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Effect of nitrogen, zinc sulphate and vermicompost on grain yield and economics of Rajmash (*Phaseolus vulgaris* L.) and soil microbial population

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ABSTRACT

A field trial was conducted at RARS, Shillongani, Nagaon to study the effect of varying doses of nitrogen, vermicompost and zinc sulphate on Rajmash (Phaseolus vulgaris L.) during Rabi 2011-12, 2012-13 and 2013-14. Application of vermicompost @ 1 t ha^{-1}resulted in better crop growth and significantly higher grain yield (1166.83 kg ha^{-1}) as compared to that under control (935.22 kg ha^{-1}). This might be attributed to better physical conditions for root growth, nutrient availability and soil microbial build up due to vermicompost application. So far as nitrogen doses were concerned, the crop responded well up to 90 kg ha^{-1}. There was no significant variations in grain yield owing to application of 90 kg N ha^{-1} (1347.82 kg ha^{-1}) and 120 kg N ha^{-1} (1454.03 kg ha^{-1}). These two treatments were significantly superior to lower doses of N. The interaction of 1 t vermicompost ha^{-1} and 90 kg N ha^{-1}recorded the grain yield of 1494.44 kg ha^{-1}. Vermicompost 1 t ha^{-1}and N 90 kg ha^{-1}recorded the benefit-cost ratio of 1.63 and 2.34, respectively. Though zinc sulphate @20 kg ha^{-1} (1085.07 kg ha^{-1}) increased the grain yield significantly over control (1016.98 kg ha^{-1}), it failed to show economic advantage. Application of vermicompost along with 30 kg N ha^{-1}resulted in higher microbial population of fungi (35.2 x 10^4 cfu g^{-1} soil) and bacteria (40.6 x 10^7 cfu g^{-1} soil).

Keywords: Benefit-cost ratio, grain yield, nitrogen, rajmash, soil microbial buildup, vermicompost, zinc sulphate

Rajmash is an emerging pulse crop in Assam. It is mainly grown in the Barak valley and Hojai district. It is more important because of its higher yield potential and nutritionally ideal complement to the cereal based Indian diet. Amongst the pulses, rajmash is the only member that exhibits the poorest symbiotic nitrogen fixation. Therefore, it responds to higher doses of applied nitrogen. Its productivity depends on the supply of organic as well as inorganic fertilizers.

Cultivation of rajmash in Assam on large scale can be extremely useful, attractive and an economic venture and more importantly for attaining self-sufficiency in pulse production. Optimum nutrition is required to get maximum grain yield and its quality. Organic manures and good complimentary sources of nutrients improve the efficiency of the applied mineral nutrients on one hand and physical and biological properties of soil on the other (Choudhuary *et al.*, 2014). Apart from nitrogen, zinc is another important nutrient for rajmah. Zinc improves plant growth, chlorophyll and crude protein content (Samreen *et al.*, 2013). A judicious and combined use of organic and inorganic sources of plant nutrients is essential to maintain soil health and to augment the efficiency of nutrients (Rana and Badiyala, 2014). Additionally, such combination of vermicompost, nitrogen doses and $ZnSO_4$ play an important role in realizing the potential yield of the crop. Application of organic manures not only helps in enhancing the productivity but also has the beneficial effect on soil properties (Pathak *et al*., 2005). Nutrients available in organic manures are released slowly, remain in the soil for longer time and are available to plants, thereby sustain soil fertility and enhance soil microbial load (Belay *et al*., 2001). Application of various organic manures stimulates plant growth, activity of soil micro-organism, results in higher population of fungi, bacteria and actinomycetes and higher activity of soil enzymes (Knapp *et al*., 2010). Application of organic manures increases microbial respiration and results in increased carbon and plant nutrient mineralization rates in soil (Powon *et al*., 2005). Hence, the present investigation was carried out to study the effect of the above mentioned production inputs on the grain yield and economics of Rajmash production system and population build up of microbes in soil system.

MATERIALS AND METHODS

The field experiment was carried out during *Rabi*, 2011-12, 2012-13 and 2013-14 at the Regional Agricultural Research Station, Assam Agricultural University, Shillongani, Nagaon, Assam. The treatments (Table 1) were tested in Randomised Block Design with three replications. The soil was sandy loam having pH 5.6, available N 270.6 kg ha^{-1}, available P_2O_5 21.3 kg ha^{-1} , available K_2O 134.2 kg ha^{-1}in 2011-12; pH 5.5, available N 275.2 kg ha^{-1}, available P_2O_5 22.4 kg ha^{-1} , available K_2O 135.6 kg ha^{-1}in 2012-13, and pH 5.5, available N 274.5 kg ha^{-1}, available P_2O_5 22.1 kg ha^{-1}, available K_2O 137.2 kg ha^{-1} in 2013-14. The crop (var.

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'HUR 301') were sown on 18th, 22nd and 30th November in respective years using a seed rate of 75 kg ha^{-1} and maintaining a spacing of 30 x 10 cm. The crop was fed with 40 kg P_2O_5 and 20 kg K_2O/ha in addition to the fertilizers under different treatments. Irrigation was given at 50 per cent flowering of the crop. The crop duration was 114, 116 and 112 days in respective years. The fungal and bacterial populations in soil before sowing and after harvest of the crop were estimated by standard plate count method using Marten's for fungi (Martin, 1950), and nutrient agar medium for bacteria (Allen, 1959). Microbial population was calculated and expressed as number of cells x10^n g^{-1} soil.

Table 1: Effect of vermicompost, nitrogen and $ZnSO_4$ on grain yield (kg ha^{-1}) of rajmash

Treatment	2011-12	2012-13	2013-14	Pooled
Vermicompost (t ha^{-1}**)**				
0	861.78	942.22	1001.67	935.22
1	1074.67	1193.61	1232.22	1166.83
LSD (0.05)	**52.15**	**43.95**	**47.50**	**50.33**
N (kg ha^{-1})				
0	634.44	496.33	732.64	621.20
30	752.22	808.33	920.83	827.13
60	865.56	1053.47	1095.83	1004.95
90	1237.22	1432.64	1373.61	1347.82
120	1351.67	1548.61	1461.81	1454.03
LSD (0.05)	**82.46**	**69.49**	**75.11**	**79.58**
$ZnSO_4$ (kg ha^{-1})				
0	936.22	1036.67	1078.06	1016.98
20	1000.22	1099.17	1155.83	1085.07
LSD (0.05)	**52.15**	**43.95**	**47.50**	**50.33**
CV (%)	**10.64**	**8.13**	**8.40**	**9.46**

RESULTS AND DISCUSSION

In all the years of experimentation, application of vermicompost @ 1 t ha^{-1}accrued in significantly higher grain yield of rajmash as compared to control, where no vermicompost was used (Table 1). This might be attributed to better soil environment caused by addition of compost for nutrient availability, soil moisture conservation and microbial population build-up (Bullack *et al*., 2002). This result was accrued in because of better growth and development of the crop owing to increase in enzymatic activity, microbial population and activity, moisture holding capacity of the soil, population and activity of earthworm and easy availability of macro and micro nutrients by application of vermicompost (Prabha *et al.*, 2007; Azarmi *et al.*, 2008; Sarma *et al.*, 2014). Increasing nitrogen doses resulted in significant increase in grain yield. The rate of increase in grain yield reached its plateau at 90 kg N/ha. There was no significant variation in grain yield owing to application of 90 and 120 kg N/ha, and these two doses of N were significantly superior to lower doses. Grain yield was significantly higher when $ZnSO_4$ was applied @ 20 kg/ha as basal dose over no $ZnSO_4$ application. This finding corroborates the finding of Sharma and Abrol (2007) in chickpea. The pooled analysis of grain yield showed an increase of 24.8 per cent under vermicompost 1 t ha^{-1}, 34.1 per cent under 90 kg N ha^{-1}and 6.7 per cent under 20 kg $ZnSO_4$/ha over immediate lower doses of respective inputs.

Table 2: Interaction effect of vermicompost and N doses on grain yield (kg ha^{-1}**) of rajmash**

Vermicompost (t ha^{-1})	N (kg ha^{-1})	2011-12	2012-13	2013-14	Pooled
0	0	576.67	481.94	576.39	545.00
	30	696.67	700.00	781.95	726.20
	60	775.56	876.39	1041.67	897.87
	90	1085.56	1229.17	1288.89	1201.20
	120	1174.44	1423.61	1319.45	1305.83
1	0	692.22	511.11	888.89	697.41
	30	807.78	916.67	1059.72	928.05
	60	955.56	1230.56	1150.00	1112.04
	90	1388.89	1636.11	1458.33	1494.44
	120	1528.89	1673.61	1508.17	1570.21
LSD (0.05)		**116.62**	**98.27**	**106.22**	**112.54**

Interaction effect of vermicompost and nitrogen led to the highest yield (1570.21 kg ha^{-1}) under the combination of 1 t vermicompost and 120 kg N ha^{-1} closely followed by that (1494.44 kg ha^{-1}) under 1 t vermicompost and 90 kg N ha^{-1} (Table 2). Singh and Singh (2014) reported that application of FYM and chemical fertilizer (urea) increased the grain yield and biological yield of lentil significantly over control. Organic manure conserves nitrogen during the initial phase of the crop cycle, reduces nitrogen loss and provides better synchronization of nitrogen availability and crop nitrogen demand during latter part of annual crop cycle. Organic manures not only provide macro and micro nutrients to the crop but also improve the physical and biological properties of the soil, which help in improving yield realization and sustainability of soil health. They increase size, biodiversity and activity of microbial population in soil, influence structure, nutrients turnover and many other related physical, chemical and biological parameters of the soil (Albiach *et al.*, 2000 and Manivannan *et al.*, 2009). Interaction between compost and Zn on grain yield of Rajmash remained non-significant (Table 3).

Table 3: Interaction effect of vermicompost and $znSO_4$ on grain yield (kg ha^{-1}) of rajmash

Vermicompost (t ha^{-1})	$ZnSO_4$ (kg ha^{-1})	2011-12	2012-13	2013-14	Pooled
0	0	828.45	923.33	955.56	902.44
	20	895.11	961.11	1047.78	968.00
1	0	1044.00	1150.00	1200.56	1131.52
	20	1105.33	1237.22	1263.89	1202.15
LSD (0.05)		NS	NS	NS	NS

Table 4: Interaction effect of vermicompost and N doses on microbial population of soil (3 years' mean)

Vermi compost (t ha^{-1})	N (kg ha^{-1})	Initial		Final	
		Fungi ($x10^4$cfu g^{-1} soil)	Bacteria ($x10^7$cfu g^{-1} soil)	Fungi ($x10^4$cfu g^{-1} soil)	Bacteria (x 10^7cfu g^{-1} soil)
	0	18.2	22.3	20.6	24.2
	30	20.3	23.6	18.2	21.3
	60	19.6	21.2	16.6	19.6
	90	18.8	22.6	15.3	20.3
0	120	19.2	21.8	12.3	17.2
	0	19.6	22.1	33.6	39.2
	30	19.2	24.2	35.2	40.6
	60	20.6	23.9	32.2	38.1
	90	17.2	22.9	30.1	32.6
1	120	20.1	23.5	27.2	29.3

Table 5: Economics of different treatments

Treatment	Gross return (Rs ha^{-1})	Cost (Rs ha^{-1})	Net return (Rs ha^{-1})	B:C
Vermicompost (t ha^{-1})				
0	37409	14723	22686	1.54
1	46673	17723	28950	1.63
N (kg ha^{-1})				
0	24848	14723	10125	0.68
30	33085	15185	17900	1.17
60	40198	15647	24551	1.57
90	53912	16109	37803	2.34
120	58161	16571	41590	2.50
$ZnSO_4$ (kg ha^{-1})				
0	40679	14723	25956	1.76
20	43402	16447	26955	1.63

The pooled data of microbial population over three years showed that the populations of bacteria and fungi were significantly affected by application of different doses of N (Table 4). With increasing N doses, there was gradual decrease in microbial population, whereas, microbial population significantly increased with application of vermicompost. Application of vermicompost along with 30 kg N ha^{-1}resulted in higher microbial population of fungi (35.2 x 10^4 cfu g^{-1} soil) and bacteria (40.6 x 10^7 cfu g^{-1} soil). The addition of organic matter enhanced the microbial counts in soil, which might be due to carbon addition and changes in physico-chemical properties of soil. The increase in microbial population with the application of organic manure might be due to stimulated growth and activities of soil microorganisms (Upadhyay *et al.*, 2011). Also, the crop plant secreted various types of organic acids from roots, which was an easily available source of food for soil microorganisms (Dotaniya *et al*., 2013).

Economic analysis of the treatments showed that considerable higher net return and benefit-cost ratio (BCR) were recorded with vermicompost application (Table 5). Net return (Rs. 41590 ha^{-1}) and BCR (2.50) were maximum under 120 kg N ha^{-1}. Application of N

@ 90 kg ha^{-1}resulted in almost Rs.3800 less net return and a BCR of 2.34. However, $ZnSO_4$ failed to show any economic advantage.

Based on the study, it might be concluded that application of vermicompost @ 1 t ha^{-1}+ 90 kg N ha^{-1}along with the recommended dose of P_2O_5 (40 kg/ha) and K_2O (20 kg ha^{-1}) would be helpful in increasing productivity and profitability of rajmash cultivation (The present recommendation of N in Assam is only 30 kg ha^{-1}. Therefore, we are not preferring to jump straight way to the level of 120 kg ha^{-1} through it is profitable considering the affordability of the farmers). In Rajmash, nitrogen is to be applied in two splits - half as basal and half as top dressing at 30 days after sowing.

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