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Effect of Integrated Nutrient Management on Growth, Seed Yield and Economics of Sunflower (*Helianthus annuus* L.)

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Abstract

A field experiment was carried out during *rabi* season of 2008-09 to study the effect of integrated nutrient management practices on hybrid sunflower variety (PAC-36). Integrated nutrient management practices significantly increased plant height, head diameter, number of seeds per head, seed weight per head, test weight, seed yield and economics of sunflower. Among the treatments, Poultry manure (PM) at 2.5 t/ha along with combined application of 50% RDF, Phosphate solubilizing bacteria (PSB) and *Azotobacter* (AZ) significantly recorded higher plant height, head diameter, number of seeds per head, seed weight per head, test weight of seed, economics and seed yield which was at par with 50% RDF along with combined application of each of two foliar spraying of NPK 19:19:19 and boron.

Key words : Sunflower, Integrated nutrient management, Plant height, Yield attributes, Seed yield and economics.

India holds an impressive position in the global oilseed scenario. Oilseeds contribute second largest commodity after cereal in India. It is the backbone of agricultural economy. 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 country. Rapid increase in area of sunflower is due to the merits of wide adaptability to different agro-climatic regions, day neutral, and fairly tolerant to salinity. It has the potential to produce the highest oil yield and production per hectare through the cultivation of sunflower. Sunflower is a fast growing and high oil yielding crop and thus it is expected to take more nutrients is of fundamental importance owing to its deficiency in Indian soil (1). Sunflower is a deep rooted crop, intermediate in water use that can extract soil water from below root zones of normal grain crops (2, 3). The potential of any variety can only be fully exploited by the judicious use of inputs. Chemical fertilizers should be substituted at least partly by organic manures, green manures, and biofertilizers. Thus the present investigation was undertaken to develop appropriate integrated nutrient management package for sustainable productivity of sunflower and to study the plant height, head diameter, number of seeds per head, seed weight per head, test weight of seed, economics and seed yield of sunflower.

Methods

A field experiment was conducted at the Agricultural Experimental Farm of Institute of Agricultural Sciences, University of Calcutta at Baruipur, 24-parganas (South) during *rabi* season of 2008-09. The soil was medium fertile clay loam in texture and neutral in reaction having 0.68% organic carbon, 305 kg/ha available nitrogen, 40 kg/ha available phosphorus and 140.5 kg/ha available potassium. Fifteen treatments, comprising different combinations of organics viz., farm yard manure (FYM) at 10 t/ha and 5 t/ha, poultry manure (PM) at 5 t/ha and 2.5 t/ha and vermicompost (VC) at 5 t/ha and 2.5 t/ha and inorganic fertilizers viz., (100 and 50% of recommended doses of 60:80:60 kg/ha of NPK), and NPK 19:19:19, micronutrient viz. boron and bio-fertilizers, viz. phosphorus solubilizing bacteria (PSB) and azotobacter (AZ) respectively including 1 unfertilized control were laid

Table 1. Effect of treatments on growth, yield attributes and seed yield of sunflower. RDF : Recommended doses of fertilizers, FYM : Farm yard manure, PM : Poultry manure, VC : Vermi compost, PSB : Phosphorus solubilizing bacteria, AZ : Azotobacter.

Treatments	Plant height (cm)	Head diameter (cm)	No. of seeds/head	Seeds wt/head (g)	Test wt (1000 seed wt) (g)	Seed yield (q/ha)
T_1 (Untreated control)	145	15.36	850	50	65.20	19.50
T_2 (100% RDF)	150	18.33	1090	81.61	70.30	30.20
T_3 (FYM 10 t/ha + PSB + AZ)	151.4	19.23	1080	77.02	71.20	28.50
T_4 (PM 5 t/ha + PSB + AZ)	159	20.10	1085	80.40	71.75	29.75
T_5 (VC 5 t/ha + PSB + AZ)	156.5	20.63	1091	79.18	73.60	29.30
T_6 (FYM 5 t/ha + 50% RDF)	155.2	20.20	1103	83.10	73.85	30.75
T_7 (PM 2.5 t/ha + 50% RDF)	159.25	21.50	1113	85.12	77.35	31.50
T_8 (VC 2.5 t/ha + 50% RDF)	158.36	20.36	1104	84.72	76.45	31.35
T_9 (FYM 5 t/ha + 50% RDF + PSB + AZ)	157.46	20.70	1095	83.37	74.45	30.85
T_{10} (PM 2.5 t/ha + 50% RDF+PSB+AZ)	163.76	22.76	1151	88.50	78.66	32.75
T_{11} (VC 2.5 t/ha+50% RDF+PSB+AZ)	159.66	20.80	1125	85.39	75.55	31.60
T_{12} (PM 2.5 t/ha+50% RDF+ 1 foliar spray, NPK 19:19:19)	160.36	20.53	1130	85.80	77.76	31.75
T_{13} (VC 2.5 t/ha+50% RDF+ 1 foliar spray, NPK 19:19:19)	159.76	21.16	1128	85.53	76.33	31.65
T_{14} (50% RDF + 2 foliar spray, NPK-19:19:19 + 2 Boron application)	163.46	22.22	1145	88.23	78.33	32.65
T_{15} (50% RDF + 2 foliar spray, NPK-19:19:19)	160	21.00	1120	84.45	75.25	31.25
CD (P=0.05)	3.27	0.532	13.72	1.06	1.45	0.081

out in randomized block design with three replications. The treatments were T_1, Control ; T_2, 100% RDF (60, 80 and 60 kg/ha of NPK) ; T_3, FYM at 10 t/ha + PSB + AZ ; T_4, PM at 5 t/ha+PSB+AZ ; T_5, VC at 5 t/ha + PSB + AZ ; T_6, FYM at 5 t/ha + 50% NPK ; T_7, PM at 2.5 t/ha + 50% NPK ; T_8, VC at 2.5 t/ha + 50% NPK ; T_9, FYM at 2.5 t/ha + 50% NPK + PSB + AZ ; T_{10}, PM at 2.5 t/ha + 50% NPK + PSB + AZ ; T_{11}, VC at 2.5 t/ha +50% NPK + PSB + AZ ; T_{12}, PM at 2.5 t/ha + 50% NPK + one foliar spraying of NPK-19:19:19 ; T_{13}, VC at 2.5 t/ha + 50% NPK + one foliar spraying of NPK-19:19:19 ; T_{14}. 50% NPK + 2 foliar spraying of NPK - 19:19:19+2 Boron spray ; T_{15}, 50% NPK+2 foliar spraying of NPK 19:19:19.

Sunflower hybrid variety PAC-36, was sown at 60 cm row-to-row and 30 cm plant-to-plant spacing in last week of January 2009 with optimum soil moisture condition at a depth of 4—5 cm with 5.5 kg of seed per hectare. The crop was thinned 15 days after sowing (DAS) to maintain one plant per hill. Three irrigations were given, first at after sowing of seeds, second at 30 DAS and another at pre-flowering stage. Hand weeding-cum-hoeing was done 15 DAS and another 30 DAS. Recommended full doses of phosphorus and potassium at 80 kg/ha and 60 kg/ha, respectively in the form of single super phosphate and muriate of potash and half of the recommended dose of nitrogenous fertilizers in the form of urea were applied as basal and rest half of nitrogen at pre-flowering stage as top dressing. FYM, PM, VC, PSB and AZ were applied as per the treatments at the time of final land preparation. Boron is applied in the form of borax at the time of 50% flowering.

The experimental site was situated at $88^0 28'$ E Longitude and $22^0 22'$ N Latitude with an average altitude of 9.75 m above mean sea level. During the crop season, the average maximum and minimum temperature varied from 27.5 to 37.6 and 14.3 to 27.1 C respectively where as the relative humidity was between 36.8 to 89.6%. The crop received 96.6 mm of rainfall.

Results and Discussion

Plant Height

The maximum plant height (163.76 cm) was obtained in treatment T_{10}, where combined application of PM at 2.5 t/ha + 50% RDF + PSB + AZ, was applied which was at par with treatment T_{14}, (50% RDF + 2

foliar spray, NPK-19:19:19 + 2 Boron application) and followed by treatment T_{12}, i.e. PM at 2.5 t/ha + 50% RDF + 1 foliar spray, NPK 19:19:19, which might be due to the balanced nutrient supply throughout the growth period of crop was possible only through the combined application of organic and inorganic fertilizer, foliar spray of NPK 19:19:19 and boron application. Significantly minimum plant height (145 cm) was recorded in T_1, (untreated control) plots, where no fertilizer was applied (Table 1).

Among the organic sources, relatively more plant height (159 cm) was obtained with the application of poultry manure at 5 t/ha (T_4) followed by farm yard manure at 10 t/ha (T_3) (151.4 cm).

Organic manures alone or in combination with inorganic fertilizers increased plant height of sunflower. Such results might be due to interaction of large amount of nutrients available to the plants at early stages (4—6).

Head Diameter

The maximum head diameter (22.76 cm) was recorded in T_{10} treatment (PM at 2.5 t/ha + 50% RDF + PSB + AZ) which was statistically at par to the treatment T_{14} (50% RDF + 2 foliar spray, NPK-19:19:19 + 2 boron application). It further revealed that sole application of organic fertilizers (FYM, Poultry manure and Vermicompost) and inorganic fertilizers (standard dose) did not differ statistically from each other for increasing the head diameter (T_2, T_3, T_4 and T_5). The minimum head diameter (15.36 cm) was recorded in T_1 (untreated control) plots (Table 1).

Combination of organic and inorganic manures significantly increased head diameter of sunflower (5, 7, 8).

Number of Seeds Per Head

Seeds per head are important yield component of sunflower. Seed yield is directly proportional to the number of seeds per head. The data on the number of seeds per head as influenced by combinations of organic and inorganic fertilizers and their sole application reveal a significant treatment effect on the parameter during the year of experimentation (Table 1).

The maximum number of seeds per head (1151) was obtained from plots treated with PM at 2.5 t/ha + 50% RDF + PSB + AZ (T_{10}), interestingly almost same number of seeds per head was also observed in the treatment T_{14} (1145) i.e. 50% RDF + 2 foliar spray of NPK-19:19:19 + 2 foliar spray of boron application, they were statistically at par. Significantly the minimum number of seeds per head (850) was noted under T_1 treatment (untreated control) plot, where no fertilizer was applied. The inorganic fertilizers and organic manures (T_2, T_3, T_4, T_5) did not differ statistically with each other in producing seeds per head.

Number of seeds per head were significantly increased by organic manures alone or in combination with synthetic fertilizers (7, 9—12).

Seeds Weight Per Head

Seeds weight per head are important yield component of sunflower. Seed yield is directly proportional to the number of seeds per head. The data pertaining to the number of seeds per head as influenced by combinations of organic and inorganic fertilizers presented in Table 1 reveal a significant treatment effect on the parameter during the experimentation.

The maximum number of seeds weight per head (88.5 g) was obtained fro plots treated with PM at 2.5 t/ha + 50% RDF + PSB + AZ (T_{10}), interestingly same seeds weight per head was also observe in the treatment T_{14} (88.23 g) i.e., 500/0 RDF + 2 foliar spray of NPK-19:19:19 + 2 foliar spray of boron application, which was statistically at par each other.

Significantly the minimum seeds weight per head (50 g) were noted in treatment T_1 (untreated control) plots, where no fertilizer was applied. The sole application of inorganic fertilizer (RDF) and organic manures (T_2, T_3, T_4, T_5) were found did not differ statistically with each other in producing seeds weight per head.

Test Weight

Test weight plays a decisive role in determining the yield potential of a seed crop, as it expresses the magnitude of seed development. Table 1 shows that the treatments under study produced significant effect on the parameter under discussion during the year of experimentation.

The maximum test weight was recorded from

Table 2. Economics of sunflower production as influenced by integrated nutrient management practices. RDF : Recommended doses of fertilizers, FYM : Farm yard manure, PM : Poultry manure, VC : Vermi compost, PSB : Phosphorus solubilizing bacteria, AZ : Azotobacter.

Treatments	Cost of cultivation (Rs/ha)	Cost of treatment (Rs)	Total cost of cultivation (Rs/ha)	Yield (q/ha)	Price of produce (Rs/q)	Gross income (Rs/ha)	Net income (Rs/ha)	Benefit : cost ratio
T_1 (Untreated control)	16775	–	16775	19.50	0.12	39000	22225	1.32
T_2 (100% RDF)	16775	2884	19659	30.20	0.15	60400	40740	2.42
T_3 (FYM 10 t/ha + PSB + AZ)	16775	2060	18835	28.50	0.15	57000	38165	2.27
T_4 (PM 5 t/ha + PSB + AZ)	16775	25160	41935	29.75	0.07	59500	17565	1.04
T_5 (VC 5 t/ha + PSB + AZ)	16775	17580	34355	29.30	0.08	58600	24245	1.44
T_6 (FYM 5 t/ha + 50% RDF)	16775	2432	19207	30.75	0.16	61500	42292	2.52
T_7 (PM 2.5 t/ha + 50% RDF)	16775	13942	30717	31.50	0.10	63000	29782	1.77
T_8 (VC 2.5 t/ha + 50% RDF)	16775	10192	26967	31.35	0.11	62700	35732	2.13
T_9 (FYM 5 t/ha + 50% RDF + PSB + AZ)	16775	2512	19287	30.85	0.15	61700	42412	2.52
T_{10} (PM 2.5 t/ha + 50% RDF + PSB + AZ)	16775	14022	30797	32.75	0.10	65500	34702	2.06
T_{11} (VC 2.5 t/ha + 50% RDF+ PSB + AZ)	16775	10272	27047	31.60	0.11	63200	36152	2.15
T_{12} (PM 2.5 t/ha + 50% RDF + 1 foliar spray, NPK 19:19:19)	16775	14142	30917	31.75	0.10	63500	32582	1.94
T_{13} (VC 2.5 t/ha + 50% RDF + 1 foliar spray, NPK 19:19:19)	16775	10392	27167	31.65	0.11	63300	36132	2.15
T_{14} 50% RDF + 2 foliar spray, NPK 19:19:19 + 2 Boron application)	16775	2442	19217	32.65	0.16	65300	46082	2.74
T_{15} (50% RDF + 2 foliar spray, NPK-19:19:19)	16775	1842	18617	31.25	0.16	62500	43882	2.61

treatment T_{10} (PM at 2.5 t/ha + 50% RQF + PSB + AZ) (78.66 g) and T_{14} (50% RDF + 2 foliar spray NPK-19:19:19 + 2 foliar spray of boron) (78.33 g) they were closely followed by treatments T_7 and T_{12}. Significantly minimum test weight (65.20 g) was observed in treatment T_1 (untreated control) where no fertilizer was applied. Intermediate test weights were recorded from treatments T_8 (76.45 g), T_9 (74.45 g), T_{11} (75.55 g), T_{13} (76.33 g), and T_{15} (75.25 g). This result might be due to the required balanced supply of nutrients to the sunflower crops throughout its vegetative and reproductive growth and development periods and help the crop to exhibit its fun potential.

The treatment T_{14} i.e. 50% RDF without any organic manures super imposed with two foliar spray of NPK-1919:19 and boron (0.2%) has shown numerical second best result that might be due to 50% NPK provided initial nutrient requirement of crop forever nutrient requirement at later stage i.e. were met from the foliar spray NPK further boron application at pre-flowering and 50% flowering stage improve the seed feeling rate and seed development which ultimate increased yield of the seed. Continuous supply of nutrient to crop from integrated application organic and inorganic fertilizers could be integrated.

Organic and inorganic fertilizers, bio-fertilizers application significantly increased 1000 seed weight or test weight of sunflower. Such result might be due to the maximum and balanced availability of nutrients to plants throughout its development process and made the crop to gain proper height, development of the heads and hence resulted into heavier seeds (7, 9, 13, 14).

Seed Yield

The highest seed yield (32.75 q/ha) was obtained in T_{10} (PM at 2.5 t/ha + 50% RDF + PSB + AZ), which

was statistically at par with the treatment T_{14} (32.65 q/ha) (50% RDF + 2 foliar spray of NPK-19:19:19+2 foliar boron application) (32.65 q/ha). The treatment T_{14} i.e. 50% RDF without any organic manures super imposed with 2 foliar spray of NPK 19:19:19 and boron (0.2%) has shown numerical second best results that might be due to the 50% NPK provided initial nutrient requirement of crop forever nutrient requirement at later stage i.e. were met from the foliar spray NPK further boron application at pre-flowering and 50% flowering stage improve the seed feeling rate and seed development which ultimate increased yield of the seed. Continuous supply of nutrient to crop from integrated application organic and inorganic fertilizers could be integrated (Table 1).

The comparison between the individual treatment means further showed that seed yield in T_1 (untreated control) was significantly lowest yield (19.50 q/ha). Inorganic fertilizer (T_2) produced significantly higher seed yield than sole application of organic manures (T_3, T_4 and T_5). It is obvious that all the treatments (T_2 to T_{15}) gave highly significant improvement in seed yield against untreated control treatment (T_1). Application of half doses of organic manures i.e. FYM at 5 t/ha, PM at 2.5 t/ha and VC at 2.5 t/ha along with 50% inorganic fertilizers (T_6, T_7 and T_8) were found to be significantly effective than sole application of FYM at 10 t/ha (T_3), PM at 5 t/ha (T_4) and VC at 5 t/ha (T_5) to increase the seed yield of sunflower. Among the three organic sources (FYM, PM and VC), poultry manure found to be the superior to other organic sources. This might be, due to higher nutrient contents of poultry manure over VC and FYM (Table 1).

When bio-fertilizers viz. PSB and AZ were superimposed with half doses of organic manures i.e. FYM at 5 t/ha, PM at 2.5 t/ha and VC at 2.5 t/ha along with 50% inorganic fertilizers (T_9, T_{10} and T_{11}) were found to be effective than half doses of organic manures i.e. FYM at 5 t/ha, PM at 5 t/ha and VC at 2.5 t/ha along with 50% inorganic fertilizers without bio-fertilizers (Table 1).

Higher yield of sunflower crop due to organic nutrition modules over the average crop productivity may be attributed to enhanced nutrient availability, improved soil health and the soil physical properties that resulted in increased profitability of sunflower production system through combined use of organic resources of nutrients. Organic resources are not only sources of major nutrients, but they also provide other micronutrients and plant growth-promoting molecules, which together lead to good crop yields (15). Significantly increase of the seed yield of sunflower was observed due to the application of organic manures alone or in combination with inorganic fertilizers (9, 16—19).

Economics

Gross Income. Different integrated nutrient management practices influenced the gross income. The highest gross income of Rs 65500/ha was recorded under treatment, T_{10} (PM at 2.5 t/ha + 50% RQF + PSB + AZ), followed by Rs 65300/ha, T_{14} (50% RDF + 2 foliar spraying of NPK – 19:19:19 + 2 foliar spraying of boron). The lowest gross income of Rs 39000/ha. Was noted under T_1 (untreated control) plot (Table 2).

Net Income. Net income was also influenced by the different integrated nutrient management practices tried in the experiment. The maximum net income of Rs 46082/ha was recorded under the treatment, T_{14}, (50% RDF + 2 foliar spraying of NPK-19:19:19 + 2 foliar spraying of boron), followed by Rs 43,882/ha, T_{15}, (50% NPK + 2 foliar spraying of NPK-19:19:19). Similarly lowest net income of Rs 22,225/ha was noted under T_1 (untreated control) plot (Table 2).

Benefit : Cost Ratio

Benefit : cost ratio was the highest (2.74) under the treatment, T_{14}, (50% RDF + 2 foliar spraying of NPK-19:19:19 + 2 foliar spraying of boron) followed by T_{15}, (2.61) (50% NPK+2 foliar spraying of NPK-19:19:19). The benefit : cost ratio was noted to be lower under T_1 (1.32) (untreated control) treatments (Table 2).

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