstration (1988kg/ha in 2015-16) and 2450kg/ha in 2016-17) as compared to cultivation of local sunflower hybrids like JK-Chitra, PAC-361 and Ganga Kaveri (1530kg/ha in 2015-16 and 1650kg/ha in 2016-17).The average seed yield of sunflower under demonstration plot was recorded 1988kg/ha in 2015-16 and 2450kg/ha in 2016-17 compared to conventional cultivation of sunflower where production was recorded 1530kg/ha in 2015-16 and 1650kg/ha in 2016-17. In West Bengal, the yield gaps between improved technology (full package of sunflower demonstration with best management practices) and farmers practice (sunflower cultivation through conventional approaches) was recorded 458-800 kg/ha and therefore, in demonstration plot were recorded 29-48% higher seed yield over farmer's practices. Spraying of Boron (micronutrient) @0.2% at ray floret opening stage also found very responsive regarding yield improvement over its non application across the years of demonstration. In addition, in all the two years study, by adopting proper spacing and thinning practices and by use of IPM based pesticides, marked improvement of seed yield and additional net return were observed in farmer's field. The study recommends that as the gross return and net return of the sunflower farmers are less in the study area, that can be can be improved by adopting component technologies *viz.* hybrid sunflower cultivars(LSFH-171, or KBSH-53),spraying of micronutrient Boron at ray floret opening stage, adopting proper spacing and thinning and use of proper bio-inoculants.

Key words : *Sunflower, FLD, Non-traditional area, Yield improvement*

Introduction

Sunflower (*Helianthus annuus* L.; 2n=2x=34) is one of the most important edible oilseed crop in the world including India. The crop is well-known for its broad range of adoptability (Koutroubas *et.al.,*2008) and high oil content about 40-43% (Nasim *et.al.,*2011). In India, sunflower is cultivated in an area of 7 million ha with a total productivity of 5 million tones (Padmaiah *et.al* 2015) and with an average productivity of 791kg/ha (Anonymous, 2016), where as in West Bengal it is grown in an area of 12,500 ha in last *rabi* season (2015-16). In India, the sunflower is mostly grown in the states of Karnataka, Maharastra, AP and Tamil Nadu with potential scope of growing in the non-traditional areas like West Bengal (Dutta, 2011). In West Bengal, Sunflower is an important emerging oilseed crop after rapeseed-mustard during*rabi*-summer season and it was grown on about 12,500 ha in last *rabi* season (2015-16) in an average productivity of sunflower was 13.05 q/ha in the year 2012-13. Due to short winter spell and delayed and heavy rainfall during rainy season, the sowing of mustard was delayed which ultimate reduced the production of rapeseed-mustard. Sunflower being a photoperiod natural crop has wide scope to replace the rapeseed-mustard cultivation with high yield potentiality. In West Bengal, South 24parganas district is most of the prominent sunflower growing areas, but there is a huge scope of growing sunflower in non-traditional Districts like Bankura and Purulia where the crop is largely cultivated under irrigated conditions during *rabi* seasons. It was observed that productivity level of sunflower in farmer's fields was low due to several biotic and abiotic factors besides unavailability of quality seeds of improved sunflower hybrids in time and non adoption of recommended production technologies. Selection of the right sunflower hybrid is very crucial as the final income is dependent on both seed yield and oil yields. As not all the hybrids available in the market maximize both the seed yield and oil yields, farmers need to be cautious while choosing the hybrids. Further, non adoption of recommended row spacing leads to low or over plant population which reduces seed setting etc. as lower plant density delays canopy closure and increases light interception leading to high seed production per plant, but low seed production per unit area(Basha,2000). More, so, excess plant population leads to more inter plant competition for soil moisture and nutrients resulting in smaller heads size and poor seed set. Hence, optimum plant population and optimum plant density plays a greater role in increasing the sunflower productivity, Also, sunflower, is one of the most sensitive crops to boron(B), and it's deficiency at flowering stage affects pollen viability and abortion of stamens and pistils resulting in poor seed yield (Dell and Longbin,1997; Chatterjee and Nautiyal,2000). The poor seed yield in farmer's fields a wide gap between the available improved techniques and it's actual application by the farmers. Hence, there is a tremendous opportunity for increasing the production and productivity of sunflower grown in the area by adopting the improved technologies which in turn helps in improving the economic and social status the farmers.

Therefore, to meet the demand of present as well as future generation there is an immense need to increase oilseed area and productivity through "**Front Line Demonstration**" Programme. In the **FLDs**, awareness of new varieties of oilseed crops under specific agro-climatic situation and better crop management practices can be achieved by the farmers which not only will increase the productivity of oilseed in a sustainable manner but also give a good economic return.

Through Front Line Demonstration(FLD) programme, the AICRP centre started disseminating the technology of sunflower cultivation through modern scientific approaches in Bankura and Purulia district by adopting best management practices for sunflower cultivation. After observing the performance of different sunflower hybrids in the on station and on farm trials, the AICRP centre recommended full package of practices for the hybrid DRSH-1, KBSH-53 or LSSH-171 to State Agriculture Department, GOWB for up-scaling the technology.There is huge demand for good quality sunflower seed (hybrid) from the farmers in this year indicating the popularity of sunflower cultivation in a backward district like Bankura and Purulia.

Materials and Methods

Front Line Demonstration (FLD) on sunflower were conducted at farmer's fields in different villages of Bankura and Purulia districts of West Bengal to assess it's performance during *rabi* season of the 2015-16 and 2016-17 under irrigated condition. The soils of the districts where FLDs were taken up are sandy loam in texture, low in nitrogen, low to medium in phosphorus and medium to high in potash. For conducting Front Line Demonstration (FLD) on sunflower two village meetings were conducted through Farm Science Club**.** In this meeting a vigorous discussion was held with the farmers to assess their needs for increasing the productivity of oilseed and pulses during the *rabi-summer* season. After that, farmers were interviewed in this regard and ultimately the technological gaps were identified which were responsible for low productivity of sunflower in this region. The farmers who expressed keen interest in adopting new technology were selected for this purpose. The training and group meeting on oilseed crops were conducted with the selected farmers as suggested by Choudhury 1999. The and critical inputs like seed, fartilizers, bio-inoculants and plant protection chemicals were distributed among the 100 selected farmers. Time to time visit and supervision of the FLD plots were conducted from sowing to harvest and the suggestions were given accordingly. Moreover, farmers and extension workers were trained up through On Campus and Off Campus training programmes.

The sunflower varieties selected for FLD programme were DRSH-1& KBDSH-53 for 2014-15, KBDSH-53 &LSF-171 and LSF-171 for 2015-16.The seed and other need based inputs were distributed among the 100nos. of farmers. The seeds of sunflower were sown in the last week of November to 1st week of December, with the seed rate of 5 kg/ha (2.0kg/acre) and recommended spacing (60cm X 30 cm). Vermicompost was applied @ 5 quintals/acre at the time of land preparation for enhancement of soil fertility and increased the seed yield of sunflower. In each FLDs, the seed treatment was done with Bio-inoculants (Bio-fungicides + bio-fertilizers (T. *viride* + *P. fluorescens*and *Azatobactor* & PSB each @ 10g /kg of seed). Chemical fertilizers for phosphate and sulphur based fertilizers like single super phosphate (SSP) or 20:20:0:13 was applied. Proper thinning was completed (single plant/hill) before 1st irrigation (21-25 DAS). 1/2th (50%)of the nitrogen (40 kg N/ha), full dose of phosphorus (40 kg P_20_5/ha) and potash (40 K_20/ha) were applied as basal and remaining 1/4th (25%)of nitrogen (20 kg/ha) was given as top dressing in the form of urea before first irrigation (25-30 DAS) at the time of earthing up and rest 25% (20kg/ha) was given as top dressing in the form of urea before second irrigation at the time of second earthing up (42-45DAS). The sunflower was sown in residual moisture and one irrigation was provided at star-bud stage (21-25DAS), the 2nd irrigation was provided at the preflowering stage (40-45 DAS) and 3rd (If needed) in post flowering stage (60-65 DAS). The satisfactory yield of sunflower was recorded by utilizing the residual moisture for germination with three life saving irrigation. Spraying of micronutrient (Boron) (concentration @2 g/liter of water) @500liter/ha at ray floret opening stage were demonstrated at farmer's field. Each FLD is conducted in an area of one acre land, compared with existing farmer's practice is adjacently taken up in one acre of land. Use of bio-fungicides like*Trichoderma viride* & *Pseudomonas flurescens* (10g +10g/lit of water) for spraying at crown region before 1st & 2nd irrigation for the management of Sunflower wilt (FLDs). In each FLDs the IPM based pesticides like flubendiamide 480SC or Spinosad (Koragen) @ 150ml/ha, (3ml /10lit of water) was applied (1-2 Sprays at 21days interval) after appearance of *Spodoptera lutera*.

A team of scientists including Plant Breeder, Agronomist and Plant Pathologists or entomologists have visited and monitored the demonstration fields at an intervals of 15-20days during the crop growth period. Finally, data on seed yield, cost of cultivation and returns were collected after harvesting of the crop. Different parameters as suggested by Yadav *et. al.* (2004) were used for calculating the gap analysis, cost and returns.

Yield Gap= Demonstration Yield –Farmer's Practice Yield

Additional return= demonstration Return-Farmer's Practice Return.

Results and Discussion

IP = Improved practice: CROP : Sunflower

1. Fertilizer— (N: P_2O_5:K_2O) 80:40:40 kg/ha;

2. Hybrid-LSFH-171 and KBSH-53; 3. Seed treatment with *T.viride* & *P. fluorescens (*10g + 10g / kg seed of seed*)*, and PSB & Azetobactor (10g+ 10g/kg of seed) ; 4. Spraying of bio-inoculants at crown region (*T.viride* & *P. fluorescens (*10g + 10g /liter of water*)*, and PSB & Azetobactor (10g+ 10g/liter of water) before 1st and 2nd irrigation for management of sunflower wilt and reduced the fertilizer consumption

5. Single plant /hill before 1st irrigation and earthing up after 1st and 2nd irrigation,

6. One time Boron spray (0.2%) at ray floret stage 7. Need based application of IPM based pesticides (flubendiamide 480SC or spinosad @150ml/ha)

FP= Farmer's Practice: Crop Sunflower (Hybrid JK Chitra, Ganga Kaveri, PAC-361), No seed treatment with bio-inoculants, No IPM based pesticide, No Boron spray and No thinning and weeding and

Table 1. Details of FLDs Implemented

Sl. No.	Crop	Technology demonstrated in case of component demo.	Area (ha)	No. of Demonstration	No. of farmers/ demo. Seed yield (IT)	Seed Yield(FP)	Achieved **Increase in yield (%)**
1. (2015-16)	Sunflower	**Hybrid LSF-171 & KBSH-53** with 80:40:40 Kg**NPK/ha** and one time**boron** spray at ray floret stage, seed treatment with Bio-inoculants and need based IPM based pesticides application,single plant/hill at 12-15DAS.	60	150	**1988**	1530	**29.9%**
2. (2016-17)	Sunflower	**Do** Hybrid **LSF-171 & KBSH-53**	60	150	**2450**	1650	**48.5%**
Average					**2219**	**1590**	**39.2%**

Table 2. Details of farming situation

Crop	Season	Farming situation (RF/ Irrigation)	Soil type	Status of soil N (kg / ha)	P_2O_5 (kg / ha)	K_2O (kg / ha)	Previous crop	Sowing date	Harvest date	Seasonal rainfall (mm)	No. of rainy days
Sun-flower	Rabi-Summer, 2013-14	**Irrigated**	Sandy-loam	182.3 to 242.7	22.9 to 45.2	387.5 to 779.6	Paddy	3rd week of November to 1st week of December	1st–last Week of March	14	2
Sun-flower	Rabi-Summer, 2014-15	**Irrigated**	Sandy-loam	195.7 to 252.1	24.2 to 46.1	395.8 to 788.1	Paddy	3rd week of November to 2ndweek of December	1st–last Week of March	18mm	3
Sun-flower	Rabi-Summer, 2015-16	**Irrigated**	Sandy-loam	167.5 to 261.2	26.1 to 46.1	372.5 to 817.2	Paddy	3rd week of November to 2ndweek of December	1st–last Week of March	25mm	3

From the above table it is observed that the soil type of FLD plots under different villages is sandy-loam in texture. The available phosphorus and nitrogen are low to medium but the available potassium is high ranging from 355.8 to 779.6kg/ha. The germination of the seed was recorded over 90% in every year.

earthing up at any crop growth stage no single plant /hill.

The study depicted that there is sufficient yield gap between improved technologies and farmer's practices and can be achieved by adoption of appropriate selection of oilseed crop for particular season, adoption of appropriate hybrid, boron spray and maintaining the optimum plant population though proper row spacing and thinning. Meanwhile, it is expected that the combination of all these technologies

TABLE 3. Suitability with existing farming system

Existing condition	Before intervention	After intervention
Land situation	Low to medium	Low to medium
Soil type	Clay-loam	Clay-loam
Salinity	More than 3.0dS/m	Less than 3.0dS/m
Irrigation opportunity	Less	Better utilization through ridge and furrow method
Cropping pattern	*Kharif*-Paddy*Rabi-summer*: fallow	***Kharif*-Paddy*Rabi-summer*: Sunflower**
Income	Avg. Rs. 36750-Rs 40,000 /ha	**Avg. Rs.** 58,800-72,000/**ha**
Seasonal Migration	More	**Less**

would have interactive impact on sunflower productivity in farmer's field.

The study suggested that the production level of oilseed crop can be improved by cultivation of suitable oilseed crop like sunflower by adopting suitable hybrids like (LSF-171 **and KBSH-53**). In demonstration plots the mean seed yield was recorded **1988kg/ha** (2015-16) to**2450 kg/ha (2015-16)** and it was produced **29-48.5%** more seed yield over the cultivation of sunflower through conventional approaches (Table-4). From the demonstration field data it was recorded that gross return of the farmers was Rs. 81,938.00/ha (2015-16) and Rs. 105,840.00/ ha (2016-17) compared to conventional practices where the farmers earned Rs. 57,225.00/ ha to Rs. 71,280.00/ha and thereby the additional net return under sunflower cultivation following the best management practices were Rs.14,310.00/ha (2015-16), Rs. 28072 .00/ha (2016-17) (Table-4). Besides suitable hybrids, seed setting is also one of the major constraints in maximizing the sunflower productivity. Unavailability of optimum "Boron" in soil leads to boron deficiency in crop plants that effects flowering, pollen germination, pollen tube growth and seed development (Cakmak and Romheld, 1997). However, in this study it was observed that, generally farmers do not apply the Boron fartilizers to oilseed crops like rapeseed mustard, sesame and sunflower in this region and hence, foliar application of boron is advised in irrigated condition in the ray floret stage in Bankura and Purulia districts.

The results from the demonstration plots indicated that, foliar application of boron in the ray floret stage (2g/lit. of water) opening stage could markedly increase the seed yield. Under irrigated condition, the yield advantage may be associated with boron as well as supplemental moisture application in the form of assured life saving irrigation and judicial application of chemical fartilizers at proper stage of the crop. The yield advantage also associated with the seed treatments with bio-inoculants like **Bio-fartilizers (*Azatobactor* & PSB) and Bio-fungicides (*T. viride* + *P. fluorescens*)** each @ 10g /kg of seed) for seed treatment as well as application of the **Bio-fartilizers (*Azatobactor* & PSB** 10g + 10g /lit. of water**) and** bio-fungicides (T.V + P. F @ 10g + 10g /lit. of water) before 1st and 2nd irrigation for reducing the need of the chemical fartilizers (20-25%)and effectively management of the Sunflower wilt which is main disease of that region.

Maintaining optimum plant population is essential for higher seed yield of sunflower in farmer's field. Through regular field level training and monitoring before sowing and during crop growth stage, the awareness was developed among the farmers regarding the proper spacing, thinning and weeding & earthing up at proper crop growth stage. Over and under population

Table 4. Comparative seed yield and economic assessment of FLD (Full package VS Farmer's Practices) of sunflower cultivation: Result demonstration (kg/ha)

Year	Mean seed yield (Kg/ha)		Yield gap (kg/h)	Cost of cultivation (ha)		Gross Return (Rs/ha)		Net return (Rs/ha)		Additional Net return (Rs/ha)	Increase in yield %	Benefit: Cost ratio	
	IP	FP		IP	FP	IP	FP	IP	FP			IP	FP
2015-16	**1988**	1530	**458**	51167	44065	**81938**	57525	**30770**	16460	**14,310**	**29.9**	**1.60**	1.30
2016-17	**2450**	1650	**800**	58,400	51912	**101840**	71280	47690	19638	**28,052**	**48.5**	**1.82**	1.37
Avg.	**2219**	**1590**	**629**	54784	47989	91889	64403	39230	18049	**21,181**	**39.6**	**1.71**	**1.33**

Table 5. Effect of foliar spray of Boron on seed yield and economics of sunflower under irrigated field situations (No. of Demostration:10)

Year	Mean seed yield (Kg/ha)		Yield gap (kg/ha)	Cost of cultivation (Rs./ha)		Gross Return (Rs./ha)		Net return (Rs./ha)		Additional Net return (Rs/ha)	Increase in yield %	Benefit: Cost ratio	
	IP	FP		IP	FP	IP	FP	IP	FP			IP	FP
2015-16	**1988**	1721	**267**	51167	49292	**81938**	74304	**30770**	25012	**5758**	**15.5**	**1.60**	1.50
2016-17	**2450**	2060	**390**	58,400	55530	**101840**	88900	**47690**	33370	**14320**	**18.9**	**1.82**	1.63
Avg.	**2219**	1891	**329**	54784	52411	**91889**	81602	39230	29191	**10039**	**17.4**	**1.71**	**1.56**

was observed in farmer's sunflower and often resulted in poor seed yield. Hence, optimum plant population should be mentioned by proper inter row and intra row spacing. The yield advantage in demonstration plot also associated with the adoption of these agronomical practices in farmer's level. The data across of the years of demonstration indicated that the economic advantage in terms of the Benefit: Cost (B:C) ratio of the farmers under improved method of sunflower cultivation was recorded 1.60 (2015-16) and 1.82 (2016-17) which were much higher compared to conventional cultivation systems /Farmer's Practice, 1.30 (2015-16)-1.37 (2016-17) (Table 5). Based on farmer's field demonstration, sowing of farmer's at 60cm x 30cm spacing with single plant /hill yielded 18-22% higher seed yield compared to farmer's practices and the farmer's sprayed Boron (0.2%) at ray floret opening stage yielded 14-17% higher seed yield compared to farmer's practices (without foliar application of boron at ray floret stage). However, combination of both spraying boron and thinning have almost additive effect and resulted 29%-48% yield improvement over conventional farmer's practices. (Table-4).

TABLE 6. Effect of Weeding and thinning on seed yield and economics of sunflower under irrigated field situations. (No. of demonstration:10)

Year	Mean seed yield (Kg/ha)		Yield gap (kg/ha)	Cost of cultivation (Rs./ha)		Gross Return (Rs./ha)		Net return (Rs./ha)		Additional Net return (Rs/ha)	Increase in yield %	Benefit: Cost ratio	
	IP	FP		IP	FP	IP	FP	IP	FP			IP	FP
2015-16	1988	1574	414	51167	46892	81938	68028	30770	21136	9634	26.3	1.60	1.45
2016-17	2450	1890	560	58,400	52400	101840	81650	47690	29250	18440	29.6	1.82	1.55
Avg.	2219	1732	487	54783	49646	91889	74839	39230	25193	14037	28.1	1.71	1.50

TABLE 7. Comparative study of different technology on seed yield and economics of sunflower under irrigated field situations. (No. of demonstration:10)

Technology	Mean seed yield (Kg/ha)		Yield gap (kg/ha)	Cost of cultivation (Rs/ha)		Gross Return (Rs/ha)		Net return (Rs/ha)		Additional Net return (Rs/ha)	Yield increase %	Benefit: Cost ratio	
	IP	FP		IP	FP	IP	FP	IP	FP			IP	FP
Full package of Practice	2219	1590	629	54784	47989	91889	64403	39230	18049	21,181	39.6	1.71	1.33
Boron Spray at ray floret stage	2219	1891	329	54784	52411	91889	81602	39230	29191	10039	17.4	1.71	1.56
Weeding & thinning	2219	1732	487	54783	49646	91889	74839	39230	25193	14037	28.1	1.71	1.50

The study depicted that there is significant yield gap between improved technologies and farmer's practices and can be combated by adoption of appropriate hybrid, boron spray and maintaining optimum plant population through proper row spacing and thinning. The yield improvement with adoption of improved technologies under irrigated condition was found in order of full package of practices > spacing/ thinning > boron spray (Table-7). Meanwhile, it is proved that the combination of all these technologies would have interactive impact on sunflower productivity in farmer's field. Ingle and Lalit Arun (1997) pointed out the Impact of farmers training programme of Krishi Vigyan Kendra on knowledge and adoption of improved practices. "The socio economic change plays the key role for adoption and dissemination of new technologies in agriculture" Have been reported by many worker, Shivram and Dalal (1994), Meti and Hanchinal (1994), Nagraj and Katteppa (2002). The socio economic condition of the farm families has been changed to words upwards direction through sunflower cultivation by adopting the modern scientific approaches through this front line demonstration (FLD) programme.

Therefore sunflower cultivation following the best management practices proven to be an potential alternative source of oilseed cultivation in *rabi-summer* season in irrigated condition in “Non-traditional (Red & Lateritic)” belts of West Bengal with an additional income of Rs. 14,037 – Rs. 21,181.00/ha. For maximization of farmer’s profit and to minimize the yield gap of oilseed crop like sunflower, more numbers of Front Line Demonstration (FLD on sunflower) is required to be conduct in different villages and different blocks in nontraditional belts of West Bengal**.**

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Synchronizing Nitrogen and Potassium Supply with Crop Demand to Enhance Nutrient and Water Use Efficiency on Bt. Cotton Hybrid (NSPL-999)

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Abstract

A field experiment was conducted to assess N and NK split application to synchronize nutrient application with crop demand. Eight timings of application and different dose of N and NK both were taken as different treatments. Timings were planned to supply the fertilizer at different crop growth stages i e., at 10, 30, 45, 60 and 75 DAS. Split application of N and NK did not have any significant effect on plant height (cm), monopodia per plant, sympodia per plant ,boll per plant, boll weight, and G.O.T. (Ginning Percentage). Bolls per plant was affected significantly with different mode of fertilizers application as well as timing of split application. The seed cotton yield did not deviate significantly due to split-cum-basal fertilizer application; however, timings of split application of fertilizers resulted in significant changes in this productivity parameter. The extra net income from F_2 was only Rs. 2884/ha. over F_1. Amongst the timing of split application, S_4 and S_5 having three splits up to 60 DAS proved significantly superior to some of the remaining treatments, seed cotton yield ranged from 21.15 to 21.19 q/ha with extra net income from Rs. 6109 to Rs. 6205 / ha over S1. Other treatments except S_7 showed monetary loss from Rs. 900 to Rs. 2250/ha. The treatment interactions were found to be significant GMR, and NMR the characters under study.

Key words: *Bt cotton, nitrogen, potassium, split application, water use efficiency and nutrient uptake*

Introduction

Cotton is a prime cash crop in India. It plays vital role in Indian economy. In India, it is cultivated about 9 million hectares area, the largest of any nations in the world, this acreage is about 25% of the total acreage in the world and 5% of India's cultivated area. None the less, productivity levels are very low with 502 kg/ha as against world acreage of 731 kg/ha. In northern cotton growing states, Viz. Punjab, Haryana and Rajasthan six Bt cotton hybrids were approved for commercial cultivation Bt cotton hybrids, two each have been developed by Mahyco (MRC 6301 Bt and MRC 6304 Bt), Rasi seeds (RCH 134 Bt and RCH 317 Bt) and Ankur seeds (Ankur 651 Bt and Ankur 2534 Bt) (Singh and Kaushik, 2007). Split application of both nitrogen and potassium is recommended in many statuses.Nitrogen is most essential nutrient for plant growth needs to be supplied in proper time and quantities. A positive correlation between vegetative growth and the number of fruiting points produced by cotton is well known. N supplement therefore by split application becomes important as it is supplied ideally in a time when crop critically requires. Bt cotton differs in its requirement either by total of it in the different stages of crop. Split applications of nitrogen fertilizer can play an important role in a nutrient management strategy that is productive, profitable and environmentally responsible.

Application of nitrogen in two or more than two splits doses can help growers enhance nutrient efficiency, promote optimum yield and mitigate the loss of nutrient. Potassium (K) is the third major essential plant nutrient along with N and P. It plays a specific role in most plant species in opening and closing of stomata which cannot be done by other cation (Saxena, 1985). It increases root growth and improves drought resistance, activates many enzymes systems, reduce water loss and willing, prevent energy losses and aids in photosynthesis, respiration and food formation (Tiwari, 2001). As the requirement of plants to potassium differ from stage to stage (Brady, 1996) and there might be better response of plants to potassium, if potassium is applied in splits at different stages. Hence, the present study was carried out using Bt cotton as test crop to assess the nutrient uptake pattern and fertility balance.

Materials and Methods

The field experiment was conducted in medium black clay – loam soil at the JNKVV, Regional Agricultural Research Station, Khandwa (M.P.) during 2010-11 and 2011-12. The soil was slightly alkaline (pH.) with low in organic carbon (0.30-0.20%), available N (191-198 kg/ha), medium in P_2O_5(13.0-19.2 kg/ha) and K_2O. (282-288 kg/ha.) The treatments consist of 02 : Mode of fertilizers application- (F1-N_{120} as split & P_{60}, K_{40} as basal and F2-N_{120}, K_{40} as split & P_{60} as basal) and 08 : Timing of split application- (S1-2 Splits (10 & 45 DAS), S2- 3 Splits (10, 45 & 75 DAS), S3- 3 Splits (10, 30 & 45 DAS), S4- 3 Splits (10, 30 & 60 DAS), S5- 3 Splits (10, 45 & 60 DAS), S6-3 Splits (10, 30 & 75 DAS), S7-4 Splits (10, 30 45 & 60 DAS) and S8-4 Splits (10, 30, 45 & 75 DAS).

The experiment was laid out in split – plot design with three replications. The hybrid cotton Bt NSPL-999 was sown on 26.05.2010 and 28.05.2011 and keeping 90 x 90 cm planting geometry. The fertilizers were applied @ 120 kg N, 60 kg P_2O_5 and 40 Kg K_2O / ha through Urea, SSP and MOP, respectively as per the treatments. In NK split dose plots, only P was applied as recommended dose, while N and K was applied at the same rates in splits as per treatments. The crop was grown as per recommended package of practices. The crop was harvested in three pickings ending by 25 and 28 February in 2011 and 2012, respectively. Samples were analyzed for N by colorimetric method (Snell and Snell, 1939), P content was determined by Vanadomolybdo phosphoric acid yellow method (Jackson, 1973) and K by flame chloral meter photometer. The Soil fertility balance was estimated by using fallowing formula:

Results and Discussion

Seed cotton yield (SCY) per kg fertilizer applied

The data on FUE with respect to SCY/kg N, P and K applied are highlighted in Table-2. In this case, the applied mode of fertilizer application (F_1 and F_2) indicates that there was no any significant impact due to these treatments with respect to quantitative fertilizer use efficiency. Nitrogen and K in splits might have supplied adequate quantity of nutrients to coincide with peak demand for nutrients to cotton. Besides, the external application of K might have increased the quantity of readily available K to cotton thus resulting in higher K uptake (Srinivasan, 2003). The range in seed cotton yield (SCY) was 13.57 to 14.86 kg/kg N applied, 25.35 to 27.86 kg/kg P applied and 36.10 to 39.74 kg/kg K applied under F_1 and F_2 having $N_{120}K_{40}$ as split performed little better than F_1 having only N_{120} as split. Thus the split application of K_{40} proved better than K_{40} applied as basal application. This is related to the increased availability of potassium to the growing plants. In fact, potassium is universally required by the all the living organism. Munson (1985) reported that in fields absence of potassium application often decreases efficiency of fertilizers. The deficiency of potassium directly or indirectly affects photosynthetic activity (Huber, 1985).\, disturbs carbohydrate metabolism (Beringer *et al.*, 1986) inhibits chlorophyll development, induces accumulation of certain elements and increases soluble nitrogenous compound contents (Kock and Mengel, 1977). Potassium is known to play a vital role in osmoregulation (Hsiao and Lauchli, 1986) and it is the most efficient cation for activation of several enzymes (Suelter, 1970). Quality of plant produces is also influenced by changes in potassium concentration as it is the quality nutrient. In the deficiency of potassium size, shape, colour, taste and shelflife of fruits are disturbed (Hughes and Evans, 1969). The varied changes in cotton metabolism due to potassium stress have been reported by Gopal *et al.* (2010).

TABLE 1. Yield, NUE (kg SCY/kg nutrient applied) and N, uptake of *Bt.* cotton hybrid NSPL-999 as influenced by N and K supply at different timings of split application **(2010-11 and 2011-12)**

Treatments (A) Mode of fertilizer application		Seed cotton yield (q/ha)			NUE (kg SCY/kg N nutrient applied)			N, uptake (kg/ha.)			Nitrogen use efficiency (%)		
		2010-11	2011-12	Mean	2010-11	2011-12	Mean	2010-11	2011-12	Mean	2010-11	2011-12	Mean
F_1	N_{120} (P_{60} K_{40}basal)	18.15	18.92	**18.53**	13.33	13.80	**13.57**	169.86	183.79	**176.82**	21.52	23.42	**22.48**
F_2	N_{120} K_{40} (P_{60}basal)	19.02	19.79	**19.40**	14.65	15.07	**14.86**	167.86	181.77	**174.82**	25.93	27.83	**26.89**
CD (P = 0.05)		**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**3.02**	**3.39**	**3.22**
(B) Timings of split applications													
S_1	2 Splits (10 & 45 DAS)	18.50	19.28	**18.88**	13.53	14.17	**13.85**	156.88	170.85	**163.83**	15.58	17.48	**16.54**
S_2	3 Splits (10, 45 & 75 DAS)	16.97	17.73	**17.35**	13.24	13.66	**13.45**	146.79	160.70	**153.74**	22.08	23.98	**23.04**
S_3	3 Splits (10, 30 & 45 DAS)	17.74	18.50	**18.12**	12.82	13.24	**13.03**	154.34	168.24	**161.29**	24.94	26.84	**25.90**
S_4	3 Splits (10, 30 & 60 DAS)	20.81	21.58	**21.19**	16.31	16.73	**16.52**	203.06	216.97	**210.02**	23.24	25.14	**24.20**
S_5	3 Splits (10, 45 & 60 DAS)	20.77	21.54	**21.15**	16.29	16.71	**16.50**	177.94	191.85	**185.06**	26.97	28.87	**27.93**
S_6	3 Splits (10, 30 & 75 DAS)	16.70	17.46	**17.08**	15.19	15.61	**15.40**	167.58	181.48	**174.53**	28.40	30.30	**29.36**
S_7	4 Splits (10, 30 45 & 60 DAS)	19.77	20.53	**20.15**	11.87	12.29	**12.08**	184.14	198.04	**191.09**	28.39	30.29	**29.35**
S_8	4 Splits (10, 30, 45 & 75 DAS)	17.43	18.19	**17.81**	12.66	13.08	**12.87**	160.18	174.08	**167.13**	20.24	22.14	**21.20**
CD (P = 0.05)		**3.90**	**3.91**	**3.89**	**3.03**	**3.06**	**3.04**	**12.25**	**12.17**	**12.22**	**6.21**	**6.48**	**6.44**

As regards with the timings of split application of N and K fertilizers, S_4 and S_5 having three splits of these nutrients (at 10, 30, 60 DAS or 10, 45, 60 DAS) performed the best, maximum FUE was 16.50 to 16.52 kg SCY/kg N applied, 31.10 to 31.19 kg SCY/kg P applied and 44.72 to 44.86 kg SCY/kg K applied. This was closely followed by S_6 having three splits of fertilization (10, 30, 75 DAS) where N, P and K efficiency was 15.40, 28.93 and 41.48 kg SCY, respectively. On the other hand, almost significantly lowest FUE of N, P and K was noticed in case of S_7 and S_8 treatments where N_{120} and K_{40} were applied in four splits (10,30, 45, 60 DAS or 10,30, 45, 75 DAS). It is apparent from these results that the full dose of N and K should be applied earlier in three splits within 60 days of plant growth. Because in case of four splits, the applied doses are curtailed for each split for actively growing plants as compared to the total three splits. Secondly in case of four splits, the fourth split approaches late after 75 days of sowing, by that time the N and K requirement of plants might have slightly reduced. Thus the fertilizer use efficiency in the fourth split is eventually reduced as compared to the complete dose finished upto three splits. Similar observations have also been reported by Bhatia and Singh (2015).

The fertilizer use efficiency with respect to either N, P, K in its percentage or in terms of its seed cotton yield, in both cases, were found to be non-significant due to mode and timings of split application of N and K fertilizers. Due to similar dose of NPK

TABLE 2. PUE (kg SCY/kg nutrient applied) and P, uptake of *Bt.* cotton hybrid NSPL-999 as influenced by N and K supply at different timings of split application (**2010-11 and 2011-12**)

Treatments (A) Mode of fertilizer application		**Seed cotton yield (q/ha)**			**PUE (kg SCY/kg P nutrient applied)**			**P, uptake (kg/ha.)**			**Phosphorus use efficiency (%)**		
		2010 -11	**2011 -12**	**Mean**	**2010 -11**	**2011 -12**	**Mean**	**2010 -11**	**2011 -12**	**Mean**	**2010 -11**	**2011 -12**	**Mean**
F_1	N_{120}(P_{60} K_{40} basal)	18.15	18.92	**18.53**	25.11	25.59	**25.35**	60.64	71.12	**65.84**	14.41	15.97	15.19
F_2	N_{120} K_{40}(P_{60} basal)	19.02	19.79	**19.40**	27.65	28.07	**27.86**	62.41	72.98	**67.70**	15.44	17.00	16.22
CD (P = 0.05)		**NS**	**NS**	**NS**	**NS**	NS	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
(B) Timings of split applications													
S_1	2 Splits (10 & 45 DAS)	18.50	19.28	**18.88**	25.50	26.14	**25.83**	54.09	64.66	**59.37**	11.55	13.11	12.33
S_2	3 Splits (10, 45 & 75 DAS)	16.97	17.73	**17.35**	24.83	25.25	**25.04**	56.98	67.55	**62.27**	14.70	16.26	15.48
S_3	3 Splits (10, 30 & 45 DAS)	17.74	18.50	**18.12**	24.36	24.78	**24.57**	62.71	73.12	**67.83**	18.65	20.21	19.43
S_4	3 Splits (10, 30 & 60 DAS)	20.81	21.58	**21.19**	30.98	31.40	**31.19**	70.61	81.02	**75.73**	14.28	15.84	15.06
S_5	3 Splits (10, 45 & 60 DAS)	20.77	21.54	**21.15**	30.89	31.31	**31.10**	73.32	83.87	**78.59**	14.36	15.92	15.14
S_6	3 Splits (10, 30 & 75 DAS)	16.70	17.46	**17.08**	28.72	29.14	**28.93**	54.98	65.55	**60.43**	16.34	17.90	17.12
S_7	4 Splits (10, 30 45 & 60 DAS)	19.77	20.53	**20.15**	22.08	22.50	**22.29**	66.38	76.95	**71.66**	12.13	13.69	12.91
S_8	4 Splits (10, 30, 45 & 75 DAS)	17.43	18.19	**17.81**	23.68	24.10	**23.89**	53.12	63.69	**58.41**	17.39	18.95	18.17
CD (P = 0.05)		**3.90**	**3.91**	**3.89**	**5.69**	**5.63**	**5.66**	**7.10**	**7.08**	**7.08**	**2.13**	**2.46**	**2.77**

fertilizers in all the treatment combinations, the reasoning for their interactions to come significant does not arise. Logically or fundamentally, the interaction between mode x timings of split application of fertilizers should not be upto the significant extent because both the such type of treatment are to play their role always on a positive direction.

Uptake of nutrients

The uptake of N, P and K nutrients was found to deviate significantly due to timings of fertilizer application, whereas only K uptake was significantly affected due to mode of fertilizer application Phosphorus and K uptake was highest when the fertilizer was applied in 4 equal doses at sowing, 30, 45 and 60 DAS (Bhatia and Singh, 2015). That means N and P uptake due to mode of application was statistically identical. The reason behind this may be ascribed with the fact that the mode of the fertilizer application in case of N_{120} and P_{60} was the same in F_1 and F_2 treatments, whereas the uptake of K was significantly higher in F_2 treatment (229.20 kg/ha) when K was splitted as against 211.5 kg/ha in F_1 where full dose of K was applied s basal. The splitting of K at different timings pr0ved more advantageous because of increased availability of K as per requirement of the speedily growing plants. Those results have also been supported by Bhatia and Singh (2015) The splitting of N and K fertilizers at different timings i.e. 2, 3 or 4 times during growth period influenced significantly upon the uptake N, P and K nutrients. The treatments S_4, S_5 and S_7 comprising 3 to 4 splits, where N and K fertilizer doses were finished within 60 days growth period of plants, proved to be the best wherein maximum N, P and K nutrients were taken up by the plants. This might be due to attributed to improved utilization of N in the presence of K. Similar positive effect of potassium application on N uptake was reported by Senthivel and Paloniappan (1985). Superiority of split application of N and NK might be attributed to availability of nutrients at growth stage when cotton crop starts growing faster. This may be due to prevention of loss through leaching.

In case of N, it ranged from 184.89 to 210.01 kg/ha, in case of P 71.66 to 78.58 kg/ha. On the other hand, the N, P and K uptake was comparatively lower when N and K fertilizers were splitted upto 75 days growth period as observed in treatments S_2, S_6 and S_8. This was the overall trend which indicates that the fertilizers should be splitted only upto 60 days of plant growth period. Beyond this period, the supply of nutrients decreased against the requirement or demand of the plants. Moreover out of the above mentioned various treatments, N-uptake was maximum (210.01 kg/ha) when N K fertilizers were applied at 10, 30 and 60 days stages (S_4). In case of P-uptake, it was maximum (78.58 kg/ha) when N K were applied at 10, 45 and 60 DAS (S_5), being very close to S_4. However, in case of K uptake, S_4, S_5, S_6 and S_7 performed equally better removing 232.75 to 243.59 kg./ha K from the soil in case of splitting almost upto 60 days of growth period. The interaction between mode and time of fertilizer application also proved significant with respect to each of the nutrient under study (Table-3). The combination of the best mode as well as time of fertilizer application further encouraged the nutrients uptake synergistically which was eventual and logically truth full. This might be attributed to improved utilization of N in the presence of K. Similar positive effect of potassium application on N uptake was reported by Senthivel and Paloniappan (1985).

Fertilizer use efficiency

The data presented in Table 1 reveal that nitrogen and potassium use efficiency was increased significantly (26.89 and 106.13%, respectively) when N_{120} K_{40} was applied as split and P_{60} as basal (F_2). This was against the treatment F_1 when only N_{120} was applied as split and P_{60} K_{40} as basal (22.48 and 49.50%, respectively). The significant impact of F_2 treatment might be owing to the fact that nitrogen and potassium both were applied as split doses, whereas in case of F1, only nitrogen was applied as split doses. In case of phosphorus, its full dose is applied as basal fundamentally. It is not applied as split doses as in case of nitrogen and potassium which remain mobile and available in the soil system. The phosphorus use efficiency did not deviate upto significantly extent because of the fact that P_{60} was applied as basal both in F_1 and F_2 treatments. It is a well known phenomenon that 2/3 of the applied phosphorus, is generally, fixed in the soil and only 1/3 is available to the crop plants. Therefore, this situation prevailed in both the treatments.

The timings of split application of N and K fertilizers exerted significant impact upon the N, P and K use efficiency in Bt cotton hybrid. The treatment S_6 and S_7 having three or four splits exhibited the highest N use efficiency (29.35 to 29.36%), whereas the significantly lowest was in case of S_1 having two splits (16.54%). However, the P use efficiency was found in the higher range (18.17 to 19.43%) in S_3 and S_8 treatments having three or four splits. The significantly lowest P use efficiency (12.33%) was recorded in case of S_1 having only two splits of fertilizer application. As in case of P use efficiency, the K use efficiency was also found highest (103.8%) from S_3 treatment having three splits. Thus, S_3 timings of split application proved the best for maximum P and K use efficiency. The equally higher K use efficiency (97.36 to 98.26%) was also obtained from S_5 and S_6 treatments having three splits. The significantly lowest K use efficiency was recorded from S_8 treatment having four splits (48.88%). The overall trend in K use efficiency indicate that splitting of N and K fertilizers upto 45 DAS brought about the maximum K use efficiency, whereas splitting of fertilizers beyond 45 DAS tended to reduce the same.

Water use efficiency

The water use was found maximum under F_2 and S_4 treatments as well as with their combination F_2S_4. The result trend was almost the same as observed in case of fertilizer use efficiency because water use efficiency is maximized with the maximization of fertilizer use efficiency. Hence FUE and WUE both are complimentary to each other. A similar trend as for yield was observed for water productivity. According to Devkota *et al.* (2013) the average water productivity of cotton was 0.88 kg m^{-3} in respective of the tillage method. (Present in table-3).

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TABLE 3. KUE (kg SCY/kg nutrient applied) and WUE (kg/cm3) of *Bt.* cotton hybrid NSPL-999 as influenced by N and K supply at different timings of split application (2010-11 and 2011-12)

Treatments (A) Mode of fertilizer application		Seed cotton yield (q/ha)			KUE (kg SCY/kg K nutrient applied)			K, uptake (kg/ha.)			Potassium use efficiency (%)			Water use efficiency (kg/cm3)		
		2010-11	2011-12	Mean	2010-11	2011-12	Mean	2010-11	2011-12	Mean	2010-11	2011-12	Mean	2010-11	2011-12	Mean
F_1	N_{120} ($P_{60}K_{40}$ basal)	18.15	18.92	**18.53**	35.48	36.72	**36.10**	206.26	216.88	**211.55**	48.65	50.35	49.50	18.06	19.30	**18.68**
F_2	N_{120} K_{40}(P_{60} basal)	19.02	19.79	**19.40**	39.12	40.36	**39.75**	223.91	234.48	**229.20**	105.28	106.98	106.13	18.68	19.92	**19.30**
CD (P = 0.05)		**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**13.89**	**13.23**	**13.28**	**20.45**	**21.23**	**21.19**	**NS**	**NS**	**NS**
(B) Timings of split applications																
S_1	2 Splits (10 & 45 DAS)	18.50	19.28	**18.88**	36.19	37.43	**36.81**	206.11	216.68	**211.39**	66.37	68.07	67.22	16.54	17.78	**17.16**
S_2	3 Splits (10, 45 & 75 DAS)	16.97	17.73	**17.35**	35.04	36.28	**35.66**	179.61	190.18	**184.90**	56.79	58.49	57.64	17.77	19.01	**18.39**
S_3	3 Splits (10, 30 & 45 DAS)	17.74	18.50	**18.12**	34.30	35.54	**34.92**	192.46	203.20	**197.74**	102.95	104.65	103.80	18.10	19.34	**18.72**
S_4	3 Splits (10, 30 & 60 DAS)	20.81	21.58	**21.19**	44.24	45.48	**44.86**	233.18	243.75	**238.47**	75.99	77.69	76.84	20.57	21.81	**21.19**
S_5	3 Splits (10, 45 & 60 DAS)	20.77	21.54	**21.15**	44.10	45.34	**44.72**	238.31	248.88	**243.60**	97.41	99.11	98.26	19.06	20.30	**19.68**
S_6	3 Splits (10, 30 & 75 DAS)	16.70	17.46	**17.08**	40.86	42.10	**41.48**	237.04	247.61	**242.32**	96.51	98.21	97.36	17.41	18.65	**18.03**
S_7	4 Splits (10, 30 45 & 60 DAS)	19.77	20.53	**20.15**	30.41	31.65	**31.03**	227.47	238.05	**232.76**	71.63	73.33	72.48	19.02	20.26	**19.64**
S_8	4 Splits (10, 30, 45 & 75 DAS)	17.43	18.19	**17.81**	33.28	34.52	**33.90**	206.53	217.10	**211.81**	48.03	49.73	48.88	18.47	19.71	**19.09**
CD (P = 0.05)		**3.90**	**3.91**	**3.89**	**8.79**	**8.78**	**8.79**	**39.39**	**40.46**	**38.57**	**42.76**	**43.17**	**43.23**	**3.03**	**3.06**	**2.62**

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Breeding and Identification of Superior Sunflower (*Helianthus Annuus* L.) Hybrids for West Bengal

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Abstract

An experiment was carried out during *rabi-summer* season of 2014-15 and 2015-16 under AICRP Sunflower, Nimpith Centre, South 24 Parganas, West Bengal, to identify the suitable sunflower hybrids growing in *rabi*/*rabi-summer* season for west Bengal. A total of 32 sunflower hybrids were evaluated. The experiment was laid out in Randomized Complete Block Design with three replications. The plot size was 4.5m x 3.0 m. The experiment was conducted by the AICRP-Sunflower, Nimpith centre at Research Farm, Baruipur under Calcutta University and Radhakantapur village (Nimpith Centre-adopted Village**)** as Multi location trial. In this study, highly significant genetic differences were observed among the sunflower hybrids in respect to the plant height at harvest, head diameter, seed weight per head, 100-seed weight, days to 50% flowering, days to maturity, husk content (%), volume weight (g/100cc), oil percentage and oil yield (kg/ha). The field observation reveals that the hybrids developed from Nimpith Center viz. CMS-607 A x R 273, CMS-607A x RHA-95C-1,CMS-607 A x R-83, & CMS-207 A x R-83 have significantly out yielded and the best check KBSH-44(668 kg oil /ha) in respect to oil yield (kg/ha)by recording oil yield of 836 kg/ha, 817 kg/ha, 810 kg/ha and 794 kg/ha respectively. The hybrids, RSFH-1887(796kg oil /ha) & SMLHT KH-12-04(796 kg oil/ha), SMLHT KH-12-03(784 kg oil/ha) and LSFH-171(719 kg oil/ha)recorded significantly high oil yield(kg/ha) than check hybrids KBSH-44 (668kg oil/ha) and DRSH-1 (696 kg oil /ha). Considering the other yield attributing parameters like plant height and days to maturity; the sunflower hybrids, CMS-207A X R-83, CMS-607 A X R 273,CMS-607A X R-83, SMLHT-KH-12-03, SMLHT-KH-12-04, were the superior sunflower hybrids developed or identified by the Nimpith centre on basis of their performance in multi location trials (MLT) and Station Hybrid Trial. The seed yield of the above said sunflower hybrids were recorded at par with the KBSH-44 but significantly higher oil yield (Kg/ha) coupled with 7-10 days earliness and 30-50 cm shorter plant height at harvest over the other hybrids and check hybrids.

Key words : *Sunflower Hybrid, Seed yield, Oil yield*

Introduction

India is facing a shortage of edible oil in recent years. Sunflower has maximum potential for bridging the gap in the demand and production of edible oil in the country. Its seeds contain high oil content ranging from 35 to 40% with some types yielding upto 50% (Skoric and Marinkovic, 1986). Sunflower (*Helianthus annuus L*) is the second important source of vegetable oil in the world due to its low to moderate production requirements, high oil quality, protein content, and utilization of all plant parts. Sunflower became an oil crop around the world during the end of the 19th century, when 'popular selection' was practiced in several parts of Russia to improve sunflower populations grown at that time. In India, sunflower is cultivated in an area of 0.7 million ha with a total productivity of 0.50 million tones (Padmaiah *et.al* 2015) and with an average productivity of 713kg/ha (Anonymous, 2016). In West Bengal it is grown in an area of 12,500 ha in last *rabi* season (2015-16).

Most of the sunflower seed is imported in the country that is actually not bred for our environment. That's why; it gives low yield due to the adaptation problem (Kokhar *et al.*, 2006). Oil content of sunflower kernel ranges from 48-53% whilst in seed from 28-35% (Reddy, 2006). For the enhancement of oil production we need to increase seed yield & oil percentage of sunflower. Genetic variability is very crucial item in the breeding programs (Sujatha *et al.*, 2002). Genetic similarities and differences existing in the genotypes are utilized efficiently as genetic resource in the breeding programs (Safavi *et al.*, 2011). Seed yield is a quantitative character which is influenced by different traits. Association is determined between the seed yield and its related traits for the improvement of yield in sunflower. Development of hybrids is the primary objective of most sunflower breeding programs in the world. National sunflower hybrid (development of new hybrid) breeding programme is a continuous programme which started in our country early 1980s. Sunflower hybrid breeding was started economically in discovering **CMS** by Leclercq in 1960 and **restorer genes** by Kinman in 1970 (Miller and Fick, 1997).

In India, the sunflower is mostly grown in the states of Karnataka, Maharastra, AP and Tamil Nadu with potential scope of growing in the non-traditional areas like West Bengal (Dutta, 2011). In West Bengal, Sunflower is second important oilseed crop after rapeseed-mustard during *rabi*-summer season and it was grown on about 21,000 ha in last *rabi* season (2014-15). Sunflower being a photoperiod natural crop has wide scope to replace the rapeseed-mustard cultivation with high yield potentiality. Present research programme was carried out during December 2012-13 to 2014-15 with a total of 32 sunflower hybrids including the two National check hybrids, KBSH-44 and DRSH-1. Though Oil yield is influenced by many plant traits like days to 50 % flowering, plant height, 100-seed weight, volume weight (seed weight in gram per 100 ml) and oil content(%) ; the present study was aimed to (i) Breeding and Evaluate the performance of the sunflower hybrids in respect to yield and yield component and (ii) To identify the superior sunflower hybrids suitable for *rabi-summer* season in West Bengal agro-climatic condition.

Materials and Methods

The experiment was carried out during *rabi* season, 2014-15 and 2015-16 at Research Farm under AICRP Sunflower, Nimpith Centre to identify the suitable sunflower hybrids for cultivation in *rabi-summer* season for West Bengal. A total of 32 sunflower hybrids (crossing) developed at AICRP-Sunflower, Nimpith centre and the sunflower hybrid entries were collected from AICRP-Sunflower, UAS, GKVK, Bangalore, AICRP-Sunflower, UAS Raichur, Latore, and Maharashtra for testingincluding the two National check hybrids, KBSH-44 and DRSH-1. The experiment was laid out in Randomized complete block design with three replications. The plot size was 4.5m x 3.0 m. In the 1st year (2014-15), a total of 32 sunflower hybrids were tested in RAKVK-AICRP (Sunflower) Research farm, Nimpith Centre, South 24 Parganas, West Bengal. In the next year, 2015-16 the same hybrids were tested including two national check, i.e. KBSH-44 and DRSH-1 in "On station" trial at Nimpith centre and another three locations viz..at Research Farm, Institute of Agriculture Sciences, Calcutta University, Baruipur and Radhakantapur (AICRP-adopted Village) and Kultali block as Multi location trial. The soil texture was clay loam in "On station" and "MLT" plots. Three irrigations were provided during the cropping period. One foliar spray was given with Boron (@ 2g/lit. of water in ray floret stage. The row per plot were five in number with a row spacing of 60 cm and plant to plant was 30 cm. Uniform dose of fertilizer @80 kg N,40 Kg P_2O_5 and 40 kg K_2O per ha was applied. The germinated seed of sunflower used as the planting materials and one plant per hill was maintained throughout the cropping period. The data was recorded in ten randomly selected plants from each plot of all replications on the following characters viz., days to 50% flowering, days to maturity, plant height at harvest (cm), head diameter per plant (cm), seed weight per head (g), 100-seed weight (g), husk content (%), volume weight (g/cc). The seed yield (kg/ha), oil percentage and oil yield (kg/ha) were estimated on plot basis. The mean values were subjected to statistical analysis.

TABLE 1. Performance of Sunflower Hybrids in "Station Hybrid Trial", AICRP-Sunflower-Nimpith centre during *rabi-summer*-2014-15

Sl. No.	Hybrid	Pl. Ht.(cm)	Head Dia. (cm)	Days to 50% Flowering	Days to Maturity	Seed yield/pl (g)	Vol. Wt (g/100 cc)	Grain Filling %	Seed yield (Kg/ha)	100 seed wt (g)	Hull cont. (%)	Oil %	Oil Yield (Kg/ha)
1.	SMLHT –KH-12-01	103.5	13.0	57.0	87.0	29.2	45.5	91.0	1619	6.4	35.8	38.5	623
2.	SMLHT –KH-12-02	136.8	12.1	60.5	90.5	25.4	43.1	96.5	1411	5.6	37.8	37.4	527
3.	SMLHT –KH-12-03	102.0	13.9	64.5	94.5	38.6	42.1	94.5	2142	4.6	34.4	39.4	843
4.	SMLHT –KH-12-04	95.6	14.6	63.0	93.0	37.8	41.0	96.5	2100	5.2	33.5	41.2	865
5.	SMLHT –KH-12-05	135.0	12.0	66.0	96.0	19.3	38.9	91.0	1069	3.9	34.7	40.5	432
6.	KBSH-1	134.4	13.9	67.0	97.0	31.7	45.0	95.0	**1761**	5.2	37.5	38.9	685
7.	KBSH-41	141.5	14.3	67.5	97.5	37.1	44.9	92.0	2061	5.1	33.7	40.8	840
8.	KBSH-42	123.7	12.6	68.5	97.5	32.4	42.7	92.5	1800	4.7	46.0	39.5	621
9.	KBSH-44	166.0	15.2	69.5	100.5	40.9	37.8	91.0	**2272**	5.6	37.1	31.2	708
10.	KBSH-55	156.7	13.8	70.0	100.5	38.3	43.9	90.0	2128	4.2	32.4	41.7	887
11.	KBSH-53	135.5	11.9	62.5	92.5	27.2	42.2	86.5	1508	5.6	30.8	42.6	642
12.	KBSH-58	91.4	9.4	59.5	90.0	21.1	38.1	93.0	1172	7.0	30.3	42.4	496
13.	KBSH-65	113.8	11.4	68.0	97.0	32.1	43.6	93.5	1783	4.0	36.7	39.2	698
14.	KBSH-68	109.3	14.6	66.0	96.0	40.6	43.8	92.0	2253	5.8	35.5	39.5	889
15.	KBSH-69	88.9	13.5	63.5	93.5	31.6	48.0	87.0	1756	5.2	36.9	38.6	677
16.	KBSH-70	79.9	10.1	57.5	87.5	26.1	40.5	94.5	1447	4.2	32.2	41.3	597
17.	RSFH-1	132.9	12.1	68.0	98.0	30.6	47.9	90.5	1697	4.5	34.7	42.5	721
18.	RSFH-130	125.8	12.7	65.0	94.5	34.0	43.1	92.5	1886	5.5	32.6	41.6	784
19.	RSFH-10-600	154.6	14.1	69.5	99.5	40.1	45.7	96.5	2228	4.8	39.8	37.1	826
20.	RSFH-1887	135.4	15.5	70.5	100.5	40.7	43.6	96.5	**2261**	5.6	34.5	40.5	915
21	LSFH-35	116.9	13.5	62.0	92.0	33.1	41.7	93.0	1836	5.6	33.3	41.5	761
22.	CMS-207A X R-103	157.5	14.6	71.0	102.0	34.6	35.2	87.5	1922	4.8	38.8	39.8	765
23.	CMS-207A X R-83	131.0	15.3	61.5	91.5	36.4	39.0	91.0	2022	4.5	35.0	39.1	790
24.	CMS207A X R-106	154.4	15.4	71.0	102.0	33.3	31.5	93.5	1850	4.4	40.0	38.5	712
25.	CMS-607 A X AK-345	154.2	16.5	72.5	103.0	36.2	36.4	85.5	2011	6.5	37.3	38.2	768
26.	CMS-607A X R-83	123.0	15.7	63.5	93.5	38.1	39.5	90.0	2117	5.6	33.6	41.3	874
27.	CMS207A XR-35	124.2	15.8	60.5	91.5	32.8	39.0	93.5	1822	1.6	38.2	39.6	721
28.	CMS-607A XR273	138.0	14.9	63.0	94.0	36.9	39.8	95.5	2050	3.9	36.6	40.4	828
29.	CMS-RR-1A X DOR-R-2	163.5	16.5	69.0	100.0	37.3	36.5	81.0	2072	6.4	40.1	37.5	777
30.	CMS607A X RHA-95C-1	152.9	16.1	69.0	100.0	39.4	42.0	90.0	2189	4.5	36.7	38.6	844
31.	DRSH-1	158.8	14.0	67.0	97.0	30.8	46.8	91.5	1708	5.5	34.1	40.8	696
32.	LSFH-171	110.6	15.0	64.5	94.5	38.3	43.5	93.5	2128	6.4	36.1	38.2	812
33.	KBSH-44	166.0	15.2	69.5	100.5	40.9	37.8	91.0	**2272**	5.6	37.1	31.2	708
SEm(±)		2.9	0.43	0.82	0.9	0.9	0.6	0.6	47	0.27	1.2	0.9	15.1
LSD(p=0.05)		8.6	1.29	2.5	2.9	2.8	1.8	1.7	142	0.82	3.8	2.7	46.2
CV (%)		10.7	9.6	7.8	9.4	10.3	8.3	8.1	10.35	11.4	10.5	9.4	11.5

Results and Discussion

Yield and yield component: The data for seed yield and other yield attributing traits for the test hybrids along with the checks are presented in Table-2. Highly significant differences were observed for seed yield and other yield attributing traits among the test hybrids. Statistical analysis of the data on seed yield (Kg/ha) in MLT and in "On Station" station hybrid trial (average data from MLT & SHT over locations in Table-3) reveals that the highest seed yield of (2232 kg/ha) was recorded in the experimental sunflower hybrid CMS-607 A x RHA-95C-1 which was closely followed by sunflower hybrid CMS-607 A x R-273 and hybrid CMS-607 A X AK-345 with seed yield 2196kg/ha and 2061Kg/ha respectively which was closely followed by other public (AICRP) sunflower hybrids LSFH-171 with seed yield 2158kg/ha and RSFH-1887 & KBSH-53 with seed yield of 2114 kg/ha & 2127 kg/ha respectively. The best national check hybrid, i.e. KBSH-44 was recorded at par seed yield (2221 kg/ha) and less yield was recorded 1758 kg/ha in DRSH-1. The other sunflower hybrids like SMLHT–KH-04 & SMLHT –KH-03 also recorded the higher seed yield in comparison to DRSH-1 (1758kg seed yield/ha) with seed yield 2033 kg /ha & 2016 kg /ha respectively. The other sunflower hybrids like SMLHT–KH-04 & SMLHT-KH-03 also recorded the higher seed yield in comparison to DRSH-1 with seed yield 2033 kg /ha & 2016 kg /ha respectively. The Maximum oil (%) was recorded in the experimental hybrids like CMS-607A x R-83 (40.1) and CMS-207 A x R-83 against the national check hybrid, DRSH-1 with 40% oil. In both the hybrids were high volume weight recorded (39-40g/100cc). The findings were supported by Vidhyavathi *et al*. (2005) and Manivannan *et al.* (2005).

The experimental data on oil yield (Kg/ha) in "On Station" trial and MLT (average data from MLT over locations in Table-2 and table-3) reveals that highest oil yield of 836 kg/ha was recorded in the sunflower hybrid CMS-607 A X R- 273. The data reveals that in response to oil yield (kg/ha), the newly developed sunflower hybrids were significantly high oil yielder over the national check hybrids, i.e. KBSH-44 and DRSH-1. The field observation indicates that, among the 32 sunflower hybrids, the sunflower hybrids developed by the AICRP-Sunflower, Nimpith Center viz. CMS-607 A x R 273, CMS-607A x RHA-95C-1,CMS-607 A x R-83, & CMS-207 A x R-83 significantly out yielded over the best national check sunflower hybrid i.e. KBSH-44(668 kg oil /ha) in respect to **oil yield** (kg/ha)by recording oil yield of 836 kg oil /ha, 817 kg oil /ha, 810 kg oil /ha and 794 kg oil/ha respectively. From the study it was also observed that, the other sunflower hybrids like, RSFH-1887(796kg oil /ha) & SMLHT KH-12-04(796 kg oil/ha), SMLHT KH-12-03(784 kg oil/ha) and LSFH-171(719 kg oil/ha) also recorded significantly high oil yield(kg/ha) than check hybrids, KBSH-44 (668kg oil/ha) and DRSH-1 (696 kg oil /ha).The similar type findings was reported by Chandra *et.al* in 2013.

The Nimpith centre developed sunflower hybrids, *viz*; CMS-207A x R-83, CMS-607A x R-83, CMS-607 A x R 273 as well as other public driven sunflower hybrids like SMLHT-KH-12-03, SMLHT-KH-12-04, LSFH-171 and RSFH-1887 were the superior sunflower hybrids identified by the Nimpith centre on basis of their performances in multi location trial (MLT) and station hybrid trial(SHT). From the study it was observed that, the sunflower hybrids, CMS-207A x R-83, CMS-607A x R-83, CMS-607A x R 273, SMLHT-KH-12-03, SMLHT-KH-12-04 were at par with the best check hybrid i.e. KBSH-44 and DRSH-1 in respect to seed yield (kg/ha) but significantly high oil yielder coupled with semi-tall in nature and matured 7-10 days earlier than the best national check hybrids i.e. KBSH-44 and DRSH-1. The semi tallness and earliness (coupled with good seed yield and high oil percentage) were the main two reasons for selection of these hybrids by the local sunflower frarmers of Nimpith and surrounding the Nimpith region where tested of these hybrids to their plots.

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TABLE 2. Performance of Sunflower Hybrids in "Multi location Trial" and AICRP-Sunflower, Nimpith centre during *rabi-summer*-2015-16

		Location: 1 (NIMPITH CENTRE)										Location: 2 (RADHAKANTAPUR) & BARUIPUR Research Farm									
Sl. No.	Hybrid	Pl. Ht. (cm)	Head Dia. (cm)	Days To Maturity	Seed yield/ pl(g)	Vol. Wt (g/ 100 cc)	Grain Filling %	Seed Yield (Kg/ha)	100 seedwt (g)	Hull cont.%	Oil %	Pl. Ht. (cm)	Head Dia. (cm)	Days To Maturity	Seed yield/ pl(g)	Vol. Wtg/ 100cc	Grain Filling %	Seed Yield (Kg/ha)	100 seed wt (g)	Hull cont. %	Oil %
1.	SMLHT –KH-12-01	104.7	12.1	86	29.6	44.3	96	1644	6.27	36.7	39.6	102.3	13.8	88	28.7	46.7	86	1594	6.49	34.9	37.4
2.	SMLHT –KH-12-02	128.5	12.2	90	24.6	42.5	98	1366	5.49	37.0	38.2	145.0	11.9	91	26.2	43.7	95	1455	5.61	38.6	36.6
3.	SMLHT-KH-12-03	92.7	12.8	93	38.2	40.5	95	2122	4.50	33.2	39.1	97.3	12.2	92	38.9	43.6	94	1910	4.77	35.6	38.7
4.	SMLHT-KH-12-04***	92.7	11.4	94	37.9	41.1	98	2105	4.78	32.0	39.2	98.5	10.9	92	38.5	40.9	95	1960	4.95	34.9	39.2
5.	SMLHT-12-05	132.6	11.7	95	17.9	38.4	91	994	3.80	33.6	38.2	137.4	12.3	97	20.6	39.3	91	1144	3.95	35.9	37.6
6.	KBSH-1	130.6	11.7	98	35.9	43.7	91	1820	4.68	36.1	39.7	134.4	12.3	97	31.7	45.0	95	1761	5.19	38.5	38.1
7.	KBSH-41	138.7	12.32	97	35.5	45.2	92	1732	4.88	32.8	38.2	144.3	14.6	98	36.7	44.5	92	1872	5.37	34.5	37.5
8.	KBSH-42	125.6	13.3	97	26.0	42.2	92	1474	4.62	39.6	30.2	121.8	13.8	98	23.8	43.2	93	1417	4.83	37.5	38.7
9.	KBSH-44	155.5	13.3	101	40.2	37.4	91	2230	5.46	30.2	30.2	150.4	14.6	100	41.6	38.2	91	2211	5.72	38.1	30.0
10.	KBSH-53	132.4	12.6	100	37.7	43.5	90	2094	4.30	31.5	36.5	141.0	12.6	101	38.9	44.3	90	2160	4.16	33.4	36.9
11.	KBSH-55	139.7	12.0	92	26.2	42.6	85	1455	5.48	29.6	34.6	131.3	11.8	93	28.1	41.8	88	1561	5.66	31.9	37.2
12.	KBSH-58	89.7	9.2	90	21.5	37.8	93	1194	7.18	30.9	30.9	93.1	9.6	90	20.7	38.3	93	1149	6.89	29.7	37.5
13.	KBSH-65	102.3	11.0	97	31.6	43.4	93	1755	4.09	35.6	35.6	125.3	11.8	97	32.6	43.8	94	1811	3.95	37.7	37.9
14.	KBSH-68	115.3	13.5	95	41.0	44.3	92	1860	5.75	34.8	34.8	103.2	13.7	97	40.1	43.2	92	1920	5.88	36.1	37.3
15.	KBSH-69	87.9	11.4	94	31.6	48.3	86	1755	5.15	36.9	37.5	89.8	11.6	93	31.6	47.6	88	1755	5.21	35.2	**38.7**
16.	KBSH-70	80.8	9.8	88	25.8	39.7	94	1433	4.18	31.8	38.1	78.9	10.4	87	26.3	41.2	95	1461	4.31	32.5	38.0
17.	RSFH-1	135.2	11.9	98	30.5	47.5	90	1694	4.51	33.5	38.6	130.6	12.3	98	30.6	48.2	91	1699	4.68	**35.9**	38.1
18.	RSFH-130	119.1	12.8	93	33.6	42.7	92	1866	5.58	33.4	38.5	132.5	12.6	96	34.3	43.5	93	1905	5.36	31.8	**38.5**
19.	RSFH-10-600	156.6	13.8	97	41.1	40.4	98	1980	4.78	38.1	37.5	152.6	14.4	98	39.1	40.9	95	1932	4.85	38.0	37.0
20.	RSFH-1887	132.2	13.2	100	41.1	40.8	95	2020	5.72	33.0	38.6	138.6	13.8	101	40.3	40.4	98	**2208**	5.49	37.0	37.0
21.	DRSH-1	156.6	13.8	96	30.1	40.3	91	1772	5.45	32.7	40.0	161.0	14.1	98	31.4	41.2	92	1744	5.52	35.6	39.6
22.	LSFH-35	111.9	10.8	92	32.5	37.8	93	1980	5.75	31.8	37.5	121.8	12.2	92	33.6	37.9	93	1866	5.41	34.8	34.8
23.	LSFH-171	113.3	12.5	94	37.3	36.2	93	2220	6.56	34.5	32.5	107.8	12.2	95	39.2	36.9	94	2180	6.29	37.7	32.7
24	CMS-207A X R-83	131.0	15.3	91	35.6	38.7	92	1977	4.72	36.5	40.0	136	15.3	92	37.2	39.2	90	2066	4.25	33.5	38.5
25	CMS-207A X R-103	155	14.8	102	35.7	34.6	87	1983	4.41	39.5	38.1	160	14.4	102	33.5	35.7	88	1861	5.22	38.1	38.1
26	CMS207A X R-106	158.6	15.6	102	32.8	31.7	91	1822	4.40	38.4	37.2	150.2	15.1	102	33.8	34.2	96	1877	4.41	41.6	37.6

27	CMS-607 A X AK-345	155.6	16.8	103	35.6	37.1	87	1977	6.58	39.1	36.8	152.7	16.2	103	36.8	35.6	84	2144	6.42	35.7	35.7
28	CMS-607A X R-83	141.0	15.5	93	40.3	39.2	92	2038	5.62	34.5	40.1	145.0	15.9	94	43.8	39.7	88	2080	5.51	37.7	38.7
29	CMS-RR -1A X DOR-R-2	161.2	16.9	100	38.9	36.2	82	1980	6.25	41.6	37.5	165.7	16.1	100	35.6	36.7	80	1977	6.57	38.7	36.1
30	CMS207A XR-35	125.6	15.8	92	33.6	39.1	93	1866	1.70	39.4	39.0	122.8	15.7	91	31.9	38.9	94	1772	1.58	37.0	37.4
31.	CMS-607A XR273	131.2	16.4	94	40.2	39.4	96	2140	4.10	37.8	38.2	136.8	16.2	94	41.4	40.1	95	2160	3.78	35.4	38.0
32.	CMS607A X RHA-95C-1	149.6	14.8	100	43.4	37.3	92	2232	3.95	38.2	36.1	156.2	14.4	100	45.2	41.7	88	2252	4.98	35.2	36.4
SEm(±)		2.7	0.44	0.91	1.03	0.63	0.57	51.3	0.28	1.2	1.1	3.1	0.41	1.0	1.1	0.56	0.51	44.2	0.26	1.1	0.8
LSD(P=0.05)		8.2	1.42	2.8	3.2	1.9	1.7	153	0.92	3.6	3.2	9.2	1.33	3.1	3.5	1.7	1.6	131	0.8	3.2	2.4
CV(%)		10.2	9.2	9.3	10.4	8.7	8.5	11.2	11.7	9.5	9.1	11.2	8.3	9.7	9.2	8.7	8.4	10.1	11.5	10.3	8.7

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TABLE 3. Performance of Sunflower Hybrid Entries in Station Hybrid Trial and Multi location Trial over in West Bengal in respect to Seed yield and Oil Yield (Kg/ha) in 2015-16

Sl. No.	Hybrid	Location -1: (Nimpith) the hybrids at CU Research Farm, Baruipur and Radhakantapur			Location -2 : Average performance of			Avg. of 2 locations	
		Seed Yield (Kg/ha)	Oil%	Oil Yield (kg/ha)	Seed Yield (Kg/ha)	Oil%	Oil Yield (kg/ha)	Seed Yield (kg/ha)	Oil Yield (kg/ha)
1.	**SMLHT –KH-12-01**	1644	39.6	651.0	1594	37.4	596.2	1619	623.6
2.	**SMLHT-KH-12-03**	2122	39.1	829.7	1910	38.7	739.2	**2016**	**784.5**
3.	**SMLHT-KH-12-04**	2105	39.2	825.2	1960	39.2	768.3	**2033**	**796.8**
4.	**KBSH-41**	1732	38.2	661.6	1872	37.5	702.0	1802	681.8
5.	**KBSH-44**(Ch-1)**	2230	30.2	673.5	2211	30.0	663.3	**2221**	**668.4**
6.	**KBSH-53****	2094	36.5	753.6	**2160**	36.9	797.0	2127	728.3
7.	**KBSH-55**	1455	34.6	430.7	1561	37.2	580.7	1508	505.7
8.	**KBSH-58**	1194	30.9	368.9	1149	37.5	430.9	1172	399.9
9.	**KBSH-65**	1755	35.6	624.8	1811	37.9	686.4	1783	655.6
10.	**KBSH-68**	1860	34.8	647.3	1920	37.3	716.2	1890	681.8
11.	**RSFH-10-600**	1980	37.5	742.5	1932	37.0	714.8	2056	728.4
12.	**RSFH-1887**	2020	38.6	779.7	**2208**	37.0	817.0	**2114**	**798.4**
13.	**DRSH-1(Ch-2)**	1772	40.0	708.8	1744	39.6	681.9	1758	695.6
14.	**LSFH-35**	1980	37.5	742.5	1866	34.8	649.4	1923	696.0
15.	**LSFH-171****	2220	32.5	725.9	2180	32.7	712.8	**2158**	**719.4**
16.	**CMS-207A X R-83**	1977	40.0	790.8	2066	38.5	795.1	2022	**793.5**
17.	**CMS-207A X R-103**	1983	38.1	755.5	1861	38.1	709.0	1922	732.3
18.	**CMS207A X R-106**	1822	37.2	677.8	1877	37.6	705.8	1850	692.8
19.	**CMS-607 A X AK-345**	1977	36.8	727.5	**2144**	35.7	765.4	2061	746.5
20.	**CMS-607A X R-83**	2038	40.1	815.4	2080	38.7	804.2	2059	**810.5**
21.	**CMS-RR-1A X DOR-R-2**	1980	37.5	742.5	1977	36.1	713.7	1979	728.1
22.	**CMS207A XR-35**	1866	39.0	727.7	1772	37.4	662.7	1819	695.2
23.	**CMS-607A XR-273**	2140	38.2	818.0	2160	38.0	820.8	**2196**	**836.7**
24.	**CMS607A X RHA-95C-1**	2232	36.1	814.8	**2252**	36.4	819.7	**2232**	**817.3**
LSD(P=0.05)		**153**	**3.2**	**47.2**	**131**	**2.4**	**42.6**	-	-
CV(%)		**11.2**	**9.1**	**9.4**	**10.1**	**8.7**	**9.8**	-	-

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Effect of Sulphur Sources and Levels on Growth and Yield of Onion (*Allium Cepa* L.)

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Abstract

Onion is one of the commercial vegetable crops of India. Sulphur has been recognised as an important nutrient for higher growth and yield of onion bulbs. Keeping this in view, field experiments were carried out for two consecutive rabi seasons of 2014-15 and 2015-16 at the experimental plots of Regional Research and Technology Transfer Station, OUAT, Keonjhar, to study the effect of sources and levels of sources of sulphur on growth and yield of onion. The treatment consists of two sources of sulphur and four levels of sulphur by adopting factorial RBD with three replications. The results on vegetative growth (plant height, number of leaves per plant), yield attributing parameters (bulb weight, bulb diameter), total bulb yield and benefit-cost ratio revealed significant variations among the levels of sulphur in onion. There were no significant variations were recorded between the sources of sulphur in onion except plant height. However, Gypsum was recorded higher plant height, number of leaves and average bulb weight and total bulb yield. Among the level of sulphur, irrespective of sources, sulphur @ 30 kg ha^{-1} recorded significantly higher plant height (47.51, 42.35 cm), number of leaves per plant (16.05,16.13), bulb diameter(5.9, 5.7cm), average bulb weight (59.22, 58.38 g), total bulb yield (168.00, 137.9 q ha^{-1}) and benefit-cost ratio (1.56,1.28) than other levels of sulphur both in 2014-15 and 2015-16 respectively.

Introduction

Onion (*Allium cepa* L.) the Queen of the kitchen is the most important and commercially valuable vegetable in India and is an integral component of Indian culinary. India ranks first in area, second in production after china and with an annual production of 16-17 million tonnes accounts of around 20% of global production. In India, onion is predominantly cultivated during rabi (Crop harvested in April-May) around 60% followed by 20% each during kharif (crop harvested during Oct-Nov) and late kharif (harvested in Jan-Feb). Season (National council of applied economic research, New Delhi. The higher productivity could be determined by selection of suitable varieties., balanced nutrition, optimum water management as well as need based plant protection measures.

Sulphur is recognized as the fourth major plant nutrient after N,P,K in vegetable crops. It is essential for a good vegetative growth and bulb development in onion and it has a strong influence on onion flavour and pungency through involvement in the volatile S-compounds (Anwar *et al.*, 2001 and Forney *et al.*, 2010).

Onion is an important sulphur loving crop and it is required for proper growth and yield of onion (Kumar and Singh, 1995). Sulphur has been found not only to increase the bulb yield but also improves its quality especially flavours and pungency (Jaggi and Dixit, 1999 and Lakkineni and Abrol, 1994). In the same respect, Bell (1981) reported that sulphur containing secondary compounds was importance for nutritive value and flavors as well as for resistance against pest and diseases.

In recent times, the deficiency of sulphur in increasing in Indian soils as a result of indiscriminate use of fertilizers (Tondon,1995). This deficiency is becoming acute over time due to extensive use of sulphur free fertilizer, intensive crop production and poor sulphur status in soil. Sulphur deficient plants also had poor utilization of macro and micro nutrients (Kumar and Singh,1994) and significantly lower total solids in onion bulbs at maturity (Kumar and Singh,1992). Severe sulphur deficiency during bulb development has detrimental effect on yield and quality of onion (Ajay and Singh, 1994).

Sulphur has a positive effect on onion and other crops (Bloem, *et al*., 2004). Application of sulphur to the soil has several effects such as reducing pH, improving soil water relation and increasing availability of nutrients (Marschner, 1995).

The highest plant height, number of green leaves, bulb diameter, weight of bulbs and yield were obtained by using sulphur (Dabhi *et al*, 2004; Jaggi,2005; Nasreen *et al*, 2007). The yield of onion bulbs was also increased by the increment of sulphur rate application (El-Shafie and El-Gamaily, 2002).

Keeping this in view, the present experiment was undertaken to investigate the effect of sources and level of sulphur on growth and yield on onion.

Materials and Methods

Two field experiments were carried out during two consecutive rabi seasons 2014-15 and 2015-16 at experimental plots of Regional Research and Technology Transfer Station (OUAT), Keonjhar, Odisha, India to study the effect of sources and level of sulphur on growth and yield on onion. The soil of experimental area was loamy sand having pH 6.3, available NPK 106:21:225 kg ha^{-1} with organic carbon 0.42%.

The present experiment constitutes 8 treatments comprising of combinations of four different levels of sulphurs (L_1: No sulphur, L_2: 15 kg S ha^{-1}, L_3: 30 kg S ha^{-1}, L_4: 4 5 kg S ha^{-1}) and two different sources of sulphurs(S1: Gypsum and S2: elemental sulphur). The seed of onion variety, N-53 was sown in the nursery bed on 12.11.2014 on first year and 1.11.2015 on second year. The experiment was laid out in Randomized Block design (factorial) with 3 replications.

Nursery bed of size 1.5 x 1.0 m size was prepared. The bed was made to a good tilth. Before sowing the nursery bed was drenched with carbendazim. After treatment with seed treating chemical the seeds were sown in lines at 10 cm apart and mulched with straw. Water was sprinkled on the straw periodically to keep the nursery bed in wet condition. The mulching materials were removed after the seeds started germinating. After about 8 weeks the seedlings were ready for transplanting in the main field. Selected good, healthy seedlings were transplanted in the main field with a spacing of 15 cm x 10 cm in the afternoon hours.

FYM @ 20 t/ha was applied at the time of final land preparation. N: P_2O_5: K_2O @ 150:50:80 kg ha^{-1} were applied in the field. Half of nitrogen, full dose of phosphorus and half of potash were applied as basal dose during final land preparation. The rest nitrogen and potash was applied at the time of hoeing and weeding. Yield parameters like marketable buld yield (q ha^{-1}) total bulb yield (q ha^{-1}) and total soluble solid (%) were calculated.

Results and Discussion

Growth parameters:

The result from tale-1 revealed that sulphur fertilization positively affected all the vegetative characters of onion plants. Increasing sulphur levels from 0 to 30 kg/ha significantly increased all growth parameters. The highest plant height (34.77 and 28.05 cm), number of green leaves per plant (11.52 and 11.62), bulb diameter (5.7 and 5.8 cm), bulb weight (59.22 and 58.38 g) at 100 days after transplanting date were recorded in the treatment applied with 30 kg/ha of sulphur which was significantly superior to rest other treatments. However, the lowest value was recorded in control.

The results on vegetative parameters as influenced by two sources of sulphur indicated non-significant variation. However, Gypsum recorded higher plant height (42.00 and 36.5 cm) during 2014-15 and 2015-16 respectively, which was significantly superior that application of elemental sulphur as a source. Similar results in onion were also reported by Yaduvanshi and Yadav in 2007, Dudhat *et al.* in 2011 and Tripathy *et al.* in 2013.

The data result from mean of two consecutive years (table-2) indicated that Gypsum (17%S) and Elemental Sulphur (90%S) were found to be statistically *at par* with respect to marketable bulb yield (132.41 to 141.32 q/ha) and income (B:C ratio of 1.25 and 1.30). However,the result indicated the better efficacy of gypsum as source of sulphur for yield and yield attributing parameters than elemental sulphur. This result confirmed the earlier results of Tripathy *et al.*, 2013. The results on yield parameters revealed significant variations among levels of sulphur in onion variety N-53. The bulb yield increased significantly with increase in the levels of sulphur upto 30 kg/ha (168.00 and 137.9 q/ha) but statistically *at par* with sulphur @ 45 kg/ha (163.32 and 131.7 q/ha) during the years 2014-15 and 2015-16 respectively. However, the lowest yield was recorded under the treatment where sulphur was not applied. Similar trend was also observed with respect to B:C ratio. Similar result was also reported by Kumar and Singh,1995 and Channagouda *et al.*, 2009.

TABLE 1. Growth and yield attributes of onion as influenced by sources and levels of Sulphur

Treatment	Plant height (cm)			Number of leaves			Weight of bulb (g)			Bulb Diameter (cm)		
	2014-15	2015-16	mean	2014-15	2015-16	mean	2014-15	2015-16	mean	2014-15	2015-16	mean
Sources of Sulphur												
S1	42.00	36.5	39.25	14.53	14.45	14.49	49.51	48.63	49.07	4.87	4.70	4.78
S2	41.99	34.68	38.33	14.23	14.28	14.34	48.23	48.88	48.56	4.93	4.64	4.79
CD (0.05)	NS	0.9	0.94	0.29	NS	NS	1.30	NS	NS	NS	NS	NS
Level of Sulphur												
L1	34.77	28.05	31.40	11.52	11.62	11.73	31.05	34.08	32.57	3.58	3.39	3.49
L2	40.68	32.47	36.57	14.38	14.30	14.34	49.07	46.73	47.9	4.63	4.42	4.53
L3	47.51	42.35	44.93	16.05	16.13	16.09	59.22	58.38	58.8	5.90	5.70	5.80
L4	45.03	39.47	42.25	15.58	15.42	15.50	56.15	55.83	55.99	5.51	5.15	5.33
CD (0.05)	1.92	1.26	1.34	0.30	0.5	0.31	1.84	1.68	1.18	0.23	0.23	0.19

TABLE 2. Total bulb yield and economics of onion as influenced by sources and levels of Sulphur

Treatment	Yield (q/ha)			Net Return (Rs./ha)			B:C ratio		
	2014-15	2015-16	mean	2014-15	2015-16	mean	2014-15	2015-16	mean
Sources of Sulphur									
S1	143.41	121.4	132.41	30047	12439	21243	1.35	1.14	1.25
S2	159.73	122.9	141.32	41363	11899	26631	1.48	1.14	1.30
CD(0.05)	NS	NS	NS	-	-	-	-	-	-
Level of Sulphur									
L1	111.51	87.9	99.705	5137	-13751	-4307	1.06	0.84	0.94
L2	163.00	131.1	147.05	45359	19839	32599	1.53	1.23	1.38
L3	168.00	137.9	152.95	48339	24259	36299	1.56	1.28	1.42
L4	163.32	131.7	147.51	43575	18279	30927	1.50	1.21	1.35
CD (0.05)	14.42	17.2	-	-	-	-	-	-	-

Conclusion

As a source of sulphur, gypsum and elemental sulphur are similar in producing marketable bulb yield and income in onion. As far as affordability of farmer is concerned gypsum is a cost-effective source. Onion responded up to 30 kg S/ha compared to 15 kg S/ha.

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Performance of Pigeonpea based Intercropping System on Rain-fed Upland of North Western Plateau Zone of Odisha

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Abstract

A field experiment was conducted during rainy (kharif) season of 2011 and 2012 on rainfed mixed red and yellow lateritic soils of Krishi Vigyan Kendra, Sundargarh, Odisha to study the performance of different pulses and oilseeds crops in intercropping system of pigeonpea (*cajanus cajan*) based intercropping systems. The experiments comprising number of pulses and oilseeds in paired row and normal row planting patterns and intercropping systems of pigeonpea. The salient points of the findings are stated here under. The results indicated that in most of the intercropping systems, higher pigeonpea equivalent yield was noted over pure culture of the systems. The Land Equivalent Ratio was higher than unity indicating advantage of the intercropping system. The association of two rows of groundnut in paired row planted pigeonpea was found more sustainable, as it gave maximum pigeonpea equivalent yield and resulted in more economically viable system which was further supported by different biological parameters.

Key words: *Pigeonpea, Cropping system, Pigeonpea equivalent yield, Net return, Benefit: cost ratio, Monetary advantages, Competition function*

Introduction

The North-western Plateau zone of Odisha is an important zone of the State in respect of area, population and agricultural production. This zone covers the district of Sundargarh, Deogarh, part of Sambalpur and Jharsuguda. The area covers about 0.48 million hectare of land area within geographical area of 9712 Square Km. The predominant Soil types in the plateau zone are principally mixed red and yellow soils occurs as a centenary associations in undulating and rolling terrains which differ in depth, texture and colour. The Soils are moderately shallow in the depth and coarse-textured. Multiple cropping in the form of intercropping is an approach which offers the opportunity to increase the productivity per unit area and per unit time by efficient utilization of natural resources (Ahmed and Rao, 1982) Intercropping has been recognised as a potentially beneficial system of crop production and evidence indicate that it can provide sustainable yield advantages over sole cropping (Tsubo *et al*. 2005). Intercropping not only provides certain insurance against biotic and environmental stress but also gives extra yield advantage by simple expedient of growing crops (Willey 1979). Paired row technique is a simple way of exploiting land resources to harness the maximum yield advantage in intercropping system (Singh and Singh, 2001). The intercropping in paired-row planting helps to maintain full population of main crop and harness the maximum yield advantage in intercropping system (Sarkar and Chakraborty, 1999). Component planted in between two pairs of rows of tall component may achieve advantage and increase cropping intensity.

Materials and Methods

A field experiment was conducted at the Instructional farm of Krishi Vigyan Kendra, Kirei, Sundargarh, OUAT Odisha, during the rainy (kharif) seasons of 2011-12 and 2012-13 in randomised block design with 3 replications. The soil of the experimental site was sandy clay loam in texture, with pH 5.6 and EC .039 dS/m. The soil was low in available N (221kg/

ha), low in available P (10.4 kg/ha) and medium in available K (139.3 kg/ha). There were 17 treatments, consisting of 7 sole cropping and 10 intercropping system. A total rainfall of 1941 and 1212 mm was received during the cropping period (June to December) during 2011and 2012 respectively, compared with the normal rainfall (average of 31 years) of 1678.3 mm.

The pigeonpea crop was harvested manually with the help of sickles on November 5, 2011 and November 7, 2012 during both growing seasons respectively. Greengram, blackgram, groundnut, cowpea and sesame were harvested on 28th August to 15th Sept 2011 first year and on 25 August 2012 and 12 August 2012 during second year, respectively. The crop were threshed manually plot wise. Pigeonpea crop was threshed plot wise with the help of the mini thresher and grain yield was recorded accordingly. A small sample of grain was drawn from each plot for estimating test weight. Observations on growth, yield attributes and yield of main and intercrop, were taken separate as per specified time. The observations for growth, yield attributes and yield were also taken on ten randomly selected plants per plot. Cost of cultivation and gross returns (Rs./ ha) for different treatments were calculated on the basis of prevailing market rates of the inputs and outputs. Net returns (Rs/ ha) were worked out by subtracting the total cost of cultivation of each treatment from gross income of respective treatment. Benefit: cost ratio was also worked out to ascertain the economic viability of different treatments.

Results and Discussion

The data in respect of growth, yield attributes, yield and computation functions and economics of the experiment indicate many points of scientific interest as evident from statistical analysis of data.

Effect of Intercropping on height and dry matter production of main crop:

The height of Pigeonpea in intercropping system as reduced considerably in intercropping system over sole cropping. Sole crop of pigeonpea in paired row planting has resulted in taller plant over uniform row and intercropping system. In intercropping system of pigeonpea paired row planting of two rows of greengram have given maximum plant height. Pigeonpea in paired row planting with two rows of sesame have given shortest plant. Similarly sole pigeonpea in paired row plant has resulted in higher dry matter production over uniform row planting of pigeonpea as well as intercropping stands. Intercropping of pigeonpea in paired row planting with two rows of greengram has exhibited maximum dry matter among the intercropping systems.

Effect of Intercropping System on Yield attributes of Pigeonpea:

Intercropping system of pigeonpea has resulted in higher numbers of pods over sole crop of pigeonpea; however sole pigeonpea in paired row planting has produced higher numbers of pods per plant over sole pigeonpea in uniform row. Paired row planted pigeonpea with two rows of greengram has given higher numbers of pods per plants. Uniform planted of pigeonpea with one row of sesame has produced lesser number of pods per plant. Pure culture of pigeonpea irrespective of uniform or paired row planting has given maximum number of grains per pod over intercropping stands. Intercropping of pigeonpea either in uniform row or paired row planting with greengram and blackgram has given higher number of grains per pod. Intercrop pigeonpea with one or two rows of sesame has produced less number of grains per pod.

The test weight of grains has increased considerably in some intercropping system over pure culture of pigeonpea. Paired row planted pigeonpea with greengram or blackgram has given maximum test weight. Paired row planted pigeonpea in sole cropping has given higher test weight over pure culture of pigeonpea in uniform row.

Effect on Yield of Pigeonpea in intercropping system:

In intercropping system yields of main crop and intercrops have reduced considerably over their pure stand. Pure culture of pigeonpea has given higher yield over its mixed stands, however there is no difference in yields obtained in uniform row or paired row of pigeonpea in pure culture. In intercropping system of pigeonpea in paired row with either greengram or groundnut has given higher yield in mixed

TABLE 1. Growth and yield attributes of pigeonpea influenced by intercropping systems

Treatments	Plant height (cm)			Dry matter/plant (g)			No of pods/plant			No of grains/pod			Test weight (1000 grains wt) in g)		
	2011	*2012*	*Pooled*	*2011*	*2012*	*Pooled*	*2011*	*2012*	*Pooled*	*2011*	*2012*	*Pooled*	*2011*	*2012*	*Pooled*
Sole PP UR	171.3	172.58	171.94	352.0	351.5	351.8	135.4	139.4	137.4	4.4	4.6	4.5	73.2	75.2	74.2
Sole PP PR	175.1	175.64	175.37	355.8	356.6	356.2	143.5	140.7	142.1	4.3	5.3	4.8	75.3	76.1	75.7
PP(UR)+IR GG	164.6	166.44	165.52	345.9	346.3	346.1	138.6	142.2	140.4	3.2	4.4	3.8	72.8	74.2	73.5
PP (UR)+1R BG	163.1	164.88	163.99	344.6	343.1	343.8	137.4	147.08	142.24	3.2	4	3.6	73.6	75	74.3
PP (UR)+1R GN	162.9	164.1	163.5	341.8	343.1	342.5	146.8	144.0	145.4	4.4	3.4	3.9	73.7	74.3	74
PP (UR)+1R cowpea	159.5	162.24	160.87	342.8	344.4	343.6	137.6	141.04	139.32	3.2	4.0	3.6	72.7	72.9	72.8
PP (UR)+1R sesame	158.7	161.8	160.25	338.3	338.8	338.6	134.6	140.4	137.5	3.4	3.6	3.5	72.4	71.6	72
PP (PR)+2R GG	164.6	166.5	165.55	344.5	343.2	343.8	144.8	147.2	146.0	3.5	4.42	3.96	74.7	76.5	75.6
PP (PR)+2R BG	161.0	161.74	161.37	341.3	341.3	341.3	143.6	142.4	143.0	4.3	3.5	3.9	75.8	75.8	75.8
PP (PR)+2R GN	158.4	159.3	158.85	338.8	341.5	340.2	142.6	152.0	147.3	4.24	3.76	4.0	75.4	77.8	76.6
PP (PR)+2R cowpe	158.8	160.34	159.57	338.8	341.8	340.3	143.6	142.8	143.2	3.9	3.5	3.7	74.1	74.5	74.3
PP (PR)+2R sesame	156.9	158.8	157.85	335	333.4	334.2	137.5	145.3	141.4	3.86	3.14	3.5	71.6	73.6	72.6
SEM (±)	0.68	0.87	0.78	2.09	2.59	2.34	0.63	0.50	0.57	0.84	0.47	0.65	1.03	1.05	1.04
CD at 0.05%	1.47	1.88	1.67	4.48	5.55	5.01	1.36	1.08	1.22	NS	NS	NS	NS	NS	NS

Table 2. Effect on main crop and intercrop yield, pigeonpea equivalent yield, Biological yield and Harvest Index in intercropping system

Treatments	Main crop yield(t/ha)			Intercrop yield(t/ha)			PYE yield(t/ha)			Biological yield(t/ha)			Harvest index (%)		
	2011	*2012*	*Pooled*	*2011*	*2012*	*Pooled*	*2011*	*2012*	*Pooled*	*2011*	*2012*	*Pooled*	*2011*	*2012*	*Pooled*
Sole PP UR	1.35	1.21	1.28				1.35	1.21	1.28	6.74	6.41	6.57	19.97	18.87	19.42
Sole PP PR	1.28	1.26	1.27				1.28	1.26	1.27	6.33	6.35	6.34	20.19	19.83	20.01
PP(UR)+IR GG	0.96	1.1	1.03	0.33	0.31	0.32	1.32	1.44	5.17	5.17	5.53	5.35	18.47	19.93	19.2
PP (UR)+1R BG	0.96	1.08	1.02	0.31	0.33	0.32	1.28	1.42	5.03	5.03	5.78	5.41	19.09	18.69	18.89
PP (UR)+1R GN	0.96	1.12	1.04	0.5	0.48	0.49	1.38	1.53	4.72	4.72	5.79	5.26	20.43	19.33	19.88
PP (UR)+1R cowpea	0.96	1.08	1.02	0.41	0.37	0.39	1.45	1.52	5.32	5.32	5.85	5.59	18.03	18.43	18.23
PP (UR)+1R sesame	1.03	0.95	0.99	0.35	0.33	0.34	1.40	1.30	5.68	5.68	5.57	5.63	18.1	17.02	17.56
PP (PR)+2R GG	0.96	1.16	1.06	0.37	0.39	0.38	1.36	1.59	4.66	4.66	6.19	5.43	20.89	18.83	19.86
PP (PR)+2R BG	1.0	1.04	1.02	0.39	0.29	0.34	1.40	1.34	5.49	5.49	5.30	5.40	18.18	19.66	18.92
PP (PR)+2R GN	1.11	1.03	1.07	0.55	0.53	0.54	1.57	1.48	5.57	5.57	5.05	5.31	20.01	20.43	20.22
PP (PR)+2R cowpea	0.98	1.04	1.01	0.41	0.43	0.42	1.47	1.55	5.29	5.29	6.18	5.73	18.43	16.93	17.68
PP (PR)+2R sesame	1.04	0.94	0.99	0.38	0.42	0.4	1.44	1.39	6.12	6.12	5.05	5.59	16.91	18.73	17.82
SEM (±)	0.12	0.11	0.11	0.03	0.05	0.04	0.20	0.10	0.58	0.58	0.50	0.54	0.80	0.84	0.82
CD at (0.05%)	0.25	0.24	0.25	0.07	0.12	0.09	0.43	0.22	1.23	1.23	1.08	1.16	1.71	1.81	1.76

Table 3. Net return, B:C ratio and Total nutrient uptake(pooled) influenced by intercropping systems

Treatments	Net return (Rs/ha)			B:C ratio			N Uptake			P Uptake			K Uptake		
	2011	*2012*	*Pooled*	*2011*	*2012*	*Pooled*	*2011*	*2012*	*Pooled*	*2011*	*2012*	*Pooled*	*2011*	*2012*	*Pooled*
Sole PP UR	24700	20220	22460	2.34	2.09	2.21	54.2	53.9	54.06	18.2	19.8	19	68.5	71.8	70.15
Sole PP PR	22460	21820	22140	2.21	2.18	2.20	50.8	49.2	50.01	14.3	15.8	15.1	64.2	66	65.1
PP(UR)+IR GG	23470	27250	25360	2.25	2.45	2.35	67.5	67.9	67.7	24	24.3	24.1	80	83.7	81.85
PP (UR)+1R BG	22150	26650	24400	2.18	2.42	2.30	70.3	71.5	70.9	23.4	25.4	24.45	75.4	78.7	77.05
PP (UR)+1R GN	25120	29700	27410	2.32	2.55	2.44	71.7	72.2	72	23.7	25.2	24.45	76.5	79.3	77.9
PP (UR)+1R cowpea	27400	29720	28560	2.45	2.57	2.51	73	72	72.5	23.7	25.1	24.4	77.6	80.5	79.05
PP (UR)+1R sesame	26160	22920	24540	2.40	2.23	2.31	72.9	73.2	73.1	24	24.8	24.45	76	78.7	77.35
PP (PR)+2R GG	24870	31970	28420	2.32	2.70	2.51	69.6	71.5	70.55	24.1	23.4	23.75	76	78.4	77.2
PP (PR)+2R BG	26070	24050	25060	2.39	2.28	2.33	69.2	72	70.6	23.1	24.2	23.7	75.5	80.3	77.9
PP (PR)+2R GN	31270	28170	29720	2.64	2.47	2.56	69	72.4	70.75	22	23.8	22.9	77.4	76.6	77
PP (PR)+2R cowpe	27940	30620	29280	2.47	2.61	2.54	72.2	74.7	73.4	23	23.1	23.1	79.4	79.8	79.6
PP (PR)+2R sesame	27400	25560	26480	2.46	2.36	2.41	70.8	70	70.4	21.8	23	22.4	79.3	77.3	78.3
SEM (±)	825	260	550	0.06	0.03	0.05	1.09	2.58	1.83	0.69	0.72	0.70	1.26	0.83	1.04
CD at 0.05%	2890	1240	2130	0.19	0.11	0.18	2.34	5.53	3.93	1.48	1.54	1.51	2.71	1.77	2.24

culture. Intercrop stand of groundnut has recorded higher yield over other intercrops stand. Pigeonpea Equivalent Yield (PEY) as recorded under intercropping system indicate that in most of the intercropping system Pigeonpea Equivalent Yield (PEY) has excelled over their pure culture among tje intercropping system , Paired row planted pigeonpea with two rows of groundnut has recorded maximum Pigeonpea Equivalent Yield (PEY). Uniform row planted pigeonpea with one rows of blackgram has given the least equivalent yield.

Competition Function

The Land equivalent ratio (LER) in all intercropping system exceeds unity. Paired row planted pigeonpea with 2 rows of greengram has given maximum LER indicating yield advantage in intercropping systems. The relative crowding coefficient (RCC) product of intercropping systems indicate competitive relationship between paired row of pigeonpea and 2 rows of greengram indicating advantages.

Economics

The value of combined intercrop yield indicates higher returns over pure culture of pigeonpea both in uniform row or paired row and also with intercrop yield in pure stands. Paired row planted pigeonpea with 2 rows of groundnut has given higher monetary values of intercropping systems. The monetary advantages indicated advantages in paired row planted pigeonpea with 2 rows of groundnut. The net returned accrued from paired row planted pigeonpea with 2 rows of groundnut has given maximum net returned with higher benefit cost ratio.

Uptake Pattern

Uptake of Nitrogen in intercropping system is always higher than inter crop stands. Paired row planted pigeonpea with one row of cowpea recorded maximum uptake of Nitrogen. In uniform of pigeonpea there is higher uptake of Phosphorus and Potassium over inter crop stands, however among the crop components sole crop of pigeonpea has recorded higher uptake of Phosphorus and Potassium over other sole crops. Uniform row planted pigeonpea has recorded higher uptake of Phosphorus in intercropping system with blackgram. Paired row planted of pigeonpea with two rows of cowpea has recorded higher uptake of Phosphorus but in case of uniform row of pigeonpea higher uptake of Potassium has been observed with intercropping system with one row of greengram. In intercropping systems intercrop of 2 rows of sesame recorded minimum uptake of Potash.

Nutrient Status of soil

There is no so pronounced effect of organic carbon status in soil however organic carbon contents is higher with uniform row planted of pigeonpea with one row of greengram or cowpea. Nitrogen, phosphorus and potassium status of the soil have been influenced greatly by intercropping system. In most of the cases nutrient status of the soil is always higher in intercropping system. Nitrogen and phosphorus status of the soil is always higher with intercropping system in paired row planted of pigeonpea with two rows of blackgram. It is evidently higher the content of nitrogen in intercropping system of paired row planted of pigeonpea with 2 rows of cowpea, however the content of phosphorus is higher with paired row planted pigeonpea with two rows of greengram. Paired rows of pigeonpea with two rows of groundnut have recorded higher nutrient status of potassium in soil.

Based on two years study, it is concluded that adjusting two rows of groundnut between the paired row planting of pigeonpea (30/70 cm) in 2:2 ratio is more sustainable, as it gives maximum pigeonpea equivalent yield and results in a more economically viable system.

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Study of Variation in the Nature of Polyembryony and Identification of Uniform Plant Type of Mandarin Using RAPD Marker

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Abstract

In the present study, Random amplified polymorphic DNA (RAPD) markers were used to study the difference between the zygotic and nucellar embryos of highly polyembryonic *Citrus reticulata* plant type collected from North Eastern Himalayan (NEH) region. Nineteen decamer oligonucleotide primers were used to amplify genomic DNA extracted from leaf samples. A total of 62 strong, unambiguous amplicons were generated out of which 47 were polymorphic. Hierarchical Cluster analysis based on Squared Euclidean distance using nearest neighbor method of binary data with SPSS software, ver. 16.0 differentiated all the seedlings into two different groups. The seedlings with 100% similarity were regarded as nucellar or true to the mother type. Other seedlings with slightest difference were regarded as zygotic. Four arbitrary primers OPA18, OPH11, OPB10, and OPAA10 were able to discriminate the zygotic and nucellar seedlings. In an open pollinated population with very less morphological distinction, RAPD analysis can rapidly identify the zygotic embryos helps to obtain genetically uniform plant types. This method saves resources and helps in execution of proper management practice to a small uniform population to fix beneficial heterosis for the poor farmers of North Eastern Himalayan region.

Introduction

Polyembryony is a genetically determined trait found in some of the angiosperm families of plants. It is a quantifiable trait and its extent varies from plant to plant. This natural phenomenon of developing more than one embryo in a seed during its development is common in citrus. A citrus seed thus may develop into more than one seedling with different combinations of zygotic and nucellar ones (Mondal, 2006). In a cross-pollinated plant like citrus the zygotic population carries the genetic load and creates heterogeneous segregated populations but the nucellar one reflects the genetic architecture of the mother plant. This differential phenomenon leads to the exploitation of polyembryony in propagation of Citrus. This phenomenon has serious importance in crop improvement as it can be utilized to fix heterosis of a hybrid by the production of true-to-the parental type progeny in the easiest way (Das *et al.,* 2004).Nucellar embryos as originated from vegetative tissues of embryo sac, nucellar seedlings are genotypically same as the mother plants. Hence, nucellar seedlings are the best option for having disease free propagules with desirable quality and high yielding ability. The North Eastern India is recognized as the natural home and origin of different cultivated species of citrus, their progenitors and primitive germplasms. For rejuvenation of the citrus orchards, supply of suitable planting material is essential. Citrus plants go through a long juvenile stage and require 6-7 years for fruiting. The assessment of fruit quality and performance requires time. The poor farmers usually compelled to wait for long period to understand the performance of the plants. They usually keep the uniform population generated from a single selected clone and after some years rogue excess plants. Till the screening of actual clone they unnecessarily spent huge resources on rearing of excess seedlings. To reduce their financial investment an early screening of the seedlings is necessary.

Citrus polyembryony can be used to propagate plants through nucellar embryos. *Citrus reticulata* shows high degree of polyembryony. Nucellar apomixis forms multiple nucellar embryos along with a fully developed zygotic embryo. The percentage of nucellar embryos varies from species to species. The nucellar embryos were somatic in origin and forms true to the type progeny. Nucellar embryos could be utilized for preservation of the desirable heterozygous state of mother plant i.e. fixing heterosis. Citrus germplasms can be introduced as budwood or seed. Budwood ensures trueness to type but increases the risk of exotic diseases and pathogen infestation. The risk of introducing diseases is less with seeds, because no citrus disease has been definitely proven to be seed transmissible (Timmer *et al.*, 2000). Citrus shows long juvenility and exploitation of morphological marker for hybrid identification is difficult. Enzymatic darkening, gas chromatography, isozyme analysis had been used to study the difference of zygotic and nucellar ones. The product of gene expression may reflect some environmental influence and produce erratic results.

Among the recently used molecular markers Random Amplified Polymorphic DNA marker is simple, cost effective and reliable. RAPD marker is used for a long time by researchers all over the world for its simplicity. RAPDs have been extensively used in assessing relationship amongst various citrus accessions (Das *et al.*, 2003), genotype identification (Deng *et al.*, 2005), estimation of relationship (Machado *et al.*, 1996). Moreover, in citrus several traits of horticultural importance, including resistance to *Citrus tristeza* virus, nematode resistance (Ling *et al.*, 2000) and dwarfing (Cheng and Roose, 1995) have been tagged with RAPD markers.

Materials and Methods

i. **Collection of fruit sample from selected plant:** Mature fruits were collected and brought to the laboratory from a single plant from Lower Mirik region of Darjeeling district of West Bengal.

ii. **Analysis of seed character and polyembryony**: Surface sterilization of seed and excision of different embryos from the seeds: record of polyembryony.

iii. **Generation of zygotic and nucellar progenies by seed germination:** the germinating seeds of one fruit was allowed to grow in aseptic conditions on a cotton bed for another 10 to 12 days, and then put into a sterile soil-sand-organic matter mixture (2:1:1) under controlled conditions with high humidity for further growth of the seedlings, and were marked separately according to their origin.

iv. **DNA Extraction from leaf sample of 15 seedlings:** CTAB Plant DNA Extraction Protocol by modified Doyle and Doyle (1990)

v. **Use of 19 RAPD marker for Analysis(Table 1)**

vi. **Scoring of fingerprinting pattern into 1, 0 matrix**

vii. **Identification of efficient decamer following PIC and MI value:** The efficiency of primers were assessed on the basis of three criteria, viz., i) Percentage of polymorphic bands, ii) Polymorphic Information Content (PIC) values, ranging between 0.0 to 0.5. [PIC= $1/n \Sigma 2F(1-F)$, where, F = proportion of bands per assay unit and n= number of loci detected] and iii) Marker Index [MI = Polymorphic Information Content (PIC) x Proportion of polymorphic bands x Average number of loci per assay unit]

viii. **Formation of Dendrogram to differenttiate the nuceller and Zygotic plant:** Squared Euclidean Distance was calculated using a binary matrix of RAPD data and Dendogram was constructed using Nearest Neighbour Method with SPSS software, ver. 16.0.

Results and Discussion

Variation in the nature of polyembryony of mandarin orange plants of the NEH region

The nature and characteristics of polyembryony of the selected mandarin orange plant was studied to understand the possible contribution of embryo source on phenotypic variation among the commonly seed propagated plant populations of mandarin orange in the region. Embryos were excised from the germinating seeds of these plants following the standardized procedure (Das *et al*., 2000; Mondal, 2006). Occurrence of more than one embryo within a matured seed was a common phenomenon in all the 100 selected seeds. Three to five days after incubation in the moist chamber when the seeds became turgid and swollen, the embryos were distinctly visible on removal of the integument (Fig. 1). The zygotic embryo was present at the micropylar region holding the two original cotyledons of the seed. This embryo was usually bigger in size than the other embryos and also took the largest space in a seed (Fig. 1). In most of the cases, rudimentary hypocotyls of the zygotic the two cotyledons rudimentary radicals and plumules were present. The cotyledon part covered largest area of an embryo (Fig. 1).

Addition to the presence of the single normal zygotic embryo, in a few seeds twin zygotic embryos was also observed. In further course of development these embryos formed twin zygotic seedlings. These embryos were apparently developed by fission of the original zygotic embryo. The original two cotyledons of a zygotic embryo of the seed was also divided and shared among the twins or triplets during germination (Fig.2). Occurrence of nucellar twin embryos was observed in the studied seeds. Abnormal features like Siamese twin

Fig. 1. Showing presence of zygotic and nucellar embryos in seeds of *Citrus reticulata*collected from Lower Mirik, Darjeeling.

embryos became visible after removal of inner seed coat. Embryos originating from the nucellar tissues were tiny, green, and heart-shaped and were crowded at the micropylar region or sometimes over the cotyledons of the zygotic embryos. Most of these could be easily separated when the integument was rolled away from the nucellus during the dissection of the seed. Individual nucellar embryos had two cotyledons, and in between or identical twin were absent in the studied seeds although it was reported in one plant of Mirik by Mondal (2006). Figure 2 reveals the presence of up to twelve embryos per seed. In some seed only one embryo is detected. Morphological identification of the zygotic and nucellar seedlings originating from the dissected embryos showed a range of 13.88-22.22 % and 75-86.12% respectively per fruit.

Fig. 2. Percentage distribution of nucellar, Zygotic and Zygotic Twin embryo of ten collected fruits of Lower Mirik, Darjeeling.

From the present investigation it could be interpreted that in the mandarin orange population of the North Eastern Himalayan Region of India in addition to the nucellar embryony the presence of zygotic twins were also common. Mondal (2006) and Das *et al.* (2004) reported that the percentage of these twins may rise up to 30% of the total seedlings and 52.38% of the total zygotic seedlings of a plant. The developmental process of the twin embryos may create some special features within the seedlings like the 'Siamese twin' or anastomotic development; such observation was not found in our study. Germination of seeds in soil : sand : organic matter mixture (2:1:1) showed a significant decrease in number of germinating embryos. The ratio of zygotic and nucellar embryo shows a ratio of 1 : 1.5. The ratio of zygotic and nucellar embryo varies widely in Citrus (Das *et al.*, 2007). The initial excision of embryo in a controlled condition and ultimate emergence of seedlings in soil bed varies greatly. Plants obtained through in vitrocultures of previously separated embryos probably increase survival and development of more embryos. This does not normally happen when the seed is placed to germinate directly in a substrate, which decreases the embryo frequency (Bastianel *et al.*, 1998).

Selection of DNA primers and standardization of RAPD protocol by PCR DNA isolated from mandarin orange leaves were used for primer screening. After preliminary screening 19 primers yielding strong, intense, unambiguous and reproducible DNA fragments were selected. The selected primers were used for RAPD analysis of 15 seedlings extracted from a single fruit of selected plant of Lower Mirik of Darjeeling. The efficiency of primers was assessed on the basis of three criteria, viz., Percentage of polymorphic bands, Polymorphic Information Content (PIC) values and Marker Index. The list of the selected primers, their sequences, maximum number of fragments obtained and range of the size of the fragments were as shown in Table 2. The amplified fragments varied from 1 to 9 (Table 2). The size of the fragments ranged from 100 bp to 750 bp and a total of 62 amplicons were generated. The citrus genome was about 563 mbp. OPAA10, OPZ10, P140, OPA04 were able to generate more bands with high level of polymorphism. As an attempt was taken to differentiate zygotic and nucellar

Fig. 3. Dendogram based on RAPD profile of fifteen seedlings of *Citrus reticulata* grown from the single plant collected from Lower Mirik, Darjeeling. S1 to S15 represent 15 seedlings.

embryos by appropriate primers, more emphasis was given to known primers which were able to generate polymorphism. The PIC value of the primers reflects that OPA04 and OPAA10 are best for discrimination of seedlings of *Citrus reticulata*. Ochoa *et al.* (2012) reported ten primers OPA-01, 02, 04, 11, 18; OPB-06, 07, 10, 12 and SAP-04 able to identify polyembryony in mango. SAP01 and SAP04 were specially constructed by the researcher to discriminate embryos. As citrus and mango are important horticultural fruit crops showing polyembryony. OPA 2, 4, 11, 18 gave polymorphism in both the fruit crops. Both SAP 1 and 4 were constructed by Ochoa *et al.* (2012) team especially for mango embryo discrimination. Those two primers were included in this experiment. SAP01 was not able to amplify any product. SAP04 primer amplified only monomorphic amplicon in citrus whereas this primer gave maximum number of bands in mango. The amplicon was present in all the fifteen seedlings of citrus. This finding reveals that the polyembryony locus of citrus and mango may not be similar. Table 3 shows that Primer OPV10 and P140 were able to characterize seedling 1 with 590 and 495 base pair amplicons. OPA11 with a 300 base pair fragment is able to detect uniqueness of seedling 2. Seedling 4 is specified by 280 base pair amplicon generated by OPAA02 primer. OPAA10 and OPB10 were useful for identification of nucellar embryos with cent percent similarity.

Identification of zygotic and nucellar seedlings using RAPD

Polymorphism was clearly observed among fifteen seedlings with four of the five primers used. A total of 62 bands were generated, and 39% were polymorphic. A Genetic similarity Matrix was calculated from the presence and absence of 62 RAPD bands obtained from 15 seedlings plant types by 19 primers according to Squared Euclidean Distance. The matrix estimated all pair wise differences in the amplification products. Based on this matrix, the highest

Plate 1. RAPD profiles of 15 mandarin orange seedlings with primers OPA18, OPAD 10, OPM10, OPAA10, OPAA2, OPB08, OPB17 and OPAT04. M = DNA ladder; Number 1 to 15 indicate seedlings S1 to S15 respectively.

TABLE 1. PCR Condition used for all markers used.

Cycling protocol RAPD PRIMER			
Initial denaturation		94°C	30 sec
denaturation	OPA18, SAP04,	92°C	30 sec
annealing	OPH11,OPM10,OPAD10,	38°C	30 sec
extension	P140,OPV10,OPAA10,OPZ10,	72°C	1 min
Extended extension	OPA11,OPA04,OPAA02,	72°C	5 min
Initial denaturation	OPB07,OPB08,OPAT04,OPB17,	94°C	5 min
denaturation	OPB10, OPM05, OPB02	92°C	1 min

TABLE 2. Synthetic deoxyribonuceotide 10-mer random primers used for molecular diversity analysis of 15 mandarin orange plant types of the NEH by using 19 decamer random primers.

Primer name	Primer sequence (5'-3')	PCR amplifi cation	total no of band	polymorphic band	polymor-phism %	band range	**PIC**	**MI**
OPA18	GACCGCT TGT	Positive and reproducible	3	2	66.67	385-590	0.273	0.315
SAP04	GGAGCTA CCT	Positive and reproducible	1	0	0	300	0	0
OPH11	CAATCGC CGT	Positive and reproducible	1	1	100	580	0.499	0.267
OPAD10	AAGAGGC CAG	Positive and reproducible	5	4	80	340-680	0.260	0.554
OPM10	TCTGGCG CAC	Positive and reproducible	4	3	75	390-680	0.267	0.765
OPV10	GGACCTG CTG	Positive and reproducible	4	3	75	320-530	0.187	0.205
OPZ10	CCGACAA ACC	Positive and reproducible	2	2	100	290-400	0.125	0.232
P140	AGGTCAC TGA	Positive and reproducible	4	4	100	100-490	0.245	0.440

OPAA10	TGGTCGG GTG	Positive and reproducible	9	9	100	200-690	0.302	0.927
OPA04	AATCGGG CTG	Positive and reproducible	5	5	100	190-600	0.356	1.114
OPA11	CAATCGC CGT	Positive and reproducible	4	4	100	300-530	0.251	0.268
OPAA02	GAGACCA GAC	Positive and reproducible	3	2	66.67	160-370	0.830	1.106
OPB07	GGTGACG CAG	Positive and reproducible	3	3	100	170-470	0.368	0.833
OPB08	GTCCACA CGG	Positive and reproducible	2	2	100	100-290	0.125	0.232
OPAT04	TTGCCTC GCC	Positive and reproducible	4	4	100	320-750	0.249	0.548
OPB17	AGGGAAC GAG	Positive and reproducible	3	3	100	360-720	0.213	0.555
OPB10	CTGCTGG GAC	Positive and reproducible	3	3	100	220-500	0.284	0.645
OPM05	CGCGGCCA	Positive and reproducible	1	1	100	300	0.124	0.116
OPB02	TGATCCC TGG	Positive and reproducible	1	1	100	350	0.124	0.116

(100%) genetic similarity was observed among the seedlings S7, S10, S11, S12, S13, S14 and S15. These seven seedlings are regarded as nucellar due to their similarity. Remaining eight seedlings were different from these seven.

The cluster analysis of the RAPD data using minimum variance algorithm and nearest neighbour method created the dendrogram as shown in Figure 3. OPA18, OPH11 and OPB10 were able to differentiate the zygotic seedlings from the nucellar ones representing the genetic architecture of the mother plant (Table 4). OPA18 was able to characterize three hybrids with similar amplicons and four with a slight difference. OPH 11 primer with very low PIC was not excluded due to high discriminating ability. OPB10 helped in grouping of nucellar in a single cluster with generation of a single band different from the rest. OPM10 and OPV10 were useful for discrimination of

TABLE 3. **Primers efficient to detect Individual Hybrids and Nucellar seedlings.**

Seedling	Unique band
S1	**OPV10 590bp, P140 495bp**
S2	**OPA11 300bp**
S4	**OPAA02 280bp**
S7, S9, S10, S11, S12, S13, S14, S15	**OPAA10 250bp OPB10 220bp**

TABLE 4. **RAPD Primers able to differentiate Zygotic & Nucellar Seedlings.**

Primer Name	Zygotic Seedlings	Nucellar Seedlings
OPA18, OPH11, OPB10, OPAA10	S1, S2, S3, S4, S5, S6, S8, S9	S7, S10, S11, S12, S13, S14, S15

zygotic seedlings. However, OPAA10 with high PIC value was able to differentiate nucellar (Table 4). The band pattern in zygotic plants was different from that of the mother plant, due mostly to the absence of some fragments, as well as to the presence of markers in zygotic seedlings. No single primer was able to identify all zygotic seedlings.

One important observation is the zygotic and nucellar seedling survival. The molecular analysis revealed 53% of the seedlings are zygotic in origin and 47% are nucellar which is different from the value of 18% and 80% obtained by morphological screening. Several factors like environment, food supply, pollination, pollen source and genetic regulation etc. were reported to influence polyembryony in citrus.

Conclusion

From this experiment an attempt was taken to differentiate nucellar and zygotic seedlings at molecular level. Previous literature stated the morphological separation of zygotic and nucellar embryo is not always correct. The detection of zygotic twin and triplet in mandarin orange population actually complicates the process. The poor farmers of North Eastern Hilly region usually scatter seed in seed bed and rogue the off type seedling. The occurrence of significant number of zygote abnormality could decrease the nucellar percentage and its identification. In an open pollinated population the morphological identification of nucellar embryos become more difficult. Keeping these points in mind DNA based molecular marker system is used for differentiation of hybrids from the nucellar. Four RAPD primers were efficient to distinguish the seedlings into two distinct clusters. One cluster comprises all the nucellar seedlings and another one clustering the zygotic seedlings. Some more primers were also found with capacity to express the difference among zygotic embryos. RAPD is the cheapest DNA marking system and within tenure of 3 to 4 days the decamer primers can identify the nucellar seedlings and aid in establishment of uniform population. The selected primers could be used for uniform Citrus reticulata plant type selection especially for North Eastern Himalayan region of this sub continent and also for other region.

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Bio-Efficacy of New Acaricide Molecules Against Garlic Leaf Mite, *Aceria Tulipae* (Keifer) In West Bengal

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Abstract

A field experiment was done at the District Seed Farm of Bidhan Chandra Krishi Viswavidyalaya, Kalyani, Nadia, West Bengal, to determine the bio-efficacy of new acaricidal molecules against garlic leaf mite, *Aceria tulipae* (Keifer) for consecutively two years 2013–2014 & 2014–2015. Among the tested acaricides against garlic leaf mite (*Aceria tulipae)*, propergite @ 1.5 ml/lit and dicofol @ 2.5 ml/ lit was significantly superior over all other treatments followed by wettable sulphur @ 2g/lit in both the year.

Key words : *Garlic, Bio-efficacy, Aceria tulipae, mite, acaricide.*

Introduction

Garlic (*Allium sativum* Linn.) or 'Lasun' or 'Rashun' belonging to the family Alliaceae, has been recognized all over the world as a valuable condiment and popular medicine for various ailments and physiological disorders. In Ayurveda it is known as the "Nectar of life" (Muthukumar & Selvakumar, 2013). Garlic is consumed as green as well as dried in the form of spice (Singh *et al*., 2009). It has been cultivated throughout the world from the antique past. It is second most important bulb crops next to onion. It has important role in Indian economy by earning a good amount of foreign currency. The major garlic producing countries in the world are China, India, Egypt, Korea, Bangladesh, Russia, Myanmar, Ukraine, Spain, Argentina, USA, Brazil and Iran. At world level China has highest area (7.85 lakh ha) and production (19.98 lakh ton) of garlic (Anonymous, (2017). India occupies second position both in area of 2.31 lakh ha and production of 12.52 lakh ton (Horticulture Statistics Division, 2016) and Egypt occupied highest position in productivity (24.34 ton/ha) followed by China (23.53 ton/ha) and USA (18.66 ton/ha) (Anonymous, 2017). In case of India, the productivity is about 5.42 ton/ha (Horticulture Statistics Division, 2016) and is commercially grown in Punjab, Haryana, Maharastra, West Bengal, Madhya pradesh, Uttar Pradesh, Gujrat, Assam and Rajasthan. Among these states Madhya Pradesh ranks first in production (2.7 lakh ton) followed by Gujrat (2.5 lakh ton) and Rajasthan (2.18 lakh ton) (Horticulture Statistics Division, 2016). In West Bengal garlic is cultivated in 3400 ha. with production of 40000 ton. (Horticulture Statistics Division, 2016) and mainly grown in the district of Nadia, Hoogly and Murshidabad (Bala *et al.,* 2015). The nationally significant pests of garlic are Onion thrips, *Trips tabaci* Lindeman, onion maggot, *Delia antique* Meigen, Bulb mite, *Rhizoglyphus robini* Claparede, garlic bulb mite, *Aceria tulipae* (Keifer), red spider mite, *Tetranychus cinnabarinus* (Boisduval) (Anonymous 2014). Among the non insect pests of garlic, the dry bulb mite, *A. tulipae* (Keifer) is one of the major constraints in garlic production. It is also known as the dry bulb mite or tulip mite and considered as one of the most damaging sucking pest of garlic (MacLeod 2007). It causes damage by infesting tender leaves creates a typical symptom like twisting and curling. Infested leaves do not open properly and gives shelter to mite colony along the mid-rib and growth is stunted, causing 32% yield loss under West Bengal conditions (Debnath and Karmakar, 2013). It is very easy to suspect that this mite was a silent menace to our crop since long and consistently being ignored or remained unnoticed by the farmers for their existence in cryptic habitat. Unfortunately, no research work has been done so far from West Bengal to develop management strategies against it. Furthermore, research literature on this agriculturally important eriophyid in Indian context is also very scanty, though its existence has been reported several years back in Karnataka (Puttarudriah and Channabasavanna 1958; Channabasavanna 1966) and Maharashtra (Pawar *et al.* 1990). In recent times, this mite has came into sight as a notorious pest of garlic in all garlic growing areas of West Bengal both in the field and in storage conditions, causing considerable yield loss every year. The objectives of the present research to evaluate the bio-efficacy of new acaricidal molecules against garlic leaf mite for its eco-friendly management and to ensure higher yield.

Material and Methods

A field experiment was carried out to determine the bio-efficacy of new acaricide molecules against garlic leaf mite, at the District Seed Farm of Bidhan Chandra Krishi Viswavidyalaya, Kalyani, Nadia, West Bengal during winter months of 2013–2014 & 2014–2015. The experiment was laid out in a Randomized Block Design with 8 treatments and three replications were provided for each of the treatments. Garlic variety *Goldana* was planted during 1st week of November in 5m X 4m plots with row to row and plant to plant spacing of 15 cm X 10 cm. Seven acaricidal molecules were used for this experiment and water was applied in untreated control plots. Sprayings were done two times at fortnight intervals. For recording observation to estimate the bio-efficacy of different acaricides against garlic mite, 10 plants were selected randomly from each plot and from each plant one moderately matured leaf was taken and brought to the laboratory in air tight polythene bags. The number of post embryonic stages of mite viz., larvae, nymphs and adults was recorded using stereo-zoom binocular microscope taking one square cm area on upper surface of leaf. The number of mite per square cm was recorded prior to spray as pre-treatment count and on 1, 3, 7 and 14 days after spraying as post-treatment counts.

Results and Discussion

Garlic mite, *Aceria tulipae* (Keifer) is considered to be the most notorious pest causing extensive damage during growing period. It is very difficult to manage due to its rapid multiplication. Aaltogether seven acaricidal molecules was screened for manage of garlic mite during 2014 and 2015 cropping season and the data has been presented in table 1-4. In the first year experiment, the pre-count population of mite ranging from 32.3 to 29.3 per cm^2 of leaf which was statistically non significant, observed an uniform distribution (Table-1). Maximum mortality of mite (75.8, 83.4%) was recorded from the treatment Propergite 57EC @ 1.5 ml/lit which was statistically at par with Dicofol 18.5 EC @2.5 ml/lit which was registered 69.4 and 82.8 % mortality at 3 and 7 days after spray. The treatment Wettable Sulpher 80 WP @ 2 g/lit was the next best option. Hexythiazox 5.45 EC @ 1ml/lit and Fenpyroximate 5EC @ 1ml/lit are comparatively less effective against mite recorded 25.8, 28.0% and 55.4, 44.9 % mortality respectively at 3 and 7 days after spraying. Similar trend of result has been found at 14 days after spraying as well as second round of spray (Table-2).

Similarly, in the second year, one day before spray mite population was ranged from 32.3 to 34.7 mites/cm^2 and it was statistically non significant showing equal distribution (Table-3). Highest mortality of mite was noticed from the treatments Propergite 57EC @ 1.5 ml/lit and recorded maximum mortality at 71.6 and 86.9 % respectively at 3, 7 days after spray. No statistical variation was observed on percent mortality mite at 3 and 7 days after spray for the treatments of Dicofol 18.5 EC @ 2.5 ml/lit and recorded maximum mortality of 67.3% and 79.9%

TABLE 1. Effect of different acaricides on garlic mite, *A. tulipae* on garlic (var. Goldana) in the year 2014.

Treatments	Doses ml/lit	Pre-treated Population/ cm^2 leaf	Percent mortality (1st round spray) 1 DAS	3 DAS	7 DAS	14 DAS
Dicofol 18.5EC	2.5 ml	32.3	44.7(42.3)^{a*}	69.4(56.7)^{a}	82.8(65.9)^{a}	26.8(31.5)^{b}
Profenophos 50EC	1 ml	31.0	37.7(38.2)^{a}	56.9(49.3)^{b}	53.8(47.5)^{c}	13.7(22.2)^{cd}
Fenpyroximate 5EC	1 ml	32.0	24.2(29.8)^{ab}	55.4(48.4)^{bc}	44.9(42.3)^{d}	12.7(21.3)^{cd}
Hexythiazox 5.45EC	1 ml	29.3	9.0(18.0)^{bc}	25.8(30.8)^{d}	28.0(32.3)^{e}	5.9(14.7)^{d}
Wettable S 80WP	2 g	30.3	32.0(34.8)^{a}	72.6(58.8)^{a}	75.9(61.0)^{b}	20.9(27.5)^{bc}
Difenthiuron 50WP	0.5 g	31.7	41.2(40.2)^{a}	45.0(42.4)^{c}	59.4(50.7)^{c}	10.8(19.7)^{cd}
Propergite 57EC	1.5 ml	29.3	47.2(43.7)^{a}	75.8(60.8)^{a}	83.4(66.3)^{a}	41.8(40.6)^{a}
Control	—-	30.3	0.0(4.1)^{c}	0.0(4.1)^{e}	0.0(4.1)^{f}	0.0(4.1)^{e}
F-test			Sig.	Sig.	Sig.	Sig.
SEM			5.12	2.17	1.30	2.68
CD at 5%			15.53	6.59	3.94	8.14

DAS: Days after spraying, * The figures in the parentheses are angular transformed. Same letters denote homogeneous means in Duncan's Multiple Range Test.

TABLE 2. Effect of different acaricides on garlic mite, *A. tulipae* on garlic (var. Goldana) in the year 2014.

Treatments	Doses ml/lit	Pre-treated Population/ cm^2 leaf	Percent mortality (1st round spray) 1 DAS	3 DAS	7 DAS	14 DAS
Dicofol 18.5EC	2.5 ml	24.7	41.8(40.6)^{a*}	68.4(56.1)^{a}	83.6(66.5)^{a}	24.4(29.9)^{b}
Profenophos 50EC	1 ml	26.7	17.4(25.0)^{b}	52.6(46.8)^{b}	62.5(52.5)^{c}	10.0(18.9)^{d}
Fenpyroximate 5EC	1 ml	25.0	16.1(24.1)^{b}	51.2(46.0)^{b}	54.0(47.6)^{c}	13.1(21.6)^{d}
Hexythiazox 5.45EC	1 ml	25.7	22.0(28.3)^{b}	36.3(37.3)^{c}	33.7(35.8)^{d}	13.0(21.5)^{d}
Wettable S 80WP	2 g	23.0	44.7(42.3)^{a}	63.5(53.2)^{a}	74.9(60.3)^{b}	27.1(31.7)^{b}
Difenthiuron 50WP	0.5 g	25.0	15.5(23.6)^{b}	46.4(43.2)^{b}	53.0(47.0)^{c}	17.8(25.3)^{c}
Propergite 57EC	1.5 ml	26.0	37.1(37.8)^{a}	65.2(54.2)^{a}	84.2(67.0)^{a}	38.2(38.5)^{a}
Control	—-	31.0	0.0(4.1)^{c}	0.0(4.1)^{d}	0.0(4.1)^{e}	0.0(4.1)^{e}
F-test			Sig.	Sig.	Sig.	Sig.
SEM			2.39	1.56	1.90	1.20
CD at 5%			7.24	4.74	5.76	3.63

DAS: Days after spraying, * The figures in the parentheses are angular transformed. Same letters denote homogeneous means in Duncan's Multiple Range Test.

respectively at 3 and 7 days after spray. The treatment Wettable sulphur @ 2g/lit was rendering satisfactory result securing second highest (64.4 and 80.0%) mortality at 3 and 7 days after spraying.

The lowest percent mortality was observed in the plots treated with Difenthiuron 50 WP@ 0.5 g /ml followed by Hexythiazox 5.45 EC @ 1 ml/lit. No mites mortality was recorded from untreated check plots.

TABLE 3. Effect of different acaricides on garlic mite, *A. tulipae* on garlic (var. Goldana) in the year 2015.

Treatments	Doses ml/lit	Pre-treated Population/ cm^2 leaf	Percent mortality (1st round spray)			
			1 DAS	3 DAS	7 DAS	14 DAS
Dicofol 18.5EC	2.5 ml	34.7	33.5(35.7)^{ab*}	67.3(55.4)^{a}	79.9(63.7)^{a}	28.8(32.8)^{a}
Profenophos 50EC	1 ml	32.7	24.3(29.9)^{bc}	57.1(49.4)^{b}	64.9(54.0)^{b}	7.0(15.9)^{c}
Fenpyroximate 5EC	1 ml	33.0	24.0(29.6)^{bc}	45.8(42.9)^{c}	37.8(38.2)^{d}	20.5(27.3)^{ab}
Hexythiazox 5.45EC	1 ml	34.0	13.8(22.2)^{cd}	24.3(29.9)^{d}	50.7(45.7)^{c}	11.6(20.4)^{bc}
Wettable S 80WP	2 g	32.3	20.8 (27.5)^{bcd}	64.4(53.7)^{ab}	80.0(63.8)^{a}	16.3(24.2)^{b}
Difenthiuron 50WP	0.5 g	34.7	10.7(19.5)^{d}	26.5 (31.3)^{d}	42.0(40.7)^{cd}	10.9(19.7)^{bc}
Propergite 57EC	1.5 ml	33.7	44.4(42.1)^{a}	71.6 (58.1)^{a}	86.9(69.2)^{a}	30.4(33.7)^{a}
Control	—-	32.3	0.0(4.1)^{e}	0.0 (4.1)^{e}	0.0(4.1)^{e}	0.0(4.1)^{d}
F-test			Sig.	Sig.	Sig.	Sig.
SEM			3.15	1.85	2.14	2.49
CD at 5%			9.54	5.61	6.49	7.54

DAS: Days after spraying, * The figures in the parentheses are angular transformed. Same letters denote homogeneous means in Duncan's Multiple Range Test.

TABLE 4. Effect of different acaricides on garlic mite, *A. tulipae* on garlic (var. Goldana) in the year 2015.

Treatments	Doses ml/lit	Pre-treated Population/ cm^2 leaf	Percent mortality (1st round spray)			
			1 DAS	3 DAS	7 DAS	14 DAS
Dicofol 18.5EC	2.5 ml	24.7	27.1(31.7)^{b*}	62.2(52.3)^{ab}	74.3(59.9)^{c}	28.3(32.5)^{bc}
Profenophos 50EC	1 ml	23.3	20.6(27.4)^{bc}	53.9(47.5)^{bc}	71.3(57.9)^{c}	28.5(32.6)^{bc}
Fenpyroximate 5EC	1 ml	23.0	10.2(19.1)^{d}	47.9(44.1)^{c}	50.5(45.6)^{d}	12.7(21.3)^{d}
Hexythiazox 5.45EC	1 ml	25.3	17.7(25.3)^{c}	44.3(42.0)^{c}	46.8(43.4)^{d}	18.9(26.2)^{cd}
Wettable Sulpher 80WP	2 g	23.7	40.8(40.0)^{a}	67.3(55.4)^{a}	87.3(69.6)^{b}	47.8(44.0)^{a}
Difenthiuron 50WP	0.5 g	24.7	16.1(24.0)^{c}	32.3(34.9)^{d}	50.1(45.3)^{d}	17.5(25.1)^{d}
Propergite 57EC	1.5 ml	23.3	40.5(39.8)^{a}	62.5(52.5)^{ab}	92.1(74.3)^{a}	32.8(35.3)^{b}
Control	—-	32.3	0.0(4.1)^{e}	0.0(4.1)^{e}	0.0(4.1)^{e}	0.0(4.1)^{e}
F-test			Sig.	Sig.	Sig.	Sig.
SEM			1.68	1.86	1.46	1.83
CD at 5%			5.10	5.64	4.41	5.55

DAS: Days after spraying, * The figures in the parentheses are angular transformed. Same letters denote homogeneous means in Duncan's Multiple Range Test.

Similar trend of mortality percent of mite was observed at 14 days after spray as well as second round of spray (table-4).

The perusals literature supports this experiment in suppressing the mite population by application of Propergite, Dicofol and Wettable Sulpher. Almaguel *et al* (1986) reported that the application Dicofol @ 0.4% and chlorobenzilate @ 0.1 alone or mixed with Citol K @ 0.1% successfully managed garlic mite population. Katkar *et a*l (1998) observed that the dipping of garlic seed in wettable sulfur or spray at standing crop @ (0.3%) + dimethoate (0.03%) was minimized the number of mites population per leaf (5.0/ cm leaf). The present investigation is a confirm of the earlier research on this same line and it has been found that the Propergite Dicofol and Wettable sulpher are the best to manage the garlic mite under Gangetic plains of West Bengal where the garlic mite ravages the crop during growing season.

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Optimization of Water Application Attachment on Seed Drill for Dry Land Farming

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Abstract

These areas produce 75% of pulses and more than 90% of sorghum, millet and groundnut from arid and semi-arid regions. Thus, dry lands/rainfed farming plays a dominant role in agricultural production. This target cannot be realized from irrigated areas alone as the irrigation potential is only for 178 million hectares. Therefore, an appropriate technology has to be developed for dry land farming. Due to dependency on rains the sowing is often delayed in dry land area which substantially reduces the yield of crop. A water application mechanism thus designed and developed wherein water will be given to the seed at the time of sowing. This will help farmer to sow crop on time, which will help to increase the production by attaining proper germination of crop at the time of sowing. The effective field capacity of water application attachment on seed drill was observed 0.420 ha/h at average operating speed of 2.5 km/h. The field efficiency calculated was 70%. Seed germination per cent in water application attachment on seed drill was 5.60% higher than normal seed drill with no attachment. Yield in water application attachment on seed drill was 16.74% higher than seed drill with no attachment.

Keywords : *Dryland, seed drill, water application attachment, planter*

Introduction

India has about 85 million hectares of rainfed area which constitutes nearly 60% of the total 143 million hectares of arable land. In such areas crop production becomes relatively difficult as it mainly depends upon intensity and frequency of rainfall. The crop production, therefore, in such areas is called rainfed farming as there is no facility to give any irrigation, and even protective or life saving irrigation is not possible. These areas get an annual rainfall between 400 mm to 1000 mm which is unevenly distributed, highly uncertain and erratic. Dry farming or dryland farming may be defined as: "a practice of growing profitable crops without irrigation in areas which receive an annual rainfall of 500 mm or even less".

Efforts are being made to bring more area under irrigated agriculture and thereby to increase cropping intensity. But, even when we achieve our target of 113 million hectares of irrigated area, we would still have about 45% area under rainfed cultivation (Annonymous, 2011). We continue to stress on intensive agriculture on irrigated land but we can not afford to be complacent with our dry lands. Therefore, improved dry farming is necessary for equity and prosperity. As such we can not achieve stability in food production with unstabilized dry land agriculture. Therefore, we are required to adopt improved technology especially developed for dry land agriculture.

Dry lands, besides being water deficient, are characterized by high evaporation rates, exceptionally high day temperature during summer, low humidity and high run off and soil erosion. The soils of such areas are often found to be saline and low in fertility. As water is the most important factor of crop production, inadequacy and uncertainty of rainfall often cause partial or complete failure of the crops which leads to period of scarcities and famines. Delay in germination period, low yield and poor economy are the most prominent problems faced by the farmers.

Due to dependency on rains the sowing is often delayed in dryland area which substantially reduces the yield of crop. Ahmed Soomro and Habib ur Rehman Khan (2003) reported a decrease in 37.5 % of yield in green gram when the sowing was delayed from third week of July to 1st week of August. Hence timely sowing is very important for better crop yields.

A water application mechanism thus designed and developed wherein water will be given to the seed at the time of sowing. This will help farmer to sow crop on time, which may help to increase the production.

Material and Methods

Construction details of Water application attachment

Water tank of mild steel, capacity 115 liter was selected for study purpose. The water tank was mounted at rear side of seed drill on a mild steel frame. At the bottom of water tank one outlet was provided to which a throttle was attached for regulating the quantity of water. The throttle was connected to metal pipe of 2 m length and 1.5 cm diameter. This metal pipe was given six openings of diameter 1.5 cm at the distance of 40 cm in which rubber tubes of diameter 1.5 cm were attached and the other end of the rubber tubes were inserted in furrow opener just behind the seed tube. The rubber tubes are used because those are very flexible and can move in any direction and the length of rubber tubes are so selected that they can easily reach up to the furrow openers. The water regulation throttle was given at the bottom of the water tank.

After the development of water application attachment on seed drill the preliminary studies on the germination of crop has been carried out in three different trials at dryland farm area of CCS HAU, Hisar, at three different positions of throttle opening i.e. 100 % open throttle, 75 % and 50 % open throttle to check the water application rate. On the basis of this preliminary study the water application rate were calculated as 2777 l ha^{-1}, 2500 l ha^{-1} and 2222 l ha^{-1} for 100 % open throttle, 75 % open throttle and 50 % open throttle, respectively.

Results and Discussion

For optimization of application rate of water application attachment on seed drill for dry land farming, its effect was seen on seed germination percent.

In the optimization study, the water application rate were calculated as 2777 l ha^{-1}, 2500 l ha^{-1} and 2222 l ha^{-1} for 100 % open throttle, 75 % open throttle and 50 % open throttle, respectively. The plots which were sown by keeping 100 % throttle open, the seed germination was observed as 93.33 % and the plots which were sown by keeping 75% and 50% throttle open, the seed germination was observed as 90 % each.

The maximum seed germination was observed when the throttle of water application system was kept open 100 % while it was at par when throttle was kept 75 % and 50% open. Hence the water application rate was fixed as 2222 l $ha^{-1}$for testing of water application attachment on seed drill.

Conclusion

1. The water application rate of 2222 l ha^{-1} increase moisture content by 12 % and germination obtain was 93.33 %.
2. The effective field capacity of water application attachment on seed drill was observed 0.414 ha h^{-1} at average operating speed of 2.5 km hr^{-1}. The field efficiency calculated was 69 %.
3. Sowing depth varied with different method of sowing. It was 4 cm by water application attachment on seed drill and seed drill while it was 7 cm for ridger seeder and 6 cm for hand plough.

Specifications of water application attachment on seed drill

Particulars	Specifications
Working width of machine	240 cm
Overall dimensions of water tank	110 cm X 30 cm X 60 cm (L X B X H)
Tank capacity (liters)	115
Length of metal pipe	260 cm
Distance between opening	40 cm
Diameter of throttle	3 cm
Length of rubber pipe	30 cm
Diameter of rubber pipe	1.5 cm
Water flow regulation	Gravity flow

Effect of water application rate on seed germination

Water application rate, l ha^{-1}	Seed Germination, %			
	R1	R2	R3	Mean
2777	92.22	93.11	94.66	93.33
2500	89	87	94	90
2200	89	89	92	90

Effect of water application rate on seed germination

4. Seed germination percent gave significant results. Seed germination percent was higher for water application attachment on seed drill + dry seed. Seed germination percent in water application attachment on seed drill + dry seed was 14% higher than ridger seeder, 7% more than water application attachment on seed drill + soaked seed and 35% more than hand plough.

   Thus the water application attachment on seed drill may be used for timely sowing of crop in dryland/rainfed area and the yield may be increased.

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Impact of Integrated Nutrient Management on Soil Properties and Yield of Tea in NE India

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Abstract

Integrated Nutrient Management (INM) involves the use of organic manures, bio fertilizers and chemical fertilizer with a view to reduce the quantity of inorganic sources nutrients. Field experiments were conducted to standardize the nutrient supply by integrated nutrient management (INM) approach in tea. Quality organic manure (QM), bioinoculants (BF) and/or inorganic fertilizers in recommended doses (RDF) were applied as $N:P_2O_5:K_2O$ (120: 40: 120 kg/ha/yr) and soil properties and yield of mature tea were monitored. During first three years of observations, the results indicated that soil parameter viz organic carbon, pH, bulk density and water stable aggregate under all integrated treatments were in suitable range for tea (0.78 to 0.87%, 4.62 to 4.72%, 1.36 to 1.38 g/cc and 84.2 to 88.5 %) and didn't show any significant difference between treatments including 100% recommended doses of fertiliser (RDF). However, all the integrated treatments maintained significantly higher build up of available phosphate in soil throughout the entire experimental period . The study also revealed that 25% replacement of RDF by either 6 tonnes QM or by mixed BF maintained yield and leaf nutrients at par with 100% recommended dose of fertilizer (RDF). From the fourth year onwards these treatments maintained significantly higher build up of organic carbon, available phosphate and yield of tea compared to RDF. Similar findings have been obtained in an ongoing field experiment where application of NASA (A granulated organic manure) @5Kg/ha in combination with RDF produced significantly higher yield of tea over only RDF applied plot. Integrated nutrient management thus would help in reducing chemical fertilizers as well as help in moderating soil properties favourably.

Introduction

At present the fertilizer recommendation for mature tea in North East India is up to 140-165 kg nitrogen/ha with 100-140 kg/ha potash and 20-50 kg/ha phosphate. But the long term use of inorganic fertilizers without organic supplements has been reported to damage the soil physical properties as shown by an increase in the bulk density, a decrease in water stable aggregate (>0.25mm) and also a decline in soil organic matter content leading to low nutrient retention capacity (Dey *et al*., 1968; Lal and Kang, 1982). The deterioration of physical properties of soil is the main factor for the loss of soil productivity and causing serious threat to long-term sustainability of tea production (Dey *et al*, 1968). The situation of deterioration of native soil fertility can possibly be retrieved only through combined use of organic manures and chemical fertilizers as components of integrated nutrient management (INM). The integrated nutrient management involves the combined use of organic, inorganic and bio fertilizer sources to improve or maintain soil chemical, physical and biological properties. Long term studies (37 years from1933-1969) carried out at Tocklai Experimental Station, have shown that cattle manure was less than half as efficient as inorganic nitrogen (Rahman, 1977). Other long term studies carried out all over India have shown that neither the organic manures nor the mineral N, P and K fertilizers alone can sustain higher productivity where the nutrient turnover in the soil - plant system is high (Singh and Yadav,1992). The present study was therefore undertaken with the objective to study the

Table 1. Effect of treatments on soil organic Carbon

Treatments	*Organic C (%)*				
	2010	2011	2012	2013	2014
T_1	0.82	0.85	0.84	0.80	0.82
T_2	0.80	0.81	0.85	0.87	0.86
T_3	0.81	0.82	0.85	0.87	0.88
T_4	0.81	0.84	0.87	0.90	0.93
T_5	0.81	0.84	0.82	0.89	0.91
T_6	0.84	0.83	0.80	0.84	0.86
T_7	0.85	0.86	0.82	0.82	0.86
T_8	0.84	0.86	0.82	0.84	0.86
T_9	0.82	0.80	0.82	0.83	0.83
T_{10}	0.80	0.78	0.80	0.78	0.80
CD (0.05)	NS	NS	NS	0.02	0.04

Table 2. Effect of treatments on soil pH

Treatments	*pH*				
	2010	2011	2012	2013	2014
T_1	4.70	4.66	4.64	4.62	4.61
T_2	4.69	4.64	4.68	4.71	4.74
T_3	4.68	4.66	4.72	4.76	4.78
T_4	4.67	4.68	4.70	4.78	4.79
T_5	4.67	4.66	4.71	4.74	4.75
T_6	4.68	4.68	4.70	4.74	4.76
T_7	4.68	4.67	4.70	4.72	4.75
T_8	4.68	4.68	4.71	4.74	4.74
T_9	4.65	4.67	4.72	4.72	4.74
T_{10}	4.67	4.66	4.62	4.64	4.66
CD (0.05)	NS	NS	NS	NS	NS

long term effect of combined application of organic, inorganic and biofertilizer on soil properties and tea productivity.

Materials and Method

i. Field trial at commercial tea estate.

A field experiment was initiated in a commercial tea estate of south bank on integrated nutrient management since 2009. The experimental plots (130 m^2) each contained 72 bushes of Clone TV23 planted in 2007 at 120 x 90 cm spacing, under shade of *Albizzia odoratisima.* Altogether eleven treatments were used for present investigations, viz. T_1: 100% Recommended doses of fertilizer (RDF); T_2: 75% RDF + 2t QM; T_3: 75% RDF + 4t QM, T_4: 75% RDF + 6 t QM; T_5: 75% RDF + 6 kg BF; T_6: 50% RDF + 2t QM; T_7: 50% RDF + 4t QM; T_8: 50% RDF + 6t QM; T_9: 55% RDF + 6 kg BF and T_{11}: 6 kg BF. The consortium of biofertilizer was Azospirilum, Azotobacter and phosphate solubilizing bacteria (PSB: *Bacillus subtilis*). Quality organic manure used was nutrient and microbial enriched vermicompost prepared at vermicomposting unit at Tocklai Tea Research Institute adopting newly standardized technology (Phukan *et al.*, 2013).

The experiment was carried out in a randomized block complete design with three replications. The area receives 2000 mm of average annual rainfall, eighty percent of which is received during the wet season. Soil chemical and physical properties were estimated by following standard methodologies (Jackson, 1973; Baruah and Barthakur, 1997).

ii. Experiment on NASA (A granulated organic manure)

Efficiency of NASA, a granulated commercial organic manure, of Tropical Agrosystem Pvt Ltd was compared with standard treatment of recommended doses of fertilizer in a field experiment carried out at Tocklai experimental field during 2015. NASA was applied either alone or in combination with recommended doses of fertilizer and with reduced doses of recommended doses of fertilizer. NASA was applied in single application during April-2015 and 2016 with normal fertilizer. Weekly green leaf yield of tea under different treatments was recorded during 2015 and 2016.

Results and Discussion

Data on organic carbon (org C) under different treatments (Table 1) indicated that during first three years i.e., 2010-2012 the numerical values of org C under all the treatments were at par. During 2013 and in subsequent year, all the integrated treatments (T_2-T_9) maintained significantly higher built up of org C over RDF which may be due to direct incorporation of organic matter through organic manure in the soil, and also probably due to increased plant growth leading to accumulation of more organic residues in the soil. Increase in organic carbon by combined use of inorganic and organic manures over inorganic-N alone has also been reported earlier (Sharma and Subehia, 2014). Dutta and Sharma (2000) reported increase in org C content in tea soil by the combined application of urea-N and tea waste. Application of biofertiliser alone resulted in lower build-up of carbon throughout the experimental period.

A perusal of data in table 2 showed that soil pH during the entire experimental period, was in the desired range for tea productivity and did not show any visible trend under different treatments. This might be due to the buffering action of the soil (Santhy *et al.*, 1999). However, from the third year onward all the integrated treatments resulted in non significant increase in pH over RDF. This marginal increase in soil pH in the integrated treatments might be due to the moderating effect of organics over the years as it decreases the activity of exchangeable Al3+ ions in solution due to chelating effect of organic molecules (Prasad *et al.*, 2010). Similar effect on pH under organic tea experiments were also reported by Stamatoados *et al* (1999).

All the integrated treatments maintained significantly higher build up of available phosphate in soil throughout the entire experimental period (Table 3). Amongst the integrated treatments (T_2-T_9), T_4 recorded the highest available phosphate which was statistically on par with T_3 and T_5. Build up in available P with conjoint use of fertilizers with organics was ascribed to the release of organic acids during decomposition which in turn helped in releasing native phosphorous through solubilizing action of these acids. Also, organic matter forms a coating on sesquioxides and makes them inactive and thus reduces the phosphate fixing capacity of soil, which ultimately helps in release of ample quantity of plant available P (Urkurkar *et al.*, 2010).It appeared that the organic acids produced during decomposition of organic manure might have solubilized both applied P and native P compounds in soil, resulting in an increase in available P content in soil. Similar increase in available P due to combined application of inorganic fertilizer and organic manure was also reported by Bhandari *et al.* (1992).

Data on soil bulk density indicated narrow variation (1.32-1.36 Mg/m^3) under different treatments and treatment effects were not significant (Data not presented). During first three years of experimentation (2010-2012), water stable aggregates did not show significant variation among different treatments. However, during 2013 and in subsequent year, the treatments comprising 100% RDF plus 6 tonnes QM

Table 3. Effect of treatments on soil available P_2O_5

Treatments	Available P_2O_5 (mg/kg)				
	2010	2011	2012	2013	2014
T_1	9	17	14	19	22
T_2	16	23	21	22	28
T_3	16.	21	22	23	31
T_4	20	24	26	28	32
T_5	19	22	25	27	31
T_6	18	24	21	23	26
T_7	17	26	22	24	27
T_8	16	23	21	28	27
T_9	16	26	23	27	27
T_{10}	11	19	18	22	23
CD (0.05)	6	4	7	2	3

Table 4. Effect of treatments on total water stable aggregates

Treatments	Water stable aggregates (%)			
	2010	2012	2013	2014
T_1	84.2	83.7	84.1	85.9
T_2	84.9	85.1	89.1	90.2
T_3	83.4	86.2	88.2	90.1
T_4	84.1	88.5	91.8	92.4
T_5	84.2	87.9	89.5	91.8
T_6	84.6	84.5	86.2	87.9
T_7	83.4	84.7	86.9	88.4
T_8	84.7	84.6	86.9	87.9
T_9	83.2	84.6	86.8	88.4
T_{10}	84.1	84.1	85.8	86.9
CD (0.05)	NS	NS	3	5

(T_4) and 100% RDF plus 6 Kg mixed BF (T_5) significantly improved this parameter over RDF (T_1) and rest of the treatments (Table 4).This might be due to higher organic carbon content of soil through organic matter addition that resulted in improved water stable aggregates. Similar findings were also reported by Gathala *et. al.*, (2007) and Singh *et. al.*, (1999).

Data in table 7 revealed that these two treatments (T_4 and T_5), significantly increased N and P_2O_5 content in shoot over RDF and rest of the treatments (Table 5). The increased N and P_2O_5 content in shoot was due to the added supply of nutrients and improved soil physical condition that in turn resulted in better absorption of nutrients. Owuor, (1989) also observed similar increase in N and P uptake in tea shoot by the application of enriched cattle manure. Significant improvement in the uptake of nutrients owing to N-fertilizer applied in conjunction with organic manures under different soil-crop conditions were reported by many workers (Millar *et al.*, 1987). However, potash

TABLE 5. Effect of treatments on N, P_2O_5 and K_2O content in shoot (%)

	N (%)	P_2O_5 (%)	K_2O (%)
T_1	4.67	0.67	2.20
T_2	4.58	0.61	2.10
T_3	4.71	0.74	2.17
T_4	4.81	0.79	2.22
T_5	4.80	0.78	2.19
T_6	4.60	0.70	2.11
T_7	4.56	0.62	2.14
T_8	4.58	0.61	2.14
T_9	4.58	0.60	2.15
T_{10}	4.56	0.58	1.98
CD (0.05)	0.11	0.10	0.09

TABLE 6. Effect of treatments on yield of tea (KMTH)*

Treatments	KMTH					Mean (2010-2014)
	2010	2011	2012	2013	2014	
T_1	1647	1937	1798	1833	1760	1795
T_2	1481	1878	1767	1840	1750	1743
T_3	1474	2007	1787	2000	1900	1834
T_4	1606	2021	1818	2215	2088	1950
T_5	1598	1993	1786	2188	2010	1915
T_6	1401	1800	1664	1770	1780	1683
T_7	1441	1823	1640	1760	1750	1683
T_8	1478	1820	1693	1765	1685	1688
T_9	1529	1812	1696	1760	1700	1699
T_{10}	1321	1583	1549	1560	1600	1523
CD (0.05)	NS	NS	NS	132	140	

KMTH: Kg made tea per hactre*

content under different treatments did not indicate much variation and treatment effects were not significant.

During first three years of experimentation yield of tea under different treatments were on par with 100% RDF (Table 6). However, from fourth year onwards, plots receiving 75% RDF in combination with 6 t QM (T_4) or 6 kg BF (T_5) produced significantly higher yield of tea over 100% RDF with an yield increase of 13.5 % and 11.0% (mean: 2012-2014) respectively over RDF.

Experiment on NASA

Data generated from the two years of experimentation (Table 7) indicated that application of NASA @5-6 kg/ha in combination with RDF (T_2 & T_3) produced significantly higher yield (14-15%) over

Table 7. Influence of NASA on yield of tea (KMTH)

Treatment No	KMTH			% increase/decrease over RDF(T_1)
	2015 (DS)	2016 (UP)	Mean	
T_1	1333	1555	1444	
T_2	1530	1802	1666	15.38
T_3	1508	1800	1654	14.54
T_4	1443	1729	1586	9.85
T_5	1387	1632	1509	4.52
T_6	1393	1501	1447	0.21
T_7	1370	1467	1418	-1.78
T_8	1201	1358	1279	-11.40
T_9	1196	1311	1253	-13.22
T_{10}	1127	1264	1195	-17.21
T_{11}	1140	1265	1203	-16.71
T_{12}	1141	1246	1193	-17.37
T_{13}	1105	1276	1191	-17.54
CD (0.05)	72	140		

RDF. The effect was found to be consistent for the two years. Replacement of 25% of RDF by NASA @ 4-6 kg/ha maintained yield of tea at par with RDF. However, beyond 25% replacement and complete replacement of RDF by NASA resulted in lower yield of tea over RDF.

Conclusion

This study showed that the present recommended dose of chemical fertilizers to tea can be reduced to 75% by integration with quality organic manure or consortium of BF without compromising the soil fertility maintenance and yield of tea under such experimental conditions as mentioned.

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A Case Study on Responsiveness of Input Factors on Gross Value Production for Govindbhog Rice in Kaimur District of Bihar

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Abstract

A survey was done to estimate the response of various input factors on "Govindbhog Rice" production and to know the Marginal Value of Productivity (MVP) of different inputs on Gross Value of Production.. Forty famers in four villages of two block under two sub-division of Kaimur district were selected purposively due to massive cultivation of aromatic super fine 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. Cobb-Douglas production function was used to assess the elasticities of explanatory variables on resultant factor. There were dissimilar influences of different independent variables on per acre gross value of crop production, although elasticities of seed cost (x_1), manure fertilizer cost (x_2), irrigation cost (x_3), human labor cost (x_4) were positive and machinery cost(x_5) was negative. Manure and fertilizer cost (x_2) was found significant and rest variables were non-significant but their influences were not similar. Enhancement of different variables except machinery cost would result unequal increase in per acre gross value of Govindbhog rice production on sample farms. The Regression Variance was found highly significant. Coefficient of multiple determination (R^2) was 0.9981 indicated that about 99.81 per cent of total variation in gross value of per acre crop production was being jointly explained by independent variables included in the equation. The summation of elasticities ($b_{i=}b_{1+}b_{2+}b_{3+}b_{4+}b_5$) was 1.033, indicated the increasing return to scale in crop production on sample farms of Govindbhog variety. That showed the possibility of additional increase in independent variables viz. seed cost (x_1), manures and fertilizers cost (x_2), irrigation cost (x_3), human labour cost (x_4) and machinery cost ($x_{5)}$ per acre by one percent to enhance per acre gross income by 1.03 per cent on sample farms. Marginal value productivity of machinery cost ($x_{5)}$ was positive and value was found 1.52. Marginal value productivity Seed cost Rs. ($x_{1),}$ Manure and fertilizer cost Rs. (x_2), Irrigation cost Rs.(x_3), Human Labor cost Rs. (x_4) were found negative and their values were -0.89,- 0.26, -6.04 and -0.87 respectively.

Key words : *Input factors, Elasticity, Coefficient of multiple determination, Return to scale and Marginal Value Productivity.*

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%. It was the predominant dietary energy source for 17 countries in Asia and the Pacific, 9 countries in North and South America and 8 countries in Africa. Rice production in India was an important part of national economy with preferred by consumer. Indian share in global rice production had been covering in the range of 19.50 to 24.52 %. The productivity of rice had been increased from 1984 Kg/ha in 2004-05 to 2372 Kg/ha in 2011-12. India's share in global rice export was 18.89% in year 2011-12.

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 tonnes 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 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.

In Kaimur district, out of total rice area 262149 acres, 31.00% area (80678 acres) was covered by fine rice while mostly area 181471 acres (69.00%) was covered by non- fine rice due to assured by canal, Govt. tube wells and private tube wells. 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 69.00% area in total district production 558570105 Kg. Average fine rice productivity was 1592 Kg/acre and 2358 Kg/acre in non-fine rice while as a whole productivity was calculated 2123 Kg/ha in Kaimur district in the year 2015-16 (District Agriculture Office, Kaimur and Analysed by researchers). Out of total value of rice in paddy form Rs.7480145568, the share of fine rice was Rs 2072811488 (27.72%) whereas non-fine rice contributed Rs 5148232644 (72.28%) in the year 2015-16. Eighteen varieties of fine rice had been cultivated –Govindbhog,Rrajendra sweta, Pooja, Krishna, Sonam, BPT-5204, Moti/Super moti/Moti gold, Katarni, Sonachur, Dehradoon, Sampda, Badsahbhog, Gopalbhog, Rajbhog, Tinsukiya , Aman, Jyotika and Damini along with two non-fine varieties /coarse varieties that were MTU-7029 (Nati mansuri) and Swarna sub-1 in Kaimur district. Grain yield of aromatic rice was comparatively lower than the coarse rice but the price of aromatic rice was 2-3 times higher than the coarse rice. Govindbhog (Aromatic rice) had wider acceptance to the consumers and were commonly used in special occasion or in festivals owing to its fineness as well as quality.

Among aromatic fine and medium fine varieties of rice, Govindbhog variety was the most popular in the district. Govindbhog was aromatic rice, had short white kernels with a good cooking quality and pleasant aroma. Some pockets of Mokari village of Bhabua block in Kaimur district, Govindbhog was famous for good aroma, taste and cooking quality due to some extra elements available in the soil. MSME-Development Institute (Ministry of Micro, Small and Medium Enterprises, Govt of India) also identified that major exportable item was the Govndbhog rice from Mokari, Bhabua in Kaimur district. That variety was grown for family consumption and marketing for income rising. That was being exported to most part of other states of the country and also some countries of the world.

Because massive cultivation/ production of aromtic 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:

Objectives:

1. To examine the status of Aromatic Fine Rice (Govindbhog) cultivation/production in the area under study.
2. To estimate the response of Govindbhog production to the various input factors on the sample farms.
3. To know the marginal value of productivity of different inputs on the sample farms.
4. To suggest the prospects of further enhancement in the profitability of cultivation/ production of "Govindbhog" Aromatic Fine Rice in the area under study.

In view of above objectives the following hypotheses were assumed to ascertain the established facts:

Hypothesis:

1. There is uniformity of crop production in contribution of various input factors on gross value of Govindbhog Rice production.

2. There is homogeneity in marginal value of productivity of inputs.

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 for this study due to massive cultivation of export quality aromatic fine rice "Govindbhog". At the second stage blocks lying in the selected sub-division were enlisted in respect of area under above fine rice. Thereafter out of 11 blocks (six in Bhabua sub-division and five in Mohania sub-division) two blocks were taken in the sample purposively 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, the villages lying in the selected blocks were enlisted in respect of area under aromatic fine rice (Govindbhog) and quantum of production. 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 farmers lying in the selected villages were enlisted in respect of area under their operational holding and area coverage under Govindbhog rice. Thereafter, ten farmers from each selected village were taken randomly in the sample for detailed survey and thus forty farmers (Govindbhog growers) were selected. Over and above two sub-divisions, 02 Blocks, 4 villages and 40 farmers were included in the sample for detailed investigation.

Tools of Analysis:

1. The acreage, production and other ingredients of aromatic fine were examined applying tabular analysis in the data with the use of various statistical measures.

2. To estimate the response of fine and aromatic rice production to various resource inputs the functional analysis of Cobb-Douglass type will be applied in the data:

The Model-

$$y = a\sum_{i=1}^{n} X_{xi}^{bi}$$

Whereas,

y = Stands for production/returns

x_i = regressors/input factors

b_i = Elasticities

a = Intercept

Elasticities will be tested applying 't' test.

$t= b_1 /(S.E. \text{ of } b_1)$

Where,

b_1 =Elasticities of X_1 variable

S.E. of b_1 =Sqrt $([\Sigma Y^2-(\Sigma X_1 Y)^2 /\Sigma X_1^2)] / [(n-k) (\Sigma X_1^2)])$

5. Coefficient of multiple determination (R^2) will be used to estimate the extent of variation in dependent variable under study due to the joint impact of the independent variables in the function.

R^2= R.S.S./T.S.S.

Where,

T.S.S. = $\Sigma Y^2 - [(\Sigma Y)^2 / n]$

R.S.S.=$b_1.Y.x_1 + b_2 .Y.x_2 + b_3.Y.x_3 \ldots\ldots + bn.Y.xn$

Results and Discussion

That part covered the discussion with the results obtained through analysis of data collected from primary source. That included the status of Aromatic Fine Rice (Govindbhog) cultivation/production in the area under study, cross sectional and tabular analysis along with Marginal Value Productivity regarding the persuasion of the objectives of the study. Cross

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

Area (in Acre),									Production (Qtl)
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
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**

Source: Block officials and field survey

sectional analysis contained the responsiveness of different variables on resultant factors.

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 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.

Cross Sectional Analysis

Cobb-Douglas production function was used to assess the elasticities of explanatory variables on resultant factor.

The model was used as

$$Y = a.\ x_1^{b_1} .\ x_2^{b_2} .\ x_3^{b_3} .\ x_4^{b_4} .\ x_5^{b_5}$$

Or In Log Form $Y = a + \log x_1 + \log x_2 + \log x_3 + \log x_4 + \log x_5$

Where:

Y = *Gross income from crops (Rs./acre)*

x_1 = *Seed Cost (Rs./acre)*

x_2 = *Manure and fertilizer cost (Rs./acre)*

x_3 = *Irrigation cost (Rs./acre)*

x_4 = *Human labour cost (Rs./acre)*

x_5 = *Machinery cost (Rs./acre)*

a = *Intercept*

b_1 = *Elasticity of* x_1

b_2 = *Elasticity of* x_2

b_3 = *Elasticity of* x_3

b_4 = *Elasticity of* x_4

b_5 = *Elasticity of* x_5

Elasticities and Coefficient of multiple determination (R^2) of Independent variables

Seed was the the most essential factor of crop production included in function. It was evident from table 2, 3 and 4 that to produce Govindbhog variety of rice, the elasticity of seed cost (x_1) on Gross value of crop production was positive but non-significant, showed positive response. It might be concluded that there was certainty of additional increase in Gross value of per acre crop production by 0.047 per cent with addition in seed cost per acre by one per cent. Thus, it was evident that there was lack of quality seed on the farm and by using quality seeds productivity would naturally increase. Manure and fertilizer was important resource for crop production as they provided nutrients to crops. The elasticity of Manure and fertilizer cost (x_2) on Gross value of crop production was positive and significant at 0.05 level of significance, showed positive response. It might be concluded that there was certainty of additional increase in Gross value of per acre crop production by 0.771 per cent with addition in Manure and fertilizer cost per acre by one per cent. It also indicated that large cultivators did not use the adequate doze of manure and fertilizer due to lack of capital resources. There might be increased in productivity of crops with enhanced doses of manure and fertilizers on the sample farms.

The elasticity of irrigation cost (x_3) on Gross value of crop production was positive but non-significant, showed positive response. It might be concluded that there was certainty of additional increase in Gross value of per acre crop production by 0.072 per cent with addition in irrigation cost (x_3) per acre by one per cent. Thus, it might be concluded that there was lack of adequate irrigation on the farms under study. Adequate irrigation would naturally increase the productivity on sample farms.

The elasticity of human labor cost per acre (x_4) on Gross value of crop production was positive and non-significant, showed positive response. It might be concluded that there was certainty of additional increase in Gross value of per acre crop production by 0.224 per cent with addition in human labor cost($x_{4)}$ per acre by one percent. Thus, it was also concluded that there was under use of human labor on the farms having surplus labor. Machinery (machine and farm implements) played a vital role to save cost, labor and time. Its elasticity on Gross value of crop production was negative and non-significant, showed negative response. It might be concluded that there was certainty of additional decrease in Gross value of per acre crop production by 0.101 per cent with addition in machinery cost (x5) per acre by one per cent.

Coefficient of multiple determination (R^2) was 0.9981 indicated that about 99.81 per cent of total variation in gross value of per acre crop production was being jointly explained by independent variables included in the equation.

Thus, finally it might be concluded that there were dissimilar influences of different independent variables on per acre gross value of crop production, although elasticities of seed cost (x_1), manure fertilizer cost (x_2), irrigation cost (x_3), human labour cost (x_4) were positive and machinery cost (x_5) was negative. Manure and fertilizer cost (x_2) was found significant and rest variables were non-significant but their influences were not similar. Enhancement of different variables except machinery cost would result unequal increase in per acre gross value of Govindbhog rice production on sample farm.

Return to Scale

The elasticity of an individual factor indicated the percentage by which output would be increased with one per cent additional increased in the factor. The summation of elasticities in Cobb-Douglas production function showed the degree of return to scale in production. Present study analysed the same.

Table 4 showed that the summation of elasticities ($b_{i=}b_{1+}b_{2+}b_{3+}b_{4+}b_5$) was 1.033. That indicated the increasing return to scale in crop production on sample farms of Govindbhog variety. That revealed the possibility of additional increase in independent variables viz. seed cost (x_1), manures and fertilizers cost (x_2), irrigation cost (x_3), human labour cost (x_4) and machinery cost (x_5) per acre by one percent to enhance per acre gross income by 1.03 per cent on sample farms.

Table 2. The Fitted Equation /Multiple Regression of Equation

Variety	Equation
Govindbhog	$Y = -0.267+x_1^{0.047}+x_2^{0.771}+x_3^{0.072}+x_4^{0.244}+x_5^{-0.101}$

Table 3. Analysis of Variance, Variety - Govindbhog

Varieties/category of farmer		Source of Variation	D.F	S.S	M.S.S	Variance ratio
		Regression	5	66.5463	13.3093	2916.64**
Govindbhog	Large	Residual	34	0.1232	0.0046	
		Total	**39**	**66.6696**		

Source : Analyzed primary data **Singnificant at 0.01 level of significance

Table 4. Elasticities and Standard error of Independent variables, Variety - Govindbhog

Independent variables	Elasticities	Standard error
Intercept (a)	-2.267	-
Seed cost/ acre (x_1)	0.047	0.115
Manure fertilizer cost per acre (x_2)	0.771*	0.172
Irrigation cost/acre (x_3)	0.072	0.140
Human labour cost per acre (x_4)	0.224	0.174
Machinery cost/ acre (x5)	-0.101	0.128
R^2	0.9981	
Sumation of elasticities (© $b_i=b_{1+}b_{2+}b_{3+}b_{4+}b_5$)	1.033	

Source : Analyzed primary data *Singnificant at 0.05 level of significance

Marginal Value Productivity

The term marginal value productivity was related to economic efficiency of the use of resources. It referred to the addition in total value product corresponding by increase as one individual unit of input. It further reflected the stages of production function in which production was performed. Varieties and categories wise some inputs were underutilized and some were over utilized therefore the marginal value productivity were positive and negative, higher and lower than unity. Table 5 revealed that in Govindbhog rice variety, Marginal value productivity of machinery cost (x_5) was positive and value was found 1.52 indicated that one rupee addition in machinery cost of per acre crop production would increase gross value of crop production per acre by Rs. 1.52. Marginal value productivity Seed cost Rs. (x_1), Manure and fertilizer cost Rs. (x_2), Irrigation cost Rs.(x_3), Human Labour cost Rs. (x_4) were found negative and their values were -0.89,- 0.26, -6.04 and -0.87 respectively. Those values of variables indicated that additional increased of rupee one for per acre crop production on sample large farms of rice variety Govindbhog would decrease per acre gross value of crop production by Rs.-0.89, Rs.- 0.26, Rs.-6.04 and Rs. -0.87 due to increased in Seed cost Rs. (x_1), Manure and fertilizer cost Rs. (x_2), Irrigation cost Rs.(x_3), Human Labour cost Rs. (x_4) per acre respectively.Those negative values also indicated that costs/ quantities of seed, fertizers and manures, irrigation and human labour would be lower than used costs /quantities in samples. Maximum loss were incurred Rs. -6.04 of seed input.

TABLE 5. Marginal Value Productivity of Different Input Factors on Sample Farms

Seed Rs. (x_1)	Manure and fertilizer Rs. (x_2)	Irrigation Rs. (x_3)	Human Labour charge Rs. (x_4)	Machinery charges Rs.(x_5)
-0.89	-0.26	-6.04	-0.87	1.52

Conclusions

Cobb-Douglas production function was used to assess the elasticities of explanatory variables on resultant factor. Marginal Value Productivity of inputs (seed, fertilizers, irrigation, human labor and machinery cost). There was no uniformity of crop production in contribution of various input factors on gross value of Govindbhog Rice production. There was no homogeneity in marginal value of productivity of inputs. The summation of elasticities ($b_{i=}b_{1+}b_{2+}b_{3+}b_{4+}b_5$) was 1.033. That revealed the possibility of additional increase in independent variables viz. seed cost (x_1), manures and fertilizers cost (x_2), irrigation cost (x_3), human labour cost (x_4) and machinery cost ($x_{5)}$ per acre by one percent to enhance per acre gross income by 1.03 per cent on sample farms. Marginal value productivity of machinery cost ($x_{5)}$ was positive and value was found 1.52 indicated that one rupee addition in machinery cost of per acre crop production would increase gross value of crop production per acre by Rs. 1.52. Marginal value productivity Seed cost Rs. ($x_{1),}$ Manure and fertilizer cost Rs. (x_2), Irrigation cost Rs.(x_3), Human Labour cost Rs. (x_4) were found negative and their values were -0.89,- 0.26, -6.04 and -0.87 respectively. On the basis of Marginal Value productivity sampled farmers could increase their gross value of Govindbhog production by increasing the cost on farm machinery and cost might be reduced on seed, fertilizers, irrigation and human labor. According to result of return to scale sampled farmers could increase their each input up to summation of elasticity would be 1.

Suggestions for enhancement of yield and income in future

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 Govt, 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 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. Govindbhog variety should be developed by using biotechnology so that yield could be increased without losing its main characters. Organic Farming with Contract Farming would also help in quality and yield enhancement as well as market management of fine rice so that sampled farmers would get better price for their produce. E-Marketing and SEZ (Special Economic Zone) would help to increase the income from Super fine aromatic rice. Sampled farmers would be protected by Govt. through economic security. 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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Status of Leaf Curl Disease of Tomato in Eastern Uttar Pradesh

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Abstract

The present study is an attempted to observe Tomato Leaf Curl Virus incidence status in ten districts viz. Bahraich, Balrampur, Basti, Deoria, Faizabad, Gonda, Santkabir Nagar, Shrawasti, Siddharthn Nagar and Sultanpur of Uttar pradesh. The study was conducted to establish the prevalence and severity of Tomato leaf curl viral disease in the major agroclimatic zone of tomatocultivating regions in Uttar Pradesh. The incidence of the disease was varying from place to place probably due to varying agro-climatic conditions.

Keywords :*TLCV, survey, tomato.*

Tomato (Lycopersiconesculentum Mill.) family solanaceae, of tropical American origin, is one of the most popular and extensively grown vegetables in the world. Now it is grown throughout the year but more commonly as winter crop in Uttar Pradesh. It is rich source of various vitamins and antioxidants. Among the factors responisible for low yield of tomato, viral diseases are considered as the most serious. Tomato is susceptible to more than 200 diseases, out of which 40 are caused by viruses (Lukyanenko 1991). Among these viral diseases, *Tomato leaf curl virus* (TLCV) belonging to family *Geminiviridae* and genus *Begomovirus* is considered most devastating. A recent socio-economic survey ranked Tomato leaf curl virus (TLCV), transmitted by B. *tabaci*, as the most important disease causing virus of tomato (Chowda, R.V 2004). There are 21 different types of *Tomato leaf curl viruses* found in India.

Tomato leaf curl disease is manifested by yellowing of leaves, upward leaf curling, bushy growth, and leaf distortion, shrinking of leaf surface, stunted plant growth, excessive branching, and abnormal growth of plants and flower and fruit abscission. Epidemics of *Tomato leaf curl virus* associated with upsurge of whiteflies (*Bemisia tabacci*) on tomato crops has been frequently reported with up to 100% yield lossesAmong the different diseases attacking tomato leaf curl is the most important, as sometimes it leads to cent percent crop losses (Butter &Rataul, 1981, Saikia & Muniyappa, 1989, Ansari &Tiwari, 2005). Tomato leaf curl virus is transmitted by whitefly, BemisiatabaciGenn. In Uttar Pradesh disease is widely prevalent and estimated to cause of 27-40% loss (Ansari, *et.al* 2005). Therefore, the present study is aimed to see the status of leaf curl disease of tomato in eastern Uttar Pradesh.

Materials and Methods

A survey of tomato field was conducted in 10 district viz. Bahraich, Balrampur, Basti, Deoria, Faizabad, Gonda, Santkabir Nagar, Shrawasti, Siddharthn Nagar and Sultanpur during October to Novenber 2016 to record the incidence of TLCV. Five villages under major areas of tomato were spotted at the distance of 15-20 km. in each district.The overall disease incidence and severity was recorded based on visual symptoms The diseased and healthy tomato plants count were taken from 3 x 2 m. area of five random places in each of five fields in every villages and percent disease incidence (PDI) was calculated by following formula-

$$\text{Disease Incidence \%} = \frac{P_1 \times 100}{P_2}$$

Where, P1 = Number of infected plant.

P2 = Total number of plant

Results and Discussion

The average incidence (based on 5 villages in each districts) was highest 38.0% in Balrampur and lowest 8.2% in Sultanpur. Bahraich, Gonda, Shrawasti were also affected with TLCV showing 35.1 to 25.2 % of disease. The number of TLCV infected plants was highest at MaharajganjTarai village in Balrampur district. The disease varied from year to year and place to place (Verma 1984, Ansariet.al. 2004, 2006), which may be due to varying agroclimatic conditions. The leaf curl disease was also higher in the field with sole crop of tomato than in field intercropped with cucumber, egg plant or corn plants (AL-Musa, 1982).

Two major factors are known to be responsible for high TLCV infection in this region Eastern Uttar Pradesh are cultural practices and climatic conditions. Our study thus supports reports of climatic influence on development of TLCV infection which is in accordance to finding of [8Polizzi, G.1994].M. Shelat1et.al (2014) reported that agroclimatic condition and cultural practices are responsible for disease incidence in Gujrat.

Conclusion

Based on the above data, it can be concluded that TLCV infection is widely spread in all regions of Uttar Pradesh varying disease incidence from 8.2% to 38%. Therefor disease management is essential to control and manage the TLCV. Various factors such as climatic conditions and cultural practices play a vital role in the level of infection.However, ecofriendly management had greater role is reducing the incidence of the disease (Tripathi and Verma, 2002, Ansari and Tewari, 2005).

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Table 1. Incidence of TLCV of Tomato.

Distric	Disease incidence* %
Bahraich	26.5
Balrampur	38.0
Basti	15.8
Deoria	10.5
Faizabad	20.8
Gonda	35.1
Santkabir Nagar	8.5
Shrawasti	25.2
Siddharth Nagar	10.8
Sultanpur	8.2

* = Average of five villages of one district

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Effect of Integrated Phosphorus Management on the Yield and Nutrition of Rice (*Oryza Sativa* L.)

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Abstract

A field experiment was conducted during the *Kharif* season of 2015 at new alluvial zone of West Bengal to evaluate the effect of integrated P management on the yield and nutrition of rice in an inceptisol using rice (Cv. IET-4786) as a test crop with six different treatment combinations in a randomised block design (RBD) replicated four. For this purpose integrated application of NPK, Zn, organic matter and PSB were used with different doses in different treatments. The amount of both P and Zn content in rice biomass were recorded an increase due to integrated use of inorganic and organic resource materials along with bioinoculants, phosphate solubilising microorganism. The highest grain yield of rice was recorded in the where 50% NPK Recommended+ organic matter at 5t ha^{-1} + Zn at 5 kg ha^{-1}+ PSB (@ 10 kg ha^{-1} was applied.

Key words : *organic manure, phosphorus nutrition, rice, zinc*

Introduction

Phosphorus is one of the seventeen essential nutrients required for plant growth. It is the second most important macronutrient next to nitrogen in limiting crop growth. Plant dry weight may contain up to 0.5% phosphorus and this nutrient is involved in an array of process in plants such as in photosynthesis, respiration, in energy generation, in nucleic acid biosynthesis and as an in plants growth and metabolism. Present rice productivity is not enough to feed ever increasing population of this country. Thus, the only alternative left is vertical increase in yield since expansion of area is not possible. Integrated nutrient management in wetland rice is a needed strategy involving conjunctive use of chemical fertilizers & bio-organic sources for realization of potential yield on sustained basis. Farmyard manure or compost and use of phosphate solubilizing bacteria in wetland rice are the common practices. Phosphorus is the least accessible macronutrient and hence most frequently deficient nutrient in most agricultural soils because of its low availability and its poor recovery from the applied fertilizers. Slow mobility of applied phosphorus and its marked fixation results in low crop recoveries in the order of 20-25%. Phosphate solubilizing bacteria (PSB) solubilize and mineralize the residual or fixed phosphorous, increases phosphorus availability in the soil and also the overall phosphate use efficiency. Keep in this view the present investigation is being undertaken to the "Effect of integrated P management on the yield and nutrition of rice (*oryza sativa L.)"*.

Materials and Methods

A field experiment was conducted during the *Kharif* season of 2015 at new alluvial zone of West Bengal to evaluate the effect of integrated P management on the yield and nutrition of rice in an inceptisol using rice (Cv. IET-4786) as a test crop with six different treatment combinations in a randomised block design (RBD) replicated four. The physic-chemical properties of the experimental field soil were: pH 6.87, EC, 0.05 dSm^{-1}; Organic Carbon, 1.00%; CEC,15.76 cmol(p+) kg^{-1}; Available N, 174.00 kg ha^{-1}; Available P, 12.18 kg ha^{-1}; Available K, 278.00 kg ha^{-1}; Available S, 7.05 mg kg^{-1}.

Treatment details:

T0 – Control, Recommended NPK (60:30:30)

T1 – NPK +Zn at 5 kg ha^{-1}

T2- 75% NPK Recommended + organic matter at 2.5 t ha^{-1}+Zn at 5 kg ha^{-1}+ PSB (@10kg ha^{-1})

T3- 50% NPK Recommended + organic matter at 5 t ha^{-1} + Zn at 5 kg ha^{-1} + PSB (@10kg ha^{-1})

T4- 50% NPK Recommended + organic matter at 10 t ha^{-1} + PSB(@10kg ha^{-1})

T5- 50% NPK Recommended + organic matter at 10 t ha^{-1} + Zn at 5 kg ha^{-1} +PSB (@10kg ha^{-1})

Half of the recommended dose of nitrogen and full dose of potassium and phosphorus were applied as basal application and remaining half nitrogen was applied in two equal splits at active tillering and panicle initiation stages uniformly to all the treatments. Organic matter was applied basally as per treatments and PSB was applied at the rate of 10 kg ha^{-1} at the time of transplanting. Zn fertilizer was applied after 7 days of transplanting.

Periodic collection and analysis of plant samples were made by spectrophotometrically following vanadomolybdate yellow colour method after oven drying and subsequent digesting plant samples (Jackson, 1973). Periodic analysis of Zn in plant samples were also done by Atomic Absorption Spectrophotometer.

Results and Discussion

The results (table 1) show that the amount of P content in rice biomass has been found to be initially increased up to 45 days and thereafter, the amount of the same decreased irrespective of treatments. However the magnitude of such changes varied with treatments, being recorded highest (9.07 mg kg^{-1}) in the treatment T3 where 50% NPK Recommended + organic matter at 5 t ha^{-1} + Zn at 5 kg ha^{-1} + PSB (@10kg ha^{-1}), at 45 days of crop growth.

Table 1. Amount of Phosphorus content (mg kg^{-1}) in rice biomass affected by integrated P management

	Days after transplanting(mean values of 4 replications)					
Treatments	**15 days**	**30 days**	**45 days**	**60 days**	**75 days**	**Mean**
T0	4.46	5.08	5.85	5.25	5.12	5.15
T1	4.90	5.54	6.81	5.78	5.16	5.64
T2	5.14	6.34	8.02	6.50	6.00	6.40
T3	6.09	7.32	**9.07**	7.61	7.24	**7.47**
T4	5.45	6.33	7.56	6.88	6.57	6.56
T5	5.00	6.41	7.95	7.25	7.08	6.74
Mean	5.17	6.17	7.54	6.54	6.19	
C.D(P=0.05)	**0.117**	**0.26**	**0.199**	**0.199**	**0.223**	

The results of the present investigation also find support from the findings reported by Singh *et.al* (2012) who showed that the application of organic and inorganic fertilizers along with bioagents increased concentration and uptake of P by rice which might be due to increased mobilisation and solubilisation of native P by increasing production of organic acids by P solubilising micro-organisms.

The mean values after 75 days of all treatments shows that P content in mg kg^{-1} in rice biomass followed the order T3>T5>T4>T2>T1.>T0.

The results (table. 2) show that the amount of Zn content in rice biomass has been found to be initially increased up to 45 days and thereafter, the amount of the same decreased irrespective of treatments. However the magnitude of such changes varied with treatments, being recorded highest (41.03 mg kg^{-1}) in the treatment T3 where 50% NPK Recommended + organic matter at 5 t ha^{-1} + Zn at 5 kg ha^{-1} + PSB (@10kg ha^{-1}), at 45 days of crop growth. The mean values after 75 days of all treatments shows that P content in mg kg^{-1} in rice biomass followed the order T3>T5>T4> T2> T1.> T0.

From table-3, it was found that the highest grain yield (7.58 t ha^{-1}) was recorded with the application of 50% NPK recommended which exhibit superiority over 75% NPK recommended. Combined application of organic matter at 5 t ha^{-1} + Zn at 5 kg ha^{-1} + PSB (@10kg ha^{-1}) recorded the maximum grain yield (7.58 t ha^{-1}) which was significantly superior to other bio-organic sources.

Maximum straw yield (9.37 t ha^{-1}) was noted with the combined use of 5 t ha^{-1} + Zn at 5 kg ha^{-1} + PSB (@10kg ha^{-1}) in combination with 50% NPK recommended which proved significantly superior over the treatments without Zn fertilizer and PSB. Nayak *et.al.*(2000) reported that the application of optimum levels of phosphorus and zinc , where both the nutrients are efficiently utilised in plants , maximised yield. They also reported that the addition of organic matter reduced the negative interaction effect between P and Zn in grain and straw yield which might be explained by the regulating effect of applied organic matter on P/Zn balance in the plant and soil. However, the yield of both rice grain and straw was significantly varied with the treatments, being greater variation was recorded between T2 and T3 treatments. The following

TABLE 2. Amount of Zinc content (mg kg^{-1}) in rice biomass affected by integrated P management

Treatments	Days after transplanting(mean values of 4 replications)					
	15 days	30 days	45 days	60 days	75 days	Mean
T0	26.29	27.61	28.42	24.85	23.90	26.21
T1	27.49	28.51	29.83	25.69	24.38	27.18
T2	28.38	29.41	31.66	27.38	25.52	28.47
T3	31.25	35.78	**41.03**	37.39	35.81	**36.25**
T4	27.79	31.51	33.69	29.63	26.54	29.83
T5	28.27	32.27	34.51	30.58	27.48	30.62
Mean	28.24	30.85	33.19	29.25	27.27	
C.D(P=0.05)	**0.252**	**0.262**	**0.207**	**0.311**	**0.324**	

TABLE 3. Grain and straw yield of rice (t ha^{-1}) affected by integrated P management (Mean data)

Treatments	Grain Yield of Rice in (t ha^{-1})	Straw Yield of Rice in (t ha^{-1})
T0	6.62	8.33
T1	6.80	8.63
T2	6.87	8.75
T3	**7.58**	**9.37**
T4	7.37	9.06
T5	7.45	9.17
C.D(P=0.05)	**0.084**	**0.318**

trend was observed with respect to the yield of both rice grain and straw:

T3 > T5 > T4 > T2 > T1 >T0

Increase in grain and straw yield might be due to higher photosynthetic activity because of increased leaf area index, which ultimately promoted dry matter production resulting higher grain and straw yield (Quyen *et. al*.,2003). Naik and Das (2007) also reported that the highest yield of rice grain and straw was recorded in the treatment receiving 1.0 kgha^{-1} Zn as Zn-EDTA with the simultaneous 37.56 percent increase in grain yield over control.

The results (Table 4) show that the both P and Zn content in rice biomass exhibited a significant positive correlation with grain and straw yield of rice

Table 4. Correlation co-efficient between different parameters with grain and straw yields

	P content	Zn content	Grain yield	Straw yield
P content	1	0.927***	0.918***	0.967***
Zn content		1	0.870***	0.904***
Grain yield			1	0.982***
Straw yield				1

Which suggest that the P content in rice biomass has been found to be contributed more towards contributing rice grain yield.

Conclusions

From the present study, it may be concluded that the phosphorus and zinc content in rice biomass have been found to be significantly varied with different integrated applications of phosphatic fertilizers, organic manures and phosphate solubilising bacteria. However, the treatment T_3 (50% NPK Recommended + organic matter at 5 t ha^{-1} + Zn at 5 kg ha^{-1} + PSB (@10kg ha^{-1}) was proved superior treatment combination with respect to yield of rice followed by the treatment ,T_5 where 50% NPK Recommended + organic matter at 10 t ha^{-1} + Zn at 5 kg ha^{-1} +PSB @10kg ha^{-1} was applied.

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Effect of Priming methods and Re-Drying duration on Germination and Vigour Characters of Paddy (*Oryza sativa* L.)

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Abstract

The experiment was conducted to standardize the best priming method and re-drying duration specific to Paddy. Two methods of priming *viz.,* hydro-priming and halo-priming were evaluated by screening a range of durations (12, 24 & 48 hrs.) and re-drying duration (2 & 4 hrs). Hydro-priming of 48 hrs.and 2 hrs. re-drying of seeds displayed significantly high per cent of seed germination, seedling length, fresh weight, dry weight, speed of germination and vigour as compared to other priming and unprimed seeds. But in case of root length, halo priming seeds shows better results. Salinity and less priming time decreased germination and vigour of seeds. It is also found that hydro-priming could be best option than halo-priming in Paddy. Hydrated seeds can be re-dried for two hours without loss of physiological advancement obtained from hydration phase. The quality of seed with the help of seed priming treatments which are cost effective, economic, non toxic, eco-friendly sources can be improved.

Key word : *Rice seed, Hydro-priming, Halo-priming, Re-Drying, Vigour*

Introduction

Rice (*Oryza sativa* L.) belongs to the grass family Poaceae, genus *Oryza* (L) of which two species are cultivated *O. sativa* (L) and *O. glaberrima* (Steud). It is normally grown as annual crop and can grow up to a height of 1 – 1.8m depending on the variety and soil fertility. In tropical areas it can survive as a perennial and can produce a ratoon crop for up to 30 years [7]. Rice cultivation is well suited to countries and regions with low labour costs and high rainfall as it is labour-intensive to cultivate and requires ample water. Rice is widely cultivated in most agro-ecological zones in India. The nutritional value per 100g of rice contains energy of about 1,527KJ (365Kcal), carbohydrate 80g, sugar 0.12g, dietary fiber 1.3g, fat 0.66g, protein 7.13g and water 11.61g. Rice is used as a staple food by more than 60% of the world population. Over boiled rice is used in Asia for starching clothes. Rice bran is used in confectionery products like biscuits, cookies *etc.* The oil from the rice bran is used as edible oil, in soap and fatty acids manufacture [6]. A hydrated seed with water and re-drying them before they complete germination (hydro priming minimizes the use of chemicals and avoids discarding materials that may be undesirable to the environment [10]. Hydro-priming is a very special, simple, economical and eco-friendly priming technique because only plain water is used. Seed priming is a procedure in which seed is soaked in water and then dried back to its original water content. This is done to make the seed perform better. The beneficial effects of priming have being associated with various biochemical cellular and molecular events including synthesis of ribonucleic acid (RNA) and proteins[2]. Hydro-priming involves soaking the seeds in water before sowing. Involve soaking of seed in water beforesowing. This pre sowing seed treatment, known as hydro-priming, allows the seed to imbibe water and go throughthe first phase of germination in which pre-germination metabolic activities are started while the latter two phases ofgermination are inhibited[11].Halo priming refers to soaking of seeds in solution of inorganic salts *i.e.*NaCl, KNO3 CaCl2, CaSO4, etc. A number of studies have shown a significant improvement in seed germination, seedling emergence and establishment, and final crop yield in salt affected soils in response to halo-priming [9]. Salt stress reduces the total dry matter, chlorophyll content, relative water content (RWC) in maize, but increases proline accumulation, enzyme activities and electrolyte leakage[17]. Seed germination is a major factor limiting the establishment of plants under saline conditions and is the most critical phase in plant life that greatly influenced by salinity.

Materials and Methods

A series of laboratotry experiment were conducted in the Post Graduate Laboratory Department of Genetics and Plant Breeding, Sam Higginbottom University of Agriculture, Technology & Science Allahabad, Uttar Pradesh, India during 2016-2017, Treatments consisted three hydro priming and halo priming durations of 12, 24, and 48 hrs at two periods of re-drying (two and four hours) and control (unprimed seeds) making a total of 13 treatments. Parameters were taken into consideration for assessment on fresh seed of the paddy (swarna). The treatments were be laid out in a completely randomized design (CRD) replicated four times. The hydro priming was imposed as per treatments. The temperature of the water during priming was 25!and the environmental temperature was 30!. The quantity of 250 ml water used to the rice seeds and Halo-primed with NaCl solution (4g/l) for different hour at same temperature. Following this treatment, seeds were washed three times for 5 min with distilled water. After priming, the seeds were dried in room temperature for 2 & 4 h at 25°C.

Results

The detail of material used and technique adopted during the course of investigation are furnished in this section.

Germination percent

Among the treatments, seeds treated with Hydro-priming (48 hours) and 2 hours dried of seeds (T_5) recorded Significantly high germination percentage (77.5%). Lower seed germination was recorded throughout the priming with untreated control (T_0) which recorded low germination percent (69.75%).

Speed of germination

The treatments, seeds treated with Hydro-priming (48 hours) and 2 hours dried of seeds (T_5) recorded Significantly high germination percentage (75%). Lower seed germination was recorded throughout the priming with untreated control (T_0) which recorded low germination percent (66%).

Root length (cm)

There was significantly high root length (cm) was recorded with seeds treated with Halo-priming (48 hours) and 2 hours dried of seeds (T_{11}) at the priming duration (6.1). Lower root length was recorded throughout the priming with untreated control (T_0) which recorded low root length (3.85).

Shoot length (cm)

Significantly high shoot length (cm) was recorded with treated with Hydro-priming (48 hours) and 2 hours dried of seeds (T_5) recorded significantly high shoot length (5.32). Lower shoot length was recorded throughout the priming with untreated control (T_0) which recorded low shoot length (2.82).

Seedling length (cm)

Seedling length gradually increased with period of increase seed priming duration in all the treatments. Significantly high seedling length (cm) was recorded with treated with Hydro-priming (48 hours) and 2 hours dried of seeds (T_5) recorded Significantly high seedling length (10.48). Lower seedling length was recorded throughout the priming with untreated control (T_0) which recorded low seedling length (7.67).

TABLE 1. Analysis of variance for first count on nine difference parameter in paddy

S.N.	Characters	Mean sum of squares	
		Treatments (df=12)	Error (df=36)
1.	Germination Percentage	36.1**	1.33
2.	Speed of germination	39.75*	14.92
3.	Root length	1.52**	0.0092
4.	Shoot Length	2.45**	0.0133
5.	Seedling Length	2.004**	0.055
6.	Seedling Fresh Weight	0.0014*	9.63
7.	Seedling Dry Weight	0.0026**	7.35
8.	Seed Vigour Index I	5943**	38.21
9.	Seed Vigour Index II	6.09**	0.0266

TABLE 2. Analysis of variance for final count on nine difference parameter in paddy

S.N.	Characters	Mean sum of squares	
		Treatments (df=12)	Error (df=36)
1.	Germination Percentage	17.35**	8.29
2.	Speed of germination	32.2*	9.1
3.	Root length	1.14**	0.51
4.	Shoot Length	2.4**	0.19
5.	Seedling Length	2.2**	0.21
6.	Seedling Fresh Weight	0.00572*	0.00042
7.	Seedling Dry Weight	0.00146**	0.000117
8.	Seed Vigour Index I	15.6746**	2.8
9.	Seed Vigour Index II	15.9**	2.4

Fresh weight of seedling (g)

Significant differences in seedling fresh weight were observed in seed treatments high fresh weight of seedling (g) was recorded with treated with Hydro-priming (48 hours) and 2 hours dried of seeds (T_5) recorded Significantly high fresh weight of seedling (0.613). Lower fresh weight of seedling was recorded throughout the priming with untreated control (T_0) which recorded low fresh weight of seedling (0.482).

Dry weight of seedling (g)

Significant differences in seedling dry weight were observed in seed treatments high dry weight of seedling (g) was recorded with treated with Hydro-priming (48 hours) and 2 hours dried of seeds (T_5) recorded Significantly high dry weight of seedling (0.233). Lower dry weight of seedling was recorded throughout the priming with untreated control (T_0) which recorded low dry weight of seedling (0.17).

TABLE 3. Effect of different treatments on nine characters of paddy

S.N.	Treatments	Germination %	Speed of germination	Root Length (cm)	Shoot Length (cm)	Seedling Length (cm)	Fresh Weight of Seedling (g)	Dry Weight of Seedling (g)	Seed Vigour Index I	Seed Vigour Index II
1	T_0	69.75	66	3.85	2.825	7.6725	0.482	0.170	534.98	11.65
2	T 1	72	67.5	5.0	3.25	8.65	0.507	0.1915	622.8	13.78
3	T_2	71.5	67	4.9	3.1	8.575	0.497	0.1865	607.75	13.33
4	T_3	74.25	70.6	5.15	3.95	9.2675	0.554	0.2015	687.55	14.76
5	T_4	73	68.5	4.9	3.7	8.8425	0.548	0.2014	645.32	14.7
6	T_5	**77.5**	**75**	5.88	**5.325**	**10.4875**	**0.613**	**0.23325**	**812.2**	**18.07**
7	T_6	75	73.5	5.625	5.075	9.735	0.573	0.230	729.75	17.25
8	T_7	71	67.5	4.85	3.0	8.525	0.491	0.18325	604.92	13
9	T_8	70.25	66	4.675	2.975	8.2175	0.482	0.17325	576.75	12.16
10	T_9	73.75	69.7	5.3	3.525	8.925	0.536	0.2015	657.85	14.86
11	T_{10}	71.75	67.5	5.175	3.375	8.75	0.512	0.19825	627.81	14.22
12	T_{11}	74.75	74	**6.1**	4.25	9.7725	0.56	0.215	723.3	16.07
13	T_{12}	73.25	72.5	5.95	4.025	9.48	0.554	0.20325	694.41	14.88
Grand Mean		72.9	69.8	5.1	3.5	8.99	523.2	0.199	656.7	14.5
C.D.(5%)		4.26	5.4	1.018	0.636	1.018	0.029	0.0155	6.9	1.5
SE(m)+_		1.49	5.3	0.356	0.222	0.356	0.01	0.0054	1.9	4.3
C.V.		4.09	13.03	13.9	12	14	3.9	5.43	2.1	2.1

Seed vigour index I

Significantly higher Seed vigour index I was recorded with treated with Hydro-priming (48 hours) and 2 hours dried of seeds (T_5) recorded significantly high Seed vigour index I(812.2). Lower Seed vigour index Iwas recorded throughout the priming with untreated control (T_0) which recorded low Seed vigour index I(534.9).

Seed vigour index II

Significantly high Seed vigour index II was recorded with treated with Hydro-priming (48 hours) and 2 hours dried of seeds (T_5) recorded significantly high Seed vigour index II(11.65). Lower Seed vigour index II was recorded throughout the priming with untreated control (T_0) which recorded low Seed vigour index II(18.07).

Discussion

Germination percent

The improve in germination percentage may be subjected to the long duration of priming. it is notices that high value of germination. Generally earlier germination might be due to higher synthesis of DNA, RNA and protein during priming and it might be due to the attributed to increased metabolic activities in the hydro-primed duration increased. These observations are lined with the observations of [1][2], It is clear from that increasing concentrations of NaCl salinity reduced germination [13][15].

Speed of germination

The promote speed of germination may be attributed to long hydro-priming may help in dormancy breakdown possibly by embryo development and/or leaching of emergence inhibitors during priming as a result the increased germination energy [2][12].

Root and shoot length (cm)

NaCl priming significantly improved root length in paddy. Seedling growth was suppressed under saline conditions, which is strongly in accordance [4], hydro-primed seeds germinate faster and produced taller seedlings when compared with untreated seeds [16]. Reported taller seedling with hydro-primed seedsat two weeks after sowing. This result might be due to Faster emergence after priming may be due to increased rate of cell division in the root tips of seedlings from NaCl primed seeds as reported in wheat [3] [5] .

Fresh weight and dry weight (gm)

Fresh weight and dry weight of seedling significantly increases with priming duration increases because physiological activities start early enough and continue at faster rate up to the point of physiological maturity [19] [14]. Salt stress reduces the total dry matter, chlorophyll content, relative water content (RWC), but increases proline accumulation, enzyme activities and electrolyte leakage [17].

Seed vigour index I and Seed vigour index II

The increase in the seed vigour mass, seed vigour index may be due to priming duration and material induce promote in germination, increase in root and shoot length, seedling dry weight and higher electrical conductivity. Higher seed vigour index in hydro-priming increase priming duration, the seed soaking was done in double physiological, enzyme active and leaching of emergence inhibiter element. similar findings were reported by [18] [13] [12].

Conclusion

From the results of the present study, table 1, 2 & 3 revealed that in case of rice there has been decrease in quality parameters in the treatments with the decrease in priming time and increase re-drying time, But in case of root length halo priming seeds shows better result. It can be concluded that T5 (Hydro-priming 48 hours and 2 hours dried) followed by T6 (Hydro-priming 48 hours and 4 hours dried) recorded high germination per cent, speed of germination, shoot length, seedling length, fresh and dry weight of seedling, vigour index I and II. Priming with wateris ecofriendly and economic in use.

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