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An Outsketch of Organic Farming in North-Eastern India :

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Abstract

Before green revolution, farmers use to cultivate using natural inputs for production of cereals, pulses, oilseeds and other vegetables and fruits. Farm-mechanization was not introduced in India till the advent of green revolution. Seed treatment, plant nutrients, pest management all were based on natural sources. But during the mid 60's chemical inputs have taken slowly on all agricultural practices and thus degradation of soil fertility, ground water started to take place leading to introduction of various health hazards in human lives. This rapid use of inorganic nutrients is slowly leading to destruction of soil micro-environment which in future may stand as a serious threat to "Mother-Nature". North-Eastern states of India consisting of 8 states are full of rich diverse flora having various indigenous crop of its own. The agro-climate of the region is generally rainfed, which is most favourable for organic farming. Less utilization of synthetic fertilizers (<12.0 kg/ha) and chemicals, huge availability of biomass and animal manure are characteristics of the region, therefore, this region, put forward enough prospects for organic farming.

Key word: Green revolution, organic farming, synthetic fertilizer.

Introduction

At present, India ranks second world wide in agriculture where 70% of rural households depends on agriculture for their livelihood. Agriculture contributes 20.2% to the GDP of India. Since from the introduction of green revolution, chemical inputs in agriculture started to take over in day to day farming activities. Highest agricultural pesticide consumption per hectare was recorded in Punjab followed by Haryana and Maharashtra according to 2016-2017 data (Ministry of Chemicals and Fertilizers, Govt. of India, GCA based on 2014-15). Today India is second largest populous country behind China. Due to ever-increasing population, food demand is increasing and due to this agro-chemical market is growing continuously for input in agricultural produce for obtaining higher productivity and leading to environmental degredation. Excess or overuse of chemical pesticide is another reason for degradation of nature. To overcome the problem of environmental degradation, farming through use of natural inputs through reducing chemical input must be adopted by farmers immediately.

According to the United States Department of Agriculture study team, "organic farming is a system that avoids or largely excludes the use of synthetic inputs and depends, to the greatest extent possible, on crop rotations, crop residues, animal manures, off-farm organic wastes, mineral grade rock additive, and biological systems of the soil." According to a survey report, In India, about 528,171-hectare cultivable area is under organic cultivation (includes certified and areas under organic conversion) with total 44,926 certified organic farms which is about 0.3% of total agricultural land (Ramesh *et al.,* 2010). The organic farming sector in India basically concentrates on exports of organic produce which worths US$78 million as per estimation. According to the Agricultural and Processed Food Products Export Development Authority (APEDA), which is a nodal agency concerned in promoting Indian organic agriculture, organic products costing Rs 301 million for about 585,970 tonnes are being exported from India.Organic agriculture is the only best suited option for prolongation of soil and surrounding nature. The basic aim of organic agriculture is to cultivate crops for human and domestic use without conventional fertilisers, synthetic pesticides,growth hormones, chemicals or genetically modifiedorganisms, maintaining ecological balance without any environmental problems. It basically comprises of traditional, innovative and scientific knowledge to sustain and balance the ecosystem and boost up the quality of life and relationship of humans with nature (Bordoloi *et al.,* 2020). India ranks 9th worldwide based on agricultural land for organic farming and contribute only 10% of organic produce in the world.

Strengths of organic farming in NE region:

At present, a total of 1,98,348 ha is used for organic cultivation in the North-East that includes approx. 1,38,328 ha area under NPOP certified organic farming while another 60,020-haarea is in the line of conversion. The main part is, the calculated area includes all eight states with the highest area of 75,475 ha in Sikkim alone under organic agriculture (Avasthe and Patel, 2023). North-East India has immense potential for bringing its remaining cultivable land under organic farming due to the people of this region mainly follows indigenous farming system with less use of synthetic fertilizers and more use of organic nutrients in their cultivation system and the rainfed condition in this part of the country is suitable for organic activities. High coverage of forest and diverse flora and faunas plays an integral part in maintaining the regions ecology. Almost every house-holds host livestocks contribute to on-farm manures for farming. North-East is the home to several indigenous crops from Assam Kagzi lime, Joha rice, Manipuri Cha-khao black rice, Harinarayana & Kalikhasa, Queen pineapple, Jampui Oranges of Tripura and many more. Around 45% of pineapple production of India comes from NE region. Agri-Export Zone (AEZ) has been set up in Tripura for organic cultivation of pineapple and Agri-Export Zone (AEZ) established for ginger in Sikkim. The ITK of the regional people in this area is good enough for boosting the eight states of NE region towards full-fledged organic area (Das *et al.,* 2018), (Babu *et al.,* 2017). In Tripura, Manipur and Assam, 90% of the cultivated area in the plain are under irrigation and the rest area is rain fed. In the mid hills, ginger, turmeric, arecanut, pineapple,orange, litchis, large cardamom, passion fruit, etc are cultivated. In the high hills and mountain areas themaximum grown crops are plums, pears, peaches, apricots, apples, potato, cabbage, cauliflower, radish, carrots,beans, broccoli, maize, millet and large cardamom. Wild Cardamom are not cultivated but are naturally grown in the region. The hills of Mizoram, Nagaland and Manipur has itspassion fruit. King of Chilli called as BhutJolokia is cultivated in Nagaland, Kakrol (*Momordica cochinchinesis* L.) and Kartoli (*M. dioica* L.) are widely cultivated spread in Assam, Garo hills of Meghalaya and the Sikkim Himalayas.Jackfruit, which grows abundantly in Tripura, Assam, Nagaland and Meghalaya with many cultivars and landraces (Avasthe and Patel, 2023).

Problems of organic culture development in NE region:

Abundant rainfall is a characteristic feature of this region. So, sudden rain, salinity, uneven topography, climaticcondition, low temperature, low mineralization inhibitbetter productivity of crops throughorganic farming in North Eastern India.Lack of preparation technique of in-situ composts and their application between cropping system also implementation of modern days bio-fertilizers and bio-pesticides are some of the serious problem. Marketing strategies and export of all organic produce of NE region are yet to be developed and low cost fetching local markets is a big deal. Location specific organic production techniques and strategies are lacking. Also due to hilly condition remoteness of the region is the main barrier for connectivity of farmers with the mainland for marketing purpose.Unavailability of proper post-harvest processing and packaging facilities and storing to avoid contamination of organic produce as reported by Kaur and Toor, (2015). Monocropping farming methods of this area lead to soil nutrient exhaustion and heavy rainfall lead to leaching of nutrients and erosion of soil which need to be researched properly for better development of organic crops. Moreover, humid condition and heavy rain causes pest problem in these areas are more which needs permanent solution organically. Only few fruits and vegetables got recognized for organic production and few agencies are working on it for accreditationwhich needs a better boost for bringing and identifying major crops under organic production with providing infrastructural support. Management of organic crops require high cost in purchasing organic inputs like organic seeds, bio-fertilizers, neem cakes, bio-innoculants for seed treatment, mycoherbicides etc. which needs to be subsidized at low cost also improved composting methods and other natural pest management options should be made available for farmers. Small land holdings, recent conversion of land from conventional to organic agriculture leads to low yield which needs to be look after for betterment of farmers or some policies or financial support programmes needs to be implemented, few traininginitiatives for organic farming, few availabilities of organic seeds and better certification processes and government schemes are some problems of this very nature diverse region (Bordoloi *et al.,* 2020), (Chaithrakumari and Babu, 2023).

Techniques for boosting organic farming in NE region:

1. Inclusion of legumes (Cow pea) after cereals is one of the good option for restoring soil health by totally avoiding monocropping.

2. Incorporation of green manuring crops before cereal crops. In-situ and ex-situ green manuring practices can be followed like sunhemp, dhaincha, berseem, cowpea etc.

3. Use of cow dung, animal wastes and other organic sources must be incoprporated for preparation of organic nutrients like FYM, vermicompost, vermiwash, azolla culture and use of phopho-compost, goat and sheep manure, azophos or rhizobial cultures, PSBs etc.

4. Biochar prepared from available non-allelopathic weeds can improve soil carbon content also other micro-nutrients can be added from this preparation.

5. Natural seed treatment methods should be adopted like panchamrit, amritpani etc.

6. Use of oil cakes, neemcakes have shown great insecticidal properties. Also, pheromone traps, light traps are also of great use.(Sankar *et al.,* 2016).

7. Stale seed bed, summer tillage,crop rotation, organic mulching, soil solarization, mycoherbicides etc. are effective for weed control.The use of biomasssuch as *Eupatorium/ Artemisia* as mulch has been reporteda good source of organic matter and weed suppressing agent fordifferent crop in NEH region. (Das *et al.,* 2016).

8. Biological control agents like *Pseudomonas* spp., *Trichoderma* spp., and *Bacillus* spp. have been successful in managementof various plant diseases (B³aszczyk *et al*., 2004).*Bacillus thuringiensis* L. *Metarhiziumanisopliae* L. and *Beauveria bassiana*were L. found best in thecontrol of stem borer (Raj *et al.,* 2021). Various other biological agents like *Trichogramma*, Nuclear Polyhedrosis Virus (NPV), *Verticillium lecanii* L. *Bacillus thuringiensis* L. are used to manage pests of different crops.

9. Use of ash and salt against cutworms, ants and grubs are famous among farmers in Sikkim. Curry leaves, bay leaf, garlic turmeric are great for various storage pest controls. Cow urine, buttermilk are also effective for pest and disease control in India. (Gopi *et al.,* 2016), (Das *et al.,* 2016), (Das *et al.,* 2017 a).

10. Cluster based marketing approach may benefit poor and marginal farmers as most of the north-eastern farmers have small land holding. Combination of all elements ensures better employment, economic growth and reducing problems by improving traditional and health of community. Vast access to local products is possible through opting better marketing strategies which provide high price. Awareness related to utilization of governmental and non-governmental strategies for financial and infrastructural support must be build up for betterment of farmers. (Singh *et al.,* 2021).

ICAR Research Complex for NEH Region, Umiam and especially its Sikkim Regional Centre have developed research-based technological options for climate resilient mountain horticulture production systems comprising of organic production process of mandarin, kiwifruit, pear, guava, chayote, cherry pepper, okra, pea, ginger and turmeric, etc. Organic production technology of 14 high value vegetables like broccoli, cauliflower, cabbage, coriander, lettuce, fenugreek, spinach, leafy mustard, pakchoi, garlic, pea, beetroot, carrot, and radish with low-cost plastic tunnels have been successfully established for year round production in different cropping sequences. Organic production technology for tomato, capsicum, cucumber, gourds, under low-cost plastic shelters during summer and rainy season and off-season vegetable production techniques in low-cost greenhouse for high priced vegetables such as broccoli, tomato, cucumber and capsicum have also been proven successful as reported by Avasthe and Patel, (2023).

Conclusion

It may be concluded that North-East India due to its richness in several indigenous plant species and the local people practising indigenous farming methods have less soil-health deterioration which is a plus point in converting all its state into organic region within a short period of time. Central government initiative like MOVCDNER covering the regions farmer under organic production and certification of organic produce is a good step from the Indian government to support the farmers financially and also through supplying organic inputs and several training programmes and business development ideas for fetching high price through their produce. According to the Ministry of Agriculture & Farmers Welfare the MOVCD-NER scheme launched during 2015-16 has facilitated 1.73 lakh ha area under organic farming benefiting 1.89 lakh farmers as on 15 July 2023. Various cereal crops should also be brought under organic produce along with present focus on betterment of existing vegetable being produced organically through proper scientific knowledge for better yield.

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Analysis of Genetic Divergence in Re-irradiated Mutants of Aromatic Non-Basmati Rice

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Abstract

Re-irradiation of induced mutatant genotypes (IET 14142 and IET 14143) of Tulaipanja, an aromatic non-basmati rice cultivar of West Bengal, led to isolation of a number of morphologically distinct mutants, retaining the characteristics aroma of mother genotype. Genetic divergence among 18 re-irradiated mutant families in M_4 generation and their two mutant mother genotypes on the basis of 10 quantitative characters was assessed following Mahalanobis D^2 statistics. Re-irradiated mutants and their mutant motherlines were grouped into seven clusters, of which four were solitary clusters. The intra-cluster distance was maximum (D^2=115.30) in cluster I comprising four re-irradiated mutants of IET 14142 and five re-irradiated mutants with their mother genotype IET14143. The inter-cluster distance was maximum (D^2=1241.33) between solitary clusters V and VI where cluster V having IET 14142 showed wide divergence with majority of the other clusters. This indicated presence of considerable divergence among the re-irradiated induced mutants and their mutant mother genotypes, where re-irradiated mutants of IET 14142 were more divergent. Inclusion of re-irradiated mutants induced from different mutant mother genotypes at different doses in a single cluster might be due to exercising similar type of selection pressure and origin of both the mutant mother genotypes having been from the single cultivar Tulaipanja. The composition of other clusters revealed no specific pattern, which is in consonance with the randomness in the event of induction of mutation. On the basis of genetic divergence, relative importance of characters in determining the yield and *per se* performance of the individuals as well as cluster means, crosses between re-irradiated induced mutants including their mutant motherlines have been suggested which are most likely to yield a considerable amount of mutant heterosis in the F_{-1} generation and to provide a wide spectrum of recombinants for useful mutant characters in segregating generations.

Keywords **:** Aromatic rice, gamma irradiation, genetic divergence, induced mutation

Indian sub-continent is the homeland for aromatic rice. The demand for aromatic rice has been increasing due to change in consumers' preference for quality rice as a result of changed life styles. Aromatic rice has an international market and is an important source of foreign exchange. The aromatic rice varieties of West Bengal and other parts of eastern India are tall short grain type with poor yield potential. Improvement in yield and other agronomic characteristics, retaining the characteristics aroma and other cooking quality of such cultivars is easier through mutation breeding than recombination breeding by crossing with high yielding non-aromatic varieties. It has been demonstrated that induced mutation can increase yield as well as other agronomic characters such as stiffness of straw, time of maturity, adaptability and numerous other characters (Borojevic, 1990; Brunner, 1991). Induced mutations may be similar to those, which occurred naturally or many of which, probably, have never occurred spontaneously or have been lost from the natural population. Thus, induced mutations can provide useful alternative or complement to natural variation as well as germplasm for hybridization. Attempts to increase the magnitude of variability through re-irradiation of two inducted mutant genotypes of Tulaipanja, an aromatic non-basmati rice cultivar of West Bengal, led to isolation of a number of morphologically distinct mutants, retaining the characteristics aroma of mutant mother genotypes as well as grandmother Tulaipanja. The present investigation aims at assessing genetic divergence among 18 mutant families and their two mother genotypes on the basis of 10 quantitative characters.

Material and Methods

Dry healthy unhusked seeds of IET 14142 (designated as T_1) and IET 14143 (designated as T_2), developed by mutagenic treatment of aromatic rice cultivar Tulaipanja (Basak, 1995), were re-irradiated separately with three different doses of gamma rays *viz.,* 250Gy, 350Gy and 450Gy (1 Gray = 1 joule per kg of matter undergoing radiations = 0.1 kR) from ^{60}Co source at Central Research Institute for Jute and Allied Fibre (CRIJAF), Barrackpore, West Bengal. The M_1, M_2 and M_3 generations were grown and individual plant selection was made following pedigree method. Seeds from the prospective mutant plants of M_3 generation, which were true-breeding for aroma and morphologically different from each other and from their respective mutant mother genotypes, were used for raising M_4 generation. In each dose of gamma rays three plants were selected in M_3 generation, which were designated as 'm' with subscript 1 to 3 for 250Gy, 4 to 6 for 350Gy and 7 to 9 for 450Gy and prefix T_1 and T_2 to indicate the mutant mother genotypes. Therefore, a total of 18 M_4 families (2 genotypes ´ 3 doses ´ 3 plants) along with their two mutant mother genotypes were sown in the nursery bed. Thirty-day-old seedlings were transplanted during warm wet season in randomized complete block design with three replications. Each plot consisted of 5 rows of 3 m length with a spacing of 15 ´ 20 cm. Standard cultural practices were followed to raise a healthy crop. Data on ten quantitative characters were recorded on five plants selected randomly from the middle rows of each replication. The data were subjected to Mahalanobis D^2 statistics (1936) to measure the genetic divergence and grouping of mutant families and their mother genotypes were done following Tocher's Method as suggested by Rao (1952).

Table 1. Grouping of mutants and their mother genotypes into various clusters in Tulaipanja group

Cluster	Number of genotypes	Name of genotypes
I	10	T1m1, T1m4, T1m7, T1m9, T2m1, T2m2, T2m4, T2m5, T2m6, T2
II	2	T1m6, T2m8
III	4	T1m2, T1m5, T1m8, T2m7
IV	1	T1m3
V	1	T1
VI	1	T2m3
VII	1	T2m9

Table 2. Average intra- and inter - cluster D2 values in of mutants and their mother genotypesTulaipanja group

Cluster	I	II	III	IV	V	VI	VII
I	115.30	136.18	197.60	294.24	883.78	218.42	157.29
II		32.99	302.16	423.37	1116.51	423.34	159.87
III			95.35	250.81	611.65	329.11	138.59
IV				0.00	671.67	223.13	418.20
V					0.00	1241.33	934.60
VI						0.00	385.13
VII							0.00

Results and Discussion

The analysis of variance showed significant difference among mutant families for all the characters. Wilk's Lambda criteria l = 0.365 ´ 10^{-9} and V = 912.71 with 190 d.f.) revealed highly significant differences among the mutant families for the pooled effect of all the characters. Based on relative magnitude of D^2 values, the populations were grouped into 7 clusters (Table 1). Cluster I comprised maximum number (10), which included four mutant families (T_1m_1, T_1m_4, T_1m_7, T_1m_9) of IET 14142 (T_1) and five mutant families (T_2m_1, T_2m_2, T_2m_4, T_2m_5, T_2m_6) with their mutant mother genotype IET14143 (T_2). Cluster II included two high yielding mutant families T_1m_6 and T_2m_8. Cluster III comprised 4 mutant families representing T_1m_2, T_1m_5, T_1m_8 and T_2m_7. Cluster IV, V, VI and VII were solitary and represented by T_1m_3, IET 14142 (T_1), T_2m_3 and T_2m_9, respectively. This indicated presence of considerable genetic divergence among the induced mutant families and their mutant mother genotypes, where re-irradiated mutant families of IET 14142 were more divergent. The composition of cluster I indicated that mutant families induced from different mutant mother genotypes at different doses were grouped in a single cluster which might be due to exercising similar selection pressure and both the mutant mother genotypes having been originated from single cultivar Tulaipanja. The composition of other clusters revealed no specific pattern, which is in consonance with the randomness in the event of induction of mutation.

The intra-cluster distance (D^2) (Table 2) varied from zero in solitary clusters to 115.30 in cluster I indicating considerable diversity between different clusters. The minimum inter cluster distance (D^2) of 136.18 was recorded between cluster I and II. The maximum inter-cluster distance (D^2) of 1241.33 was observed between solitary clusters V and VI while cluster V having genotype IET14142 (T_1) showed wide divergence with majority of the other clusters. This indicated considerable amount of divergence within and between clusters.

These results indicated the presence of considerable genetic divergence among the re-irradiated induced mutant families. It would, therefore, be logical to effect crossing between individuals separated by considerable statistical distance to produce superior mutant hybrids and promising recombinants, combining desirable mutant characters, in the segregating generations. Kole and chakraborty (2012) have also pointed out that selection of parents for hybridization should be done from two clusters having wider inter-cluster distance to get maximum variability.

The salient features of different clusters (Table 3) are given below :

Cluster I: This cluster showed moderate values for most of the characters except high value for test weight.

Cluster II: It was characterized by highest values for spikelet number, straw weight and grain yield.

Cluster III: All the characters had moderate values.

Cluster IV: It showed moderate values for most of the characters except low values for days to flowering and plant height and high value for spikelet number.

Cluster V: This cluster exhibited highest values for test weight and panicle number.

TABLE 3. Cluster means of ten quantitative characters in mutants and their mother genotypes inTulaipanja group

Cluster	Days to flower	Flag leaf angle (O)	Plant height (cm)	Panicle number	Panicle length (cm)	Spikelet number	Spikelet fertility (%)	Test weight (g)	Straw weight (g)	Grain yield (g)
I	126.55	15.53	104.12	13.66	23.95	87.91	76.90	13.36	47.65	11.59
II	127.80	14.00	114.14	14.67	23.92	95.01	79.00	12.91	56.36	14.15
III	132.47	18.08	93.04	13.03	22.49	87.61	75.25	12.86	42.81	10.47
IV	122.20	21.35	96.47	15.60	21.70	93.47	70.00	11.90	37.74	11.41
V	130.13	44.32	97.80	16.80	23.23	74.28	72.00	13.53	56.20	11.61
VI	120.73	11.68	80.50	8.67	22.67	92.40	82.00	12.96	34.02	8.30
VII	134.20	11.30	115.43	11.80	23.50	91.65	64.00	13.07	44.59	8.93
Relative contribution (%)	12.54	12.24	8.96	9.38	8.60	9.10	9.34	8.15	12.91	8.78

Cluster VI: This cluster was characterized by lowest values for plant height, panicle number and straw weight while it had highest value for spikelet fertility (%).

Cluster VII: This cluster exhibited highest value for plant height and days to flower. High value for spikelet number and test weight were found in this cluster.

None of the clusters contained mutants with highest values for all characters. Also, most of the minimum and maximum cluster mean values were distributed in relatively distant clusters. The hybridization between individuals of different clusters was necessary for the development of desirable genotypes. Endang *et al.* (1971) have stated that the clustering pattern could be utilized in choosing parents for cross combinations likely to generate the highest possible variability for various economic characters. Recombination breeding between genotypes of different clusters has also been suggested by Kole (2000).

It was observed that the straw weight (12.91%), days to flowering (12.54%), flag leaf angle (12.24%), panicle number (9.38%), spikelet fertility (9.34%), spikelet number (9.10%) and plant height (8.96%) contributed maximum towards divergence of different clusters (Table 3). These results are in agreement Contributions towards divergence have been reported for plant height (Mishra *et al.*, 2020; Sar and Kole, 2022), for grain yield (Palaniyappan *et al.*, 2020; Sar and Kole, 2022), for total spikelets panicle^{-1}(Palaniyappan *et al.*, 2020) and for test weight (Mishra *et al.*, 2020; Sar and Kole, 2022).

Considering genetic divergence, relative importance of characters in determining the yield and *per se* performance of the individuals as well as cluster means, crossing between individuals within the cluster *viz.,* $T_1m_1 \times T_1m_6$, $T_1m_1 \times T_2m_4$ and $T_2m_2 \times T_2m_4$ of cluster I and $T_1m_8 \times T_2m_7$ of cluster III in Tulaipanja group and crossing between individuals of different clusters $T_1m_1 \times T_1m_8$ (cluster I × III), $T_2m_8 \times T_1m_8$ (cluster II × III), $T_1m_1 \times T_2m_3$ (cluster I × VI) and $T_1m_3 \times T_1$ (cluster IV × V) are most likely to yield a considerable amount of mutant heterosis in F_{-1} and to provide a wide spectrum of recombinants for useful mutant characters in segregating generations. Such crosses may help in cleaning of harmful mutant alleles and altering pleiotropic patterns of mutant alleles (Kole and Ganguli, 2005; Kole, 2007).

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Baby Corn (*Zea mays* L.) Production Under Balanced Fertility and Adequate Plant Geometry

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Abstract

Maize production as baby corn adds diversity and value to the food industry. Baby corn is the female inflorescence of the maize plant that is sweet in flavor and harvested at the silk emergence stage. Plant geometry and proper integration with zinc fortification are highly recommended for profitable and sustainable baby corn production. In terms of both qualitative and quantitative production of baby corn, it is critical to maintain an optimum plant population with appropriate crop geometry for efficient utilization of both above ground and below ground resources, resulting in good crop performance. The amount of nutrients added by fertilizers is far less than the total annual removal of nutrients by crop and cropping system, resulting in negative nutrient balance in the soil and reduced soil productivity. Zinc is essential for the normal, healthy growth of flora and fauna all over the world. The physiological stresses observed in plants which may due to the irregular function of several enzyme systems and other metabolites caused by the lack of critical zinc level. Among field crops, maize is the most susceptible to zinc deficiency and can be used as an indicator plant for zinc deficiency. In this review an attempt was made to determine the significance of crop geometry, major nutrients and Zn fertilizer on crop growth and yield.

Introduction

The novelty of maize (*Zea mays* L.) is its cultivation and consumption especially for grain, vegetable and fodder purpose. Now days, maize is popularly grown as "baby corn" because of its utility as vegetable purpose. Maize, the photo-insensitive crop is considered as "Queen of Cereal" that is grown throughout the year for multiple purposes such as cereal, vegetable, and fodder. The baby corn is a maize ear produced from regular corn plants harvested quite earlier, especially when the silks are 2-3 cm in size (Thavaprakaash et al., 2005). The baby corn with high nutritive and economic value is the unfertilized young cob that can bear two or more cobs per plant. Baby corn consumption is gaining popularity and acceptance all over the world, clearly for high nutritive value. Due to high demand in the National and International markets and lower production costs, India is emerging as a potential producer of baby corn (Barzur et al., 1990). One of the important factors in achieving maximum yield and quality of baby corn is the role of balanced and adequate nutrition. Ample and balanced supply of nitrogen, phosphorus, and potassium to the crop favoured greater availability of these nutrients in soil, which ultimately resulted in enhanced plant growth (Kumar et al., 2015). Among the micro nutrients Zn is very essential and the maize crop ranks third in zinc demand, after rice and wheat (Meena et al., 2013). Beside the nutrients crop geometry is another important factors for high production through effective growth factor utilization. As the baby corn plant is a non-tillering crop, therefore, the effects of various plant populations on baby corn are quite significant.

Nutrient required for Baby corn production

Nitrogen application has a significant impact on quality parameters of baby corn such as starch, total sugar, protein, sugar, and crude protein (Grazia et al. 2003). Phosphorus is the second, but still one of the most important nutrients for maize production. Meanwhile, phosphorus deficiency is as important as nitrogen deficiency in slowing maize crop growth and performance (Gul et al.2015). Phosphorus, as a component of ADP and ATP, is essential in energy transformation. It also aids in the conversion of photosynthates into other metabolites, thereby serving as an activity zone for CO_2 assimilation. It is necessary for seed and fruit development as well as crop maturation. Phosphorus accelerates the ripening of both climatic and non-climatic fruits, offsetting the effect of excessive nitrogen application to the soil. Furthermore, as a component of chromosomes, it promotes cell division and is required for meristematic growth. Similarly, potassium is a necessary element as well as the most abundant cation in various plant species. According to Gul et al. 2015, it is essential for enzyme activation, protein synthesis, photosynthesis, osmoregulation, stomatal movement, energy transfer, phloem transport, cation-anion balance, and stress resistance. Similarly, zinc is essential for plant cell oxidation processes and aids in the transformation of protein, carbohydrates, and sugar in plants; promotes cell division, multiplication, and elongation; and serves as a catalytic component in photosynthesis.

Importance of micronutrient in baby corn production

Primary micronutrients in the soil include boron, iron, zinc and chloride. Although plant only require relatively small amount of micronutrient, still they are very essential for plant growth. Chloride plays key role in stomatal regulation, the evolution of oxygen in photosynthesis, disease resistance and tolerance. Zinc is the constituent of many enzymes, protein, and play important role in growth hormone production. Boron is essential for cell division, reproductive growth, and seed development. Iron is the constituent of several enzymes, assists in nitrate reduction and energy production and essential for formation of cholorophyll. Yield is the end result of many yield contributing components, physiological and morphological processes occurring in plants during growth and development. Kumar *et al.* (2015) and Mohsin *et al.* (2014) discovered that each successive level of zinc allocation resulted in a significant increase in root length, root dry weight, and root volume at various growth stages, plant height, and leaf area index (Raskar *et al.* 2012; Mahdi *et al.* 2012; Meena *et al.* 2013).

Plant geometry

As the closely spaced crops produced taller plants due to increased competition for sunlight, nutrients, space, and water, the growth attributes must be maintained at an optimum level to effectively utilize the available resources such as nutrients, water, light and space (Neelam and Dutta 2018). Dar *et al.* (2014) discovered that in maize crop the growth characters *viz*, plant height, leaf area index was higher at 50×15cm spacing. For taking maximum grain yield the optimum plant population is very important factor because with successive increment in plant density from 50000 to 140000 plants ha^{-1}increased plant height by the time 15.1% (Moosavi *et al.* 2012).Sobhana *et al.* (2012) studied plant populations ranging from 66,666-83,333 plants ha^{-1} and discovered that increasing plant population led to an increase in plant height at 50 days after sowing. Due to intra-row plant competition for light and other environmental resources such as temperature and rainfall, the taller plants with more plant population were discovered, and other individual characteristics such as per plant dry matter accumulation and leaf area index were reduced which could be attributed to competition among the plants for space, moisture, nutrients, light, and other factors. Kunjir *et al.* (2007) provided proof of his findings and confirmed his findings by recording higher plant height with closer spacing as opposed to wider spacing. According to Zarapkar (2006) individual plant characteristics such as the number of functional leaves and dry matter accumulation per plant were higher in the case of wider spacing (60×20 cm) than in the case of closer spacing. Various studies have shown that individual plant production is reduced because dry matter decreases progressively as the number of plants increases under high density (Hamidia *et al.* 2010). A higher leaf area index was observed in densely placed plant populations due to narrow spacing values caused by increased plant density, which accommodates a greater number of plants (Wasnik *et al.* 2012).

Soil fertility

Adequate and balanced application and supply of nutrients such as nitrogen, phosphorus, and potassium to the baby corn crop favored greater availability of nutrients, which resulted in increased crop yield. In comparison to chemical fertilizers, the application of well-decomposed compost slows the development rate of baby corn plants (Jaime and Viola, 2011). This is because compost releases almost all nutrients for a longer period of time, which plants take slowly for a longer period of time, causing plants to become green and active for photosynthetic activities. Increased availability of photosynthates may have promoted the number of flowers and their fertilization, resulting in a greater number of plants. Furthermore, in most cereals, a larger area of assimilating surface at reproductive development results in better green cob formation due to adequate metabolite production and translocation towards the cob. Some study showed positive response of various yield and yield attributes to higher NPK fertilization (Chillar and Kumar, 2006; Gosavi and Bhagat, 2009). Arif *et al.* (2010) stated that the value of grain and biological yield increases with successive increments in plant population from 4.5 to 7.5 plants m^{-2}, but further increase in plant population did not significantly promote maize grain and biological yield due to competition for nutrients among the plants. The supply of 200% recommended dose of N (RDN) in four splits produced significantly higher yield and yield attributes of baby corn than the supply of 100% RDN in four splits and was comparable to the treatment receiving 150% RDN in four splits (Harikrishna et al. 2005). Application of zinc fertilizer in the soil and as a foliar spray, influences auxin and starch synthesis in baby corn. The crop growth parameters, such as plant height, dry matter production, and chlorophyll content, yield attributes enhanced by the foliar application of Zn (Kumar and Bohra, 2014; Chand *et al.*, 2017). According to Kumar *et al.* (2015), zinc application of 5 and 10 kg Zn ha^{-1} increased cob yield by 7.8 and 12.8%, and corn yield by 10.5 and 16%, respectively over control where no Zn was applied (Amanullah *et al* 2016).

Conclusion

It is very clear from the above information that along with major nutrient, the micro nutrient like Zn application will boon to the effect of the major nutrient utilization with optimum plant population for efficient utilization of both above ground and below ground resources, resulting in good crop performance in terms of positive impact on the growth, yields, and quality parameters. Therefore, balanced and efficient use macro and micronutrients, not only conserves nutrients in the soil, but also makes nutrient uptake more efficiently.

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Characterization of Green Gram Genotypes through Morphological Parameters and Chemical Tests

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Abstract

Characterization of genotypes is of significant importance for maintaining genetic purity during seed production and it is also necessary for the protection under plant variety protection. Therefore, the present experiment was conducted to characterize eight genotypes (Sonali, Sukumar, Samrat, Meha, Panna, PDM 139, IPM 2-3 and SML 668) of green gram based on their morphology and response to different chemical (NaOH, KOH and Peroxidase) tests. According to the DUS descriptors twenty-three morphological characters were evaluated and study revealed that all the characters together can effectively distinguish among the selected genotypes. Stem colour was recorded as green with purple splashes for seven varieties except Meha for which it was green. Largest leaves were recorded for SML 668 while Samrat, PDM 139 and IPM 2-3 exhibited small sized leaves and rest four genotypes were characterized with medium sized leaves. Sonali could be identified with yellow and dull seed whereas rest of the genotypes exhibited green and shiny seed. Sukumar and SML 668 could be recorded as large sized seed with the exception of having oval and drum shaped seed, respectively whereas the rest six genotypes could be characterized with drum shaped small sized seed except PDM 139 which produced oval seed. In case of chemical tests, results showed that according to identification key consisting of three chemical tests all the genotypes can be easily grouped and four among them (Sonali, Sukumar, Panna and IPM 2-3) can easily be identified. Thus, Characterization through morphological parameters and chemical tests played a convenient role in identification or classification of green gram genotypes which is vital for genetic purity of cultivars.

Key words : Characterization, Green gram, DUS descriptors, Chemical tests.

Introduction

Green gram [*Vigna radiata* (L.) Wilczek] is one of the most important pulse crops in India belonging to the family Fabaceae. It is a short duration self-pollinated crop that thrives well in a broad range of environments owing to its short crop period (Rai *et al.,* 2024). In India green gram is well suited to a large number of cropping system and it also improves the soil fertility through nitrogen fixation. It forms a major source of protein (240g/kg) and a range of micronutrients to the diet of vegetarian population of India (Nair *et al.,* 2013).

Characterization of germplasm is the basic step in forming groups of lines having similar characteristics to get an idea of variability present in the lines and their utilization in breeding programmes (Tantasawat *et al.,* 2010). As per the standard measures stated under Protection of Plant Varieties and Farmers' Rights Act (PPV & FRA, 2001), Distinctness, Uniformity and Stability (DUS) characterization is crucial for identification and prevention of duplication as well as for proper varietal registration (Rai *et al.,* 2023). DUS characterization has a considerable significance in the quality seed production and certification (Janghel *et al.,* 2020). Therefore, it is necessary to properly characterize and assess the variation present in green gram genotypes in order to select suitable genotypes that can be marketed as a variety appropriate for a particular agro-climatic zone (Dhaliwal *et al*., 2020).

Seed technologists must be well equipped to identify different varieties and hybrids, both at field and at seed level. Varietal descriptions given by the breeders most often relate to field characters and not sufficient to identify genotypes or seed lot adequately. The alternative way to speed up the testing procedures is to use chemical tests in place of morphological markers. These chemical tests are very quick, easy to do, reproducible and can be undertaken throughout the year under controlled conditions (Hiremath *et al.*, 2016).

Hence, an effort was made to characterize some green gram genotypes of West Bengal through both morphological parameters and chemical tests as well as their identification was intended.

Materials and Methods

Seeds of eight green gram genotypes viz., Sonali, Sukumar, Samrat, Meha, Panna, PDM 139, IPM 2-3 and SML 668 were collected from different parts of West Bengal and those eight varieties were sown in field for morphological characterization following Randomized Block Design (RBD) with three replications during *rabi* seasons of 2017-18. Field experiment was conducted at the Agricultural Experimental Farm of Calcutta University, Baruipur, South 24 Parganas, West Bengal while characterization through chemical tests was performed at the laboratory of Department of Seed Science and Technology, Institute of Agricultural Science, University of Calcutta.

Morphological characterization was done as per the guidelines prescribed by PPV & FRA, Govt. of India for DUS testing specified for green gram (Anon., 2007). The observations were recorded on the following characters at various stages of growth – (i) Time of flowering- Early (<40 days)/Medium (40-50 days)/Late (>50 days), (ii) Plant growth habit (Erect/ Semi-erect/Spreading), (iii) Plant habit (Determinate/ Indeterminate), (iv) Stem colour (Green/Green with purple splashes/Purple), (v) Stem pubescence (Absent/ Present), (vi) Terminal leaflet lobes (Absent/Present), (vii) Terminal leaf shape (Deltoid/Ovate/Lanceolate/ Cuneate), (viii) Leaf colour (Green/Dark green/Leaf vein colour), (ix) Leaf vein colour (Green/Greenish purple/Purple), (x) Petiole colour (Green/Green with purple splashes/Purple), (xi) Leaf size (at 5th node from the base) (Small/Medium/Large), (xii) Flower colour of petal (Yellow/Light yellow), (xiii) Pod colour of premature pod (Green/Green with pigmented suture/ Pod pubescence), (xiv) Pod pubescence (at fully developed green pods stage) (Absent/Present), (xv) Pod position (Above canopy/Intermediate/Not visible), (xvi) Plant height - Short (<50 cm)/Medium (50-70 cm)/Long (>70 cm), (xvii) Pod colour of mature pod (Brown/Black), (xviii) Pod curvature of mature pod (Straight/Curved), (xix) Pod length of mature pod - Short (<8 cm)/Medium (8-10 cm)/Long (>10 cm), (xx) Seed colour (Yellow/Green/Mottled/Black), (xxi) Seed lusture (Shiny/Dull), (xxii) Seed shape (Oval/Drum shaped) and (xxiii)Seed size (weight of 100 seeds) - Small (<3 g)/Medium (3-5 g)/Large (>5 g).

Three chemical tests viz., Sodium hydroxide test, Potassium hydroxide test and Peroxidase test were carried out on the green gram seeds. Procedure of these chemical tests are briefly stated below –

Sodium hydroxide (NaOH) test: Three replications of 50 seeds each were soaked in 5% NaOH solution for one hour and the change in colour of the solution was observed (Agrawal and Dadlani, 1987). On the basis of colour developed, the genotypes were classified into three groups viz., orange colour solution, orange red colour solution, deep wine red colour solution.

Potassium hydroxide (KOH) test: Seeds were soaked in 5% KOH solution in three replications of 50 seeds each and kept at room temperature for three hours (Vanangamudi *et al.*, 1988). The colour change of the KOH solution was observed and based on the colour reaction the genotypes were divided into three groups viz., light brown colour solution, brown colour solution, deep wine red colour solution.

Peroxidase test: Ten seed coats were removed and placed separately in test tube, with three replications for all the genotypes and added 10 drops of 0.5 % Guaiacol solution into test tube, after ten minutes one drop of 0.1 % solution of hydrogen peroxide (H_2O_2) was added and the reactions were noted exactly after sixty seconds (Buttery and Buzzell, 1968). The colouration due to peroxidase activity was observed and the genotypes were grouped as light-yellow solution and colourless solution.

Results and Discussion

Morphological characterization

According to the morphological characters prescribed by PPV & FRA, Govt. of India for DUS testing specified for this crop were critically recorded and presented through (Table 1). For the characters like time of flowering, plant growth habit, plant habit, stem pubescence, leaflet lobes, leaf shape, petiole colour, colour of petal, pod pubescence, pod position, mature pod colour and mature pod curvature of all the eight genotypes did not show any variations. All the genotype exhibited early flowering, semi erect growth habit, determinate plant habit, stem and pod pubescence, no leaflet lobes (terminal) and produced ovate leaf (terminal), green petiole with purple splashes, yellow coloured flower petal (standard), black coloured straight mature pod above plant canopy signaling that those characters are not sufficient enough to distinguish among those varieties.

However, stem colour was recorded as green with purple splashes for seven varieties except Meha for which it was green. Green coloured leaf was observed for three varieties viz., Samrat, Meha and Panna whereas leaf colour of the rest five varieties were dark green. Unlike leaf, the colour of leaf vein could be noticed as greenish purple only for Meha and IPM 2-3 while the same was green for the rest. Largest leaves were recorded for SML 668 while Samrat, PDM 139 and IPM 2-3 exhibited small sized leaves and rest four genotypes were characterized with medium sized leaves. Although mature pod colour was black for all the genotypes, Sonali, Sukumar and Panna exhibited pre mature pod colour as green with pigmented suture whereas Samrat, Meha, PDM 139, IPM 2-3 and SML 668 produced green coloured pod. Mature pod length was found to be long for Sonali and Sukumar, medium for Panna and PDM 139 and short for Samrat, Meha, IPM 2-3 and SML 668. Sonali could be identified with yellow and dull seed whereas rest of the genotypes exhibited green and shiny seed. Similar findings were reported by Chakraborty *et al.* (2022) for seed colour and lusture. Sukumar and SML 668 could be recorded as large sized seed with the exception of having oval and drum shaped seed, respectively whereas the rest six genotypes could be characterized with drum shaped small sized seed except PDM 139 which produced oval seed. Among all, four genotypes (Sonali, Sukumar, Samrat, and PDM 139) were characterized with short plant height while the rest four genotypes viz., Meha, Panna, IPM 2-3 and SML 668 exhibited medium plant height. Considering all these twenty-three morphological characters, uniqueness of Sonali and Meha can be judged through dull yellow seed and green stem, respectively. Also, large leaf size could be identified as unique characteristics of the genotype SML 668.

Similar sort of approach to group and characterize the green gram genotypes according to their morphological characters was also reported by Sabatina *et al.* (2021), Rai *et al.* (2023) and Rai *et al.* (2024).

Chemical tests

The genotypes exhibited varied response to chemical tests. On the basis of colour reaction with sodium hydroxide and potassium hydroxide solution the genotypes were grouped into three categories whereas for peroxidase test it was two (Table 2). From sodium hydroxide test Sonali could be grouped into orange category, Samrat and PDM 139 in orange red category and rest five genotypes viz., Sukumar, Meha, Panna, IPM 2-3 and SML 668 were grouped into deep wine red category. The response of PDM 139 seeds towards sodium hydroxide test was in conformity with findings of Madhavi *et al.* (2022). Potassium hydroxide test resulted into three categories light brown (Sonali), dark brown (Meha, IPM 2-3 and SML 668) and deep wine red (Sukumar, Samrat, Panna and PDM 139). On the basis of peroxidase test, no colouration was observed for Sonali, Sukumar, Meha and SML 668 whereas yellow colouration was noticed for Samrat, Panna, PDM 139 and IPM 2-3. The difference in colour reaction of seeds seems to be due to difference in genetic background concerning the enzyme system (Chakrabarthy and Agrawal, 1990). These types of chemical tests were previously exploited by the researchers like Vijayalakshmi and Vijay (2009), Viswanath *et al.* (2013), Hiremath *et al.* (2016) and Ukani *et al.* (2016) in various crops.

Therefore, the seed keys developed based on three chemical tests could clearly distinguish some genotypes from others except Meha with SML 668 and Samrat with PDM 139 as they showed similar

Table 1. Morphological characters of eight varieties of green gram

Characters	Stage of observation	Type of assessment	Varieties							
			Sonali	**Sukumar**	**Samrat**	**Meha**	**Panna**	**PDM 139**	**IPM 2-3**	**SML 668**
Time of flowering	50% plants with at least one open flower	VG	Early	Early	Early	Early	Early	Early	Early	Early
Plant growth habit		VG	Semi erect	Semi erect	Semi erect	Semi erect	Semi erect	Semi erect	Semi erect	Semi erect
Plant habit		VG	Determinate	Determinate	Determinate	Determinate	Determinate	Determinate	Determinate	Determinate
Stem colour		VG	Green with purple splashes	Green with purple splashes	Green with purple splashes	Green	Green with purple splashes	Green with purple splashes	Green with purple splashes	Green with purple splashes
Stem pubescence		VG	Present	Present	Present	Present	Present	Present	Present	Present
Leaflet lobes (terminal)		VG	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent
Leaf shape (terminal)	50% flowering	VG	Ovate	Ovate	Ovate	Ovate	Ovate	Ovate	Ovate	Ovate
Leaf colour		VG	Dark green	Dark green	Green	Green	Green	Dark green	Dark green	Dark green
Leaf vein colour		VG	Green	Green	Green	Greenish purple	Green	Green	Greenish purple	Green
Petiole colour		VG	Green with purple splashes	Green with purple splashes	Green with purple splashes	Green with purple splashes	Green with purple splashes	Green with purple splashesë	Green with purple splashes	Green with purple splashes
Leaf size (at 5th node from the base)		MS	Medium	Medium	Small	Medium	Medium	Small	Small	Large
Flower: colour of petal (standard)		VG	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow

Table 1: Morphological characters of eight varieties of green gram (cont....)

Characters	Stage of observation	Type of assessment	Varieties							
			Sonali	Sukumar	Samrat	Meha	Panna	PDM 139	IPM 2-3	SML 668
Pod: colour of premature pod		VG	Green with pigmented suture	Green with pigmented suture	Green	Green	Green with pigmented suture	Green	Green	Green
Pod pubescence	Fully	VG	Present	Present	Present	Present	Present	Present	Present	Present
Pod position	developed green pods	VG	Above canopy	Above canopy	Above canopy	Above canopy	Above canopy	Above canopy	Above canopy	Above canopy
Plant height		VG	Short	Short	Short	Medium	Medium	Short	Medium	Medium
Pod colour (mature)		VG	Black	Black	Black	Black	Black	Black	Black	Black
Pod curvature of mature pod	Harvest maturity	VG	Straight	Straight	Straight	Straight	Straight	Straight	Straight	Straight
Pod length (mature pod)		MS	Long	Long	Short	Short	Medium	Medium	Short	Short
Seed colour		VG	Yellow	Green	Green	Green	Green	Green	Green	Green
Seed lusture		VG	Dull	Shiny	Shiny	Shiny	Shiny	Shiny	Shiny	Shiny
Seed shape	Mature	VG	Drum shaped	Oval	Drum shaped	Drum shaped	Drum shaped	Oval	Drum shaped	Drum shaped
Seed size (weight of 100 seeds)	seeds	MG	Small	Large	Small	Small	Small	Small	Small	Large

VG: Visual assessment by a single observation of a group of plants or parts of plants, MS: Measurement of a number of individual plants or parts of plants, MG: Measurement by a single observation of a group of plants or parts of plants.

Table 2. Green gram genotypes showing different colour reactions to chemical tests

Sl. No		NaOH test			KOH test			Peroxidase test	
	Genotypes	Orange	Orange Red	Deep wine Red	Light Brown	Dark Brown	Deep wine red	No Colour	Yellow
1	Sonali	O			+			-ve	
2	Sukumar			DWR			+++	-ve	
3	Samrat		OR				+++		+ve
4	Meha			DW		++		-ve	
5	Panna			DWR			+++		+ve
6	PDM 139		OR				+++		+ve
7	IPM 2-3			DWR		++			+ve
8	SML 668			DWR		++		-ve	

Orange: O; Orange Red: OR; Deep wine Red: DWR; Light Brown: +; Dark Brown: ++; Deep wine Red: +++; No Colour: -ve; Yellow: +ve

results (Figure 1). Hence, these chemical tests can be used as simple, rapid and cost-effective method to quickly group and characterize green gram genotypes to provide support to the varietal identification.

Conclusion

Assessment of genetic purity is an important aspect in seed production. In this experiment, the genotypes under consideration could easily be identified through some unique characters. The study suggested that use of both morphological characterization and laboratory chemical tests will facilitate varietal distinction and identification as well as make assured conformation towards the pureness of a genotype.

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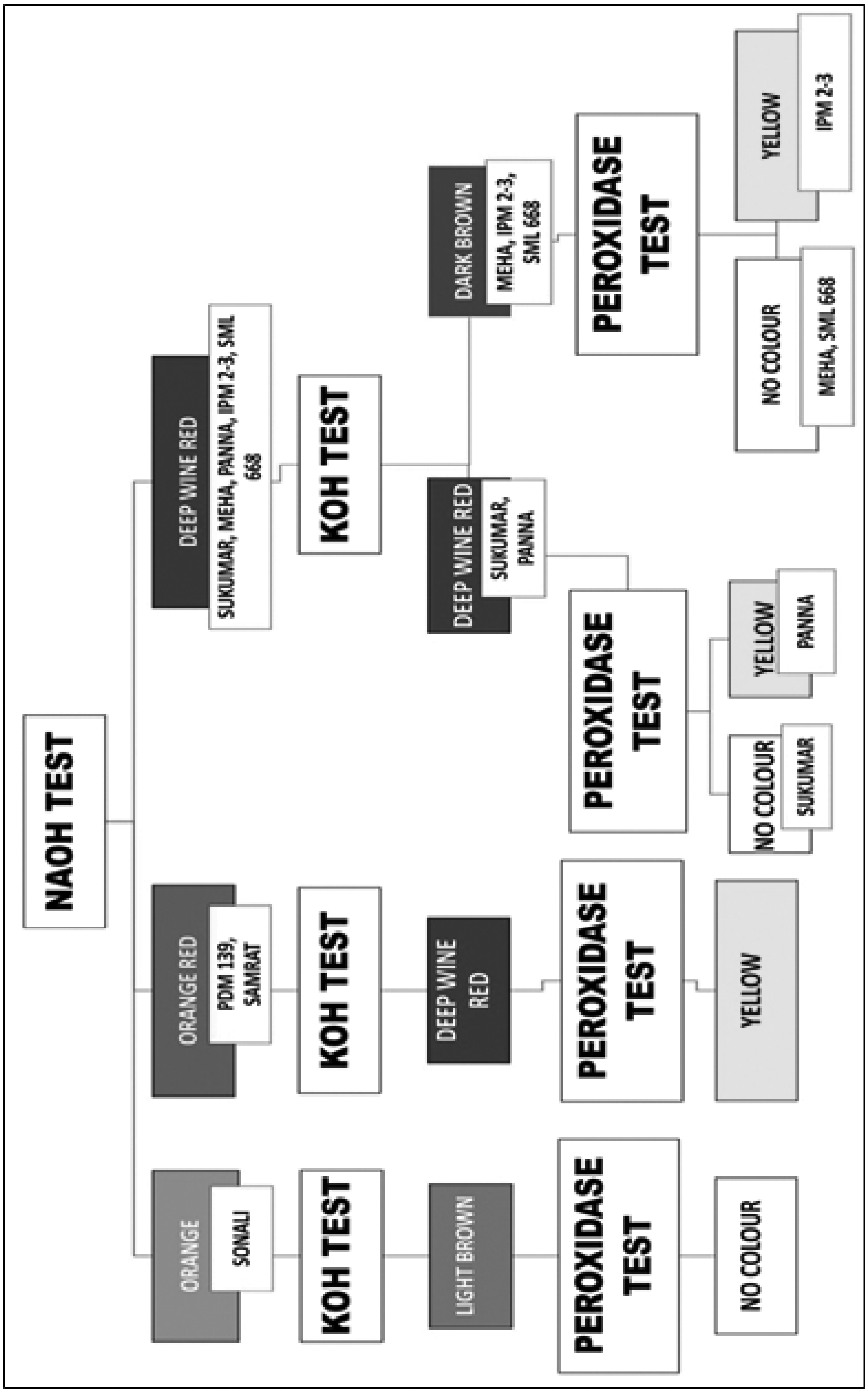

Fig. 1 Identification Key for green gram genotypes based on chemical tests

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Cultivating Resilient Rice: Overcoming the Threat of Yellow Stem Borer (*Scirpophaga incertulas*)

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Abstract

Safe rice farming is crucial for sustainable agriculture, particularly in combating the yellow stem borer (*Scirpophaga incertulas*), one of the most damaging pests affecting rice production globally. This review explores the integration of pest management strategies to effectively control yellow stem borer populations while minimizing environmental impact and promoting biodiversity. Emphasizing an Integrated Pest Management (IPM) approach, the study discusses cultural practices, such as synchronized planting and crop rotation, which disrupt pest life cycles. Additionally, the role of biological controls, including the use of parasitoids and biopesticides, is examined as a means to enhance pest resistance without relying solely on chemical interventions.

Furthermore, the importance of timely monitoring and implementing chemical controls only when pest populations exceed economic threshold levels is highlighted. Selective insecticides are discussed as options that minimize harm to beneficial organisms. The review advocates for the enhancement of agricultural extension services and farmer education to encourage the adoption of these sustainable practices. By fostering collaboration among farmers, researchers, and policymakers, safe rice farming can significantly reduce the impact of the yellow stem borer, ensuring food security and ecological balance in rice-growing regions.

Keywords : Yellow Stem Borer, Integrated Pest Management (IPM), Sustainable Agriculture, Biological Control, Chemical Practices, Pest Monitoring.

Introduction

Rice (Oryza sativa L.) is the most common staple food in India and other developing countries, with Asia producing and consuming more than 90% of the world's rice. However, rice serves as a host for numerous insect pests, with stem borers like *Scirpophaga incertulas* (Walker) and *Scirpophaga innotata* (Walker) (Lepidoptera: Pyralidae) being the most destructive. Among these, *S. incertulas* constitutes more than 90% of the borer population. Flooding and stem elongation provide an ideal environment for *S. incertulas*, leading to yield losses in two critical phases: dead heart and white earhead damage (Muralidharan *et al*., 2006). The activity of rice borers intensifies in the first three to four months after flooding, damaging an average of 23% of stems by the blooming stage.

Given the significance of rice in Indian agriculture, managing the yellow stem borer (YSB) is crucial. This review focuses on understanding YSB biology and promoting sustainable management strategies, including integrated pest management (IPM). It emphasizes the adoption of resistant varieties, cultural practices, and the conservation of natural enemies to reduce dependence on chemical controls. By addressing YSB infestations, this review contributes to protecting rice yields, ensuring food security, and fostering environmental sustainability in India.

1. Taxonomic position

a. Scientific name – *Scirpophaga incertulas*

b. Kingdom: Animalia

c. Phylum: Arthropoda

d. Class: Insecta

e. Order: Lepidoptera

f. Family: Crambidae

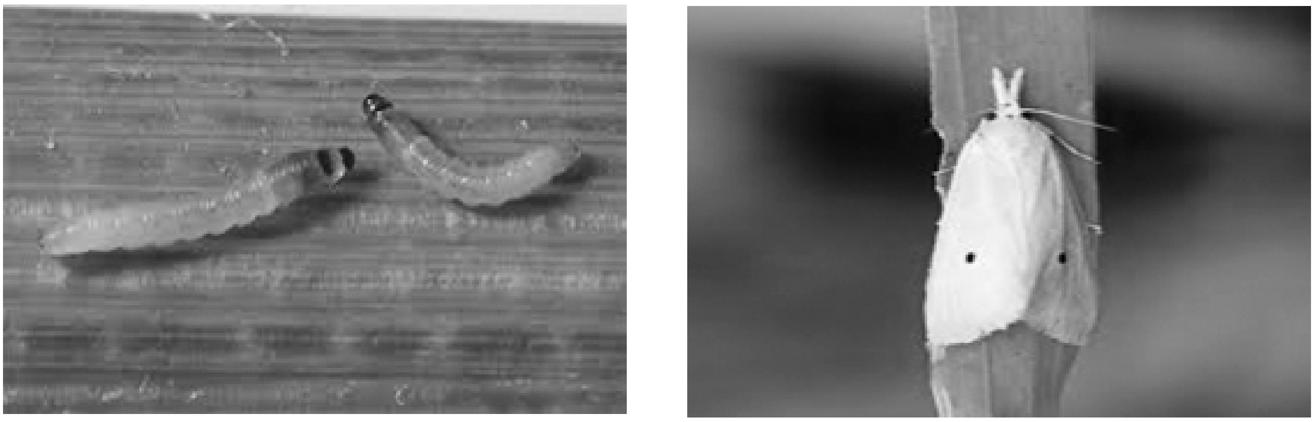

Fig. 1 Rice yellow stem borer (*Scirpophaga incertulas*)

g. Genus: Scirpophaga

h. Species: incertulas

2. Important species of rice stem borers

In Asian countries including India about 20 species of rice stem borers have been reported but only 5 *species viz. Scirpophaga incertulas (Walker), Scirpophaga innotata (Walker), Chilo* suppressalis (Walker), *Chilo polychrysus* (Meyr) and *Sesamia inferens* (Walker) are most important (Chaudhary *et al*., 1984 & Prakash *et al.,* 2004). White Stem Borer, *Scirpophaga innotata* mostly confined to Indonesia (excluding Sumatra), southern Philippines and Northern Australia (Angoon L, 1981). Studies on *Scirpophaga innotata* in Pakistan reported coexistence of *Scirpophaga incertulas* and *Scirpophaga innotata* i.e. the outbreak years of the former species were actually those in which the later species was not abundant and vice-versa (Inayatullah & Rehman, 1990) and further mentioned of its occurrence and damage from India (Anganath *et al*., 2002). The average of 25 years of data revealed that in Punjab province of Pakistan 94% of the borers belonged to *Scirpophaga spp*. and *Sesamia spp.* population was only 6% (Mahi & Brar, 1998; Hashmi, 1988). In India, thirteen species of rice stem borers have been reported infesting rice stem but only five borer species viz. *Scirpophaga incertulas*, *Scirpophaga innotata, Chilo suppressalis, Chilo polychrysus* and *Sesamia inferens* are predominant (Pathak, 1968; Prakash & Rao, 2004). A few other species viz. *Chilo auricilius, Chilo partellus* and *Scirpophaga novella* have got localized distribution. Some rare species like *Ancylolomia chrysographella* Koll., *Scirpophaga gilviberbis* Zell. and *Maliarpha separatella* Ragon are also reported to infest rice from India (Prakash & Rao, 2004).

3. Host plants of YSB

Yellow stem borers are monophagous pests of rice (Nishintha *et al*., 2019). They feed only on rice plants.

4. Damage symptoms caused by rice stem borers

Dead heart and white ear head are prominent symptoms caused by stem borer infestation. The larvae initially bore into the inner portions of the leaf sheath, resulting in yellowish-white or whitish discolored patches at the feeding site, which eventually cause the wilting and drying of leaf blades (Pathak, 1975; Dale, 1994). Their feeding on the apical parts of the plant from the base leads to stem tunneling, causing the central leaf whorl to turn brown, fails to unfurl, and dry out. Despite this, the lower leaves may remain green and healthy. This damage prevents the affected tillers from producing effective panicles, a condition known as “dead heart” (Pathak, 1975; Islam, 1991). Over time, these progresses to “white ear head,” where panicles become erect but contain empty grains. Larval feeding during the early booting stage can result in empty panicles and significant yield losses, exceeding 70% (Zahirul-Islam & Islam Z, 1997; Catling HD & Islam Z, 1999).

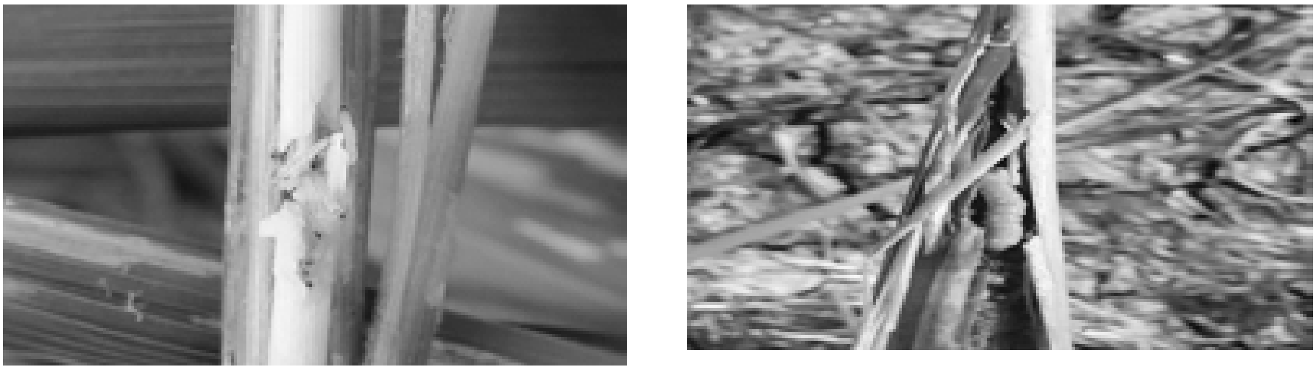

Fig. 2 Damage symptoms caused by rice stem borers

5. Life cycle of yellow stem borers

Yellow stem borer encompasses its life cycle through four stages viz, egg stage, larval stage, pupal stage, and adult stage (Sirvi *et al.*, 2021).

6.1 Egg stage: The eggs of YSB are creamy white, oval, and flattened, resembling a disc. They are laid in clusters and covered with brownish hairs from the anal tufts of the female moths (Hugar *et al.*, 2010). Typically, the eggs are deposited on the dorsal side of leaves (Kumar *et al.*, 2023). A single female is capable of laying between 100 and 200 eggs, with each cluster containing 50–80 eggs. The incubation period of the eggs ranges from 5 to 8 days (Muralidharan & Pasalu, 2006). The development of the YSB life cycle is highly influenced by temperature and relative humidity, with an estimated reduction of approximately 2 days in development time for every 1°C increase in temperature. The optimal temperature for maximum egg deposition is around 29°C with 90% relative humidity, while the ideal conditions for hatching are temperatures of 24–29°C and relative humidity levels of 90–100% (Kalra, 2018).

6.2 Larva: The larvae have a cream-colored body with a reddish-brown head and can grow up to 20 mm in length when fully developed. They display a yellowish-white coloration and possess a finely divided prothoracic shield (Omkar, 2018). The larval stage lasts for about 28–30 days, during which the larvae create an exit hole and typically pupate near the base of the plant (Sirvi *et al.*, 2021). The larvae go through four to six instar stages before reaching adulthood. The first instar larvae are immobile and do not migrate (Omkar, 2018). Moderate movement is observed in the second and fourth instar larvae, whereas the third instar larvae are highly mobile, and the fifth instar larvae are mostly stationary (Satpathi *et al.*, 2012). During the second instar stage, larvae construct tubular enclosures using leaves, later detaching themselves and falling onto the water surface, where they attach to the tiller and bore into the stem. The larvae's coloration varies with their development: the second, third, and fourth instars are creamy white, the fifth instar appears dirty white, and the sixth instar displays a greenish-yellow to yellowish-white hue (Panigrahi & Rajamani, 2008).

6.3 Pupa: The pupal stage continues for 6 to 12 days. The pupa is light green in color. It forms a silky white cocoon and rests underneath the base of the plant and harvested plants (Sirvi *et al.,* 2021).

6.4 Adult: The yellow stem borer (YSB) exhibits sexual dimorphism. Females have a broad abdomen with a circular pattern of yellowish hairs at the tip, while males have a slender abdomen with a thin hairy covering on the dorsal side. Female forewings are dark to pale yellow, sometimes orange-tinged, with a distinct black disc-like spot, and white hind wings with yellow shades on the coastal half. Males have moderately orange-yellow forewings with darker undersides and pale straw-colored hindwings featuring transparent, traceable veins. The wingspan ranges from 20–30 mm in males and 24–36 mm in females (Sirvi *et al.*, 2021; Omkar, 2018).

The YSB eggs hatch in 5–8 days, producing larvae that develop over 28–30 days before pupating. The pupal stage lasts 8–10 days, after which adults emerge. Adults live for 2–3 days. The complete life cycle spans approximately 43–51 days (Kumar *et al.*, 2023; Panigrahi & Rajamani, 2008).

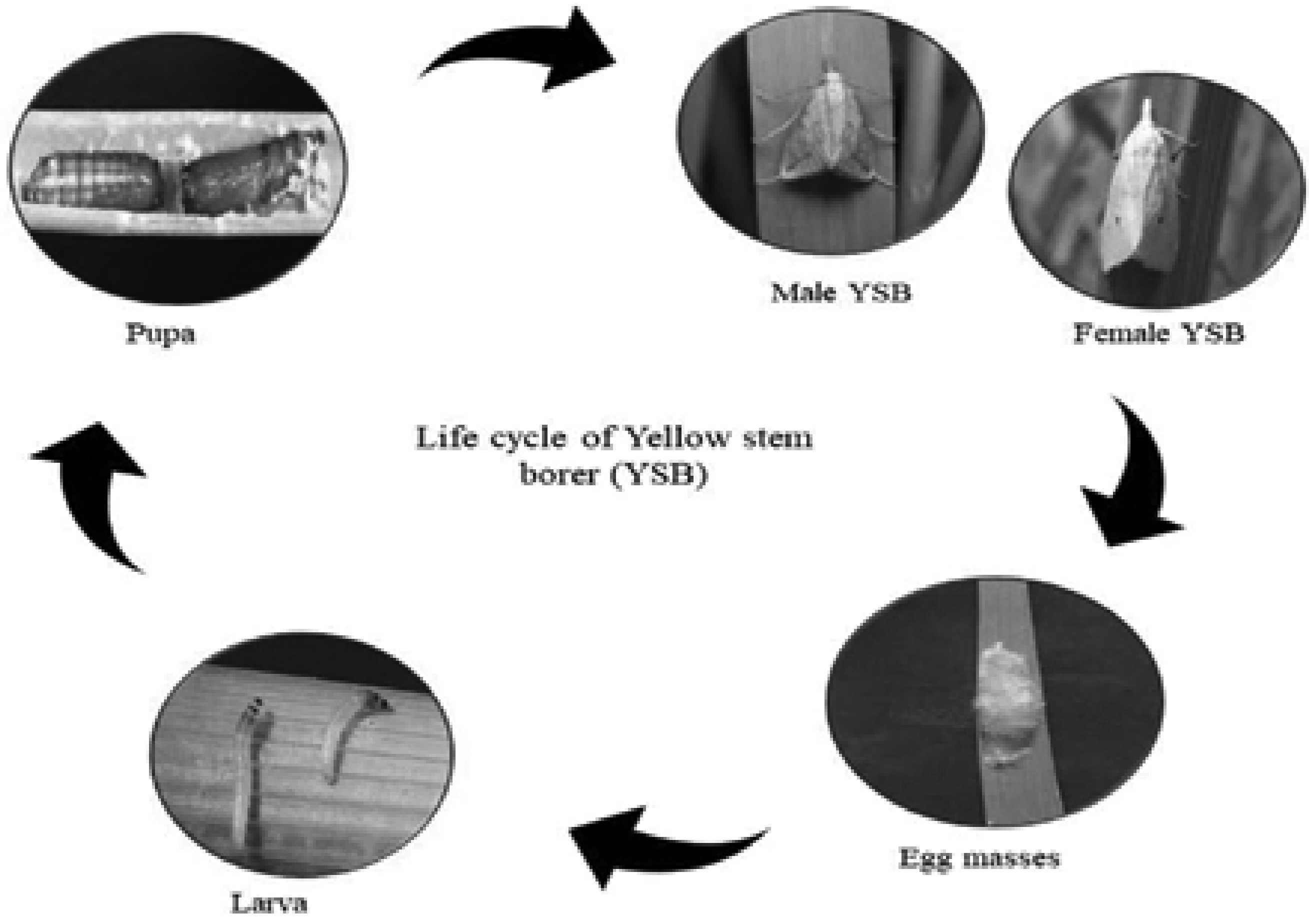

Fig. 3 Life cycle of yellow stem borers

6. Distribution of YSB

The yellow stem borer (YSB) is a monophagous pest that feeds exclusively on paddy plants (Deka & Barthakur, 2010). It is predominantly distributed across tropical Asia and temperate regions where temperatures exceed 10° C and annual rainfall surpasses 1000 mm. Commonly found in countries like India, Nepal, Pakistan, China, and Vietnam, YSB thrives in lowland and flood-prone rice ecosystems, often residing in leaf-over stubbles within aquatic environments (Omkar, 2018).

7. Economic threshold level (ETL) and economic injury level (EIL)

8.1 Economic threshold level (ETL): The economic threshold level (ETL) represents the pest density at which control measures should be initiated to prevent the population from reaching the economic injury level (EIL). This concept often used for insect management, acts as a preventive strategy (Hoidal & Koch, 2021). Control is unnecessary if pest density remains below the threshold; however, intervention is recommended if it exceeds this level. ETL aims to prevent pest damage from reaching the EIL, where the monetary losses caused by pests equal the cost of control measures (Seiter, 2018). For YSB, the ETL is 5%–10% dead hearts with 2% white ears (Suhail *et al.*, 2008).

8.2 Economic injury level: The economic injury level (EIL) is essential in crop production as it determines the cost-benefit balance, guiding pest control decisions in sustainable agriculture and integrated pest management (IPM). It represents the minimum pest population causing economic harm (Damos, 2014). In agriculture, EIL is the threshold where the cost of pest control equals the benefits (Dunford *et al*., 2008). For stem borers, EIL occurs above 10% dead hearts (Brownson, 1987).

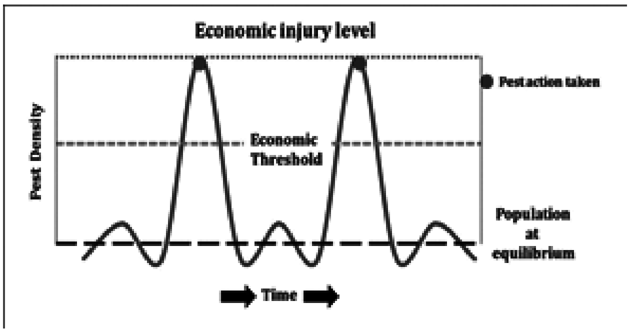

Fig. 4 Economic threshold level (ETL) and economic injury level (EIL)

1. IPM management of stem borers

Integrated Pest Management (IPM) is an approach that focuses on combining various pest control strategies to manage pests effectively while minimizing the use of chemical pesticides. Here are some IPM strategies for managing rice stem borer:

9.1 Cultural practices: Implementing cultural practices can help reduce the risk of stem borer infestations. These include early planting, synchronized planting, maintaining proper plant spacing, and avoiding excessive nitrogen fertilization, as high nitrogen levels attract stem borers (January *et al.,* 2020). To remove egg masses before transplanting, clip the seedling tips.

9.2 Resistant varieties: Planting rice varieties that are resistant to stem borers can significantly reduce the damage caused by these pests. Resistant varieties have genes that provide natural defense mechanisms against stem borer infestations.

9.3 Biological control: Encouraging natural enemies of the stem borers, such as parasitic wasps, predators, and pathogens, can help control their populations. Conservation and augmentation of natural enemies through habitat manipulation, like planting nectar-rich flowering plants, can enhance their effectiveness. Release the egg parasite *Trichogramma japonicum* at a rate of 2 cc/ac three times at a narrow interval.

9.4 Trapping and monitoring: Using pheromone traps, light traps, or sticky traps can help monitor and capture adult stem borers, providing valuable information about their population dynamics. This information can guide the timing of control measures.

9.5 Mechanical control: Physical methods like handpicking and destroying egg masses, larvae, or infested stems can be effective for small-scale farming systems or localized infestations. It is important to destroy the infested plant material properly to prevent the spread of stem borers.

Set up a light trap at 1 per hectare and a pheromone trap at 5 per acre.

9.6 Chemical control: Chemical control remains a significant component of managing rice stem borer infestations in India, especially when pest populations exceed the economic threshold level. Various insecticides have been recommended to effectively control the pest during its vulnerable stages, particularly the egg and early larval phases. 10% Symptoms of a dead heart and 2% have symptoms of whitish ears are considered as Economic Threshold Level.

Chlorantraniliprole (18.5% SC): This systemic insecticide is highly effective against rice stem borer larvae and is applied at 60 ml/acre in 150–200 liters of water. It targets larvae within the stems, preventing further damage to rice crops.

Cartap Hydrochloride (50% SP): Used at a dose of 300–400 g/acre, this insecticide effectively controls stem borer larvae, especially during the whitehead stage of the panicle .

Fipronil (0.3% GR): A granular formulation applied to soil for long-lasting protection, particularly effective in waterlogged paddy fields.

Combination Formulations: Recent trials have demonstrated the synergistic effects of combining insecticides like azadirachtin with chlorantraniliprole, which enhances control and reduces the development of resistance.

Some other pesticides are- Flubendiamide 20% WG 50 g/ac, Thiamethoxam 25% WG 40 g/ac etc.

These chemical controls are often integrated with cultural, biological, and mechanical pest management practices to minimize resistance and ensure sustainable production. Regular monitoring and adherence to Economic Threshold Levels (ETLs) are essential to optimize the use of these chemicals and reduce environmental impacts.

9. Government policies, extension and farmers education

Government policies, extension services, and farmer education play crucial roles in combating the yellow stem borer (YSB) in rice cultivation. Effective policy frameworks support research and development of pest-resistant rice varieties and promote Integrated Pest Management (IPM) practices that incorporate cultural, biological, and chemical control methods. Agricultural extension services facilitate knowledge transfer by providing farmers with training on pest identification, monitoring, and management strategies tailored to local conditions (Deka & Barthakur, 2010).

Educational programs are essential for equipping farmers with the skills to implement IPM practices effectively. Initiatives such as farmer field schools foster collaboration and knowledge sharing among farmers, helping them adopt sustainable practices and reduce reliance on chemical pesticides (Kumar *et al.*, 2023). Additionally, government support through subsidies and incentives for adopting eco-friendly pest management practices can further encourage sustainable rice farming. By aligning policy, education, and extension services, stakeholders can enhance resilience against YSB, ensuring better rice production and food security.

3. Conclusion

The yellow stem borer (*Scirpophaga incertulas*) poses a significant threat to rice crops globally, making its management essential for rice production and food security in India. Integrated Pest Management (IPM) approaches, encompassing cultural, biological, mechanical, and chemical methods, are vital for sustainable control of YSB. Farmers are encouraged to apply pesticides only when pest populations exceed the economic threshold level (ETL) and when biological controls are insufficient. Selective insecticides such as chlorantraniliprole and fipronil can be effective, but educating farmers on optimal application timing is crucial to minimize environmental impact and protect beneficial organisms.

Implementing timely control strategies not only improves rice yield but also contributes to global food security. Sustainable pest management includes the use of biopesticides, mating disruption techniques, and agroecological practices like refugia plants, which enhance biodiversity and reduce reliance on chemical pesticides. Strengthening agricultural extension services, enhancing Farmer Field Schools, and investing in research for resistant rice varieties and biological control agents are essential. Collaborative efforts among farmers, researchers, and policymakers will promote the adoption of these practices, leading to improved pest control and environmental sustainability in regions affected by YSB.

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Effect of KNO_3 and NPK 10:26:26 as Foliar Nutrients on three Soybean (*Glycine max* (L.) Marrill) Varieties in Early Spring Season in Gangetic Alluvial Soils of West Bengal

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Abstract

The experiment was conducted at the Agricultural Experimental Farm of Calcutta University, Baruipur, South 24 Parganas, West Bengal during early spring season of 2017, to study the effect of foliar nutrients sprayed on growth and development of three different soybean varieties (*Glycine max* (L.) Merrill). The experiment was conducted in factorial randomized block design comprised of four foliar nutrients treatment viz. KNO_3 @0.3%, KNO_3 @0.75%, NPK 10:26:26 @1% and control (water spray) over three varieties of soybean JSS-335, JS 93-05, JS 97-52. In order to scan the effect of foliar nutrients feeding no basal fertilizers were applied; instead three foliar nutrients feeding at 30, 50 and 70 DAS were given. Among the three varieties, JS 97-52 resulted the highest plant height (42.65 cm), dry matter production (18.49 g), number of pods/plant (45.58), number of seeds/plant (116.75), grain yield (910.62 kg/ha), stover yield (1057.3 kg/ha) and net return (Rs.28314/ha) which was followed JS 93-05 and JS-335. Among the foliar nutrients application, NPK 10:26:26 @1% recorded the highest plant height (44.37 cm), number of trifoliated leaves (13.89), number of pods/plant (43.78), number of seeds/plant (113.2), seed yield (1003.96 kg/ha), stover yield (1160.24 kg/ha) and net return (JS-335=₹25914, JS 93-05=27914 and JS 97-52=28314/ha) which was followed by KNO_3 @.75%. All the foliar nutrients treatments registered pronounced effect on growth and yield attributing character and seed yield over the control.

Key words : Soybean, Varieties and foliar nutrients

Soybean is considered as the miracle bean due to its rich quality protein and edible oil. It is the world's most important oilseed crop, supplying half of the world vegetable oil and protein (Oerke, 2006). It is a nutritive and energy rich crop having energy value of 416 kcal, protein of 37g, carbohydrate 31g, fats 20g, fibers of 9.3g and zero cholesterol (Vlahoviæ *et al*., 2013). The protein of soybean is also called complete protein as it contain sufficient amounts of amino acid required for building and repair of body tissue. In addition to its dietary consumption, it has important value for its functional food as it contains zero cholesterol. Soybean is known for its wide adaptability coupled with its higher productivity per unit area compared to other grain leguminous crop (Boyer, 1970). In India, soybean is a major crop producing 11.49 million tonnes from 10.97 m ha with the productivity of 1047 kg/ha (SOPA Databank, *kharif* 2016). Farmers in West Bengal are not yet able to explore the efficiency of soybean crop as the major oilseed crop. Due to the land situation and heavy rains in the *kharif* season, farmers have preference on rice; soybean is not popularly grown here. However in the early spring season the farmer can explore the addition income by growing soybean in there rice fallow lands.

Foliar application of nutrient is important in the recent year due to availability of soluble fertilizer and the changing climatic condition. Nutrient applied through foliage play a pivotal role in increasing the seed yield in pulses and oilseeds (Chandrasekhar and Bangaruswamy, 2003). Although soybean is a leguminous crop and able to fix atmospheric nitrogen, in symbiotic association with rhizobia, it has been demonstrated that supplementary fertilization can lead to improved performance of these crops (Tayo, 1981, Ashour and Thalooth, 1983, Mallarino, 2005). It is also been shown that it replenished the reservoir of nutrients in the leaves of legumes during pod development, since the efficiency of nutrient uptake by roots, as well as symbiotic fixation activities are known to decline at this stage. Foliar application of major nutrients NPK was more advantageous than soil application as quick and efficient utilization of nutrients, elimination of losses through leaching and fixation and helps in regulating the uptake of nutrients by plants. It also avoid the depletion of these nutrients in leaves, thereby resulting in an increased photosynthetic rate, better nutrient translocation of these nutrients from the leaves to the developing seeds (Manonmani and Srimathi, (2009), Saravana, (2013)).Potassium (K) acts as a very essential and important nutrient for the plant growth and development. It is necessary in plants to improve the efficiency of photosynthesis and use of water (Ross M. K., 2001). The readily and timely availability of nutrients provided by foliar feeding stimulate enzymatic cycles to greater efficiency and quicker response.

Materials and Method

The field experiment was carried out during the early spring season of 2017 at the Agricultural Experimental Farm of Calcutta University, Baruipur (22.35°N 88.44°E and at the altitude of about 9 m (29 feet) above mean sea level), South 24 Parganas, situated within the area of Greater Kolkata in the Gangetic region of West Bengal, India. The experiment was conducted on sandy loam soil having pH 6.5, organic C (0.75%), available N (169.3 kg/ha), available P (15.1 kg/ha) and available K (257.2 kg/ha). The maximum and minimum temperatures recorded during the crop growth period were 36.9^{o}c and 10.3^{o}c. The experiment consist of four different foliar nutrients treatment *viz*. control (water), KNO_3 @0.3%, KNO_3 @.75% and NPK 10:26:26 @1% and three varieties of soybean *viz*. JS-335, JS 93-05 and JS 97-52. No basal fertilizers were given and instead three foliar nutrients spray was given at 30, 50 and 70 DAS. Soybean varieties were sown @75 kg/ha seed rate at an inter-row spacing of 30 cm on 28 January 2017. Since there were no enough rainfall during the crop season six irrigation were given at germination, 30 DAS, pre-flowering, post flowering, pod formation and pod development stages of the crop. Two hand weeding were given at 20 and 45 DAS. Five random plants were selected from the net plot and tag for recording the growth parameters (plant height and dry matter production at 30, 60, 80 DAS and at harvest), phenological characters (days to flower initiation, 50% flowering and days to maturity) and yield attributing character (number of pods/plant, number of seeds/pod, number of seeds/plant, test weight, seed yield/ha, stover yield/ha and harvest index).

Results and Disucssion

Growth parameters

All the foliar nutrients treatments recorded significantly higher plants height over control (Table 1). Foliar nutrients application of NPK 10:26:26 @1% resulted significantly taller plants. The increase in plant height might be due to application of nutrients at different growth stages which increased the availability of nutrients for plant growth and development and better utilization of applied nutrients. In addition biological nitrogen fixation does operate at the beginning of crop growth which in turn increases the vegetative growth of the plant.This could also be due to the translocation of stored photo-assimilates towards the development of reproductive organs and senescence. This type of growth behaviour in plant height has also been reported by Kumar and Yadav (2007). Among the tested varieties, JS-97-52 produced significantly higher plant height at every stage whereas, JS-335 recorded lowest plant height than other tested varieties. These results are in close conformity with the findings of Thakur *et al.* (2003), Sihag *et al.* (2004), Chettri *et al.* (2005) Ramana and Satyanarayana (2005).

Higher dry matter production at harvest was resulted in variety JS 97-52 (18.49 g). Significantly lower dry matter production was recorded in variety JS-335 (table 1). Among the foliar nutrients application, KNO_3 @75% resulted significantly better dry matter accumulation. The increase in dry matter production of foliar applied nutrients over control might be due to increased uptake of all the nutrients which in turn helped in better plant growth, increased branches, more number of pods and adequate supply of nutrients which increased the carboxylation efficiency and increased the ribulose-1-5 diphospate carboxylase activity resulting in increased photosynthetic rate. Similar finding regarding the influence of foliar spray on dry matter production were also reported by Sarkar *et al.* (1999), Hugar and Kurdikeri (2000), Aruna *et al.* (2001), Rao (2002) and Mallick *et al.* (2014).

Phenological characters

The varieties that mature early without any reduction in yield are the desirable character in high yielding varieties of crops. Out of three soybean varieties, JS-93-05 attained earliest flower initiation in 42 DAS, 50 % flowering in 45 DAS and finally crop maturity in 92 DAS. The variety which matured five days late in 97 DAS was JS-335. JS-97-52 attained 50% flowering and maturity too late as compared to other two varieties i.e. 51 and 105 DAS. Variation in the phenological parameters among the varieties reflects that there were wide differences in the duration of vegetative growth, especially the reproductive phase which are genetically controlled. The variation in phenological parameters among the varieties has been also reported by Raut *et al.* (2001), Hundal *et al.* (2003) and Sharma (2013). Among the foliar treatments delay in flowering and maturity were also observed but without any significant difference. Foliar spray of NPK 10:26:26 @1% observed little bit delayed maturity (99 DAS) over the other foliar spray treatments (98 DAS) and the control (97 DAS).The delay maturity in NPK 10:26:26 @1% and other foliar nutrients spray may be due to delaying the formation of abcission layer and easy availability of nutrients to the crop. These results corroborate the findings of Mallick and Sarkar (2009) in sunflower.

Yield attributes

Significantly higher number of pods/plant (45.58), number of seeds/plant (116.75) and test weight (90.7 g) were recorded in variety JS 97-52 which was follow by JS 93-05(Table 2). The variation in pod bearing ability and seed size among the varieties may be due to variability in the varietal inheritance. Similar finding trends were also reported by Billore *et al.* (2000), Chandankar *et al.* (2002), Thakur *et al.* (2003), Sihag *et al.* (2004), Chettri *et al.* (2005), Ramesh *et al.* (2006) and Sharma *et al.* (2009). Among the foliar nutrients application NPK 10:26:26 @1% resulted better performance in number of pods/plant (43.78), number of seeds/plant (113.2) and test weight (94.2 g) over the other treatments (Table 2). The probable reason of this higher yield attributing characters may be due to the foliar application of N, P and K requirement of the crop during flowering periods resulting in greater availability, absorption of nutrient and efficient translocation of assimilates to reproductive as was reported by Sarkar *et al.* (2007).

Productivity parameters

Seed yield is the final product of cumulative effect of all the factors contributing to growth and development. Significantly the maximum seed yield per ha was recorded in treatment receiving NPK 10:26:26 @1% (1003.96 kg/ha), follow by KNO_3 @0.75% (964.67 kg/ha) and KNO_3 @0.3% (816.13 kg/ha) showing significantly higher yield over control (table 2). Similarly stover yield of NPK 10:26:26 @1% (1160.24 kg/ha), followed by KNO_3 @0.75% (1115.51 kg/ha) and KNO_3 @0.3% (964.27 kg/ha). The improvement in the seed yield may be attributed due to more number of nodes, retention of flowers, development of pod and increase in test weight. The increase in stover yield may be attributed due to increased number of branches, more number of leaves, more number of pods and more seed density, dry matter production due to application of major nutrients at different stages of crop growth. The superiority of N P K 10:26:26 over other foliar applied treatments was attributed towards prolonged assimilation activity of leaves, as reflected on growth parameters due to the present of three primary nutrients in adequate amount and suitable proportion. The similar results were also observed by Odeleye *et al.* (2007), Sarkar *et al.* (2007), Mallick and Mallick (2014) and Khalid and Shedeed (2015). Among the varieties, JS 97-52 recorded higher yield over other tested varieties (Table 2). The variation in yield and yield –attributing characters among the varieties may be due to genetic variation, photoperiodic response and genetic potentiality. These results are in agreement with those of Thakur *et al.* (2003), Singh and Singh (2005), Mondal *et al.* (2005),Sarawgi *et al.* (2005), Sharma *et al.* (2009), Abayomi and Mahamood (2009) and Myo and Tint (2011). Higher harvest index was resulted in variety JS 97-52 (46.15), followed by

Table 1. Effect of foliar nutrients application on growth parameters and phenological characters in different varieties of soybean

Treatments at harvest (cm)	Plant height matter at harvest (g)	Plant dry initiation (DAS)	Flower (DAS)	50% flowering (DAS)	Maturity
Foliar					
Water spray	35.61	9.52	45	48	97
KNO_3 @0.3%	40.50	14.74	45	49	98
KNO_3 @0.75%	43.09	18.04	46	49	98
NPK 10:26:26 @1%	45.38	17.92	46	49	99
SEm(±)	0.78	0.75	0.139	0.198	0.191
CD at 5%	2.28	2.21	**NS**	0.581	0.560
cultivar					
JS-335	39.49	12.66	46	50	97
JS-93-05	40.72	14.01	42	46	92
JS-97-52	42.65	18.49	47	51	105
SEm (±)	0.68	0.65	0.120	0.172	0.165
CD at 5%	1.97	1.91	0.352	0.503	0.485
Interaction					
SEm(±)	1.34	1.30	0.240	0.3434	0.331
CD at 5%	**NS**	3.82	**NS**	**NS**	**NS**

JS 93-05 and significantly lower harvest index was recorded in JS-335 (table 2). Foliar nutrients application of NPK 10:26:26 was exhibited better effect over other foliar nutrients treatments.

Economics

All foliar nutrients treatments provided higher net returns and benefit: cost ratio than control (table 3). The highest net return Rs.28314/ha was recorded in variety JS 97-52 with foliar nutrient treatment of NPK 10:26:26 @1%. Among all foliar nutrients treatments NPK 10:26:26 @1% was proved as the best treatments and among varieties, JS 97-52 excelled the best variety having highest net return and B: C ratio (table 3).

Based on the results, it can be concluded that foliar nutrients application result better growth and development of the crop plants and the varieties JS 97-52 perform the best under the present variety set up investigation.

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TABLE 2. Effect of foliar nutrients application on yield attributing, productivity characters

Treatment	Number of pod/plant	Number of seeds/plant	Test weight (g)	Grain yield (kg/ha)	Stover yield (kg/ha)	Harvest index (%)
Foliar						
Water spray	22.89	56.78	83.7	635.00	778.27	44.91
KNO_3 @0.3%	32.78	92	86.7	816.13	964.27	45.84
KNO_3 @0.75%	43	110.22	91.4	964.67	1115.51	46.33
NPK 10:26:26 @1%	43.78	113.2	94.2	1003.96	1160.24	46.36
SEm(±)	1.43	3.57	0.067	10.39	11.76	0.068
CD at 5%	4.19	10.48	0.197	30.46	34.50	0.20
Cultivar						
JS-335	29.17	77.57	87.2	812.18	962.64	45.67
JS-93-05	32.09	84.84	89	842.03	993.78	45.76
JS-97-52	45.58	116.75	90.7	910.62	1057.30	46.15
SEm (±)	1.24	3.09	0.058	9.00	10.19	0.058
CD at 5%	3.62	9.07	0.171	26.38	29.87	0.17
Interaction						
SEm(±)	2.47	6.19	0.116	18.00	20.37	0.12
CD at 5%	7.25	18.15	0.342	52.76	59.75	0.35

TABLE 3. Effect of foliar nutrients application on Net return and Benefit cost ratio

Variety	Treatment	Net return (₹/ha)	Benefit cost ratio
JS-335	Water spray	13715	1.28
	Foliar spray of KNO_3 @0.3% at 30, 50 and 70 DAS	17835	1.28
	Foliar spray of KNO_3@0.75% at 30, 50 and 70 DAS	19105	1.19
	Foliar spray of NPK 10:26:26 @1% at 30, 50 and 70 DAS	25914	2.03
JS-93-05	Water spray	14515	1.36
	Foliar spray of KNO_3 @0.3% at 30, 50 and 70 DAS	18435	1.32
	Foliar spray of KNO_3@0.75% at 30, 50 and 70 DAS	20505	1.28
	Foliar spray of NPK 10:26:26 @1% at 30, 50 and 70 DAS	27914	2.18
JS-97-52	Water spray	16015	1.50
	Foliar spray of KNO_3 @0.3% at 30, 50 and 70 DAS	19835	1.42
	Foliar spray of KNO_3@0.75% at 30, 50 and 70 DAS	28245	1.77
	Foliar spray of NPK 10:26:26 @1% at 30, 50 and 70 DAS	28314	2.21

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Effect of Phosphorus, Sulphur and Boron on Sunflower (*Helianthus annuus*)

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Abstract

A field experiment was conducted with varying levels of Phosphorus, Sulphur and Boron in a factorial block design during winter seasons of 2019-20 and 2021-21 at the Experimental station of Calcutta University, Baruipur, Dist 24 Parganas, West Bengal on Gangetic alluvial Land. The results revealed that higher dose of phosphorus, sulphur and baron proved them beneficial effects on growth and physiological parameters like plant height, dry matter / Plant, LAI, CGR, RAR and NAR in sunflower. Application of 60 kg each of Phosphorus, Sulphur and 2kg Boron per ha improved yield contributing characters and resulted in higher seed yield over lower doses of respective nutrients. The sunflower crop showed a Quadratic nature of response with varying levels of P_2O_5, S and B. the most profitable dose of P_2O_5, S and B for sunflower were found to be 57.1, 55.51 and 1.78 kg/ha respectively.

Introduction

Sunflower (*Helianthus annuus* L.) being a day neutral, short duration, drought and salt tolerant crop with deep root system with wide adaptability crop capable of growing with residual moisture can also show good prospect for its cultivation in winter in vast rice fallows in Gangetic soil conditions of West Bengal. Besides many factors responsible for its production optimum use of fertilizers and their management in consequential for obtaining its higher Potential yield. Response of Phosphorus application has been established (Prasad *et al*, 1983). Phosphorus is an important plant nutrition and it affects seed germination, call wall division, flowering, fruiting, synthesis of fat, starch and infact most biochemical activities (Singh and Singh, 2012). Sulphur being an essential element influences plant growth, dry matter production and seed yield of sunflower (Ramu and Reddy, 2003; Maity *et al.*, 2003). Boron application leads higher photosynthetic activity and translocation of photosynthates of the sink, consequently results in better development in yield attributes and finally higher seed yield of Sunflower (Sankar and Sasmal, 1989.) Considering all these points in view the present investigation has been undertaken.

Materials and methods

The field experiment entitled "Effect of Phosphorus, Sulphur and Boron on Sunflower (*Helianthus annuus* L.) way conducted during winter season of 2019-20 20 and 2020-21 at the Experimental station of Calcutta University, Baruipur, Dist. 24 Parganas, West Bengal on Gangatic alluvial soil under Inceptisol having clay loam texture. The soil contained available N 169.3 kg, available P 15.1 kg, available K 257.2kg with boron with traces with organic carbon 6.73%. The experiment comprising four levels of P at 0, 20, 40 and 60 kg P_20_5/ha, three level of S at 0, 20 and 40 kg/ha and Boron at 0, 1 and 2 kg/ha was tested in a factorial design with three replications on land vacated after rainy season rice. Recommended dose of N and K_2O were applied at 80 kg and 60 kg/ha respectively at planting. The Variety J.K. Chitra was sown with geometry of 45cm x 30 cm during second forth night of November in both the years. The crop was sown with residual moisture. In all three irrigations each at Budding, flowering and grain filling stages was given. The crop was harvested in third week of march in both the years.

Results and Discussion

Plant height was maximum with 60 kg P_20_5/ha at harvest in both the years (Table I). The increase in height with 60 kg P_20_5/ha might be attributed to rapid mobilization of P from inorganic fertilizer which might have met the P requirement in cell elongation and cell

TABLE 1. Effect of Phosphorus, Sulphur and Boron on growth parameters of Sunflower

Treatments	Plant Height at harvest (cm)		Dry matter/ plant (g) at harvest		Leaf Area Index (LAI 160 DAS) 45-60 DAS		Crop Growth Rate (CGR g/cm^2/day)	
	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
Phosphorus (P_2O_5)								
levels (kg/ha)								
0	159.00	145.60	87.58	83.13	3.36	3.27	1.72	1.63
20	173.80	159.60	108.45	102.56	4.65	4.36	2.21	2.05
40	175.30	162.60	107.10	105.90	4.65	4.27	2.23	2.09
60	176.80	165.60	107.20	106.66	4.66	4.19	2.26	2.14
SEm±	2.64	2.52	1.63	1.49	0.07	0.07	0.07	0.04
LSD (P=0.05)	7.1	7.6	7.98	5.35	0.21	0.14	0.029	0.028
Sulphur levels(kg/ha)								
0	168.60	151.20	104.18	96.01	4.42	4.07	2.13	1.99
20	174.70	165.30	107.43	105.09	4.73	4.28	2.22	2.12
40	175.80	166.20	109.20	107.20	4.69	4.29	2.27	2.09
60	182.70	172.50	113.56	112.75	4.80	4.47	2.35	2.17
Sem$^+$-	3.24	2.81	1.99	2.44	0.08	0.08	0.08	0.03
LSD (P=0.05)	8.99	7.80	5.53	6.75	0.23	0.13	0.029	0.022
Boron levels kg/ha								
0	166.70	151.30	99.54	95.81	4.33	3.91	2.06	1.96
1	174.70	161.50	108.88	103.21	4.71	4.22	2.25	1.08
2	184.50	174.90	116.06	114.82	4.92	4.70	2.39	1.22
Sem$^+$-	3.24	2.18	1.99	2.44	0.08	0.08	0.08	0.03
LSD (P=0.05)	8.99	7.80	5.53	6.53	0.21	0.18	0.022	0.025

division at critical stage of plant growth (Joybal, *et al.,* 2000). Similarly, the height was more with higher rate of S application at 60kg/ha perhaps due to better nutritional environment for plant growth, cell multiplication, elongation and cell expression in the plant body (Steffenson, 1954), which ultimately increased plant height. Increase in plant height with application of the higher rate of 2kg B/ha might be due to potent role of B in cell elongation, photosynthesis and respiration (Brown and Hu, 1996).

Increased in dry matter at harvest with 60 kg P_2O_5/ha at harvest may be accounted for its ability to absorb inorganic materials for growth parameters and synthesize carbohydrate which ultimately enhanced dry matter (Ramanujan and Rao, 1971; Singh and Kaushal, 1975). The highest dry matter accumulation was recorded with 60 kg S/ha (Budhar, *et al.,* 2003). The results thus revealed that there was positive response of S application on rate of dry matter accumulation in sunflower (Wani *et al.*, 2005). Application of B showed the positive effect in dry matter accumulation (Oyinlola, 2007). Dry matter accumulation in sunflower responded positively to the increased level of B applied (Prasad *et al*., 1978). The plant attained maximum LAI at 60 days of growth with 60kg P_2O_5/ha probably due to production of more vegetative tissues owing to better availability of nutrients (Haggai, 1996). The crop showed maximum LAI during 60 days of growth due to 60kg S/ha which was possibly owing positive role of S on elongation (Ahmed and Abdin, 2000). The crop attained peak value of CGR between 30 to 45 days due to 60 kg P_2O_5, 60 kg S and 2kg B/ha possibly on account of increase in leaf area index and dry matter. In general, the control treatments gave comparatively higher RGR value probably due to higher rate of dry matter production and crop growth. The relative improvement in RGR under control treatment could be attributed to corresponding variation in NAR. Increased NAR under control treatments over higher doses of P, S and B signifies for the resultant gain in photosynthesis over loss in in respiration

Levels of P, S and B showed pronounced effect on yield components of sunflower. P fertilization at higher rate increased size of capitulum (Mojiri and Arzani, 2003). Increased in S application showed positive effect on increasing capitulum diameter possibly due to increased absorption of S from soil resulting in formation of reproductive structure on sink diameter (Budhar *et al.,* 2003). A major effect of B nutrition was reported to be on seed set. (Blamey, 1976). This might be due to application of B which contributed to the improvement of pollen development and growth (Dell and Huang. 1997). Highest number of seeds / capitulum was recorded with 60 kg P_2O_5/ha. Number of seeds / capitulum significantly increased with increment of S application. Such response to increasing P and S levels might be ascribed to adequate supply of these nutrients that resulted in higher production of photosynthates and their translocation to sink (Rana *et al.,* 2005). Application of 2kg B/ha produced highest number of seeds/ capitulum. The results corroborate the findings of Renuka devi *et al.,* (2003). Maximum 1000-seeds weight was produced with 60 kg P/ha; Sarkar *et al.,* reported increased test weight with increasing p rates. Application of S proved effective in increasing test weight through the development of reproductive structure as well as production of assimilates to fill economically important sink 'Sharma and Singh' (2005). The improvement of test weight with B might be because of the role of boron in fertility improvement and translocation of photosynthates (Ahmed Khan *et al.*, 1990).

Phosphorus application up to 60 kg/ha increased seed yield of sunflower by 15.58, 40.02and 3.13% over control, 20 kg P_2O_5 and 40 kg P_2O_5 /ha respectively on pooled basis. Phosphorus increases photosynthetic activities in plants and helps develop a more extensive root system and thus enables the plant to extract more water and nutrients from depths, resulting in better development of plant growth and yield attribute and higher seed yield (Prabhuraj *et al.,* 1993). The increase in seed yield due to S fertilization was mainly due to enhanced rate of photosynthesis and carbohydrate metabolism by S application (Legha and Giri, 1999). The results indicated that 60 kg S/ha increased seed yield by 7.2, 5.9 and 5.0 % over control, 20kg S and 40 kg S/ha respectively on pooled basis. Increased in seed yield with increased in B fertilization indicated the necessity of B by Sunflower (Blamey

TABLE 2. Effect of Phosphorus, Sulphur and Boron on physiological growth parameters and yield components of Sunflower

Treatments	Relative Growth Rate (RGR) g/g/day at 30-45 DAS		Net Assimilation Rate (NAR) g/g/day at 30-45 DAS		Capitulum Diameter (cm)		Number of seeds/ capitulum	
	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
Phosphorus (P_2O_5) levels (kg/ha)								
0	0.130	0.110	1.600	1.510	12.8	11.8	753.4	752.1
20	0.111	0.112	1.570	1.610	17.1	16.6	854.8	830.8
40	0.110	0.112	1.580	1.560	17.1	16.1	874.1	845.5
60	0.110	0.113	1.600	1.520	19.2	17.2	885.6	856.1
Sem^{+}-	0.001	0.002	0.020	0.030	0.18	0.22	8.89	8.85
LSD (P=0.05)	0.002	0.001	0.001	0.003	0.53	0.45	26.69	24.85
Sulphur levels (kg/ha)								
0	0.112	0.115	1.530	1.490	15.9	14.8	812.8	801.2
20	0.109	0.112	1.550	1.570	17.0	17.3	848.4	850.2
40	0.110	0.112	1.615	1.605	18.4	17.7	903.3	901.2
60	0.112	0.111	1.680	1.640	19.1	18.2	923.7	912.3
Sem^{+}-	0.002	0.002	0.020	0.040	0.2	0.26	10.9	11.02
LSD (P=0.05)	0.001	0.004	0.001	0.001	0.66	0.72	30.21	30.52
Boron levels kg/ha								
0	0.110	0.119	1.550	1.510	15.5	14.4	825.30	821.70
1	0.111	0.113	1.600	1.570	17.4	17.2	857.50	851.70
2	0.111	0.114	1.610	1.600	18.5	18.2	881.00	876.90
Sem^{+}-	0.002	0.002	0.020	0.040	0.2	0.26	10.9	11.02
LSD (P=0.05)	0.001	0.007	0.006	0.003	0.66	0.72	30.21	30.52

Table 3. Effect of Phosphorus, Sulphur and Boron on yield components and yield of Sunflower

Treatments	1000- Seed weight (g)		Seed yield (kg/ha)		Stover yield (kg/ha)		Biological yield (kg/ha)		Harvest Index (HI)	
	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
Phosphorus (P_2O_5) levels (kg/ha)										
0	32.5	30.25	2040.7	1895.9	1870.5	1885.4	3936.4	3864.1	52.2	50.1
20	39.79	40.55	2868.5	2878.2	2078.3	2040.4	5746.7	5751.55	57.7	57.9
40	39.38	40.85	2888.5	2892.4	2096.3	2080.6	5780.9	5782.85	57.8	58
60	40.91	40.95	3019.2	2921.4	2161.9	2109.7	5940.6	5891.7	58.3	58.1
Sem$^+$-	0.45	1.05	97.3	85	56	29	111	83	1.9	0.8
LSD (P=0.05)	2.07	2.11	196.6	153	113.1	52.2	224.3	167.7	2.7	1.6
Sulphur levels(kg/ha)										
0	37.46	37.83	2537.5	2516.2	2111.6	1920.6	4649.1	4436.8	54.6	56.8
20	41.11	40.73	2785.7	2613.5	2137.8	2090.3	4923.5	4703.8	57.6	58
40	42.60	43.10	2837.4	2755.4	2145.1	2198.7	4982.5	4954.1	59.2	58.8
60	43.60	43.60	2814.5	2803.7	2265.7	2269.5	5080.2	5073.2	59.7	59.4
Sem$^+$-	0.78	1.62	39.8	28	29.1	22	41.1	75	0.8	0.6
LSD (P=0.05)	2.16	4.45	110	77	77.2	72.6	114. 1	210.2	1.6	1.3
Boron levels kg/ha										
0	37.31	38.25	2876.3	2699.2	2040.7	1932.9	4917	4632.1	55.7	57.5
1	40.43	40.15	3056.1	2918.6	2181.3	2102.9	5237.4	5021.5	57	57.5
2	44.63	43.25	3176. I	3096.5	2195.2	2175.5	5371.3	5272	59.9	59.2
Sem$^+$-	0.78	1.62	39.8	28	29.1	22	41.1	75	0.9	0.7
LSD (P=0.05)	2.16	4.45	110	77	90	82.1	66.5	157.7	1.7	1.5

TABLE 4. Effect of Phosphorus, Sulphur and Boron levels on total nutrient uptake

Treatments	P kg/ha		S (kg/ha)		B (kg/ha)	
	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
Phosphorus (P_2O_5) levels (kg/ha)						
0	16.83	16.81	16.26	16.11	193.28	192.43
20	26.49	27.58	24.08	24.33	284.46	288.15
40	28.98	27.43	24.57	24.75	289.05	292.61
60	30.59	30.72	25.43	25.51	298.81	299.30
Sem^{+}-	0.01	0.01	0.01	0.01	0.04	0.06
LSD (P=0.05)	1.51	1.62	1.51	1.62	7.51	6.29
Sulphur levels(kg/ha)						
0	23.09	23.61	19.71	18.50	230.13	219.18
20	26.62	27.22	21.22	20.04	243.22	235.19
40	27.90	29.16	21.67	21.40	247.63	248.70
60	28.43	30.05	22.45	22.12	254.01	255.69
Sem^{+}-	0.02	0.05	0.02	0.05	0.04	0.07
LSD (P=0.05)	1.98	1.91	1.98	1.91	8.24	8.41
Boron levels kg/ha						
0	23.57	21.41	20.70	19.22	247.33	231.14
1	25.36	24.62	22.47	21.14	265.01	252.58
2	27.93	27.05	23.31	22.56	278.23	269.40
Sem^{+}-	1.01	1.05	1.01	1.05	2.31	2.07
LSD (P=0.05)	1.3	1.8	0.39	0.52	6.29	7.91

TABLE 5. Response function of Sunflower and maximum dose (X-max) maximum Yield (Y- max) maximum yield treatment ratio (Y-max/ X- max and economic optimum dose (X-opt) for Sunflower

Response functions of treatments	X-max (kg/ha)	Y-max (kg/ha)	Y-max/X-max	X-opt (kg/ha)
$Y=2959.3+6.8725\ P_2O_5 - 0.1288(P_2O_5)^2$	60	2970	49.5	57.1
$Y=2787.8+24.495S -0.2S35\ (S)^2$	60	2809.1	46.81	55.51
$Y=2518.7+11.148B-0.1051(B)^2$	2	3136	1568	1.78

TABLE 6. Sunflower grain yield and net profit due to application of P, S and B

Sunflower grain yield and net profit due to application of Phosphorus

Level of Production	Level of P_2O_5 (kg/ha)	Cost of P_2O_5 (kg/ha)	Expected Yield (kg/ha)	Response in yield (kg/ha)	Value of responses of yield (kg/ha)	Net returns to P_2O_5 (kg/ha)	Gross returns to P_2O_5 (Rs)	Net Profit per rupee invested on P_2O_5 (Rs)
Maximum Physical level	60	480	2970	63	1260	780	123.75	1.63
Most profitable level	57.1	456.8	2962.53	180.95	3619	3162.2	129.71	6.92

Sunflower grain yield and net profit due to application of Sulphur

Level of Production	Level of S (kg/ha)	Cost of S (kg/ha)	Expected Yield (kg/ha)	Response in yield (kg/ha)	Value of responses of yield (kg/ha)	Net returns to S (kg/ha)	Gross returns to S (Rs)	Net Profit per rupee invested on S (Rs)
Maximum Physical level	60	4800	2809.10	662.06	13241	8441	11.70	1.76
Most profitable level	55.51	4440.8	2804.71	786.93	15739	11298	12.63	2.54

Sunflower grain yield and net profit due to application of Boron

Level of Production	Level of B (kg/ha)	Cost of B (kg/ha)	Expected Yield (kg/ha)	Response in yield (kg/ha)	Value of responses of yield (kg/ha)	Net returns to B (kg/ha)	Gross returns to B (Rs)	Net Profit per rupee invested on B (Rs)
Maximum Physical level	2	400	3136.3	597.3	11946	11546	156.82	28.87
Most profitable level	1.78	356	3135.6	598.09	11962	11606	176.16	32.60

*et al,.*1976). The increased day stover production under higher level of P may be due to efficient physiological and metabolic process resulting in intensive growth. Increased stover with S application might be due to more uptake of nutrients resulting greater photosynthetic activities and consequent to greater vegetative growth of plants and ultimately higher stave yield . Improved harvest index (HI) due to increase in P. S and B is an indication of increased physiological capacity to mobilize the photosynthates towards economic yield.

There was significant increase in the total uptake of P, S and B owing to their application, Phosphorus application increased the total uptake of P, Sand B. Increase in S application also increased P, S and B uptake by sunflower crop. Similarly, increased in B also enhanced P, S and B uptake. Uptake could be ascribed partly to variation in the availability of these nutrients in the soil and partly due to priming effect of one nutrient on the other (Rana *et al.,*2005). The analysis of response functions indicated to be significant to Quadratic effect on pooled data. The most profitable dose of P_2O_5, S and B were found to be 57.1, 55.51, and 1.78 kg respectively. Economic optimum on P, S and B usages revealed that the net returns from P, S and B would respectively be Rs. 6.29, Rs. 2.54 and Rs. 36.60 and gross profit would be Rs 129.71, Rs. 12.63 and Rs. 176.16 per rupee invested on P_2O_5, S and B respectively for sunflower.

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Estimates of Variability, Heritability in Some Reproductive Characters and Yield in Chilli (*Capsicum annuum* L)

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Abstract

Forty one chilli genotypes were grown in a Randomized Block Design with three replications during autumn-winter season of 2016-17, at the AB block Farm, Kalyani, BCKV, to estimate variability and heritability for important reproductive and yield characters. In the present experiment GCV and PCV estimates closely corresponded in case of days to 50% flowering, fruit length, placenta length and 1000 seed weight; in others it differed moderately, altogether suggesting low to medium influence of environment in the expression. Close estimates of PCV and GCV were noted in all the characters except fruit width, which imply that contribution towards final phenotypic expression of these characters, are mostly genetic rather than environmental. Very high GA as % of mean was recorded in fruit yield/plant and moderately high GA as % of mean was recorded in days to 50% flowering, placenta length, fruit length, number of fruits/plant and number of seeds/plant, indicating that these characters are most likely governed by additive gene action and hence would be rewarding in selection.

Introduction

Chilies either green or as dried red ripe fruits, are used throughout world for its pungency in culinary preparations or as pickles. India is a leading chilli producer and exporter and has great many diversity of this solanaceous fruit.

Any genetic improvement in a crop can be achieved by bringing beneficial and desirable genes in a genotype and discouraging genes that govern undesirable traits. Yield and productivity are the two major desirable attributes in chilli. No doubt productivity of chilli in our country is low, though area under cultivation is huge. To upscale such low yielding genotypes, it is mandatory to understand the basic genetic makeup, variability and interrelationships among various characters as well as yield components. So, for proper choice of parents and framing any future improvement programme in chilli, the present investigation was carried out with fifty three genotypes to determine and illustrate the nature and magnitude of genetic variability among important growth and fruit characters, their interrelationship and their direct and indirect effect on yield.

Materials and Methods

Fifty-three chilli genotypes were grown in a Randomized Block Design with three replications during autumn-winter season of 2016-17. Thirty day old seedlings were transplanted at spacing of 45 x 45 cm. accommodating twenty plants per plot. Standard recommended crop management practices including plant protection were followed to raise the crop. Five randomly selected plants from each replication were used to record observations on days to 50% flowering, fruit length (cm), fruit pedicel length (cm), placenta length (cm), No. of fruits/plant, fruit weight (g), seeds per fruit, 1000 seed weight (g) and fruit yield/plant. The phenotypic and genotypic correlation co-efficient and path co-efficient were calculated to estimate the direct and indirect effects among the characters as per Deway and Lu (1957).

Results and Discussion

Analysis of variance for different characters in Chilli is given in Table-1. The extent of variability present in the genotypes was measured in terms of

Table 1. Analysis of variance for different characters in Chilli

Characters	Mean sum of squares		
	Genotypes	Replication	Error
Days to 50% flowering	432.79**	1.541	18.958
Fruit length (cm)	7.28**	0.100	0.338
Fruit width (cm)	0.149**	0.170	0.037
Fruit Pedicel length (cm)	0.702**	0.047	0.125
Placenta length (cm)	6.37**	0.016	0.304
No. of fruits/plant	698.94**	251.75	83.58
Fruit weight (g)	0.417**	0.009	0.067
No. of seeds/plant	984.88**	26.718	86.319
1000 seed weight (g)	2.024**	0.146	0.092
Fruit yield/plant	4796.32**	109.50	273.58

*Significant at $p = 0.05$; ** Significant at $p = 0.01$

range, co-efficient of variation, genotypic co-efficient of variation (GCV), phenotypic co-efficient of variation (PCV), broad sense heritability and genetic advance (GA). From the Table-2 it is clear that moderate to high range of variation was recorded in all the characters, indicating better scope for improvement through selection. The co-efficient of variation in all the fruits ranged from 6.08 to 20.27; Plant height, canopy width, fruit width, number of fruits per plant and fruit yield recorded a bit higher CV values. In the present experiment GCV and PCV estimates closely corresponded in case of days to 50% flowering, fruit length, placenta length and 1000 seed weight; in others it differed moderately, altogether suggesting low to medium influence of environment in the expression as also noticed earlier by Sreelathakumary and Rajamony (2002) and Prabhakaran *et al* (2004). Higher PCV and GCV values were recorded in plant height, number of fruits/plant and marketable green fruit yield per plant. In other characters, it was medium to high. Higher magnitude of PCV and GCV indicate presence of substantial variability that could be potently exploited through direct selection.

Close estimates of PCV and GCV were noted in all the characters except plant canopy width and fruit width, which imply that contribution towards final phenotypic expression of these characters, are mostly genetic rather than any environmental influence. Hence, selection only on the basis of phenotypic attributes would be effective with equal probability of success. But, to be conclusive on fair estimation of genetic make ups and its contribution to phenotypic expression of characters, such evaluation experiments must be conducted over the seasons at different locations. High GCV values, in the experiment, were noted in case of plant height, number of fruits/plant ad fruit yield /plant and this finding is earlier supported by Chandra *et al.* (1990), Choudhury and Samadia (2004), Manju and Sreelathakumary (2002), Rani *et al.* (1996) and many others. However genetic co-efficient of variation alone provides insufficient evidence to indicate that the majority of variation is inheritable.

TABLE 2. Genetic variability and heritability estimates for different characters in Chilli

Characterss Components of variation	Days to 50% flowering	Fruit length (cm)	Fruit width (cm)	Fruit pedicel length (cm)	Placenta length (cm)	No. of fruits/ plant	Fruit weight (g)	No. of seeds/ plant	1000 seed weight(g)	Fruit yield plant
Range	29.00-70.33	4.23-9.74	0.58-1.60	2.22-4.42	4.0-9.45	22.50-86.35	1.53-2.82	32.51-110.84	3.46-6.80	50.40-218.70
Grand mean	49.60	6.36	1.01	3.10	6.06	45.09	2.16	73.06	4.99	97.34
S.Em	0.36	0.47	0.15	0.28	0.45	0.74	0.211	0.75	0.24	0.13
Coefficient of variation (CV %)	9.10	9.14	19.19	11.41	9.10	20.27	11.95	12.71	6.08	16.99
PCV (%)	26.16	23.94	27.23	17.99	25.16	38.86	19.58	27.00	17.18	43.37
GCV (%)	24.50	22.13	19.31	13.90	23.45	36.16	15.86	23.82	16.07	39.90
Heritability (%)	87.5	85.4	50.3	59.7	86.9	72.8	63.5	77.8	87.5	84.5
Genetic Advance(GA)	22.57	2.68	0.29	0.69	2.73	26.28	0.56	31.62	1.55	73.61
GA % of mean	46.3	43.1	26.5	21.6	45.0	58.2	25.8	43.2	31.0	75.6

A majority of the traits (Table-2) exhibited high heritability. The GCV x selection differential estimates the maximum effectiveness of selection; and heritability indicates how closely the goal can be achieved (Singh *et al*., 1968). In the present case very high broad sense heritability (> 80%) was noted in days to 50% flowering, fruit length, placenta length, 1000 seed weight and fruit yield/plant, as also earlier recorded by Choudhury and Samadia (2004), Rathod *et al.* (2002), Rani *et al,* (1996) and Bhagyalakshmi *et al* (1990). Above average to high heritability estimates (60-80%) were observed in plant height, number of fruits/plant, fruit weight, number of seeds/plant. High estimates of heritability in quantitative characters have been found to be useful for selection based upon phenotypic performance.

Johnson *et al* (1955) had suggested that heritability estimates along with genetic gain is usually were helpful rather that heritability alone in predicting the resultant effect for selection the best individuals. Very high GA as % of mean was recorded in fruit yield/plant and moderately high GA as % of mean was recorded in plant height, days to 50% flowering, placenta length, number of fruits/plant and number of seeds/plant, indicating that these characters are most likely governed by additive gene action (Acharyya *et al*., 2003, Bhagyalakshmi *et al.* 1990). Other characters have been under the influence of pre-dominantly non-additive gene action and hence are comparatively less reliable for direct selection; these characters need to be improved through hybridization (Panse,1957). For indirect selection, the mutual relationships between various characters have to be worked out through correlation studies. In general, estimates of genotypic correlations were higher than the phenotypic ones in the present investigation, which is in tune with the findings of Krishna *et al.* (2007). With phenotypic correlations taken as reference, it is found from the Table-3, that fruit yield/plant is significantly and positively correlated with fruit length, fruit pedicel length, placenta length, number of fruits/plant, fruit weight and 1000 seed weight. These findings are in consonance with Dutta *et al.* (1979). Both genotypic and phenotypic correlation profiles indicate that fruit length and weight are important yield components; this is in tune with an earlier finding of Pandit *et al.* (2009). So, it can be said that fruit yield in chili could be increased by giving weightage to fruit length, number of fruits/plants, fruit weight and 1000 seed weight in the selection programme.

Phenotypic correlations of the different characters were partitioned to path coefficient (Table-4) with view to identify important fruit characters having direct effect on yield. Highest direct positive effects on yield were given by number of fruits/plant (0.626), followed by 1000 seed weight (0.174) and placental length (0.171). This finding was supported by the earlier reports of Jose *et al*. (2002), Rani *et al.* (1996) and Jabeen *et al.* (1999). From the study of character associationship, combining correlation and path coefficient, the characters, namely, fruits/plant, placenta length, fruit weight and 1000 seed weight emerged as the most important fruit yield components. Genetic variability parameters for these characters were also considerably high. Significance of these characters as important selection indices was also suggested by some earlier workers like Munshi *et al.*, 2000; Devi *et al.*, 1999; Kataria *et al.*, 1997.

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Field Bio-Efficacy of Some New Molecules Against Major Hopper Complex in *Kharif* Rice

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Abstract

A field experiment was carried out at Rice Research Station, Chinsurah, Hooghly during *kharif*, 2014 and 2015 to evaluate the bio-efficacy of some insecticides against important and major rice hoppers viz. green leafhopper (GLH) and brown planthopper (BPH). The trial included nine insecticidal treatments viz. carbosulfan 25% EC, imidacloprid 17.8% SL, acephate 75% WP, novaluron 10% EC, dinotefuran 20% SG, buprofezin 25% SC, sulfoxaflor 21.8% W/W SC, thiamethoxam 25% WG and ethiprole 40%+imidacloprid 40% WG along with untreated control where no insecticide was applied. The plots were laid out in randomized complete block design with three replications. During *kharif* 2014, the ethiprole+imidacloprid treatment was responsible to 77.97 and 67.79 per cent reduction over control against GLH and BPH population respectively, followed by dinotefuran treatment (72.88% GLH & 62.02 BPH). In same year, the highest yield increase over control was found in ethiprole+imidacloprid treatment (25.69%) followed by dinotefuran treatment (22.70%) which was at par with sulfoxaflor (20.55%) and imidacloprid (19.73%) treatments. During *kharif* 2015, the highest population reduction over control was calculated in ethiprole+imidacloprid treatment (80.62% GLH & 70.78% BPH) followed by dinotefuran treatment (74.33% GLH & 64.04% BPH) in GLH and BPH respectively. In the same year, the highest yield increase over control was calculated in ethiprole+imidacloprid treatment (37.80%) followed by dinotefuran treatment (31.86%) which was at par with sulfoxaflor (29.64%) treatments. The insecticide, ethiprole+imidacloprid was recorded as the best to manage the rice hopper complex, both BPH and GLH followed by dinotefuran. The ethiprole+imidacloprid treated plots provided the highest grain yield followed by dinotefuran treatment. The highest BCR (Benefit:Cost) value was showed in imidacloprid treatment (0.74:1) followed by ethiprole+imidacloprid treatment (0.68:1) which was at par with dinotefuran (0.64:1) and sulfoxaflor (0.61:1) treatments.

Keywords **:** Rice hopper, brown planthopper, green leafhopper, ethiprole+imidacloprid, dinotefuran

Introduction

Rice *(Oryza sativa* L.), is one of the important staple food of more than half of the world population and rice production and it's consumption are concentrated mainly in Asian countries (Chatterjee and Mondal, 2014). In West Bengal, rice is considered as the dominant food crop and is grown in all six agro-climatic zones of the state under diversified situations (Gangopadhyay and Chatterjee, 2020). The state is suffering from poor productivity due to different biotic stresses like, insect-pests, mites, nematodes, diseases etc. (Chatterjee *et al*., 2015). Yield losses due to pests of rice in tropical Asia range 25–43% and therefore, there is a need to explore management options for judicious use of chemicals (Chatterjee *et al*. 2021). Among them brown planthoppers constitute one of the most important pest causing substantial yield losses (Konchada *et al*., 2017). Both adults and nymphs of brown planthopper (BPH), *Nilaparvata lugens* (Stål) suck cell sap from paddy, congregate at the base of the plant above the water level. Affected plants leaves turn pale, yellow and later wither away leading to total drying of plant and if excessive attack occurs, the rice plants give a scorched appearance called "hopper burn" where circular patches of quick drying and lodging of matured plants are found. BPH may act as a vector of grassy stunt, ragged stunt and wilted stunt diseases. They secret honeydew at plant base exposing the plant to fungal and bacterial infections resulting "sooty mould". Small sized hoppers are brown to grey in colour. Green leaf hopper (*Nephotettix virescens* Dist.) do noticeable damage to the rice crop causing 15-20

% reduction in yield (Prakash and Rao, 1999). In case of green leaf hopper (GLH) the damage is caused by both adults and nymphs due to feeding, oviposition and sucking of xylem sap. GLH is a wedge shaped greenish coloured hopper. Adults have black spot on each of its forewings and black patch towards outer margin. Both the nymphs and adults suck cell sap from leaves of the plants, turn pale, yellow and later wither away leading to total drying of plants. GLH also act as the vector of rice tungro virus (causing tungro disease). The yellowing of leaves is seen from tip to downwards when tungro disease is transmitted.

The indiscriminate use of broad spectrum insecticides against insect-pests reduces the biodiversity of natural enemies as well as reduces the natural control and induces secondary pests outbreak and pollutes eco-system (Singh, 2000). But still chemical control forms the first line of defense of pests (Pasalu *et al*., 2002). Now a days, the pest resistance to existing insecticides is an on-going problem that requires the development of new insect control tools (Whalon et al., 2008). The conventional insecticides are becoming ineffective against these insect pests within a short span of time as they have either lost their efficacy or become obsolete due to the development of resistance in insect against them or for their residual toxicity problem (Adhikari *et al*., 2019). So, there is a need to evaluate the new groups of insecticides and their combinations for their target and non target effects in crops. Therefore, this present investigation was carried out to evaluate new insecticide molecules against hopper complex i.e. GLH and BPH infesting rice.

Materials and Methods

A field experiments was conducted at Rice Research Station, Chinsurah, Hooghly, India (at 22°52´N latitude, 88°24´E longitude and 8.6 m of MSL altitude) in randomized complete block design (RCBD) with three replications during *kharif* 2014 and 2015. The plot size was 6 × 4 m^2 with spacing of 20 × 15 cm^2 (row to row and plant to plant) leaving 1.0 m on each replication and treatment border between the plots. The popular *kharif* cv, *Swarna* (MTU 7029) was sown during 2^{nd} week of July and 25 days old seedlings were transplanted as single plant transplantation with recommended package of practices excluding any plant protection measure. In main field, standard package of practices with fertilizer dose @ $N:P_2O_5:K_2O$::80:40:40 kg ha^{-1} (¼ N, full P_2O_5 and ¾ K_2O as basal, ½ N at active tillering stage and rest ¼ N & ¼ K_2O at panicle initiation stage) were applied. The treatments included nine insecticides and one untreated check, *viz*. T_1:carbosulfan 25% EC (*Marshal*; FMC) @ 2 ml/l, T_2:imidacloprid 17.8% SL (*Media*; Dhanuka Agritech Ltd.) @ 0.5 ml/ l, T_3:acephate 75% WP (*Acemain*; ADAMA India Pvt. Ltd.) @ 0.75 g/l, T_4:novaluron 10% EC (*RimOn*; Indofil Ltd.) @ 1 ml/l, T_5:dinotefuran 20% SG (*Trigus*; ADAMA India Pvt. Ltd.) @ 0.5 g/l, T_6:buprofezin 25% SC (*Apple*; Dhanuka Agritech Ltd.) @ 1.6 ml/l, T_7:sulfoxaflor 21.8% W/W SC (*D-one*; Dhanuka Agritech Ltd.) @ 0.6 ml/l, T_8:thiamethoxam 25% WG (*Actara*; Syngenta India Ltd.) @ 5 g/15l, T_9:ethiprole 40%+imidacloprid 40% WG (*Glamore*; Bayer Crop Science Ltd.) @ 5g/15 l of water and T_{10}:untreated control. Two spraying of each treatment was done at 40 and 60 days after transplanting (DAT) with high volume spray (@ 500 litres of water for one hectare). The sprayings were given with a hand compression knapsack high volume sprayer during morning hours and the spraying of respective insecticides on the plots of each treatment was sprayed ensuring uniform coverage of insecticide. The observations of GLH and BPH population were registered on 80 and 90 DAT from randomly selected 10 hills across the diagonal line of each replicated plot. All the pest population data were converted into square root transformed values. Crop harvesting was done during the end of November and the grain yield per plot was converted into kg ha^{-1}. The yield data was considered by excluding two border rows from all sides for each plot. The pest population and grain yield data were compared for significance using critical difference at 0.05 probability level.

Results and Discussion

In both the years (*kharif*, 2014 & 2015), no 'hopper burn' symptoms or rice tungro disease symptoms was observed in the experimental field. During the experimental period, a general trend was observed that population of hoppers was lower in all the treatments the at panicle initiation stage (80 DAT) than flowering stage (90 DAT) (Table 1, 2). In majority of the treatments GLH population was lower than BPH population in *kharif* 2014 (Table 1). During the season at 80 and 90 DAT the lowest population of GLH was noticed in ethiprole+imidacloprid treatment (4.00 & 9.00 GLH) followed by dinotefuran treated plots (6.67 & 9.33 GLH) as well as lowest BPH population was recorded in ethiprole+imidacloprid treatment (8.00 & 14.33 BPH) followed by dinotefuran treated plots (9.67 & 16.67 BPH). Adhikari et al. (2019) found good result against GLH with application of dinotefuran chemical. The pooled data analysis reflected that both the pests, GLH and BPH population were recorded the highest in control plots (29.50 GLH & 34.67 BPH) where as the lowest in ethiprole+imidacloprid (6.50 GLH & 11.17 BPH) followed by dinotefuran (8.00 GLH & 13.17 BPH) treated plots. The next best result was noticed in sulfoxaflor treatment against GLH (10.83 GLH) and in imidacloprid against BPH (17.33 BPH). The ethiprole+imidacloprid treatment was responsible to 77.97 and 67.79 per cent reduction over control against GLH and BPH population respectively, followed by dinotefuran treatment (72.88% GLH & 62.02 BPH). There is no significant difference was found in grain yield (kg ha^{-1}) among the treatments. The highest rice grain yield was obtained from ethiprole+imidacloprid treatment (5167 kg ha^{-1}) followed by dinotefuran treatment (5044 kg ha^{-1}). The highest yield increase over control was found in ethiprole+imidacloprid treatment (25.69%) followed by dinotefuran treatment (22.70%) which was at par with sulfoxaflor (20.55%) and imidacloprid (19.73%) treatments. Good rice grain yield was also recorded by Adhikari et al. (2019) in dinotefuran treatment against GLH.

In *kharif* 2015 most of the treatments showed lower population of GLH than BPH (Table 2). At panicle initiation stage (80 DAT) and flowering stage (90 DAT), the lowest population of GLH was noticed in ethiprole+imidacloprid treatment (3.33 & 9.00 GLH) followed by dinotefuran treatment (5.00 GLH) at 80 DAT and imidacloprid treatment (11.00 GLH) at 90 DAT. The lowest BPH population was recorded in ethiprole+imidacloprid treatment (5.00 & 12.33 BPH) followed by dinotefuran treated plots (6.67 & 14.67 BPH). During *kharif* 2015 the lowest pooled population of GLH and BPH was recorded in ethiprole+ imidacloprid (6.17 GLH & 8.67 BPH) followed by dinotefuran (8.17 GLH & 10.67 BPH) followed by buprofezin (9.17 GLH) and imidacloprid (17.00 BPH) treated plots. The insecticide, dinotefuran was very effective to manage GLH (Adhikari et al., 2019). The pooled data analysis showed that the highest population of both the hoppers, GLH and BPH were found in untreated control plots (31.83 GLH & 29.67 BPH). The highest population reduction over control was calculated in ethiprole+imidacloprid treatment (80.62% GLH & 70.78% BPH) followed by dinotefuran treatment (74.33% GLH & 64.04% BPH) in GLH and BPH respectively. There is no significant difference among the treatments of grain yield (kg ha^{-1}) was found. The ethiprole+imidacloprid treatment (5355 kg ha^{-1}) recorded the highest grain yield followed by dinotefuran treatment (5124 kg ha^{-1}) which was close proximity with the experimental results recorded by Adhikari et al. (2019). The highest yield increase over control was calculated in ethiprole+imidacloprid treatment (37.80%) followed by dinotefuran treatment (31.86%) which was at par with sulfoxaflor (29.64%) treatments.

The two years mean data represented that ethiprole+imidacloprid was found best effective treatment to lowering down both the hopper population (6.34 BPH & 9.92 GLH) followed by dinotefuran (8.09 GLH & 11.92 BPH) (Fig. 1). The ethiprole+imidacloprid recorded the highest rice grain yield (5261 kg ha^{-1}) followed by dinotefuran (5084 kg ha^{-1}) treatment. The overall results of this experiment on incidence of BPH and grain yield have close proximity to the result of Konchada et al., 2017 who revealed that dinotefuran 20 SG @ 0.4 g l^{-1} was found to be good effective against BPH and also recorded good grain yield.

The economic benefit on hectare basis of individual of treatment over two years (*kharif*, 2014 & 2015) was calculated in Table 3 and the results revealed that total cultivation cost (ha^{-1}) was calculated the highest in ethiprole+imidacloprid treatment (Rs. 34333/-) followed by novaluron treatment (Rs. 34159/-) and the lowest in untreated control (Rs. 30259/-) followed by imidacloprid treatment

Table 1. Effect of different insecticidal treatments on plant hopper population and grain yield during *kharif* 2014

Treatments	GLH population in 10 hills^{-1} 80 DAT	GLH population in 10 hills^{-1} 90 DAT	GLH population in 10 hills^{-1} Pooled value	Population reduction over control (%)	BPH population in 10 hills^{-1} 80 DAT	BPH population in 10 hills^{-1} 90 DAT	BPH population in 10 hills^{-1} Pooled value	Population reduction over control (%)	Grain yield (kg ha^{-1})	Yield increase control
T_1:carbosulfan 25% EC	15.00 (3.94)	21.33 (4.67)	18.17 (4.32)	38.42	15.00 (3.94)	27.67 (5.31)	21.33 (4.67)	38.46	4489	9.19
T_2:imidacloprid 17.8% SL	9.00 (3.08)	13.33 (3.72)	11.17 (3.42)	62.15	10.00 (3.24)	24.67 (5.02)	17.33 (4.22)	50.00	4922	19.73
T_3:acephate 75% WP	12.00 (3.54)	16.00 (4.06)	14.00 (3.81)	52.54	13.67 (3.76)	28.00 (5.34)	20.83 (4.62)	39.90	4389	6.76
T_4:novaluron EC 10%	20.00 (4.53)	22.67 (4.81)	21.33 (4.67)	27.68	19.33 (4.45)	33.33 (5.82)	26.33 (5.18)	24.04	4311	4.86
T_5:dinotefuran 20% SG	6.67 (2.68)	9.33 (3.14)	8.00 (2.92)	72.88	9.67 (3.19)	16.67 (4.14)	13.17 (3.70)	62.02	5044	22.70
T_6:buprofezin 25% SC	8.33 (2.97)	11.67 (3.49)	10.00 (3.24)	66.10	11.33 (3.44)	29.00 (5.43)	20.17 (4.55)	41.83	4478	8.93
T_7:sulfoxaflor 21.8% W/W SC	8.33 (2.97)	13.33 (3.72)	10.83 (3.37)	63.28	12.33 (3.58)	30.00 (5.52)	21.17 (4.65)	38.94	4956	20.55
T_8:thiamethoxam 25% WG	10.33 (3.29)	15.00 (3.94)	12.67 (3.63)	57.06	14.67 (3.89)	35.67 (6.01)	25.17 (5.07)	27.40	4333	5.40
T_9:ethiprole 40%+ imidacloprid 40% WG	4.00 (2.12)	9.00 (3.08)	6.50 (2.65)	77.97	8.00 (2.92)	14.33 (3.85)	11.17 (3.42)	67.79	5167	25.69
T_{10}:untreated control	22.33 (4.78)	36.67 (6.10)	29.50 (5.48)	-	23.00 (4.85)	46.33 (6.84)	34.67 (5.93)	-	4111	-
CD (p=0.05)	0.72	0.64	0.45	-	0.68	0.77	0.52	-	NS	-
SEm (±)	0.24	0.21	0.16	-	0.23	0.26	0.18	-	-	-

Figures in parentheses are (X + 0.5) square root transformed values

(Rs. 31259/-). The highest gross income (Rs.) as well as net profit (Rs.) (Gross income -Total cost) were calculated in ethiprole+imidacloprid treatment (Rs. 92068/- and Rs. 57734/-, respectively). The highest BCR (Benefit:Cost) value was showed in imidacloprid treatment (0.74:1) followed by ethiprole+imidacloprid treatment (0.68:1) which was at par with dinotefuran (0.64:1) and sulfoxaflor (0.61:1) treatments. The imidacloprid treatment reflected the highest BCR value due to the lower insecticide cost with good hopper control during *kharif* season.

Conclusion

Ethiprole+imidacloprid was the best the insecticide to manage the rice hopper complex, both BPH and GLH followed by dinotefuran. The insecticidal treatment, ethiprole+imidacloprid provided the highest grain yield followed by dinotefuran treatment. The highest BCR (Benefit:Cost) value was calculated in imidacloprid treatment (0.74:1) followed by ethiprole +imidacloprid treatment (0.68:1) followed by dinotefuran (0.64:1) and sulfoxaflor (0.61:1) treatments.

TABLE 2. Effect of different insecticidal treatments on plant hopper population and grain yield during *kharif* 2015

Treatments	GLH population in 10 hills^{-1} 80 DAT	90 DAT	Pooled value	Population reduction over control (%)	BPH population in 10 hills^{-1} 80 DAT	90 DAT	Pooled value	Population reduction over control (%)	Grain yield (kg ha^{-1})	Yield in-crease control
T_1:carbosulfan 25% EC	13.33 (3.72)	20.00 (4.53)	16.67 (4.14)	47.63	13.67 (3.76)	25.33 (5.08)	19.50 (4.47)	34.28	4569	17.58
T_2:imidacloprid 17.8% SL	7.00 (2.74)	11.00 (3.39)	9.00 (3.08)	71.72	10.00 (3.24)	24.00 (4.95)	17.00 (4.18)	42.70	4878	25.53
T_3:acephate 75% WP	11.67 (3.49)	18.33 (4.34)	15.00 (3.94)	52.87	11.33 (3.44)	27.67 (5.31)	19.50 (4.47)	34.28	4250	9.37
T_4:novaluron 10% EC	21.33 (4.67)	24.67 (5.02)	23.00 (4.85)	27.74	20.00 (4.53)	35.33 (5.99)	27.67 (5.31)	6.74	4453	14.59
T_5:dinotefuran 20% SG	5.00 (2.35)	11.33 (3.44)	8.17 (2.94)	74.33	6.67 (2.68)	14.67 (3.89)	10.67 (3.34)	64.04	5124	31.86
T_6:buprofezin 25% SC	6.67 (2.68)	11.67 (3.49)	9.17 (3.11)	71.19	10.00 (3.24)	25.00 (5.05)	17.50 (4.24)	41.02	4518	16.26
T_7:sulfoxaflor 21.8% W/W SC	8.33 (2.97)	14.00 (3.81)	11.17 (3.42)	64.91	12.33 (3.58)	30.00 (5.52)	21.17 (4.66)	28.65	5038	29.64
T_8:thia methoxam 25% WG	9.67 (3.19)	15.67 (4.02)	12.67 (3.63)	60.19	15.00 (3.94)	32.33 (5.73)	23.67 (4.92)	20.22	4255	9.50
T_9:ethiprole 40%+imida-cloprid 40% WG	3.33 (1.96)	9.00 (3.08)	6.17 (2.58)	80.62	5.00 (2.35)	12.33 (3.58)	8.67 (3.03)	70.78	5355	37.80
T_{10}:untreated control	24.33 (4.98)	39.33 (6.31)	31.83 (5.69)	-	20.67 (4.60)	38.67 (6.26)	29.67 (5.49)	-	3886	-
CD (p=0.05)	0.68	0.77	0.63	-	0.74	0.82	0.35	-	NS	-
SEm (±)	0.23	0.26	0.21	-	0.25	0.28	0.12	-	-	-

Figures in parentheses are (X + 0.5) square root transformed values

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TABLE 3. Economic benefit on hectare basis due to individual of treatment over two years (*kharif*, 2014 & 2015)

Treatments	Seed cost cost in Rs. (ha^{-1})	Two cultivation cost in Rs. (ha^{-1})	Seed sowing + land preparation cost in Rs. (15 labours ha^{-1})	Two hand weeding cost in Rs. (@ 23 labours each time ha^{-1})	*Labour cost in Rs. (fertilizer and insecticide application ha^{-1})	Fertilizers cost in Rs. (@ N:P_2O_5: K_2O :: 80:40:40 kg ha^{-1})	#Two times insec-ticide spraying cost in Rs. (@ 500 l of water ha^{-1})	Harvesting and threshing cost Rs. in Rs. (@ 500 l of water ha^{-1})	Total cost in Rs. ha^{-1})	Grain yield (kg ha^{-1}) (@ 46 labours	Addi-tional yield over control (kg ha^{-1})	Gross income (Rs.)	Net profit (Rs.) (Gross income -Total cost)	**BCR Net (kg ha^{-1})
T_1	750	4500	3000	9200	1000	3009	2400	9200	33059	4529	531	79258	46199	0.40:1
T_2	750	4500	3000	9200	1000	3009	600	9200	31259	4900	902	85750	54491	0.74:1
T_3	750	4500	3000	9200	1000	3009	630	9200	31289	4320	321	75591	44302	0.42:1
T_4	750	4500	3000	9200	1000	3009	3500	9200	34159	4382	384	76685	42526	0.24:1
T_5	750	4500	3000	9200	1000	3009	3076	9200	33735	5084	1086	88970	55235	0.64:1
T_6	750	4500	3000	9200	1000	3009	1040	9200	31699	4498	500	78715	47016	0.48:1
T_7	750	4500	3000	9200	1000	3009	2800	9200	33459	4997	999	87448	53988	0.61:1
T_8	750	4500	3000	9200	1000	3009	1002	9200	31661	4294	296	75145	43484	0.37:1
T_9	750	4500	3000	9200	1000	3009	3674	9200	34333	5261	1263	92068	57734	0.68:1
T_{10}	750	4500	3000	9200	600	3009	-	9200	30259	3999	-	69974	39715	0.31:1

*only fertilizer was applied in control plots

**BCR (Benefit:Cost) value was calculated on the basis of seed cost @ Rs 25 kg^{-1} (@ 30 kg ha^{-1}), twice land preparation cost @ power tiller hiring Rs. 300 hr^{-1} (7.5 hr^{-1} ha^{-1} cultivation), hand weeding 2 times @ 23 labours ha^{-1} each time, harvesting + threshing (46 labours ha^{-1}), urea @ Rs. 480 q^{-1}, SSP @ Rs. 600 q^{-1}, MOP @ Rs. 1000 q^{-1}, fertilizer application by labour : 1 manday for basal, 1 manday for 1st top dress, 1 man day for 2nd top dress, insecticide application by labour : 1 manday at 40 DAT, 1 manday for 60 DAT, labour cost = Rs. 200 $manday^{-1}$, paddy @ Rs. 1750 q^{-1} and insecticide cost

#Twice applied insecticide cost calculated as T_1:carbosulfan 25% EC (*Marshal* @ Rs. 300 for 250 ml) @ 1000 ml ha^{-1} = Rs. 1200, T_2:imidacloprid 17.8% SL (*Media* @ Rs. 300 for 250 ml) @ 250 ml ha^{-1} = Rs. 300, T_3:acephate 75% WP (*Acemain* @ Rs. 210 for 250 g) @ 375 g ha^{-1} = Rs. 315, T_4:novaluron 10% EC (*RimOn* @ Rs. 350 for 100 ml) @ 500 ml ha^{-1} = Rs. 1750, T_5:dinotefuran 20% SG (*Trigus* @ Rs. 40 for 6.5 g) @ 250 g ha^{-1} = Rs. 1538, T_6:buprofezin 25% SC (*Apple* @ Rs. 650 for 1000 ml) @ 800 ml ha^{-1} = Rs. 520, T_7:sulfoxaflor 21.8% W/W SC (*D-one* @ Rs. 700 for 150 ml) @ 300 ml ha^{-1} = Rs. 1400, T_8:thiamethoxam 25% WG (*Actara* @ Rs. 15 for 5 g) @ 167 g ha^{-1} = Rs. 501, T_9:ethiprole 40%+imidacloprid 40% WG (*Glamore* @ Rs. 55 for 5 g) @ 167 g ha^{-1} = Rs. 1837

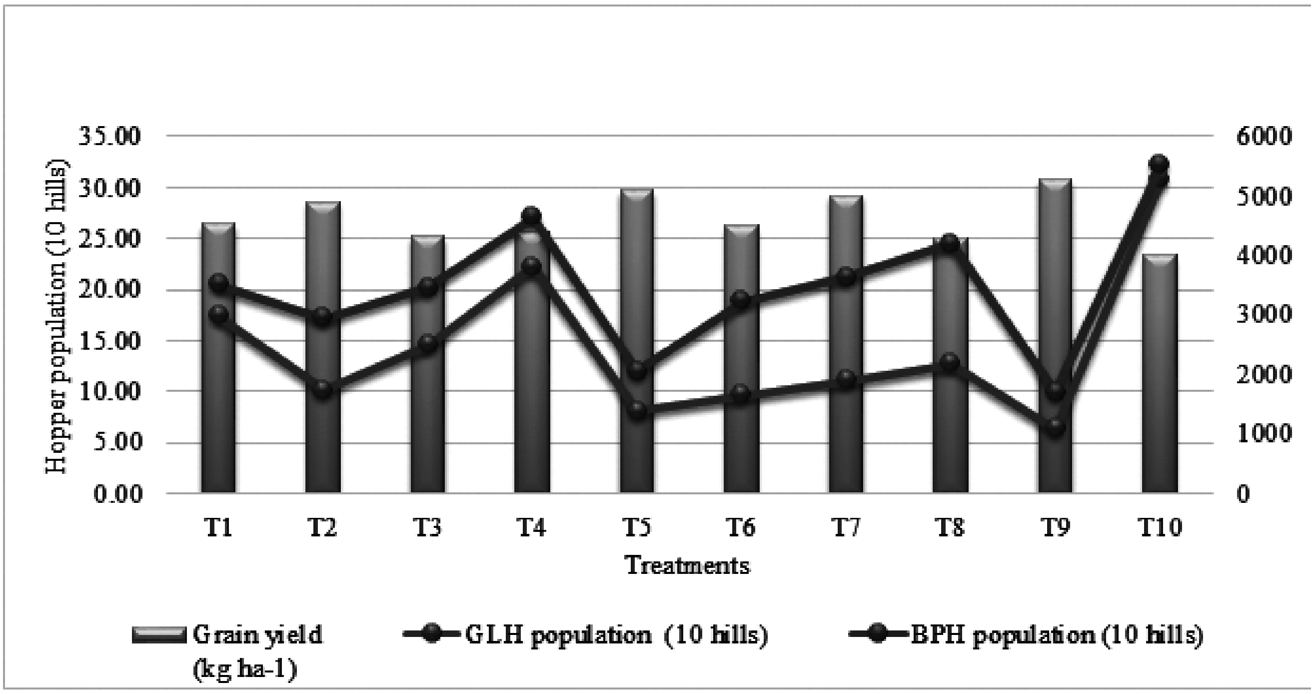

Fig. 1. Comparison between plant hopper population and grain yield of rice during *kharif* 2014 & 2015

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Study to Ascertain How Vase Preservatives Affect Cut Roses

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Abstract

Flowers loses their post harvest life very soon, therefore the present study was mainly undertaken to provide and judge rose cut flowers with different combination of preservative vase solutions, so that the flowers can ultimately maintain their attractiveness for an extended period. Roses for the experiment were brought from the local market in a condition where only 1-2 petal opening in them have initiated. After bringing the flowers in the Departmental laboratory, the stems were cut, maintaining a length of 12-15 cm. Thereafter the cut flowers were dipped in solutions in conical flask with preservatives or chemicals. Eight treatment combinations including control were used as vase preservatives solutions in the experiment. Analysis for different attributes was done in the laboratory at timely gaps during the storage. From the study it was obtained that the rose cut flowers which were dipped in the vase solution containing citric acid, silver nitrate and sucrose were able to show significant good results for different parameters which were analyzed.

Keywords : rose, chemicals, dipping, storage, charm

Introduction

Rose can be used in preparation of various types of items in varied sectors, however the central theme remains fixed of it being utilized as a cut flower (Butt, 2003). However, typical challenges unique to the group of cut flowers come along for roses. Studies and previous findings have reported that a percentage of near about 20, of these cut flowers have been seen to discharge their possessed standards after harvest, specifically during the time of post harvest operations like packaging, carrying and marketing. This ultimately renders the cut flowers to substandard quality and lately it is the consumer who has compromise due to improper postharvest maintenance (Panhwar, 2006; Asfanani *et al*., 2008). It's a very common thing to know that a cut flower will not last long as because unlike of fruits and vegetables it doesn't contain any storage reserve. If the conditions are ordinary to the cut flower then it would withhold its charm for a span of days. But we humans would very much want that these flowers should have their desirability a bit long so that we can enjoy them longer (Tsegaw *et al*., 2011; Zamani *et al*., 2011).

Various types of biochemical activities take place inside a flower when it is detached from its mother plant. A major phenomenon which does happen is transpiration leading in extensive water loss from the cut flower after and when it is separated from the principle branch. However this moisture degradation is compensated by dipping the cut flowers in a vase or pulsing solution which helps in sustaining the balance of the water flow and absorption and also stabilizes the freshness of the flowers which finally results in a better storage life (Reddy *et al*., 1994). Multiple types of preservatives can be used in the vase solution which do have a pronounced effect in the after harvest life of the cut flowers. The vase solution containing the preservatives or chemicals helps in providing a readymade source of energy to the cut flowers for respiration and it enhances the ability of the stalk to uptake the vase solution. Furthermore with the incorporation of biocide in the vase solution the negative microbial activity is reduced to a great extent which lowers the vascular blocking and also the preservatives helps in counteracting the effect of ethylene in the cut flower which otherwise would have resulted in an accelerated senescence (Nigussie, 2005). Hence it is very much recommended to use preservatives in vase solution to increase the post harvest utility and beauty of the cut flowers (Ichimura *et al.*, 2006). Thus, keeping in mind, the consumer demand to enjoy the beauty of the flower for longer duration and the importance of vase preservatives in maintaining the post-harvest utility, the current study was conducted.

Materials and Methods

The experiment took place in the laboratory of the Department of Horticulture which is under Institute of Agricultural Science, of University of Calcutta, situated in Kolkata. The study was being conducted during the academic year of 2016-2017. For the study rose flower at tight bud stage with 1-2 petal opening were used. The flower buds were purchased from the local market and instantly brought in Laboratory of the mentioned Department. Thereafter the flower stems were cut maintaining a length of 12-15 cm. All leaves, except 1-2 on the lower section of the stems were removed. For every stem, a clean slanting cut was made. The cut given was slanting as it increases the surface area and facilitates proper uptake of the given solution.

Then the cut flowers were placed in conical flasks containing the preservatives of various combinations, considered as treatments in the study. The treatments which were used here are: $\mathbf{T_1}$: Citric acid 1% + Sucrose 2%; $\mathbf{T_2}$: Citric acid 1% + Sucrose 4%; $\mathbf{T_3}$: Citric acid 1% + Sucrose 6%; $\mathbf{T_4}$: $AgNO_3$ 100ppm + Sucrose 2%; $\mathbf{T_5}$: $AgNO_3$ 100ppm + Sucrose 4%; $\mathbf{T_6}$: $AgNO_3$ 100ppm + Sucrose 6%; $\mathbf{T_7}$: Citric acid 1% + $AgNO_3$ 100ppm + Sucrose 4%; $\mathbf{T_8}$: Control (water). (For combination treatment using Silver Nitrate the cut flowers were only dipped in them for a period of 30 seconds). Henceforth various parameters were taken into account for analysis at periodic intervals. The attributes which were recorded are appearance quality (Peryam & Girardot, 1952; Peryam & Pilgrim, 1957). relative fresh weight (Joyce and Jones, 1992), vase solution uptake (Damunupola, 2009), maximum flower head diameter (Van Doorn *et al.,* 1991), days for complete opening (Liao *et al.*, 2000), vase life (Liao *et al.*, 2000) and total phenolic content (Singleton *et al.*, 1999). All the treatment was replicated three times and Completely Randomized Design (CRD) was used to layout the experiment (Gomez and Gomez, 1984). Analysis was finally carried by an online statistical tool or software (Sheoran *et al.*, 1998).

Results and Discussion

Appearance quality

The 9-point hedonic scaling was used to summarize the appearance quality, as shown in table: 1. At the 2nd day of storage all the flowers showed a appreciable score with maximum value of 9.00 for rose flowers treated with T_7 (Citric acid 1% +$AgNO_3$ 100 ppm + Sucrose 4%) and T_6 ($AgNO_3$ 100 ppm + Sucrose 6%). At 4th day and 6th day of storage the appearance score decreased with lowest value were seen for control T_8 (water). At last interval rose flowers treated with T_7 (Citric acid 1% +$AgNO_3$ 100 ppm + Sucrose 4%) was able to maintain a score of 5.33. This was followed by flowers treated with T_6 ($AgNO_3$ 100 ppm + Sucrose 6%) and T_5 ($AgNO_3$ 100 ppm + Sucrose 4%) with an appearance score of 5.00. Flowers treated with control showed the least value of 2.33.

Relative fresh weigh

The values regarding to this parameter has been depicted in the Table: 2. At 2nd day of storage rose flower treated with vase preservative solution containing combination of citric acid, sucrose and silver nitrate showed the maximum value of 100.26 followed by cut flower treated with T_6 ($AgNO_3$ 100 ppm+ Sucrose 6%) and flower treated with T_8 (water) showed the lowest value 97.81%. The pattern of decrease in relative fresh weight was similar for 4th day and 6th day of storage. At the 8th day of storage, the best relative fresh weight was found for the rose flower treated with T_7 (citric acid 1%+$AgNO_3$ 100 ppm+ Sucrose 4%), followed by T_6 ($AgNO_3$ 100 ppm+ Sucrose 6%), T_5 ($AgNO_3$ 100 ppm+ Sucrose 4%), T_3 (Citric acid 1% + Sucrose 6%), T_2 (Citric acid 1% + Sucrose 4%), T_1 (Citric acid 1% + Sucrose 2%) and control (T_8).

TABLE 1. Hedonic scaling of rose cut flower treated with different vase preservatives during the storage period

Treatment/Days	2 DAS	4 DAS	6 DAS	8 DAS
T_1	8.00	6.67	4.67	3.67
T_2	8.33	7.00	5.33	4.00
T_3	8.33	7.33	5.33	4.67
T_4	8.00	6.33	4.00	3.33
T_5	8.67	7.33	6.33	5.00
T_6	9.00	8.00	6.67	5.00
T_7	9.00	8.67	7.00	5.33
T_8	7.33	5.67	3.67	2.33
C.D	**0.713**	**0.873**	**0.873**	**0.797**
S.Em±	**0.236**	**0.289**	**0.289**	**0.264**

TABLE 2. Relative fresh weigh (percentage) of rose cut flower treated with different vase preservatives during the storage period

Treatment/Days	2 DAS	4 DAS	6 DAS	8 DAS
T_1	98.60	97.50	84.39	80.75
T_2	98.73	97.67	86.04	83.05
T_3	97.81	98.93	86.27	83.55
T_4	98.18	97.24	83.82	79.92
T_5	99.72	99.25	86.83	83.76
T_6	100.15	99.25	91.08	88.18
T_7	100.26	99.54	93.49	90.28
T_8	97.81	99.67	80.25	77.66
C.D	**0.266**	**0.073**	**0.064**	**0.054**
S.Em±	**0.088**	**0.024**	**0.021**	**0.018**

Solution uptake

Maximum uptake of solution by the cut flowers dipped in various vase solution was seen was seen at the earlier stages of storage which gradually decreased by the end of experiment (Table 3). Highest uptake of vase solution was for T_7 (Citric acid 1% +$AgNO_3$100 ppm + Sucrose 4%) and T_6 ($AgNO_3$ 100 ppm + Sucrose 6%) at second day of storage with 0.54 ml. The solution uptake decreased at 4th day of storage with 0.46 ml for T_7 (citric acid 1% +$AgNO_3$ 100 ppm + sucrose 6%) 0.28 ml for T8 (water). Further decrease in uptake of solution was observed at 6th day of storage and finally at 8th day of storage, rose cut flower treated with T_7 (Citric acid 1% +$AgNO_3$ 100 ppm + Sucrose 4%) was able to uptake the vase solution of 0.35 ml followed by T_6 ($AgNO_3$ 100 ppm + Sucrose 6%) with 0.32 ml.

Flower head diameter

Table 4. Shows the changes in size of the flower treated with different treatments during storage. During that day when the experiment was set up all flowers were kept at one or two petal opening stage. Therefore

Table 3. Solution uptake (ml/day) of rose cut flower treated with different vase preservatives during the storage period

Treatment/Days	2 DAS	4 DAS	6 DAS	8 DAS
T_1	0.47	0.38	0.30	0.25
T_2	0.48	0.38	0.32	0.28
T_3	0.49	0.39	0.37	0.28
T_4	0.42	0.36	0.29	0.23
T_5	0.51	0.40	0.39	0.30
T_6	0.54	0.41	0.40	0.32
T_7	0.54	0.46	0.42	0.35
T_8	0.31	0.28	0.24	0.18
C.D	**0.014**	**0.011**	**0.011**	**0.012**
S.Em±	**0.005**	**0.004**	**0.004**	**0.004**

Table 4. Flower head diameter (mm) of rose cut flower treated with different vase preservatives during the storage period

Treatment/Days	2 DAS	4 DAS	6 DAS	8 DAS
T_1	28.59	35.50	46.91	46.09
T_2	28.11	31.95	43.57	46.32
T_3	28.11	30.42	39.59	47.25
T_4	28.65	38.05	49.01	46.85
T_5	27.98	30.28	39.07	43.89
T_6	27.32	29.48	37.53	42.07
T_7	26.73	28.20	34.99	40.68
T_8	28.93	40.13	50.60	47.34
C.D	**0.361**	**0.855**	**0.833**	**0.504**
S.Em±	**0.119**	**0.283**	**0.275**	**0.167**

during storage period unfurling of petal were observed for flowers dipped in different treatments. It was seen that the cut flower with the combination of citric acid, silver nitrate and sucrose (T_7) took the maximum time for petal spreading and hence forth depicted a steady progress in the flower head diameter in difference to the other treatments where more flower diameter was obtained throughout the storage period. Thus at the 2nd day of storage minimum flower diameter was seen for T_7 (Citric acid 1% +$AgNO_3$ 100 ppm + Sucrose 4%) with 26.73 mm and flowers treated with control showed the max value of 28.93 mm. At 6th day of storage flowers treated with T_7 (Citric acid 1% +$AgNO_3$ 100 ppm + Sucrose 4%) were with the minimum flower diameter of 34.99 mm followed by the flower treated with T_6 ($AgNO_3$100 ppm + Sucrose 6%) with 37.53 mm and control with the max petal spreading showing the diameter of 50.60 mm. However at the 8th day of storage, due to dropping of petals, there was decrease of flower diameter for flowers under some treatments. T_7 (Citric acid 1% +$AgNO_3$ 100 ppm + Sucrose 4%) at the final day maintained the flower diameter of 40.68 mm and flowers treated with control irrespective of dropping of petals showed the max flower head diameter of 47.34 mm.

Days for complete opening and vase life

Table 5 shows the time taken in days for complete opening of flowers and the max vase life for which the cut flowers can be stored in different preservatives solutions. It was observed that flowers treated withT_7 (Citric acid 1% +$AgNO_3$ 100 ppm + Sucrose 4%) took the maximum time for opening of flowers with 3.67 days. Flowers treated with T_6 ($AgNO_3$ 100 ppm + Sucrose 6%) and T_5 ($AgNO_3$ 100 ppm + Sucrose 4%) took a period of 3.33 days. Flowers with T_3 and T_2 showed complete opening at 2.33 days. T_1 (Citric acid 1% + Sucrose 2%) was able to open the flowers at 2.00 days. Flowers with T_4 ($AgNO_3$ 100 ppm + Sucrose 2%) took 1.67 days and the flowers treated with control took the least time of 1.33 days for final opening. Maximum vase life of 10.33 days were seen for flowers dipped in preservative solution of T_7 (Citric acid 1% +$AgNO_3$ 100 ppm + Sucrose 4%) followed by 9.33 days for flowers in with T_6 ($AgNO_3$ 100 ppm + Sucrose 6%) and T_5 ($AgNO_3$ 100 ppm + Sucrose 4%). Flowers dipped in treatments of T_3 (Citric acid 1% + Sucrose 6%) and T_2 (Citric acid 1% + Sucrose 4%) demonstration vase life of 9.00 and 8.67 days respectively. Vase life of 8.33 days were seen for flowers with treatment T_1 (Citric acid 1% + Sucrose 2%) and T_4 ($AgNO_3$ 100 ppm + Sucrose 2%) and flowers treated with control exhibited the minimum vase life of 8.00 days.

TABLE 5. Days for complete opening and vase life of rose cut flower treated with different vase preservatives during the storage period

Treatment/Days	Complete flower opening (days)	Vase life in days
T_1	2.00	8.33
T_2	2.33	8.67
T_3	2.33	9.00
T_4	1.67	8.33
T_5	3.33	9.33
T_6	3.33	9.33
T_7	3.67	10.33
T_8	1.33	8.00
C.D	**0.943**	**0.873**
S.Em±	**0.312**	**0.289**

Total Phenolic content

The total phenolic content is shown in Figure 1. At second day of storage T_7 (Citric acid 1% +$AgNO_3$ 100 ppm + Sucrose 4%) showed a phenolic content of 17.66, flower treated with T_6 ($AgNO_3$ 100 ppm + Sucrose 6%) was the second-best treatment containing phenolic content of 17.05 and flowers treated with control showed the least phenolic content of 15.74. Then at the 4th and 6th day of storage, an increasing pattern for the phenolic contents was seen for flowers treated with different vase preservatives. At the 6th day of storage the phenolic content of flowers treated with T_7 (Citric acid 1% +$AgNO_3$ 100 ppm + Sucrose 4%) became as high as of 38.74 followed by flowers treated with T_6 ($AgNO_3$ 100 ppm + Sucrose 6%) showing a phenolic content of 35.69 and flowers treated with control showed the phenolic content of 19.19. After reaching a maximum peak at the 6th day, a down fall in the phenolic amount was seen for the flowers dipped with different preservatives. Thus, at last the phenolic content decreased, but still in appreciable amount was being maintained by flowers treated with T_7 (Citric acid 1% +$AgNO_3$ 100 ppm + Sucrose 4%) containing 26.59 followed by 26.43 in flowers treated with T_6 ($AgNO_3$ 100 ppm + Sucrose 6%).

Various parameters used in the study showed different types of variation of the rose cut flowers

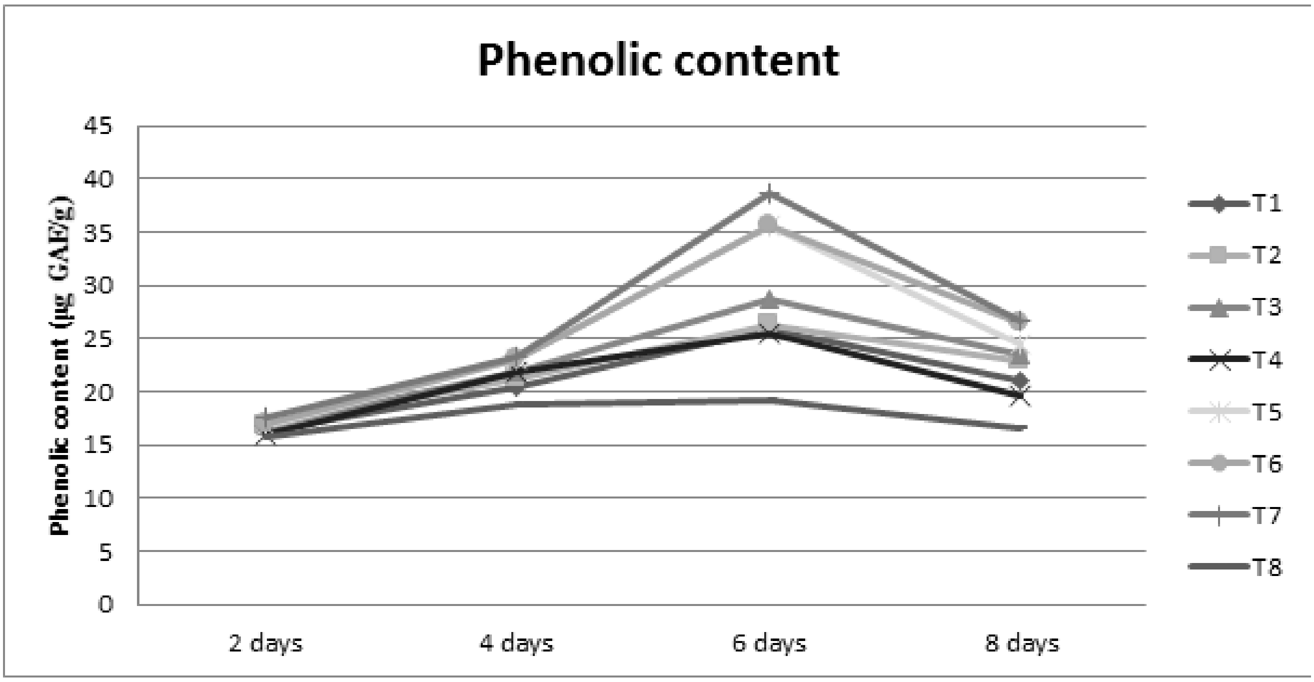

Fig. 1 Phenolic content (mg GAE/g) of rose cut flower treated with different vase preservatives during the storage period

during the analysis period. The relative fresh weight of the flowers for instance got decreased. The results for this were very much similar to the works of Hajizadeh *et al*., (2012) where again the relative fresh weight of Rosa hybrid cv. Black magic got lowered during the vase life study and the maximum decrease was obtained for the control flowers. Also the vase solution which is up taken by the cut flower is very much dependent upon its chemical type and the variety which is being used for the study. It is generally observed that this uptake of solution becomes less with passage of time. Same type of result for solution uptake has been obtained in the present study. The reason behind this may be because of deposition of air bubbles in the stem cut region, internal activity of the plant against the wound or injury or because by some microorganism (Tsegaw *et al*., 2011). The total phenolic content of the flowers varied periodically in the study. It, at the beginning, from a stable point increased to a certain peak and thereafter decreased to a low at the last day of storage. The results were at par to the works of Schmitzer *et al*., (2010) where they suggested that the decreased phenolic content in the flowers at the later stage makes it more prone to stress which are oxidative in nature eventually leading up to a speeded up necrosis.

Conclusion

From the study it was found that the rose cut flowers treated or dipped in combination of citric acid, sucrose and silver nitrate (T_7) was best in retaining the maximum relative fresh weight percentage, showed maximum uptake of solution till the end of the storage, demonstrated steady unfurling of petals with optimum flower head diameter till the end, showed better appearance quality and was with maximum retainment of total phenolic content. Rose cut flowers dipped in T_6 ($AgNO_3$ 100 ppm + Sucrose 6%) was the second-best treatment followed by dipping done in $\mathbf{T_5}$ ($AgNO_3$ 100ppm + Sucrose 4%).

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