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Full Research Article

Integrated Nutrient Management on Growth and Productivity of Rapeseed-mustard Cultivars

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Abstract

To find out the efficacy of different integrated nutrient management a field experiment was conducted at Pulses and Oilseeds Research Station, Berhampore, W.B, during *Rabi* season of 2009-10 and 2010-11 on Rapeseed-Mustard. The experiment was laid out in split plot design and replicated thrice with three varieties viz., V_1, Binoy (B -9); V_2, Sarama; V_3, Kalyan(WBBN-1) in main plots and five fertility management {F_1= 100-50-50-30 N-P_2O_5-K_2O, S kg ha^{-1} (recommended), F_2=RD+5 t FYM ha^{-1}, F_3=RD+5 t FYM+*Azotobacter,* F_4=RD+5 t FYM+PSB., F_5=RD+5 t FYM+PSB.+*Azotobacter*} as sub-plot treatments. The highest plant height (cm), number of primary branches plant^{-1} and dry matter accumulation (g) were achieved in the crops receiving a combinations of fertility treatment with the recommended dose of chemical fertilizers along with FYM, *Azotobacter* and PSB during both the years. Significant increase in yield was found in Sarama variety followed by the variety Binoy and Kalyan. The application of RD+2 t FYM+PSB+*Azotobacter* resulted significant increase in Seed yield, biological yield and oil percentage in all Rapeseed-Mustard varieties. The highest net return of ₹ 22106.56 and ₹ 23262.11 ha^{-1} respectively during the two years of the experimentation were recorded from the rapeseed-mustard crop raised with the recommended dose of chemical fertilizers, FYM, *Azotobacter* and PSB together. The benefit cost ratio also indicated that the treatment R.D+2 t FYM+PSB+*Azotobacter* was more remunerative.

1. Introduction

Rapeseed-Mustard are the third important oilseed crop in the world after soybean (*Glysine max*) and palm (*Elaeis guineensis*) oil. In India, it is the second most important edible oilseed after groundnut among nine annual oilseed crops grown. It is one of the best edible oils available, having lowest amount of saturated fats as compared to other vegetable oils and provides both essential fatty acids and also the animal feed through oil-free meal rich in protein having well-balanced aminoacid and equally having the potential for purpose of biofuel (Anjum et al., 2012; Shekhawat et al., 2012; Cardole et al., 2003.). To meet the ever increasing demand of oilseeds, we require stepping up average productivity of oilseeds crops from present level of productions (Mohiuddin et al., 2011). The estimated area, production and yield of rapeseed-mustard in the world was 34.19 mha, 63.09 mt and 1,850 kg ha^{-1}, respectively, during 2013-14. Globally, India account for 19.29% and 11.127% of the total acreage and production (Economic Survey, 2014-15).

The Rapeseed-Mustard group includes brown sarson, *raya* and *toria* crops. Indian mustard (*Brassica juncea* (L.) Czernj. and Czern) is predominantly cultivated in Rajasthan, UP, Haryana, Madhya Pradesh and Gujrat. It is also grown under some nontraditional areas of south India including Karnataka, Tamil Nadu and Andhra Pradesh. The crop can also be raised well under both irrigated and rainfed conditions. Yellow sarson (*B. rapa* var. *trilocularis*) is cultivated in Assam, Bihar, Orissa and West Bengal as *rabi* crop. *Gobhi sarson* (*B. napus* I. ssp. *oleferia* DC. Var. *annua* L.) and *karan rai* (*Brassica carinata*) are the new emerging oilseed crops having limited area of cultivation. Rapeseed-Mustard are cultivated in most temperate climates and also grown in certain tropical and subtropical regions as a cold weather crop. Since, there is a vast variability in the climate and edaphic conditions in the mustard growing areas of India, the selection of appropriate cultivars is important as it helps in increasing the productivity (Shekhawat et al., 2012).

Indiscriminate use of chemical fertilizers for the supply of major nutrients and declining use of secondary nutrients and organic sources of inputs over time led to the deficiency of secondary and micronutrients (De et al., 2014). Through the approach of integrated nutrient management, it is important to exploit the potential of organic manures, composts, crop residues, agricultural wastes, biofertilizers and synergistic effect with chemical fertilizers for increasing balanced nutrient supply and their use efficiency for increasing productivity, sustainability of agriculture, and improving soil health and environment safety. Judicious combination of FYM, bio-fertilizers and chemical fertilizers facilitate profitable and sustainable production (Singh and Sinsinwar, 2006. and De et al., 2009). The bio-fertilizers have an important role to play in improving the nutrient's supplies (by way of nitrogen fixation or solubilization of phosphorus), their availability in crop production; production of growth hormones and antifungal substances favorably effect crop growth (Tripathi et al., 2010. De and Sinha., 2011. and AICRP-RM. 2005). The introduction of leguminous crops in the rotational and intercropping sequence and use of bacterial and algal cultures play an important role in increasing the nutrient use efficiency (Prasad et al., 1992; Maiti et al., 2005). Therefore, the present study was carried out to develop suitable package for sustainable productivity of rapeseed-mustard in Gangetic Alluvial Zones of West Bengal.

2. Materials and Methods

The field experiment was conducted during *Rabi* and Pre-*kharif* seasons of 2009-2010 and 2010-11 at Pulses & Oilseeds Research Station, Berhampore, Mursidabad, West Bengal (24°50´ N latitude and 88°13´ E longitude with an altitude of 9.75 masl. The experimental site falls under subtropical humid climate. The average annual rainfall was 1450 mm, 75% of which was received during Monsoon months of June to September. The temperature begins to rise from the end of February reaching maximum towards April-May. The relative humidity remains high during June-October. The soil of the experimental field was moderately well drained typical Gangetic alluvial (Entisol) soil with sandy clay loam texture having 6.6 pH, 0.56% organic carbon, 160:16:124:8.1 kg ha^{-1} available N-P-K-S, good water holding capacity,. The experiment was laid out in a split plot design having three varieties-V_1:B-9 (Binoy); V_2:RW-85-59 (Sarama); V_3:WBBN-1 (Kalyan) as main plots and five nutrient management treatments F_1=100:50:50:30 (N:P_2O_5-K_2O), S kg ha^{-1} (recommended), F_2=RD+5 t FYM ha^{-1}, F_3=RD+5 t FYM+*Azotobacter,* F_4=RD+5t FYM+PSB., F_5=RD+5 t FYM+PSB+*Azotobacter* as sub-plot treatments and were replicated thrice. During the two years of experimentation, Rapeseed-mustard was sown in 2.11.2009 and 1.11.2010 respectively. The N, K, P and S were supplied through Urea, Muriate of Potash, Single Super Phosphate and elemental sulphur respectively and well decomposed farm yard manure(FYM) was applied as per treatment. The half part of the recommended dose of nitrogenous fertilizer and full dose of P_2O_5, K_2O and S were applied as basal and rest half part of the recommended dose of nitrogenous fertilizer was applied as first top dressing (30 DAS). The Rapeseed-mustard were harvested between first week to third week of February. The oil content was estimated by Soxhlet apparatus (utilized for oil extraction and petroleum ether used as solvent), the volume of oil content concentrated by using water bath and the concentrated oil estimated by weight basis.

3. Results and Discussion

3.1. Growth

The plant height (cm), number of primary branches per plant, dry matter accumulation (g), of rapeseed-mustard at various stages of crop growth was significantly influenced by different nutrient management practices and also by different varieties (Table 1). The highest plant height, number of primary branches per plant, dry matter accumulation (g), were achieved in the crops receiving a combination of fertility treatment with the recommended dose of chemical fertilizers along with FYM, *Azotobacter* and PSB during both the years and were widely followed by the crops under fertility treatment the recommended dose of chemical fertilizers along with FYM and *Azotobacter.* In comparison between these two treatments, withdrawal of PSB made significant difference in dry matter yield when the other components were same. High plant height, number of primary branches per plant, Dry matter accumulation (g), recorded at the combined applications was the resultant effect of balanced crop nutrition. A strong and positive relationship between LAI and dry matter yield helped this fertility treatment to show highest value. Taller plants produced more dry matter because of more opportunity to production and accumulation of photosynthates. These results are in accordance with the findings of Mondal and Sinha (2002); Shukla et al. (2002); Tripathi et al. (2010); Giri et al. (2005).

3.2. Yield components and yield

The yield components, viz., number of siliquae $plant^{-1}$, number of seeds per siliqua and test weight (1000 seed weight) showed significant variation due to the effect of different fertility levels used in the nutrient management schedule during the two years of experimentation (Table 1). The highest number of siliquae per plant, number of seeds per siliqua and test weight (1000 seed weight) were obtained from the plot having recommended dose, FYM, *Azotobacter* and PSB and was closely followed by the treatments consisting of recommended dose along with FYM and *Azotobacter* and recommended dose along with FYM and PSB. The more number of branches under above treatment

Table 1: Effect of rapeseed-mustard varieties and nutrient management on plant height, primary branches, dry matter accumulation, yield component, seed and biological yield (kg ha^{-1})

Treatments	Plant height (cm)		Primary branches		Dry matter accumulation (g) (2009-10)			Dry matter accumulation (g) (2010-11)		
	2009-10	2010-11	2009-10	2010-11	2009-10	2010-11	2009-10	2010-11	2009-10	2010-11
Varieties (V)										
V_1-B-9	103	106	7.84	8.11	247.64	417.65	496.49	249.22	419.45	501.57
V_2-RW 85-59(Sarama)	178	180	8.63	9.01	277.22	500.03	590.58	278.94	501.69	593.89
V_3-WBB N-1(Kalyan)	96	97	6.83	7.65	226.08	341.65	428.52	227.64	343.14	434.89
SEm±	0.406	0.185	0.038	0.028	0.19	0.51	1.20	0.27	0.55	0.47
CD (p=0.05)	1.592	0.726	0.148	0.109	0.75	2.01	4.70	1.07	2.15	1.86
Nutrient management (F)										
F_1-RD	116	122	7.40	7.88	240.51	386.67	452.34	241.99	388.39	457.97
F_2-RD+5 t FYM	126	126	7.59	8.08	246.50	411.41	496.34	248.22	413.42	496.58
F_3-RD+5 t FYM+Azo	128	130	7.76	8.42	253.63	430.83	524.16	255.36	432.55	526.93
F_4 -RD+5 t FYM+PSB	129	129	7.94	8.31	250.08	419.54	509.34	251.66	421.17	512.68
F_5-RD+5 t FYM+ Azo+PSB	131	132	8.14	8.58	260.84	450.41	543.80	262.44	451.60	556.44
SEm±	0.514	0.326	0.052	0.072	0.45	0.80	1.30	0.42	0.76	0.74
CD (p=0.05)	1.502	0.951	0.151	0.211	1.30	2.34	3.78	1.22	2.21	2.16

Treatments	Test weight (g)		No. of siliquae plant^{-1}		No. of seeds /siliqua		Seed Yield (Kg ha^{-1})		Bio. yield (Kg ha^{-1})	
	2009-10	2010-11	2009-10	2010-11	2009-10	2010-11	2009-10	2010-11	2009-10	2010-11
Varieties (V)										
V_1-B-9	3.97	4.14	115.92	123.73	27.14	28.51	1309	1347	5283	5462
V_2-RW 85-59(Sarama)	3.78	3.81	179.93	182.35	14.18	14.83	1378	1438	6526	6627
V_3-WBB N-1(Kalyan)	4.23	4.33	74.90	76.76	24.37	24.75	1222	1248	4947	5214
SEm±	0.02	0.03	0.22	4.88	0.17	0.16	3	5	24	17
CD (p=0.05)	0.07	0.11	0.84	19.14	0.65	0.64	12	18	96	67
Nutrient management (F)										
F_1-RD	3.77	3.87	115.38	118.57	20.04	21.24	1177	1267	5306	5510
F_2-RD+5 t FYM	3.97	4.06	121.21	124.56	21.28	21.92	1297	1321	5504	5671
F_3-RD+5 t FYM+Azo	4.07	4.16	127.39	131.26	22.81	23.34	1341	1373	5614	5858
F_4 -RD+5 t FYM+PSB	4.06	4.14	124.31	127.04	22.01	23.02	1316	1344	5713	5810
F_5-RD+5 t FYM+ Azo+PSB	4.11	4.24	129.63	136.64	23.34	23.94	1384	1418	5781	5990
SEm±	0.02	0.04	0.34	6.91	0.13	0.21	9	6	23	28
CD (p=0.05)	0.06	0.11	0.98	20.16	0.37	0.62	25	19	66	82

may be correlated with the more plant height and dry matter accumulation as a result better nutrient supply to the crop resulting in profuse branching. Profuse branching provided area to develop more number of siliquae in the same treatment. Increase in seeds/siliqua and test weight could be ascribed to the better growth and more photosynthetic accumulation as a result of adequate nutrients availability to the crop.

Seed and biological yield of rapeseed-mustard was markedly influenced as a result of application of plant nutrient from different sources that is in nutrient management manner (Table 1). The significant highest yield was obtained from the plots where rapeseed-mustard received the nutrients in a combination of inorganic, organic and bio-fertilizers, which means the recommended dose of chemical fertilizers were used in that treatment along with FYM, *Azotobacter* and PSB. It was followed by the application of the recommended dose along with FYM, *Azotobacter* and the recommended dose along with FYM, PSB and these two treatments was found at par. Other fertility level except the plots received only inorganic source of nutrients also showed considerable effect on the seed yield of rapeseed-mustard. Nutrient management treatment devoid of any and organics or bio-fertilizers showed poor effect on productivity of rapeseed-mustard. The interaction of nutrient management and variety significantly influenced the yield and yield components of rapeseed mustard. Maximum yield was recorded with the variety Sarama along with the nutrient management consisting of the recommended dose of chemical fertilizers, FYM, *Azotobacter* and PSB (V_2F_5) and lowest seed yield was recorded with the treatment $V_3 F_1$. One of the important non-symbiotic nitrogen fixing bacteria *Azotobacter* and phosphate solubulizing bacteria (PSB) beside fixing ambient nitrogen to the soil and solubilize phosphates in the soil, can benefit rapeseed and mustard by producing growth hormones viz., IAA and gibberellins also. Increased seed and biological yield are the resultant effect of better growth and development in this study. With the increment in supply of essential nutrient to rapeseed-mustard, their availability, acquisition, mobilization and influx into the plant tissues increased and thus improved growth attributes, yield components and finally yield. These results are in agreement with the findings of Singh and Sinsinwar (2006); Tripathi et al. (2010); Subhas and Ram (2007); De et al., 2013 and AICRP-RM.(2005). Significant increase in yield was found in the variety Sarama followed by Binoy and Kalyan.

3.3. Nutrient uptake

The nutrient uptake varied significantly due to different fertility levels (Table 2). The highest nutrient uptake (N, P, K and S) by rapeseed-mustard was noted with the application of the fertility treatment with a combination of the recommended dose of chemical fertilizer along with FYM and bio-fertilizers (*Azotobacter* and PSB) during both the years. The increased uptake could be ascribed to all nutrients availability to crop that has increased biomass production and thus uptake. Similar results were reported by Mandal and Sinha (2002); Tripathi et al. (2010).

3.4. Oil content and oil yield

Oil content (%) and oil yield of rapeseed-mustard also followed similar trend to that of seed yield (Table 3). Different nutrient management treatments exerted differential effect on oil content (%) and oil yield of rapeseed-mustard. Maximum oil content (%) and oil yield of rapeseed-mustard was recorded from the plot that received FYM, *Azotobacter*, PSB and chemical fertilizer. It was closely followed by the fertility treatments consisting of the recommended dose, FYM and *Azotobacter*; recommended dose, FYM and PSB; and these two treatments were at par with each other. The nutrient management practice devoid of any organics showed poor oil content (%) and oil yield of rapeseed-mustard. It was observed that the varieties used in this study had significant effect on oil content (%) of rapeseed and mustard. This trend was found in both the years of the study. Here the variety *Binoy* exerted maximum oil content (%) which was followed by the variety *Sarama*. It was also observed that both the varieties showed better effect on oil content (%) over the variety *Kalyan*. Increase in biological yield could be ascribed to better growth and more photosynthates accumulation as a result of adequate nutrients availability to the crop. It was observed that the varieties used in this study had significant effect on oil yield (q ha^{-1}) of rapeseed and mustard. This trend was found in both the years

Table 2: Effect of rapeseed-mustard varieties and nutrient management on uptake

Treatments	Avail. N (kg ha^{-1})		Avail. P (kg ha^{-1})		Avail. K (kg ha^{-1})		Avail. S (kg ha^{-1})	
	09-10	10-11	09-10	10-11	09-10	10-11	09-10	10-11
Varietties (V)								
V_1-B-9	91.07	92.27	30.83	31.21	105.27	106.00	10.56	10.65
V_2-RW 85-59	95.13	96.60	32.40	32.63	108.67	109.16	11.19	11.38
V_3-WBB N-1	85.13	86.13	29.64	30.25	102.19	102.60	10.13	10.31
SEm±	0.17	0.16	0.13	0.12	0.09	0.15	0.03	0.03
CD (p=0.05)	0.66	0.62	0.52	0.47	0.35	0.59	0.12	0.11
Nutrient management (F)								
F_1-RD	83.33	84.50	26.08	26.48	101.49	102.07	10.17	10.36
F_2-RD+5 t FYM	90.78	91.96	30.51	31.07	105.84	106.28	10.60	10.76
F_3-RD+5 t FYM+Azo	92.89	94.32	30.76	31.13	106.49	106.97	10.76	10.90
F_4-RD+5 t FYM+PSB	91.11	92.20	33.64	34.08	105.50	106.08	10.66	10.81
F_5-RD+5 t FYM+Azo+PSB	94.11	95.36	33.80	34.07	107.54	108.21	10.96	11.07
SEm±	0.23	0.33	0.14	0.15	0.13	0.16	0.04	0.03
CD (p=0.05)	0.68	0.98	0.40	0.45	0.39	0.48	0.11	0.08

Table 3: Effect of rapeseed-mustard varieties and nutrient management on oil quality, oil yield and economics

Treatments	Oil content (%)		Oil yield (q ha^{-1})		Cost of Cultiva-tion (₹ ha^{-1})	Gross return (₹)		Net return (₹)		Benefit:Cost	
	2009-10	2010-11	2009-10	2010-11		2009-10	2010-11	2009-10	2010-11	2009-10	2010-11
Varieties (V)											
V_1-B-9	40.10	39.82	525	539	13469	34027.0	35195.3	20558.1	21726.3	2.52	2.62
V_2-RW 85-59	38.21	38.11	527	549	13469	35828.0	37396.6	22359.0	23927.7	2.66	2.78
V_3-WBB N-1	37.13	37.75	454	471	13469	31772.0	32449.7	18303.0	18980.7	2.36	2.41
SEm±	0.02	0.14	04	06	-	239.3	281.1	239.3	281.1	0.02	0.02
CD (p=0.05)	0.09	0.56	15	23	-	939.4	1103.40	939.4	1103.4	0.07	0.08
Nutrient management (F)											
F_1 :RD	37.98	37.88	447	480	12189	29863.0	30472.5	18404.3	20758.8	2.45	2.50
F_2 :RD+5 t FYM	38.28	38.26	497	505	13689	33713.3	34337.3	20024.3	20648.3	2.46	2.51
F_3 :RD+5 t FYM+Azo	38.59	38.76	518	532	13789	34868.8	35692.2	21079.9	21903.2	2.53	2.59
F_4 :RD+5 t FYM + PSB	38.49	38.69	509	520	13789	34207.3	34941.1	20418.3	21152.1	2.48	2.53
F_5 :RD+5 t FYM +Azo +PSB	38.88	39.22	538	561	13889	35995.5	37151.1	22106.6	23262.1	2.59	2.67
SEm±	0.04	0.12	05	07	-	348.7	470.0	348.7	470.1	0.03	0.03
CD (p=0.05)	0.11	0.34	15	22	-	1017.7	1371.8	1017.7	1371.8	0.08	0.10

Land preparation @ ₹ 1900 ha^{-1}; Cost of seed @ ₹ 25 kg^{-1}; 3 Irrigations @ ₹ 620 ha^{-1} irrigation; 47 Labours @ ₹ 120 labour; Urea @ ₹ 5.30 kg^{-1}; SSP @ ₹ 5.20 kg^{-1}; MOP @ ₹ 5.10 kg^{-1}; FYM @ ₹ 300 t^{-1}; *Azotobacter* @ ₹ 100 400 g^{-1} packet; PSB @ ₹ 100 400 g^{-1} packet^{-1}; Sale rate of Rapeseed-mustard product @ ₹ 26 kg^{-1}

of the study. Here the variety *Sarama* exerted maximum oil yield (q ha^{-1}) which was at par with the variety *Binoy*. It was also observed that both the varieties showed better effect on oil yield (q ha^{-1}) over the variety *Kalyan*.

3.5. Economics

The economics of integrated nutrient management on rapeseed-mustard showed that during both the years of the study, the significantly higher gross return, net returns and benefit-cost ratio were obtained from the treatments where nutrients from different sources that is from chemical along with either organic matter or organic matter and bio-fertilizers were applied together (Table 3). The highest gross return, net returns and benefit-cost ratio during the two years of the experimentation were recorded from the rapeseed-mustard crop raised with the application of recommended dose of chemical fertilizers, FYM, Azotobacter and PSB together.

4. Conclusion

Application of nutrient management treatments consisting of the recommended dose, FYM and bio-fertilizers (*Azotobacter* and PSB) with either of the variety Sarama or Binoy are best for higher productivity and profitability in cultivation of rapeseed-mustard in Gangetic alluvial zone of West Bengal.

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