Journal of Agricultural Engineering and Food Technology
p-ISSN: 2350-0085; e-ISSN: 2350-0263; Volume 3, Issue 3; July-September, 2016 pp. 167-171

http://www.krishisanskriti.org/Publication.html

Effect of Various Sources of Nutrients on Growth and Productivity of Indian Mustard (*Brassica Juncea*) under Terraced Cultivation

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Abstract—*A field experiment was conducted during 2012-14 to study the effect of various doses of organic sources of nutrient along with chemical fertilizer on growth, yield and economics of mustard under terraced situation. The field experiment was conducted with split plot design with three replication, having twenty treatment combinations including four organic source in main plot and five inorganic sources in subplot treatment. Maximum number of branches/plant was registered with the application of poultry manure @ 5 t/ha (10.12) and was closely followed by mixed application of Azotobactor + PSB (9.98). Amongst inorganic sources of nutrients higher branches/plant was registered with 125 % RDF and was remained at par with 100 and 150 % RDF, treated plots. Number of siliqua/plant was recorded significantly maximum of 123.11 at poultry manure @ 5 t/ha, and significantly superior to other main plot treatment sets. With respect of subplot treatments maximum of this parameter was found with the application of 125 % RDF and showed parity with 100 % RDF application. Field treated with vermicompost @ 5 t/ha gave 22.42 % more seed/siliqua compared to the FYM @10 t/ha. Amongst chemical doses, maximum of seed/siliqua was recorded with 150 % RDF and was at par with all the subplot treatments except 50 % RDF, which recorded least number of seed/siliqua. Significantly maximum seed yield of 1.44 t/ha was obtained under poultry manure @ 5 t/ha and was statistically at par with vermicompost @ 5 t/ha (1.43 t/ ha) and application of Azotobactor + PSB (1.35 q/ha). Treatment with poultry manure @ 5 t/ha produced 17.07 % more seed yield compared to the FYM @10 t/ha incorporation treatment. Amongst various subplot treatments highest seed yield was recorded with the application of 125 % RDF and this was statistically similar to 100 % RDF. This treatment gave 18.05 % more seed yield compared to the half dose of recommended doses of fertilizer, which produced least seed yield. Stover yield was significantly more with the poultry manure @ 5 t/ha (4.11 t/ha) and was at par with vermicompost (3.81 t/ha) and application of Azotobactor + PSB (3.38 t/ha). Uptake of primary nutrient was more registered with poultry manure @ 5 t/ha and significantly better to all other main plot treatment. However with the fertility level, significantly more nutrient uptake was registered with 125 % RDF. Economics revealed that more return (₹ 26871/ha) and benefit: cost ratio (2.82) was recorded with the application of poultry manure @ 5 t/ha. Application of various fertilizer sources revealed that highest benefit: cost ratio (2.05) was recorded with the application of 75 % RDF.*

Keywords*: Bio-fertilizer, Economics, Farm Yard Manure, Poultry manure*

1. INTRODUCTION

Oilseeds together occupy 27.45 million ha which accounts for 14% of total cropped area in the country with a production of 24.72 million tonnes, accounting for nearly 5% of the gross national product and 10% of the value of all the agricultural products. Rapeseed and mustard ranks third in area (21%) and production (23%) after groundnut (*Arachis hypogaea* L.) and soybean (*Glycine max* L. Merr) amongst total oilseeds. The per hectare productivity of the crop is quite low in the country (1152 kg/ha) against the world average of 1400 kg/ha in world (Piri and Sharma, 2006). Mustard is one of the most important crop adopted by the farmers in the north- eastern hill region of India. This is a potential crop in winter (*rabi*) season due to its wider adaptability and suitability to exploit residual moisture. Cropping sequence with mustard in the mid hill areas without proper nutrient management leading to fast depletion of soil fertility and crop productivity. The rising prices and lack of availability of inorganic fertilizers at right time to the farmers due to poor transport facility necessitates some alternative ways of nutrients supply. Further, as the mineral fertilizer alone cannot meet the requirement of crop stand in cropping systems because of high cost and also environment related risks involved in its application and usage integrated use of organic and inorganic is desired to attain the sustainability of a system (Yadav *et al*., 2010)). Beneficial effects of earthworms and their casts were known as early as in Darwin's era. But the potential of vemicompost to supply nutrients and to support beneficial microbes is being recognized recently. Vermicompost is rich in humus forming microbes and nitrogen fixers and drying of the vermicompost does not deteriorate the microbial population. Hence, these characters recognize the vermicompost as biofertilizer. In recent years in Darjeeling himalaya, mustard crop gave good yield with vermicompost and poultry manure application. The potential of poultry manure to supply nutrients and enhance beneficial microbes for faster decomposition is being recognized widely under hill condition. Use of organics alone does not result in spectacular increase in crop yields, due to their low nutrient

status. Sustainable yields could be achieved by integrated use of organics and chemical fertilizers. Continuous use of organics helps to build up soil humus and beneficial microbes, besides improvement of soil physical properties. Whereas, chemical fertilizers provide one or more essential plant nutrients which the soil cannot supply in adequate quantities. Thus judicious combination of organics and chemical fertilizers helps to maintain soil productivity. Most of the soils in Darjeeling hill are poor in phosphorus due to phosphate fixation as acidic soil in nature. Therefore use of Phosphate Solubilizing Bacteria (PSB) may enhance availability of phosphorus in soil and its use by plant (De and Singh, 2010) PSB is a group of beneficial bacteria capable of hydrolyzing organic and inorganic phosphorus from insoluble compounds. P-solubilization ability of the microorganisms is considered to be one of the most important traits associated with plant phosphate nutrition. Biofertilizers are known to play a number of vital roles in soil fertility, crop productivity and production in agriculture as they are eco-friendly but cannot at any cost replace chemical fertilizers that are indispensable for getting maximum crop yields (Subba, 1986). They supplement chemical fertilizers for meeting the integrated nutrient demand of the crops (Chandhary, 2004). *Azotobacter* inoculants when applied to many non-leguminous crop plants, promote seed germination and initial vigor of plants by producing growth promoting substances (Singh and Dutta, 2006). Application of biofertilizers results in increased mineral and water uptake, root development and vegetative growth of the mustard plant. Application of *Azotobactor* to mustard crop significantly improve nitrogen uptake. Plant height, leaf number, number of primary and secondary branches/plant and seed/siliqua of mustard increased significantly with *Azotobactor* inoculation (Singh and Dutta, 2006). Therefore, the present study was carried out with objective to study the effect of organic and inorganic sources of nutrients on growth and biomass production, economics and nutrient uptake of mustard under terraced situation mid hill condition.

2. MATERIALS AND METHODS

The present experiment was conducted during *rabi* season of 20012-13 and 2013-14, with a view to find out the impact of various source of nutrient and bio-fertilizers on growth and yield of Indian mustard at Regional Research Station (Hill Zone) under the aegis of Uttar Banga Krishi Viswavidyalay, Kalimpong with an altitude of 1250 m asl. The soil was sandy loam in texture, high in organic carbon (0.83%), available N (270.15 kg/ha), P_2O_5 (21.32 kg/ha) and K_2O (156.19 kg/ha) content with pH 4.9. The total rainfall recorded during crop growth period was 17.3 and 13.5 mm, minimum temperature ranges from 2.1 to 12.3 and 2.9 to 17.8, and maximum temperature 17.2 to 30.4 and 14.7 to 29.3^0 C during winter 2009-10 and 2010-11, respectively. The field experiment was conducted with split plot design with three replication, having twenty treatments combinations including four organic source of treatment in main plot which includes FYM @10 t/ha, vermicompost @ 5 t/ha, poultry manure @ 5 t/ha and *Azotobactor* (@ 200 g/10 kg of seed inoculated) + PSB (@ 1 kg/10 kg of seed), and five subplot treatment viz. 50% RDF , 75 % RDF, 100 % RDF, 125 % RDF and 150 % RDF. The recommended dose of fertilizer (RDF) 60:40:40 kg N, P_2O_5 and K_2O /ha, respectively for mustard. Primary nutrients were supplied through urea, single superphosphate and muriate of potash. Mustard cultivar Varuna (T 59) was shown on 26th October 2012 and 30th October 2013, respectively. Organic sources of nutrients viz., FYM, verimocompost, poultry manure were applied two weeks before sowing of mustard cultivar during both the years of experimentation. Seed treatment with bioferilizer was done one days before sowing of crop. The average NPK content in FYM (0.73, 0.25, 0.91%), vermicompost (1.95, 1.89, 1.01) and poultry manure (1.91, 1.01, 1.49) were analysed on dry weight basis before their application. Full amount of phosphorus and potash and half amount of nitrogen should be applied at the time of sowing, while the remaining dose of nitrogen should be top dressed at the pre-flowering stage. The irrigation was given and other recommended packages of practice were adopted during the crop growth period in both the years. The five randomly selected plants from each plot were uprooted and later cleaned and observation like plant height and leaf area at peak growth stage i.e. 60 days after sowing (DAS) were recorded and averaged. The yield attributes were recorded at harvests to assess the contribution to yield. The branches of five randomly selected plants were counted and reported as number of branches/plant. Similarly, the total siliqua of five sample plants were counted and expressed as number of siliqua/plant. The 1000 seed weight were counted from the lot, weighed and expressed as 1000 seed weight. The seed and stover yield was computed from the harvest of net plot and expressed in tone/ha. Plant and soil sample were analyzed for uptake of nitrogen, phosphorus and potash as per standard laboratory procedures (Jackson, 1973). Available phosphorous was determined by Olsen's method as outlined by Jackson (1973), using spectrophotometer (660 nm wave length). Available potassium was extracted with neutral normal ammonium acetate and the content of K in the solution was estimated by flame photometer (Jackson, 1973). The experimental data were analyzed statistically by applying the technique of analysis of variance (ANOVA) prescribed for the design to test the significance of overall difference among treatments by the F test and conclusions were drawn at 5 % probability level. Benefit: cost ratio (B: C) was obtained by dividing the gross income with cost of cultivation. The effect of treatments was evaluated on pooled analysis basis on growth, yield attributes and yields. For working out the economics, prevailing market prices for mustard seeds (₹ 93.50/kg), urea (₹ 9.15/kg), SSP (₹ 13.60/kg), MOP (₹ 7.75/kg) and cost of labour (₹ 112.50 /day) were considered.

3. RESULT AND DISCUSSION

Growth characters

Data presented in Table 1 indicates that the plant height was significant, with various organic source of fertilizer in main plot treatments. Maximum plant height was observed with vermicompost @ 5 t/ha and was significantly better than other sources of treatment in main plot. Amongst inorganic sources application of 125 % RDF registered significantly more plant height at 60 DAS and was statically similar with full dose of RDF and 150 % of RDF application. However significantly poor plant height was recorded with half dose of RDF. Further, leaf area index was maximum registered with the application of vermicompost @ 5 t/ha (0.38) and was followed by application of *Azotobactor* + PSB (0.36) and poultry manure @ 5 t/ha (0.33). These treatments were at par with each other. However, LAI failed to produce any significant response with respect to various doses of chemical fertilizer. Moreover, maximum of LAI was recorded with the 125 % and 100 % RDF (0.38). Higher availability of essential nutrients particularly nitrogen increased the plant height and leaf area (Kumar, 2006).

Yield attributes

Entire yield attributing character was statistically influenced by various treatments combinations (Table 1). Number of branches/plant failed to produce any significant response with various organic sources of treatments. Moreover, maximum number of branches/plant was registered with the application of poultry manure @ 5 t/ha (10.12) and was closely followed by mixed application of *Azotobactor* + PSB (9.98). Amongst inorganic sources of nutrients higher branches/plant was registered with 125 % RDF and was remained at par with 100 and 150 % RDF, treated plots. Number of siliqua/plant was recorded significantly maximum of 123.11 at poultry manure @ 5 t/ha, and significantly superior to other main plot treatment sets. With respect of subplot treatments maximum of this parameter was found with the application of 125 % RDF and showed parity with 100 % RDF application. However, least siliqua formation was recorded with lowest level of fertilizer (98.33). Seed/siliqua was maximum with vermicompost @ 5 t/ha and significantly better then rest of the treatment combinations. This was followed by poultry manure @ 5 t/ha. Field treated with vermicompost @ 5 t/ha gave 22.42 % more seed/siliqua compared to the FYM @10 t/ha treated plot, which produced lowest number of seed/siliqua. Amongst chemical doses, maximum of seed/siliqua was recorded with 150 % RDF and was at par with all the subplot treatments except 50 % RDF, which recorded least number of seed/siliqua. Application of 150 % RDF gave 39.83 % more seed/siliqua compared to least application of fertilizer dose. The higher value of yield attributes is the result of higher fertility levels resulted in to better growth and more transloction of photosynthates from source to sink (Tripathi *et al*., 2005 and Rana *et al*., 2005). Further observation revealed that 1000 seed weight failed to produce any significant response with any treatment combination, moreover maximum test weight was recorded with the application of poultry manure @ 5 t/ha and with 125 % RDF.

Table 1: Effect of various source of nutrient on growth and yield attributing parameter of mustard (pooled data of two years).

Treatments	Plant height at 60 DAS (cm)	LAI at 60 DAS	Branches/plant (No.)	Siliqua/plant (No.)	Seed/Siliqua (No.)	1000 seed weight (g)	Seed yield (tones/ha)	Stover yield (tones/ha)	Harvest Index (%)
Organic sources									
FYM (@10 t/ha)	53.24	0.28	8.83	93.50	8.52	4.02	1.23	3.02	28.29
Vermicompost (5 t/ha)	67.13	0.38	9.36	111.38	10.43	3.96	1.43	3.81	27.01
Poultry manure (5 t/ha)	61.16	0.33	10.12	123.11	9.15	4.08	1.44	4.11	25.59
Azotobactor (@ 200 g/10 kg of seed inoculated) + PSB (@ 1 kg/10 kg of seed)	62.04	0.36	9.98	81.33	9.01	4.12	1.35	3.38	28.52
SEm±	1.19	0.02	1.39	3.66	0.29	0.21	0.03	0.19	0.56
CD (p=0.05)	3.94	0.07	NS*	10.83	0.86	NS	0.09	0.56	1.66
Inorganic sources									
50 % RDF	51.11	0.30	7.33	98.33	7.33	3.93	1.12	2.09	28.55
75 % RDF	58.89	0.35	7.83	106.11	9.52	4.11	1.38	3.39	28.08
100 % RDF	65.84	0.38	9.86	111.31	9.86	4.06	1.40	4.01	29.56
125 % RDF	69.23	0.39	10.15	123.19	9.31	4.26	1.45	4.13	28.14

150 % RDF	66.13	0.36	10.02	112.44	10.25	3.99	1.30	3.16	29.18
SEm±	2.32	0.08	0.39	2.34	0.81	0.16	0.13	0.11	0.96
CD (p=0.05)	7.31	NS	1.29	7.65	2.31	NS	0.52	0.34	NS

NS*= Non significant

Table 2: Economics and nutrient uptake of mustard crop as influenced by integrated nutrient management practices (pooled data of two years)

Treatments	Total nutrient uptake(kg/ha)			Economics (10^3 x ₹/ha)		
	N	P	K	Gross Return	Net return	Benefit : cost ratio
Organic sources						
FYM (@10 t/ha)	117.61	43.96	162.36	25.86	14.81	2.34
Vermicompost (5 t/ha)	157.98	64.91	238.27	46.89	25.26	2.16
Poultry manure (5 t/ha)	187.31	67.82	269.22	41.58	26.87	2.82
Azotobactor (@ 200 g/10 kg of seed inoculated) + PSB (@ 1 kg/10 kg of seed)	43.25	55.16	205.98	38.95	19.20	1.97
SEm±	4.81	1.62	4.03			
CD (p=0.05)	14.36	4.95	14.34			
Inorganic sources						
50 % RDF	106.11	42.45	161.99	40.58	12.83	1.46
75 % RDF	151.03	54.59	186.62	43.87	22.54	2.05
100 % RDF	174.51	67.93	231.21	53.68	25.61	1.91
125 % RDF	193.31	79.32	256.11	56.95	28.25	1.98
150 % RDF	137.21	58.12	208.93	59.19	21.54	1.57
SEm±	4.06	1.89	7.19			
CD (p=0.05)	11.94	5.59	21.03			

Yield parameters

Significantly maximum seed yield of 1.44 t/ha was obtained under poultry manure @ 5 t/ha and was statistically at par with vermicompost @ 5 t/ha (1.43 t/ ha) and application of *Azotobactor* + PSB (1.35 t/ha). However, statistically poor yield was registered with the incorporation of FYM @10 t/ha. Treatment with poultry manure @ 5 t/ha produced 17.07 % more seed yield compared to the FYM @10 t/ha incorporation field. Amongst various subplot treatment highest seed yield was recorded with the application of 125 % RDF and this was statistically similar to full doses of recommended fertilizer treatment. Application of 125 % RDF gave 18.05 % more seed yield compared to the half dose of recommended doses of fertilizer, which produced least seed yield. Stover yield was significantly more with the poultry manure @ 5 t/ha (4.11 t/ha) and was at par with vermicompost (3.81 t/ha) and application of *Azotobactor* + PSB (3.38 t/ha). Application of various main plot treatment revealed that poultry manure @ 5 t/ha gave 14.55 % more stover yield compared to the FYM @10 t/ha incorporation, which gave least stover yield. Further table revealed that field treated with various chemical doses, maximum yield was registered with the application of 125 % RDF and was at par with the application of 100 and 75% RDF. Field treated with the 125 % RDF registered 19.61 % more stover yield compared to lowest fertilizer level. The greater stover yield at higher fertility was attributed to increased plant height and leaf area and finally more accumulation of dry matter per plant and this was also concluded by Kumar (2006).

Harvest index was maximum registered with the combination of *Azotobactor* + PSB and showed parity with the vermicompost @ 5 t/ha and FYM @ 10 t/ha. As per the subplot treatment harvest index failed to produce any significant response, however maximum harvest index was registered with full doses of recommended fertilizer.

Nutrient uptake

Amongst various treatment uptake of nitrogen was more registered with poultry manure @ 5 t/ha and was statistically superior to rest of the main plot treatments. This was followed by incorporation of vermicompost @ 5 t/ha. With different fertilizer levels, highest uptake of nitrogen was recorded with 125 % RDF and was statistically superior to all other levels of application. As far uptake pattern of phosphorus is concerned, more was observed with the poultry manure @ 5 t/ha and significantly better to other doses of organic fertilizer application. This was followed by treatment with vermicompost @ 5 t/ha and *Azotobactor* + PSB. However with respect to chemical fertilizer application maximum was recorded with the application of 125 % RDF and was statistically better to other levels of fertilizer application. This was followed by treatment with 100 % and 75 % RDF level. Further, observation revealed that uptake of potassium was more recorded with the poultry manure @ 5 t/ha and was statistically superior to other main plot treatments. Amongst various chemical sources of fertilizer application maximum uptake was registered with the 125 % RDF and was significantly better to other treatments. This was followed by 100 and 150 % RDF application. Observation of table 2 revealed that more nutrient uptake in case of organic sources particularly poultry manure and vermicompost application. More primary nutrient uptake by this treatment might be because of soil and rhizosphere bacteria and microrganism can affect the mineral nutrition of plants by changing root-uptake characteristics, due to a modification of root morphology or alteration of uptake mechanism, relative growth rate or internal composition of mustard plant (Amanullah *et al*., 2010)

Economics

Economics revealed that application of vermicompost @ 5 t/ha gave maximum gross return (₹ 46895 / ha) compared to rest of organic sources of treatment. However, application of poultry manures @ 5 t/ha gave good return (₹ 26871) and highest benefit: cost ratio (2.82). Further with subplot treatment highest net return (₹ 28256) was observed with the application of 125 % RDF with B:C ration of 1.98. However maximum benefit: cost ratio (2.05) was recorded with the application of 75 % RDF and was closely followed by 100 and 125 % RDF application. From the table 2, the best performance was revealed by application of 75 % RDF coupled with vermicompost @ 5 t/ha.

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