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INTEGRATED APPROACH IN NUTRIENT MANAGEMENT OF SESAME WITH SPECIAL REFERENCE TO ITS YIELD, QUALITY AND NUTRIENT UPTAKE

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ABSTRACT

An experiment on integrated nutrient management practice for augmenting the productivity of sesame (*Sesamum indicum*) and improving the soil fertility build-up with different quantum of inorganic nutrients (chemical fertilizers) in conjugation with/without organic manure (FYM and neematex) was carried out in Inseptisol soil of New Alluvial zone of West Bengal, India under subtropical climate at Bidhan Chandra Krishi Viswavidyalaya (State Agricultural University) during the summer and rainy seasons of 2009 and 2010. The experiment was laid out in split plot design replicated thrice with two bio-fertilizer treatments in main plots, six levels of nutrient management practices (combination of organic and inorganic nutrient sources) in sub plots. The relative performances of all the nutrient management practices in terms of plant height, dry matter accumulation, yield attributes, yield and oil content as well as nutrient status of soil (N, P and K status of soil) were assessed. Application of higher doses of inorganic nutrients alongwith neematex increased the yield and oil content. It can be summarized that the application of 40 kg N + 60 kg P_2O_5 + 40 kg K_2O ha^{-1} in combination with 1t neematex ha^{-1} exhibited the best results in both summer and rainy seasons in terms of various growth, yield and quality parameters along with soil nutrient status.

INTRODUCTION

The country has now been achieving self-sufficiency in cereal food production but vegetable oil is also necessary in suitable proportion along with the cereal food grains as these have been proved to be indispensable for maintaining balanced human nutrition vis-à-vis combating against a number of fatal human diseases. The state like West Bengal contributes a little over 2% of the oilseed pool of the country. Moreover, the shortage of edible oil is a perennial problem of West Bengal because of its low productivity due to its cultivation in marginal land and no fertilizer is applied to the oilseed crops. The state requires providing at least 15 lakh tonnes of oilseeds per year, whereas, it's annual average production is only 5 lakh tonnes. This situation calls for a reorientation in our agricultural strategy to achieve a rapid breakthrough in the productivity of oilseeds specially sesame, on an enduring basis. Moreover, it should be kept in mind that qualitative aspects of the agricultural produces is the prime factor for achieving a very strong position with our agricultural commodities in the global market. So, higher quality of the produces should be confirmed along with productivity improvement of the crops without hampering the sustainability.

That's why this experiment had been formulated to work out a best integrated nutrient management practice for sesame using chemical fertilizer, bio-fertilizer and organic manure/ matter which helps in maintaining stability in crop production by improving the physico-chemical properties of soil.

MATERIALS AND METHODS

A field experiment was conducted at 'C' Block farm of Bidhan Chandra Krishi Viswavidyalaya (State Agricultural University), Kalyani, Nadia, West Bengal, India under subtropical climate (located at 23°5′ N latitude, 89°0′ E longitude and at an altitude of 9.75 m above mean sea level) during the summer (March-April to June-July) and rainy season (June-July to October-November) seasons of 2009 and 2010. The experimental site is of sub-tropical humid type with an average annual rainfall of 1460 mm, mostly precipitated during June to September and the mean temperature ranges between 10°C to 37°C. The experimental soil is typically of gangetic alluvial type (Inseptisol) and sandy loam in texture with a pH of 6.7, Organic carbon 0.57%, total N 0.056%, available P_2O_5 26.29 kg ha^{-1}, available K_2O 168.72 kg ha^{-1}.

The experiment was laid out in split plot design with three replications having 2 main plots and 6 sub plots. The main plot size was 12 × 5 m^2, sub plot size: 5 × 2 m^2. The two main plot treatments were B_0-without bio-fertilizer and B_1- with bio-fertilizer using *Azospirillum sp.* strain for seed inoculation of sesame (cultivar Roma). Six levels of nutrient management practices were F_1: N, P_2O_5, K_2O @ 20, 40 & 20 kg ha^{-1}, F_2: N, P_2O_5, K_2O @ 40, 60 & 40 kg ha^{-1}, F_3: F_1 + 5 t FYM ha^{-1}, F_4: F_1 + 1 t neematex ha^{-1}, F_5: F_2 + 5 t FYM ha^{-1} and F_6: F_2 + 1 t neematex ha^{-1} in the sub plots. Urea, single super phosphate and muriate of potash were used as the sources of N, P_2O_5 & K_2O.

Nutrient contents of organic manures viz. FYM and neematex are as follow:

Manures	Nutrient composition (%)		
	N	P_2O_5	K_2O
Farm yard manure (FYM)	0.5	0.19	0.49
Neematex	2.50	1.00	1.00

RESULTS AND DISCUSSION

The data depicted in the Table 1 showed significant variation in case of plant height and dry matter accumulation of sesame at harvest due to difference in bio-fertilizer treatment in both summer and rainy seasons. The tallest plants and maximum amount of dry matter were found when the sesame seeds were inoculated with *Azosprillum* (B_1) during summer and rainy season. Different nutrient management practices had a significant role in changing the growth parameters viz. plant height & day matter accumulation at harvest in summer and rainy season. It has been found that, addition of nutrients through organic sources (5 t FYM or 1 t neematex ha^{-1}) alongwith higher (40 kg N + 60 kg P_2O_5 + 40 kg K_2O ha^{-1}) or lower (20 kg N + 40 kg P_2O_5 + 20 kg K-$_2$O ha^{-1}) doses of inorganic ones significantly improved the growth parameters at harvest during the aforesaid respective seasons. The maximum plant heights and dry matter at harvest were observed when the crop was treated with 40 kg N + 60 kg P_2O_5 + 40 kg K_2O ha^{-1} alongwith 1t neematex per ha (F_6).

The data presented in Table 1 represent the LAI at 30, 60 & 90 DAS of summer and rainy season. The LAI differed significantly with the difference in bio-fertilizer treatments. The maximum values of LAI at 30, 60 & 90 DAS in the aforesaid respective seasons were registered when the seeds of sesame were inoculated with A*zosprillum* culture in both the years of experimentation. Incorporation of nutrients from organic sources (5 t FYM or 1 t neematex ha^{-1}) along with lower and higher doses of inorganic ones (20 kg N + 40 kg P_2O_5 + 20 kg K_2O ha^{-1} or 40 kg N + 60 kg P_2O_5 + 40 kg K_2O ha^{-1}) significantly improved the LAI at 30, 60 and 90 DAS. Similar observation on growth parameters was reported by Abo-El-Wafa *et al.(*2006) & Barik and Fulamli (2011).

The data depicted in Table 1 and 2 represent the number of primary branches $plant^{-1}$, number of capsule $plant^{-1}$ and numbers of seeds $capsule^{-1}$ and yield respectively. Seed inoculation of sesame with *Azosprillum* did not significantly change the number of primary branches $plant^{-1}$ in both summer and rainy seasons. Although the maximum numbers of primary branches $plant^{-1}$ were recorded when the seeds were inoculated with bio-fertilizer. The number of primary branches $plant^{-1}$ changed significantly with the changes in nutritional management practices in both the seasons. The highest numbers of primary branches $plant^{-1}$ in summer and rainy seasons were obtained in the treatment consisting of 1 t neematex ha^{-1} alongwith 40 kg N + 60 kg P_2O_5 + 40 kg K_2O ha^{-1} (F_6).

In both summer and rainy seasons, number of capsules $plant^{-1}$ varied significantly with the inoculation of seeds by *Azosprillum*. The maximum numbers of capsules $plant^{-1}$ in summer and rainy seasons were obtained when the seeds were inoculated with *Azosprillum* culture (B_1). Number of capsules $plant^{-1}$ grown during those seasons was significantly influenced by various nutritional management practices. The highest numbers of capsules $plant^{-1}$ during the summer and rainy season sesame were recorded in the treatment F_6. Inoculation of seeds with *Azosprillum* culture had a significant role in differentiating the number of seeds $capsule^{-1}$ in both the seasons. The higher number of seeds $capsule^{-1}$ in summer and rainy seasons were recorded in B_1. The treatment F_6 produced the maximum number of seeds $capsule^{-1}$ in respective seasons. Similar observations yield attributes were reported by Abo-El-Wafa *et al.* (2006) and Anandan *et al.* (2012).

The results illustrated in Table 2 also depict the yield of sesame under bio fertilizer and different nutrient management practices in rainy and summer seasons. Inoculation of seeds with *Azosprillum* culture had a significant role on the seed yields in both the seasons. The highest seed yields in summer and rainy seasons were obtained when seeds were inoculated with *Azosprillum* culture. Whereas, the lowest seed yield were

Table1: Effect of bio-fertilizers and nutrient management practices on growth parameters (pooled of 2 years)

Treatments	Plant height (cm)		Dry weight (g m^{-2})		Primary branches $plant^{-1}$		Leaf area index					
							30 DAS		60 DAS		90 DAS	
	Summer	Rainy	Summer	Rainy	Summer	Rainy	Summer	Rainy	Summer	Rainy	Summer	Rainy
Bio fertilizer treatment												
B_0	92.85	76.92	577.68	460.87	4.79	4.72	1.35	1.32	2.25	2.25	1.17	1.15
B_1	95.13	80.02	615.05	468.17	4.86	4.79	1.21	1.20	2.85	2.84	1.18	1.18
SEm ±	0.32	0.29	2.22	1.18	0.04	0.03	0.005	0.006	0.004	0.005	0.003	0.004
CD (p = 0.05)	0.94	0.85	6.63	3.53	NS	NS	0.029	0.038	0.022	0.031	0.010	0.010
Nutrient management treatment												
F_1	82.11	64.37	528.91	424.42	4.47	4.49	1.20	1.20	2.45	2.43	1.09	1.07
F_2	85.91	70.34	557.10	436.73	4.62	4.58	1.23	1.22	2.49	2.47	1.13	1.12
F_3	91.85	75.41	583.21	460.91	4.72	4.68	1.25	1.25	2.53	2.52	1.17	1.15
F_4	96.32	80.45	593.22	469.06	4.88	4.78	1.29	1.28	2.57	2.57	1.20	1.19
F_5	102.12	87.03	614.33	494.39	5.03	4.89	1.33	1.31	2.61	2.62	1.22	1.22
F_6	105.64	93.22	701.45	501.62	5.24	5.11	1.36	1.34	2.65	2.67	1.24	1.25
SEm ±	0.71	0.51	4.23	3.08	0.08	0.01	0.009	0.005	0.010	0.007	0.006	0.006
CD (p = 0.05)	2.11	1.51	12.64	9.10	0.22	0.04	0.025	0.014	0.029	0.020	0.018	0.018
Interaction B × F												
SEm ±	2.08	1.34	9.12	8.64	0.89	0.63	0.35	0.29	0.34	0.41	0.47	0.39
CD (p = 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 2: Effect of bio-fertilizers and nutrient management practices on yield attributes, yields & oil content of sesame (pooled of 2 years)

Treatments	Capsules plant^{-1}		Seeds capsule^{-1}		Yield (t ha^{-1})		Oil content (%)	
	Summer	Rainy	Summer	Rainy	Summer	Rainy	Summer	Rainy
Bio fertilizer treatment								
B_0	74.85	68.28	56.12	55.19	1.14	0.87	38.74	39.01
B_1	76.74	70.25	58.03	57.06	1.18	0.92	39.56	39.78
SEm ±	0.40	0.32	0.42	0.31	0.01	0.01	0.17	0.19
CD (p = 0.05)	1.17	0.95	1.22	0.91	0.03	0.03	0.40	0.54
Nutrient management treatment								
F_1	68.78	63.19	50.41	52.45	1.03	0.80	36.16	36.17
F_2	72.33	67.25	54.49	54.73	1.10	0.84	36.96	37.01
F_3	76.13	69.03	57.64	56.25	1.15	0.88	38.40	38.13
F_4	77.55	71.16	57.91	57.07	1.18	0.90	39.50	39.68
F_5	78.45	71.03	60.17	57.52	1.19	0.90	41.12	41.69
F_6	81.56	73.94	61.83	58.75	1.29	1.00	42.78	43.68
SEm ±	0.744	0.60	0.71	0.49	0.05	0.06	0.17	0.36
CD (p = 0.05)	2.19	1.78	2.10	1.44	0.14	0.17	0.51	1.06
Interaction B × F								
SEm ±	2.12	1.96	1.32	1.07	0.86	0.71	1.09	0.97
CD (p = 0.05)	NS	NS	NS	NS	NS	NS	NS	NS

Table 3: Effect of bio-fertilizers and nutrient management practices on uptake by plant (pooled of 2 years)

Treatments	Nitrogen uptake (kg ha^{-1})		Phosphorous uptake (kg ha^{-1})		Potassium uptake (kg ha^{-1})	
	Summer	Rainy	Summer	Rainy	Summer	Rainy
Bio fertilizer treatment						
B_0	87.63	69.17	20.50	14.61	82.20	63.04
B_1	97.11	72.09	23.98	16.76	90.28	67.18
SEm ±	1.31	1.21	0.64	0.45	1.27	1.00
CD (p = 0.05)	3.93	3.64	1.92	1.34	3.84	3.01
Nutrient management treatment						
F_1	76.48	59.03	14.65	11.41	68.01	53.01
F_2	82.06	62.40	16.49	12.27	74.76	56.86
F_3	88.64	69.45	20.17	14.28	83.04	64.20
F_4	92.54	71.25	21.83	15.57	83.64	64.49
F_5	99.70	80.58	28.07	19.62	99.15	77.12
F_6	116.93	82.61	34.51	21.82	112.09	76.69
SEm ±	2.98	3.34	2.08	1.92	3.48	2.74
CD (p = 0.05)	8.96	10.04	6.24	5.74	10.43	8.24
Interaction B × F						
SEm ±	2.72	2.19	1.67	1.37	2.03	1.76
CD (p = 0.05)	NS	NS	NS	NS	NS	NS

obtained when the seeds were not inoculated with *Azosprillum*. Changes in nutritional management practices had a significant effect in changing the seed yield in both the seasons. The maximum seed yields i.e 1.29 t ha^{-1} in summer and 1.00 t ha^{-1} in rainy season were observed in the treatments consisting of 40 kg N + 60 kg P_2O_5 + 40 kg K_2O + 1 t neematex ha^{-1}. On the contrary, application of nutrients only through inorganic sources showed poor performance with respect to seed yield. The minimum seed yields were noticed when the crop was treated with only 20 kg N + 40 kg P_2O_5 + 20 kg K_2O per ha. This result supports the observations of Khanda *et al.* (2005) and Hanumanthappa *et al.* (2008). The extents of increase in seed yield of sesame due to the inoculation of seeds with bio-fertilizer over that of non-inoculated sesame crops in summer and rainy seasons were 3.14% and 2.84% respectively. This type of increase in seed yields of sesame under study occurred probably due to the fact that inoculation of seeds of sesame with bio-fertilizer supplied additional nutrients to the crops, which might increase the number of capsules plant^{-1}, seeds capsule^{-1} of crop and ultimately the yield of sesame. This result is in agreement with the findings of Singaravel and Govindasamy (1998) and Thanki *et al.* (2004). Similarly the degrees of increase in seed yield of sesame by applying the nutrient dose of 40 kg N + 60 kg P_2O_5 + 40 kg K_2O ha^{-1} alongwith 1 t neematex ha^{-1} were 16.41% and 18.43% in summer and rainy seasons respectively over the treatment containing 40 kg N + 60 kg P_2O_5 + 40 kg K_2O ha^{-1} only. The increase in productivity of crop receiving organic manures might be due to the fact that organic manures in conjugation with inorganic nutrients not only provide additional nutrients other than N, P and K but also maintain the soil health as a whole reflecting all round development of the crop *vis-a-vis* smooth and proper translocation of photosynthates from source to sink. These results support the findings of Soni and Sikarwar (1991), Rajput and Warsi (1992).

The results summarized in Table 2 revealed the quality parameter of sesame. In both the seasons, the oil content varied significantly with the variation in bio-fertilizer treatments. The oil content of sesame differed significantly with the difference in nutrient management practices in both the season. The maximum oil percentages were recorded by the crop receiving

Table 4: Economics of various nutrient management practices in soybean during rainy and summer season

Fertilizer management practices(per ha)	Cost of fertilizer (B)	Total cost of cultivation (A + B)	Total value of produce (C)	Net Profit NP = [C – (A + B)]	B : C [NP/ A + B]
Rainy season					
20 kg N + 40 kgP_2O_5 + 20 kg K_2O + B_0	1833.12	6833.12	21356	14522.88	2.13
20 kg N + 40 kgP_2O_5 + 20 kg K_2O + B_1	1929.12	6929.12	22420	15490.88	2.23
40 kg N + 60 kgP_2O_5 + 40 kg K_2O + B_0	2991.24	7991.24	23389	15397.76	1.93
40 kg N + 60 kgP_2O_5 + 40 kg K_2O + B_1	3087.24	8087.24	23655	15567.76	1.92
20 kg N + 40 kgP_2O_5 + 20 kg K_2O + 5t FYM + B_0	4833.12	9833.12	24111	14277.88	1.45
20 kg N+ 40 kg P_2O_5 + 20 kg K_2O + 5t FYM + B_1	4929.12	9929.12	24757	14827.88	1.49
20 kg N + 40 kg P_2O_5 + 20 kg K_2O +1 t Neematex + B_0	12633.12	17633.12	25004	7370.88	0.42
20 kg N + 40 kg P_2O_5 + 20 kg K_2O + 1 t Neematex + B_1	12729.12	17729.12	25555	7825.88	0.44
40 kg N + 60 kg P_2O_5 + 40 kg K_2O + 5 t FYM + B_0	5991.24	10991.24	25232	14240.76	1.29
40 kg N + 60 kg P_2O_5 + 40 kg K_2O + 5 t FYM+B_1	6087.24	11087.24	25821	14733.76	1.33
40 kg N + 60 kg P_2O_5 + 40kg K_2O + 1 t Neematex + B_0	13791.24	18791.24	27531	8739.76	0.46
40 kg N + 60 kg P_2O_5 + 40 kg K_2O + 1 t Neematex + B_1	13887.24	18887.24	28633	9745.76	0.52
Summer season					
20 kg N + 40 kg P_2O_5 + 20 kg K_2O + B_0	1833.12	6833.12	17271	10437.88	1.53
20 kg N + 40 kg P_2O_5 + 20 kg K_2O + B_1	1929.12	6929.12	17955	11025.88	1.59
40 kg N + 60 kg P_2O_5 + 40 kg K_2O + B_0	2991.24	7991.24	18354	10362.76	1.30
40 kg N + 60 kg P_2O_5 + 40 kg K_2O + B_1	3087.24	8087.24	19133	11045.76	1.37
20 kg N + 40 kg P_2O_5 + 20 kg K_2O + 5 t FYM + B_0	4833.12	9833.12	19437	9603.88	0.98
20 kg N + 40 kg P_2O_5 + 20 kg K_2O + 5 t FYM + B_1	4929.12	9929.12	20976	11046.88	1.11
20 kg N + 40 kg P_2O_5 + 20 kg K_2O + 1 t Neematex + B_0	12633.12	17633.12	20425	2791.88	0.16
20 kg N + 40 kg P_2O_5 + 20 kg K_2O + 1 t Neematex + B_1	12729.12	17729.12	20558	2828.88	0.15
40 kg N + 60 kg P_2O_5 + 40 kg K_2O +5 t FYM + B_0	5991.24	10991.24	19551	8559.76	0.78
40 kg N + 60 kg P_2O_5 + 40 kg K_2O + 5 t FYM + B_1	6087.24	11087.24	19893	8805.76	0.79
40 kg N + 60 kg P_2O_5 + 40 kg K_2O + 1 t Neematex + B_0	13791.24	18791.24	21166	2374.76	0.13
40 kg N + 60 kg P_2O_5 + 40 kg K_2O + 1 t Neematex + B_1	13887.24	18887.24	22002	3114.76	0.16

the treatment containing 1 t neematex ha^{-1} alongwith 40 kg N + 60 kg P_2O_5 + 40 kg K_2O ha^{-1}. This increase in oil percentage may be due to the fact that better availability of all the nutrients to the sesame plants through both organic and inorganic sources resulting high oil production in the seeds. This result supports the observations of Singaravel and Govindasamy (1998) and Mandal and Pramanik (1996).

The results illustrated in Table 3 revealed that seed inoculation with *Azosprillum* had a significant effect on the nitrogen and potassium uptake by sesame in both the seasons but had no significant effect on phosphorous uptake. Addition of nutrients through organic sources (FYM or neematex) alongwith higher and lower (40 kg N + 60 kg P_2O_5 + 40 kg K_2O ha^{-1} and 20 kg N + 40 kg P_2O_5 + 20 kg K_2O ha^{-1}) doses of inorganic ones significantly improved the nitrogen uptake by this crop in both the seasons. The highest nitrogen, phosphorous & potassium uptakes in summer and rainy seasons were obtained in the treatment consisting of 1 t neematex ha^{-1} alongwith 40 kg N + 60 kg P_2O_5 + 40 kg K_2O ha^{-1}. Integration of organic and inorganic sources of plant nutrient elements results in more uptake of them as compared to sole use of organic or inorganic ones. This may be due to the fact that the balanced and combined use of various plant nutrient sources results in proper absorption, translocation and assimilation of those nutrients, ultimately increasing the dry-matter accumulation and nutrient contents of sesame and thus showing more uptake of elemental nutrients. It is also a fact that improvement of physiological efficiencies of different macro and trace elements resulted from the combined application of organic and inorganic sources of nutrients produces crop with superior quality under investigation. Similar findings were reported by Ghosh and Mohiuddin (2000) and Anandan and Natarajan (2012).

It was a great concern to evaluate the benefit cost ratio and the results are presented in the Table 4. Application of only 20 kg N + 40 kg P_2O_5 + 20 kg K_2O ha^{-1} and inoculation of seeds with bio-fertilizer recorded the higher values of B:C in both the seasons of experimentation. Application of 20 kg N + 40 kg P_2O_5 + 20 kg K_2O alongwith 1 t neematex ha^{-1} with or without bio-fertilizer recorded the lowest values of B:C in both the seasons.

From the above discussion it may be opined that combined application of organic manure and higher doses of inorganic nutrients (40 kg N + 60 Kg P_2O_5 + 40 kg K_2O ha^{-1}) improved the seed yield, oil quality and fertility status (N, P and K) of soil with respect to that the application of only inorganic nutrients performed. Combined use of inorganic and biological sources of nutrients may be suggested for higher economic return alongwith overall betterment of sesame crop. Whereas, though the organic manure (neematex) showed better growth, development, yield and quality of sesame the high price of neematex becomes barrier in using it by the farmers in their sesame crop.

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