Nutrient Management in Summer Sesame (*Sesamum indicum* L.) and its Residual Effect on Black Gram (*Vigna mungo* L.)

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Article History

Manuscript No. 319
Received in 18th December, 2012
Received in revised form 8th October, 2013
Accepted in final form 4th December, 2013

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Keywords

Sesame, nutrient management, *Azospirillum*, FYM, vermicompost, black gram

Abstract

Field experiments were carried out to study the effect of nutrient management in summer sesame and its residual effect on succeeding *kharif* black gram during 2003 and 2004 in sub-humid lateritic tract of West Bengal. The crop growth was better with integrated application of 50% recommended dose of NPK through fertilizer (RDF), 50% N through vermicompost (VC) or FYM along with *Azospirillum* in sesame. The number of capsules plant^{-1}, seeds capsule^{-1}, seed and oil yield of sesame increased significantly due to integrated application of 50% RDF+50% N through FYM along with *Azospirillum* in sesame during both the years. However, the treatment was at par with those of 75% RDF+25% N through FYM or VC along with *Azospirillum* and 50% RDF+50% N through VC along with *Azospirillum.* Integrated use of fertilizer, organic manure and *Azospirillum* produced higher seed and oil yield of sesame compared to 100% RDF through fertilizer alone. Further, substitution of 25% N through FYM along with *Azospirillum* produced higher seed and oil yield of sesame than that of 100% RDF. Integrated use of 50% RDF+50% N through FYM+*Azospirillum* recorded 12.2, 20 and 15.6% higher yield over 100% RDF in 2003, 2004 and pooled over the years, respectively. This treatment also gave higher gross and net return. Application of 50% RDF and 50% N through vermicompost or FYM along with *Azospirillum* in sesame exerted greater residual effect on the growth, yield components and seed yield of succeeding black gram as compared to other treatments. It also helped in improving the fertility status of the soil under this cropping system in red and lateritic belt of West Bengal.

1. Introduction

The demand for vegetable oil in India is increasing steeply owing to increase in population, improvement in standard of living, increasing industrial requirement besides the current global pressure on bio-fuels. Except for a brief period of satisfaction during 1986-90 wherein the country had witnessed near self-sufficiency in vegetable oils, in spite of continuous increase in domestic oilseeds production, only of 50% the requirement of vegetable oil is met and nearly half is made through imports at a huge cost of 9.7 billion US dollars as incurred during 2011-12 (Hegde et al., 2012). Sesame (*Sesamum indicum* L.) is one of the important oilseed crops in Indian agriculture. Sesame seeds are rich source of food, nutrition, edible oil and bio-medicine. Its oil has excellent nutritional, medicinal, cosmetic and cooking qualities for which it is known as 'the queen of oils'. It is cultivated on a large area in the states of Maharashtra, Uttar Pradesh, Rajasthan, Orissa, Andhra Pradesh, Madhya Pradesh, Tamil Nadu, West Bengal, Gujarat, Karnataka, Kerala, Bihar, Assam and Punjab and to a limited extent, in Tripura and Himachal Pradesh. By virtue of its early maturing, sesame fits well into a number of multiple cropping systems either as a catch crop or a sequence crop in *rabi* and pre-*kharif* seasons. India ranks first in area, production and export of sesame in the world. Sesame ranks third in terms of total oilseed area and fourth in terms of total oilseed production in India. The average yield of sesame in India is very low (274 kg ha^{-1}) (Anonymous, 2012a). It is one of the important oilseed crops in West Bengal and mainly grown in marginal land with minimum care. Sesame is cultivated in summer, *kharif* and post-*kharif* season in West Bengal with an area of about 0.182 m ha (Anonymous, 2012b). The area, production and productivity of sesame are higher in summer season than those of post-*kharif* and *kharif* seasons (Anonymous, 2006). But the productivity of sesame in general is much lower than its potential yield. Lower productivity of is due to use of sub-optimal rate of fertilizer, poor management and cultivation of sesame in marginal and sub-marginal lands where deficiency of macronutrients such as nitrogen, phosphorus, potassium and micronutrient is predominant. This indicates the scope and need to increase the productivity of sesame. Integrated use

of organic manures and chemical fertilizers in sesame helps maintaining stability in crop production, besides improving soil physical conditions (Deshmukh et al., 2002 and Verma et al., 2012). FYM is a key fertilizer in organic and sustainable soil management. It contains many of the elements that are needed for plant growth and development. Higher seed yield of sesame can be obtained by integrated use of fertilizer along with FYM, vermicompost and *Azospirillum* (Purushottam, 2005 and Jaishankar and Wahab, 2005). *Azospirillum* increases dry matter production and yields in sesame (Senthilkumar et al., 2000 and Verma et al., 2012). Further, combined application of organics and inorganics during *kharif* season in sesame exerts significant residual effect on succeeding chickpea (Purushottam, 2005). Black gram is one of the important pulse crops in West Bengal and cultivated in summer, *kharif* and post-*kharif* season. Growing black gram in succession creates an opportunity for proper utilization of residual soil fertility and to expand the area under pulses. With this background, the present investigation was carried out to study the effect of integrated use of bio-organic sources of plant nutrients with chemical fertilizers on productivity of summer sesame and their residual effect on succeeding black gram.

2. Materials and Methods

A field experiment was conducted during February 2003 to October 2004 at Sriniketan (23°39' N, 87°42' E and 51 m above mean sea level) where the average rainfall is 1480 mm, distributed mainly in July-September, and the temperature reaches around 40-41°C in April-May. The soil was sandy loam, acidic (pH 5.25), low in organic carbon (0.46%), low in available nitrogen (N) (142.4 kg ha^{-1}), medium in available phosphorus (P) (18.75 kg ha^{-1}) and potassium (K) (139 kg ha^{-1}). Experiment on sesame was laid out in a randomized black design having three replications with fourteen treatments viz. T_1-Control (no fertilizer and manure), T_2-100% of recommended dose of NPK through fertilizer (RDF) (80:40:40 kg N: P_2O_5: K_2O ha^{-1}), T_3-75% of RDF (60:30:30 kg N: P_2O_5: K_2O ha^{-1}), T_4-50% of RDF (40:20:20 kg N: P_2O_5: K_2O ha^{-1}), T_5-T_3+25% of recommended N through farmyard manure (FYM), T_6-T_4+50% of recommended N through FYM, T_7-T_3+25% of recommended N from vermicompost (VC), T_8-T_4+50% of recommended N from VC, T_9-T_3+*Azospirillum,* T_{10}-T_4+*Azospirillum,* T_{11}-T_5+*Azospirillum,* T_{12}-T_6+*Azospirillum,* T_{13}-T_7+*Azospirillum* and T_{14}-T_8+*Azospirillum.* Black gram was sown in the same plots as a residual crop after harvesting of sesame. Sesame cv. Roma (Improved Selection-5) was sown at a spacing of 30×10 cm^2 and that of black gram cv. Sarada (WBU-108) at a spacing of 45×10 cm^2, respectively. *Azospirillum* was applied @ 1.5 kg ha^{-1} by mixing with seed. FYM and vermicompost were applied 10 days before sowing at the time of ploughing for thorough mixing with soil. Full dose of P and K and half dose of N in the form of single super phosphate, muriate of potash and urea, respectively were applied as basal during the final ploughing. The rest half of N was applied as top dressing at 30 days after sowing (DAS). Sesame was sown during last week of February in 2003 and first week of March in 2004 using a seed rate of 7.5 kg ha^{-1}. Black gram was sown during last week of June in both years using seed rate of 15.0 kg ha^{-1}. Sesame was irrigated twice and thrice during the first and second year, respectively. No irrigation was required to apply in blackgram. Both the crops were kept free from major insect pests and diseases. Available N, P and K, organic carbon and soil pH were estimated following the standard procedures. Seed oil content was analyzed by Soxhlet's extraction method as per Ward and Johnston (1960). Seed protein content was calculated by multiplying N (%) with 5.30 (Merrill and Watt, 1973).

3. Results and Discussions

3.1. Growth, yield components and yield of sesame

The partial replacement of chemical fertilizer by bio-organic nutrient sources in different combinations induced marked variation in growth and yield attributes and yield of summer sesame (Table 1). The tallest plant at maturity and highest dry weight of sesame at 75 DAS were recorded with 50% RDF+50% recommended dose of nitrogen through VC+*Azospirillum* @ 1.5 kg ha^{-1}. However, the dry weight at 75 DAS was at par with that of 50% RDF+50% N through FYM+*Azospirillum*. The plant height at maturity was at par in the treatments involving integrated application of chemical, organic manure and biofertilizer and 50% substitution made only through FYM or vermicompost. Application of 50% RDF+50% N through FYM+*Azospirillum* recorded the highest number of capsules $plant^{-1}$ and number of seeds $capsule^{-1}$, while 100% RDF recorded the highest number of branches $plant^{-1}$. Plant height at maturity, number of capsules $plant^{-1}$, seeds $capsule^{-1}$ and test weight of sesame did not vary significantly among the treatments where chemical fertilizers were substituted through different sources of organic manures along with *Azospirillum*. The results clearly indicate that integrated use of chemical fertilizer, organic manure and biofertilizer was better than application of chemical and organic or biofertilizer or chemical sources of nutrient alone. This may be due to supply of nutrients from diversified sources and prolonged availability of nutrients to the growing plants. The beneficial role of free living nitrogen fixing microorganisms for enhancing plant growth through their ability in nitrogen fixation as well as the effect of their metabolites secretion on the crop may also be attributed for the same. Using organic manure to supplement chemical fertilizer with respect to N might have resulted in good supply of potassium also. These results are in agreement with Jaishankar and Wahab (2005), Imayavaramban et al. (2002) and Verma et al. (2012). Application of 50% RDF+50% N through FYM+*Azospirillum* recorded the highest seed yield, harvest index, oil and protein yield of sesame (Tables 1 and 3). Yield attributes and seed yield of sesame were statistically at par among the treatments involving integrated nutrient

management. Application of 50% RDF+50% N through FYM+*Azospirillum* recorded 12.2, 20 and 15.6% higher yield over 100% RDF in 2003, 2004 and pooled over the years, respectively. The results indicated that integrated application of chemical fertilizer, organic manure and biofertilizer might have supplied plant nutrients for a longer period. The improvement in yield could also be attributed to higher uptake of nutrients by sesame (Table 4). Similar results were also reported by Duhoon et al. (2004) and Verma et al. (2013). Performance of *Azospirillum* was better in the plots where higher quantity of organic manure was applied along with *Azospirillum*. This might be due to increased rate of decomposition and release of nutrients due to activity of *Azospirillum*. These results are in conformity with those obtained by Duhoon et al. (2004) and Nayak et al. (2005).

3.2. Economics

The cost of sesame cultivation was highest due to integrated application of 50% RDF and 50% N through VC along with *Azospirillum.* Highest gross return from sesame cultivation was obtained with integrated application of 50% RDF+50% N through FYM along with *Azospirillum* closely followed by integrated application of 75% RDF+25% N through VC and *Azospirillum* and 50% RDF+50% N through VC and *Azospirillum*. Application of fertilizer and VC gave higher gross

Table 1: Growth, yield components, seed yield and economics of sesame as influenced by various nutrient management treatments

Treatments	PH (cm)	NBP	PDW (g m^{-2})	NCP	NSC	TW (g)	Seed yield (kg ha^{-1})			CC (₹ ha^{-1})	GR (₹ ha^{-1})	NR (₹ ha^{-1})	RI (₹$^{-1}$)
							2003	2004	Pooled				
Control	72.8	1.5	299	15.6	33.0	2.7	623	515	569	8486	9626	1140	1.14
100 % RDF	90.4	5.3	614	28.0	51.5	3.1	1390	1042	1216	11070	20236	9166	1.82
75% RDF	87.9	4.1	535	24.8	48.5	3.0	1140	992	1066	10385	17800	7415	1.72
50% RDF	80.1	3.4	447	23.2	44.5	2.9	927	804	865	9757	14502	4745	1.49
75% RDF+25% RDN (FYM)	88.6	4.4	546	24.8	50.0	3.1	1170	1013	1092	12064	18190	6126	1.51
50% RDF+50% RDN (FYM)	93.8	3.5	593	24.0	47.5	3.0	1030	963	1018	13058	16995	3937	1.30
75% RDF+25% RDN (VC)	89.9	4.6	572	27.7	51.0	3.1	1287	1062	1174	13113	19535	6422	1.49
50% RDF+50% RDN (VC)	95.8	3.2	632	27.0	49.0	3.1	1200	1020	1077	14916	18452	3536	1.24
75% RDF+ *Azospirillum*	90.0	4.5	570	25.0	49.0	3.0	1193	932	1063	10460	17769	7309	1.70
50% RDF+ *Azospirillum*	83.7	3.3	507	23.5	47.0	2.8	997	946	971	9832	16289	6457	1.66
75% RDF+25% RDN (FYM)+ *Azospirillum*	92.1	5.0	655	29.7	52.0	3.1	1447	1140	1295	12139	21518	9379	1.77
50% RDF+50% RDN (FYM)+ *Azospirillum*	97.2	4.6	703	32.8	54.5	3.2	1560	1251	1406	13133	23296	10163	1.77
75% RDF+ 25% RDN (VC) +*Azospirillum*	97.0	5.1	692	30.5	53.0	3.2	1477	1173	1325	13188	22026	8838	1.67
50% RDF+ 50% RDN (VC) +*Azospirillum*	101.3	4.6	759	31.8	54.0	3.3	1510	1106	1318	14991	21696	6705	1.44
SEm ±	3.29	0.17	19.8	1.19	1.69	0.09	52	45	48	-	-	-	-
CD (*p*=0.05)	9.39	0.48	56.3	3.39	4.82	0.25	152	131	137	-	-	-	-

PH: Plant height at maturity; NBP: Number of branches plant^{-1}; PDW: Plant dry weight at 75 DAS; NCP: Number of capsules plant^{-1}; NSP: Number of seeds capsule^{-1}; TW: TW: Test weight; CC: Cost of cultivation; GR: Gross return; NR: Net return; RI: Return on Investment; Cost of seed used: ₹ 40.0 kg^{-1}, urea: ₹ 4.50 kg^{-1}, SSP: ₹ 4.0 kg^{-1}, MOP: ₹ 4.50 kg^{-1}; FYM: ₹ 0.50 kg^{-1}; VC: ₹ 2.50 kg^{-1}, *Azospirillum*: ₹ 10 200g^{-1}, sesame seed produced: ₹ 16.0 kg^{-1}, sesame stick: ₹ 0.2 kg^{-1}

Table 2: Residual effect of different treatments on growth, yield components, seed and stover yield of succeeding black gram

Treatments	PH (cm)	NBP	PDW (g m^{-2})	NPP	NSP	TW (g)	Seed yield (kg ha^{-1})			Stover yield (kg ha^{-1})		
							2003	2004	Pooled	2003	2004	Pooled
Control	28.1	11.6	91.3	14.5	4.5	35.4	318	298	308	690	670	680
100 % RDF	38.0	19.0	106.7	26.4	6.3	36.4	492	454	473	970	970	960
75% RDF	31.8	14.9	132.8	16.4	5.8	35.1	382	348	365	790	760	770
50% RDF	28.4	9.6	112.8	15.4	5.9	35.4	308	341	325	660	760	710
75% RDF+25% RDN (FYM)	34.4	15.0	128.6	21.2	6.1	37.1	320	392	356	630	800	720
50% RDF+50% RDN (FYM)	35.2	19.6	158.5	22.7	6.4	36.7	397	440	419	760	850	810
75% RDF+25% RDN (VC)	35.2	17.5	129.4	27.3	6.0	36.6	418	390	404	850	810	830
50% RDF+50% RDN (VC)	38.8	20.0	175.8	27.6	6.3	36.4	492	412	452	930	800	870
75% RDF+*Azospirillum*	35.1	14.2	127.7	18.3	6.0	36.3	371	333	352	760	710	740
50% RDF+Azospirillum	33.3	11.8	110.9	18.4	5.9	35.0	394	411	402	840	920	880
75% RDF+25% RDN (FYM) +*Azospirillum*	39.5	20.5	188.1	21.6	6.2	36.1	539	516	528	1010	1010	1010
50% RDF+50% RDN (FYM) +*Azospirillum*	40.8	23.8	207.8	31.2	6.3	36.3	613	542	578	1140	1040	1090
75% RDF+25% RDN (VC)+*Azospirillum*	38.4	21.3	195.2	23.2	6.2	37.8	553	524	539	1040	1030	1030
50% RDF+50% RDN (VC) +*Azospirillum*	41.9	24.3	223.4	32.4	6.4	37.7	672	597	635	1204	1120	1180
SEm±	1.05	0.81	4.78	1.13	0.27	1.32	23	21	22	55	49	52
CD (p=0.05)	3.00	2.30	13.62	3.22	0.77	NS	67	63	64	159	143	147

PH: Plant height at maturity; NBP: Number of branches plant^{-1}; PDW: Plant dry weight at 75 DAS; NPP: Number of pods plant^{-1}; NSP: Number of seeds pod^{-1}; TW: Test weight

Table 3: Harvest index and protein yield of sesame and succeeding black gram and oil yield of sesame as influenced by various nutrient management treatments applied in sesame (mean of 2 years)

Treatments	Sesame			Black gram	
	Harvest index (%)	Protein yield (kg ha^{-1})	Oil yield (kg ha^{-1})	Harvest index (%)	Protein yield (kg ha^{-1})
Control	17.8	140.4	220	31.1	51.1
100 % RDF	23.6	405.1	520	33.1	93.7
75% RDF	22.4	331.7	440	32.1	65.6
50% RDF	21.0	257.2	350	31.5	56.3
75% RDF+25% RDN (FYM)	23.4	326.8	460	33.2	62.3
50% RDF+50% RDN (FYM)	22.4	296.5	420	34.2	76.4
75% RDF+25% RDN (VC)	24.2	365.2	490	32.8	74.5
50% RDF+50% RDN (VC)	23.9	317.4	450	34.2	83.3
75% RDF+*Azospirillum*	21.6	321.1	440	32.4	61.7
50% RDF+Azospirillum	20.8	270.9	400	31.3	74.1
75% RDF+25% RDN (FYM)+*Azospirillum*	24.7	398.7	550	34.2	107.1
50% RDF+50% RDN (FYM)+*Azospirillum*	25.8	451.8	590	34.6	119.9
75% RDF+25% RDN (VC)+*Azospirillum*	24.4	421.1	570	34.4	109.3
50% RDF+50% RDN (VC)+*Azospirillum*	25.3	425.3	540	35.1	134.7
SEm±	1.06	18.5	19.6	0.65	5.8
CD (p=0.05)	3.03	53.5	56	1.87	16.6

return than use of fertilizer and FYM (Table 1). The highest net return was also obtained from tretament 50% RDF+50% N through FYM along with *Azospirillum* and it was closely followed by 75% RDF+25% N through FYM and *Azospirillum* and 100% RDF alone. Application of *Azospirillum* increased the net return when applied with different organic manures and fertilizer over that of without *Azospirillum.* However, the highest return on investment (₹$^{-1}$) was recorded due in 100% RDF only through fertilizers and was closely followed by integrated application of 50% RDF+50 % N through FYM and *Azospirillum*, 75% RDF+25% N through FYM and *Azospirillum*. Similar results were also obtained by Duhoon et al. (2004) and Verma et al. (2013).

3.3. Residual effect of nutrients on succeeding black gram

Application of 50% RDF+50% RDN through VC along with *Azospirillum* in sesame recorded the highest plant height at maturity, number of pod bearing branches plant^{-1}, dry weight at 75 DAS, number of pods plant^{-1} and number of seeds pod^{-1} of succeeding black gram-grown under residual fertility. Substitution of 50% recommended N through different sources of organic manures along with *Azospirillum* application in sesame did not record any significant difference in growth and yield attributes of succeeding black gram. Application of 50% RDF+50% N through VC+*Azospirillum* in sesame also recorded the highest seed and stover yield, harvest index and protein yield of black gram which were at par with those with the use of 50% RDF+50% N through FYM+*Azospirillum* in sesame (Tables 2 and 3). This might be due to application of higher proportion of nutrients through organic sources in summer sesame and its carry over effect on succeeding black gram. Similar results were reported by Purushottom (2005) and Longkumer and Singh (2013).

3.4. Oil and protein yield

Application of 50% RDF+50% N through FYM along with *Azospirillum* recorded the highest oil and protein yield of sesame which was at par with the treatments involving integrated nutrient management (Table 3). The treatment recorded 11.5 and 13.5% higher protein and oil yield of sesame, respectively than that of 100% RDF. Application of 50% RDF+50% N through VC and *Azospirillum* in sesame recorded the highest protein yield of succeeding black gram. The results corroborate the findings of Thiruppathi et al. (2001), Verma et al. (2012) and Purushottam (2005).

3.5. Nutrient uptake

The maximum uptake of nutrients by sesame was recorded under 75% RDF+25% N through VC+*Azospirillum* followed by 50% RDF+50% N through FYM+*Azospirillum*. Higher uptake of nutrients with above treatments was attributed to higher biological yield due to sufficient availability of nutrients in suitable proportion from diversified sources, prolonged availability of nutrients and probably availability of growth regulators form *Azospirillum* to crop. The succeeding black gram crop also showed similar trend. The result corroborates the findings of Purushottam (2005). The lowest value of nutrient uptake by sesame was recorded in control plot (Table 4).

3.6. Soil fertility

Available N, P, K and organic carbon content in soil was

Table 4: Nutrient uptake by sesame and black gram and residual soil fertility status as influenced by various nutrient management treatments in sesame

Treatments	Nutrient uptake (kg ha^{-1})						Residual soil fertility				pH	BD (g cm^{-2})
	Sesame			Black gram			Available nutrients (kg ha^{-1})			Org. C (%)		
	N	P	K	N	P	K	N	P_2O_5	K_2O			
Control	23.3	10.3	33.8	28.4	5.5	29.2	106.5	12.1	94.5	0.31	5.5	1.58
100 % RFD	51.7	19.5	57.9	44.9	6.4	46.4	145.2	22.2	150.3	0.44	5.6	1.57
75% RFD	45.9	18.1	47.9	41.9	6.1	41.9	140.1	19.0	140.3	0.40	5.6	1.57
50% RFD	43.6	15.1	41.7	38.7	6.0	35.2	131.6	15.8	130.1	0.38	5.5	1.57
75% RFD+25% N (FYM)	47.2	17.1	46.6	42.2	6.8	42.5	144.5	20.5	141.3	0.55	5.9	1.51
50% RFD+50% N (FYM)	45.9	16.6	47.0	45.2	7.0	41.1	146.5	20.1	132.7	0.58	6.0	1.50
75% RFD+25% N (VC)	50.5	19.3	48.1	43.9	7.0	43.9	146.2	20.9	138.9	0.47	5.5	1.54
50% RFD+50% N (VC)	48.3	18.8	45.0	45.2	7.4	41.8	150.9	19.8	134.7	0.49	5.8	1.52
75% RFD+*Azospirillum*	43.8	17.3	48.1	36.7	6.2	39.1	142.8	17.5	136.9	0.42	5.5	1.57
50% RFD+*Azospirillum*	43.5	17.0	46.0	35.3	5.9	37.4	133.3	15.4	131.5	0.43	5.4	1.57
75% RFD+25% N FYM)+*Azospirillum*	49.2	20.2	53.0	45.8	7.9	49.0	156.5	25.3	145.2	0.54	5.9	1.52
50% RFD+50% N (FYM)+*Azospirillum*	54.0	21.6	54.5	47.7	8.0	47.1	161.8	23.9	142.1	0.55	6.0	1.50
75% RFD+25% N (VC)+*Azospirillum*	54.4	21.5	55.4	44.6	8.9	52.8	155.2	27.1	146.9	0.48	5.8	1.52
50% RFD+50% N (VC)+*Azospirillum*	51.1	19.5	52.9	44.0	9.6	49.1	160.5	24.4	140.7	0.50	5.9	1.51
Initial Value							141.1	18.5	137.4	0.46	5.2	1.58

improved under integrated application of chemical, organic and biological sources of nutrients compared to its initial soil fertility (Table 4). It could be attributed to addition of root biomass of sesame, fallen leaves of sesame and black gram, and organic matter though FYM or VC. Similar findings of augmented soil fertility with partial substitution of chemical fertilizer by organic source of nutrients were also reported by Singh et al. (2005) and Brahmachari et al. (2011). The bulk density of soil decreased slightly in all the treatments where chemical fertilizer, organic manure and biofertilizer were integrated as compared to initial status. The lowest value of bulk density was recorded with 50% RDF+50% N through FYM+*Azospirillum* application in sesame. Little increase in soil pH was also observed in all the treatments. The results are in conformity with the findings of Haruana and Abumiki (2012).

4. Conclusion

Integrated nutrient management involving the use of 50% recommended dose through chemical fertilizer+50% N through FYM or vermicompost along with *Azospirillum* was found most effective for achieving higher growth and yield attributes, seed, oil and protein yield and higher gross and net return of sesame. This also exerted greater residual effect on the growth attributes, yield components and seed yield of succeeding black gram through improvement in soil fertility. Thus, it may be recommended for the farmers in red and lateritic belt of West Bengal.

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