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Integrated Nutrient Management in Sunflower (*Helianthus annuus* L.)

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ABSTRACT

Background: Importance of Integrated nutrient management through recycling of organic sources of wastes and renewable sources of bio-fertilizers are gaining popularity due to rising cost of energy and limited input availability. The current study aimed to investigate the combined effects of inorganic fertilizer, organic manures and bio-fertilizers (INM) on growth and productivity of sunflower.

Methods: This experiment comprised of ten treatments which includes farm yard manure (FYM @ 10 t/ha, FYM @ 5 t/ha), Vermicompost (VC @ 5 t/ha, VC @ 2.5 t/ha), Bio-fertilizers (PSB, AZ), foliar spray NPK 19:19:19.

Result: Maximum seed yield of 2.48 t/ha and 2.41 t/ha were obtained by the treatments T_{10} and T_6respectively.The physiological trait like CGR (3.216 and 3.210 g/day/plant) also recorded significantly higher values for the treatments T_{10} and T_6 than all other treatments. It was also found that among organic manures, vermicompost at 5 t/ha produced higher seed yield than FYM at 10 t/ha. From this investigation, treatment T_{10} (VC @ 2.5 t/ha + PSB + AZ + 50% RDF + foliar spray) could be recommended to the farmers for sunflower cultivation. In case of acute shortage of vermicompost, farmers can go for treatment T_6 (FYM @ 5 t/ha + PSB + AZ + 50% RDF + foliar spray) as this could be eco-friendly since chemical load to the environment has been 50% curtailed.

Key words: Bio-fertilizers, Farm yard manure, Foliar spray, Sunflower, Vermicompost, Yield attributes.

INTRODUCTION

Sunflower [*Helianthus annuus* (L.)] popularly known as "Surajmukhi" is third most important oilseed crop in the world and one of the fastest growing important oilseed crop in India. Sunflower is a non-traditional oilseed crop introduced in India during the year 1969. The shortage of edible oils has become a chronic problem in India. Sunflower can play an important role in meeting out the shortage of edible oil in the country.

In the southern part of West Bengal there is a vast tract of fallow areas about 0.35 million hectares of Gangetic alluvial land. Due to late harvest of traditional *aman* rice as well as due to late receding of water from low lying *kharif* rice fields, sowing of important winter crops like potato, wheat, rape-seed and mustard is not practically possible on such rice fallow land (Sarkar and Mallick, 2009). Sunflower is a short duration, photo and thermo-insensitive and flexibility in sowing time may be grown on those lands to reduce the shortage of oilseeds in the state of West Bengal (Sarkar *et al.* 2007).

In West Bengal sunflower was grown in an area of 0.01150 m ha with a production of 0.01509 million tonnes and a productivity of 1312 kg/ ha (2016-17). Compared to cereal crops, sunflower produces much more dry matter in a shorter life cycle. This high rate of dry matter production results in huge amounts of nutrients removed per unit time, which generally most of the soils are not able to supply adequately throughout growing period. Higher and sustainable yields can only be achieved through the application of optimal NPK doses along with organics in balanced proportion. Integrated Nutrient Management (INM) involving combination of organic manure along with bio-fertiliser and chemical fertilizers is an essential tool for balanced fertilization and sustainability of crop production on long term basis.

Fertilizer is a scare and becoming very costly input, therefore its judicious application is essential to achieve higher benefits. As no single source is capable of supplying the required amount of plant nutrients, integrated use of all sources of plant nutrients is a must to supply balanced nutrition to the crops (Choudhary *et al*., 2010). Total organic farming may be a desirable proposition for improving the quality of agricultural produce. It may not be possible to maintain the quantity of the produce in commercial agriculture, where mostly the stress will be given mainly on yield. It is impossible to meet the nutrient requirement of the crops, exclusively through the organic farming. Under

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these circumstances, integrated soil nutrient management involving judicious combination of organic manures, biofertilizers and chemical fertilizers seems to be a feasible option for sustained agriculture on a commercial and profitable scale. Therefore, emphasis is now focused on the use of organic manures such as compost, vermicompost, farm yard manures and biofertilizers like *Azotobacter*, *Azospirillium* and phosphate solubilizing bacteria (PSB). With this view in mind an experiment was set up to investigate the combined effects of inorganic fertilizer, organic manures and bio-fertilizers (INM) on growth and productivity of sunflower.

MATERIALS AND METHODS

The experiment conducted at agricultural experiment farm of the university of Calcutta at Baruipur, 24-parganas (south) [88°28′ East longitude, 22°22′ North Latitude] during 2018 and 2019 in a randomized block design with 3 replications. The individual plot size was 10 m^2. The treatment was allocated randomly to different plots with the help of random number table (Fisher and Yates, 1948). Hybrid sunflower variety *i.e*. Aditya was used as experimental material. The experimental treatments include Farm Yard Manure (FYM @ 10tn/ha, FYM @ 5 tn/ha), Vermicompost (VC @ 5 tn/ha, VC @ 2.5 tn/ha), Bio-fertilizers (PSB, AZ), foliar spray 19:19:19 was applied during the final field preparation. To study the response of sunflower to different treatments; the observations have been recorded in respect of morphological, physiological growth parameters, yield components and yield of the crop. The head diameter was measured by taking distance between the two diagonally opposite edges of the head was recorded as the head diameter at different stages of crop growth. The dried heads from each net plot were threshed, cleaned and the number of seeds per plant was counted. 1000-seed were counted, after drying, from the samples drawn for seed yield of each plot and the weight of 100-seeds was recorded and expressed in gram. The dried heads from each net plot were threshed, cleaned and the weight of seeds was recorded and expressed in gram and it was converted into tonne per hectare.

RESULTS AND DISCUSSION

The results recorded in the present experiment revealed appreciable and significant variation in different vegetative and physiological growth parameters, yield attributing characters and yield of sunflower due to different treatments of integrated nutrient management in gangetic alluvial soils of West Bengal. The basic objectives of integrated plant nutrition systems (IPNS) are to reduce the inorganic fertilizer requirement, to restore organic matter in soil, to increase nutrient use efficiency and to retain soil quality in terms of physical, chemical and biological properties. Bulky organic manures may not be able to supply adequate amount of nutrients, nevertheless their role becomes important in meeting the above objectives (Subbarao and Sammireddy, 2008).

Sunflower plants exhibited a typical linear pattern of growth in plant height, irrespective of variation in treatments till 60 days after sowing.After 60 days of sowing, the rate of increase in plant height has shown a diminishing rate of increase (Table 1). The increase in height with T10 *i.e.* VC @ 2.5 t/ha + PSB + AZ +50% RDF + Foliar spray NPK 19:19:19 may be attributed to rapid mobilization of N, P, K from inorganic fertilizers and steady supply of N and P from VC which might have met N and P requirement in cell elongation and cell division at early growing period and later from foliar application at critical stages of plant growth.This might be due to release of P and N as a result of action of P solubilizing bacteria and azotobacter. The production of auxin and gibberellin type plant growth regulators is known to help in higher plant growth.Azotobacter inoculation showed improved plant growth due to plant growth substances produced and released continuously in the rhizosphere and it increased the ability of absorption of nutrients by the crop resulting in maximum plant height which was significantly superior in T_{10}. These results showed that AZ and PSB performed better in presence of vermicompost (Raj and Mallick, 2017 and Mukherjee *et al*, (2019).

The results obtained are in confirmation with the findings of Raj and Mallick, (2017) Mukherjee *et al*, (2019) Gayathri *et al*. (2004) also reported that combined application of biofertilizers, vermicompost with inorganic fertilizers significantly increased the number of leaves, leaf area and stem girth in limonium.

The increase in dry matter production under high levels of phosphorus and nitrogen may thus be attributable to the efficient physiological and metabolic processes resulting in luxuriant vegetative growth, functional photosynthesis which in turn account for synthesis of protein and carbohydrates (Fujiwara, 1965). Increased dry matter in this treatment might be due to positive role of the bio-fertilizer in presence of organic manures. Supply of the required nutrients through organic and inorganic sources and bio-fertilizer facilitated balanced nutrient of the crop, which resulted in enhanced dry matter in sunflower (Jeyabal *et al*., 2000).

Physiological growth parameters

A perusal of the data (Table 1) relating to effect of treatment on total number of green leaves per plant showed that, T_{10} exhibited more number of leaves per plant (20.60) followed by T_6 (20.03). The minimal total number of leaves was recorded in T_1 (17.75) *i.e.* in control.

The dry matter production per plant was increased linearly and reaching maximum during 90 DAS. The maximum dry matter production (77.45 g/plant) was recorded in treatment T_{10} followed by T_6 (77.35 g/plant). Whereas, significantly minimum dry matter production was recorded in T_1 (64.19 g/plant).

In case of crop growth rate (CGR), T_{10} (VC @ 2.5 t/ha + PSB + AZ + 50% RDF + Foliar spray NPK 19:19:19) had recorded maximum rate of growth (3.216 g/day/plant)

Table 1: Effect of treatments on physiological growth parameters, yield attributing character, seed yield of sunflower.

Treatments	Plant height (cm)			Dry matter production (g/plant)			Crop growth rate (g/day/plant)		Head diameter (cm)	No. of seeds per head	Seed weight per head (gm)	Test weight of seeds (g)	Seed yield (t/ha)
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30-60 DAS	60-90 DAS					
T_1- Untreated control	17	97	145	0.04	18	64.19	1.52	2.498	13.23	750	23.23	29.55	1.37
T_2- 100%RDF	21.5	111.18	149.25	0.77	24.14	72.79	1.604	3.114	18.58	990	28.19	30.98	2.31
T_3- FYM @10 t/ha	20.63	111.12	146.31	0.67	23.22	71.9	1.55	3.04	17.09	980	26.33	31.61	2.11
T_4- FYM @10 t/ha + PSB + AZ	21	110.62	148.36	0.76	24.78	73.5	1.586	3.024	19.67	985	27.85	32.75	2.28
T_5- FYM @ 5 t/ha + PSB = AZ+50% RDF	21.73	112.66	149	0.8	25.34	75.35	1.616	3.102	20.05	1020	28.34	33.35	2.34
T_6- FYM@5 t/ha +PSB +AZ+50%RDF+ Foliar spray NPK 19:19:19	21.80	113.18	153.46	0.83	26.14	77.34	1.648	3.210	20.87	1045	28.81	34.97	2.41
T_7- VC@5 t/ha	21.03	110.58	147.69	0.71	24.25	73.3	1.572	3.112	17.67	991	26.43	31.97	2.14
T_8- VC@5 t/ha+PSB+AZ	21.65	111.86	149.76	0.78	25	75.24	1.608	3.122	19.90	1003	27.31	32.85	2.33
T_9- VC@2.5 t/ha+PSB+ AZ+50%RDF	21.78	112.86	150.36	0.81	25.47	75.5	1.626	3.142	20.19	1004	28.47	32.97	2.37
T_{10}- VC@2.5t/ha+PSB+AZ+ 50%RDF+Foliar spray NPK 19:19:19	21.83	113.26	153.76	0.83	26.21	77.45	1.65	3.216	21.05	1051	29.31	35.08	2.48
SEm(+)	0.51	0.43	1.48	0.043	0.544	0.033	0.067	0.133	0.329	8.837	0.604	0.006	0.034
C.D.	1.074	1.044	3.111	0.089	1.144	0.068	0.142	0.279	0.692	18.57	1.27	0.013	0.071

Table 2: Effect of different treatments on benefit: cost ratio in sunflower.

Treatment	Treatment cost (Rs)	Total cost of cultivation (Rs)	Gross return (Rs)	Net return (Rs)	Benefit: cost ratio
T_1- Untreated Control	0	16262.5	41100	24837.5	1.53
T_2- 100%RDF	6419.5	22682	69300	46618	2.06
T_3- FYM @10 t/ha	20000	36862.5	63300	26437.5	0.72
T_4- FYM @10 t/ha +PSB +AZ	20600	36862.5	68400	31537.5	0.86
T_5- FYM @ 5 t/ha +PSB + AZ + 50%RDF	13809.75	30072.25	70200	40127.75	1.33
T_6- FYM @ 5 t/ha +PSB + AZ + 50% RDF + Foliar spray NPK 19:19:19	14559.75	30822.25	72300	41477.75	1.35
T_7- VC@ 5 t/ha	20000	36262.5	64200	27937.5	0.77
T_8- VC @ 5 t/ha + PSB + AZ	20600	36862.5	69900	33037.5	0.89
T_9- VC @ 2.5 t/ha + PSB + AZ + 50%RDF	13809.75	30072.25	71100	41027.75	1.36
T_{10}- VC @ 2.5 t/ha + PSB + AZ + 50% RDF+Foliar spray NPK 19:19:19	14559.75	30822.25	74400	43577.75	1.41

followed by T_6 (3.210 g/day/plant) which were at par with each other. The minimum crop growth rate was observed in T_1 (2.498 g/day/plant).

Yield attributing character

The results on yield attributes of sunflower revealed that application of different treatments of INM exerted profound influence on important yield contributing characters like diameter of the head, number of seeds/head and 1000-seed weight (Table 1).

Increase in yield attributes with VC @ 2.5 t/ha + PSB + AZ + 50% RDF + Foliar spray NPK 19:19:19 was attributable to adequate nutrient availability at critical growth stages and thus enhanced photosynthetic efficiency. The results are in line with the findings of Reddy *et al.* (2005). The probable reason of highest yield attributing characters might be due to higher availability of P, N and simultaneously better nutrition since early stage of growth. It means that PSB and AZ played an important role in sunflower generative growth and therefore to make a significant increase in the number of seeds per head and head diameter. Tohidi-Moghaddam *et al.,* (2004) reported that phosphorus solubilising organisms (PSB) increased the available phosphorus in the soil which could enhance the seed number in plant and also azotobactors fix atmospheric nitrogen and made them available to plant. The improvement of P in soil might be due to solublization of inorganic P through the secretion of soil organic acid by inoculation of phosphate-solubilizinig bacteria (PSB) (Dubey, 1997) might have influenced favourably yield attributes.

Seed yield

Seed yield of sunflower had been significantly influenced due to different treatments of INM. Combined effect of T10 *i.e.* VC @ 2.5 t/ha + PSB + AZ +50% RDF + Foliar spray NPK 19:19:19 was more spectacular on sunflower seed yield (Table 1). The application of 50% RDF in combination with VC, foliar spray and bio-fertilizers (PSB and AZ) produced significantly and appreciably higher seed yield over other nutrient management treatments and control. The beneficial effect of biofertilizer might be ascribed to biological N fixation and solubilization of P by phosphate solubilizing bacteria (Raj and Mallick, 2017; Mukherjee *et al*, 2019. Microorganisms with phosphate solubilizing potential increased the availability of soluble phosphate and enhance the plant growth and yield due to better root growth and increase uptake of nutrients (Watson *et al*., 1965, Kucey *et al*., 1989; Ponmurugan and Gopi, 2006) and nitrogen fixing bacteria azotobactor also increased the plant growth and yield due to luxuriant vegetative growth (Fujiwara, 1965).

Thus, it is assumed that the better growth, enhanced yield attributes and final seed yield of sunflower under reduced rate of RDF at 50% in conjunction with organic manure and bio-fertilizers might be due to the increased availability of essential nutrients from integration of chemical fertilizer, organic manure and bio-fertilizer. The findings are in close conformity with the earlier findings of Jeyabal *et al*., (2000), Raj and Mallick,(2017) and Mukherjee *et al*., (2019).

Economics

In this experiment, the benefit: cost ratio was also worked out for different levels of NPK fertilizers, organic manures and biofertilizers (Table 2). The cost of cultivation of integrated nutrient management treatments was higher than sole application of 100% RDF resulting in highest benefit: cost ratio was recorded in sole application of recommended dose of chemical fertilizer treatment. Lowest benefit: cost ratio was noticed where only sole farm yard manure or vermicompst was applied (0.72 and 0.77 respectively). But integration of chemical fertilizer, farm yard manure or vermicompost along with biofertilizers (INM treatments) gave intermediate the net monetary returns and benefit: cost ratio. Among the INM treatments, the net monetary returns and benefit: cost ratio was found highest with 50% RDF integrated with VC @ 2.5 t/ha + PSB + AZ + 50% RDF + One Foliar spray of NPK 19:19:19.

CONCLUSION

Integrated nutrient management has a great promise in meeting the growing nutrient demand of modern agriculture.

It can also help in maintaining production sustainability without deterioration of the soil health and crop productivity. The present field experiment clearly stated that the application of VC (2.5 t/ ha) or FYM (5 t/ ha) inoculated with azotobacter and phosphate solubilising bacteria along with 50% recommended doses of chemical fertilizers in alluvial soil with one supplementary foliar application of NPK 19:19:19 @ 0.5% at 50% flowering stage in sunflower was the better possible combination for obtaining higher yield of sunflower. This investigation also showed that between the two organic sources of plant nutrient, vermicompost performed better than farm yard manure. Therefore, this integration of nutrient sources can be better nutrient management option of sunflower in new alluvial soil of West Bengal.

Conflict of interest: none.

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