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STUDY ON GROWTH, YIELD AND ECONOMICS IN MAIZE AS INFLUENCED BY DIFFERENT LEVELS OF NITROGEN APPLIED THROUGH VERMICOMPOST AND SPACING IN HILL AREAS OF NORTH EAST INDIA

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ABSTRACT

The experiment was carried out in the experimental farm of KVK, Kiphire, ICAR for NEH Region, Nagaland Centre during the *kharif* season of the year 2018. The experiment was laid out in "Factorial Randomised Block Design" with three replications. The treatments for the experiment consisted of four levels of nitrogen which were applied through vermicompost *viz.*, Control (N_0), 50 % RD of N through vermicompost (N_1), 75 % RD of N through vermicompost (N_2) and 100 % RD of N through vermicompost (N_3) and two spacing which were 75cm x 15 cm (S_1) and 75 cm x 25 cm (S_2). The results showed that application of 100 % RD through vermicompost had significant effect on the growth and yield parameters as compared to rest of the treatments. The effect of spacing was also observed to be significant where it was found that 75 cm x 25 cm outperformed 75 cm x 15 cm spacing both in growth as well as in yield aspects. The economic analysis, however, revealed that though the combination of 100 % RD of N through vermicompost and 75 cm x 25 cm obtained highest yield and net return, the combination of 75 % RD of N through vermicompost and 75cm x 25 cm showed better B:C ratio. Therefore, it can be concluded that application of 75 % RD of N through vermicompost and 75 cm x 25 cm spacing which resulted in highest B:C ratio may be considered for adoption by the farmers of Kiphire District.

(Key words; Maize, nitrogen, spacing, vermicompost, yield, economics)

INTRODUCTION

The use of organic matter such as animal manures, human wastes, food wastes, yard wastes, sewage sludges and composts has long been recognized in agriculture as beneficial for plant growth and yield and the maintenance of soil fertility. The new approaches to the use of organic amendments in farming have proven to be effective means of improving soil structure, enhancing soil fertility and increasing crop yields. Vermi-composts are organic materials broken down by interactions between micro-organism and earthworms in a mesophilic process, to produce fully stabilized organic soil amendments with low C: N ratios (Ramasamy *et al*., 2011). The results of several long-term studies have shown that the addition of compost improves soil physical properties by decreasing bulk density and increasing the soil water holding capacity (Weber *et al*., 2007). Moreover, in comparison with mineral fertilizers, compost produces significantly greater increase in soil organic carbon and some plant nutrients (García-Gil *et al*., 2000, Bulluck *et al.*, 2002, Nardi *et al*., 2004, Weber *et al*., 2007). In addition to the changes exerted on the chemical and physical properties, composted materials have a clear impact on soil biological properties, such as increase in microbial biomass and activity (Knapp *et al*., 2010), as well as changes in the activity of soil enzymes (Garcia-Gil *et al*., 2000 and Ros *et al*., 2006) and in the structure of the soil microbial community (Ros *et al*., 2006). The use of vermicompost helps in maintaining soil fertility since the mineral elements contained in it were changed to forms more that could be readily taken up by plants such as nitrates, exchangeable phosphorus, soluble potassium, calcium, manganese etc. Various workers have examined the suitability of vermicompost as plant growth media and have addressed their potential commercial value.

Maize is the major crop grown by the people of Kiphire, Nagaland grown mostly in hilly slopes as cash crop under rainfed condition. Over the years it has been observe to reduce in the production of maize crop which may be attributed to various reasons. It is observed that maize is grown without any definite row arrangements (random dippling) and without any application of fertilizers be it organic or inorganic. All these unscientific practices ultimately lead to reduction in crop yield. Among several

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agronomic approaches for maize, spacing and nitrogen fertilizer application remains the most important factor affecting the growth and yield of maize. Thus, the present investigation was carried out to standardize the optimum nitrogen level that is to be applied through vermicompost and optimum spacing for maize in Kiphire District, Nagaland.

MATERIALS AND METHODS

The experiment was carried out in the experimental farm of KVK, Kiphire, ICAR for NEH Region, Nagaland Centre during the *kharif* season of the year 2018. The experimental farm is located at an altitude of 896.42 MSL with humid and hot during summer and cold during winter with winter temperature touching a low of 27^0C and a high of 37.0^0C during summer. Monsoon period extends from June to September and sometimes up to October. The average rain fall for the last three years was 876 mm. Undulating topography with sandy loam to fine rich humus soil constitutes the main soil condition. The experiment was laid out in "Factorial Randomised Block Design" with three replications. The treatments for the experiment consisted of three levels of nitrogen which was applied through vermicompost *viz.*, 50 % RD of N through vermicompost (N_1), 75 % RD of N through vermicompost (N_2) and 100 % RD of N through vermicompost (N_3) and Control (N_0), and two spacing which were 75 cm x 15 cm (S_1) and 75 cm x 25 cm (S_2). All recommended agronomic practices were followed. Plant height was recorded at 30 DAS, 60 DAS and at harvest. Leaf area index was calculated by given formula. Observations on number of grains cob^{-1}, test weight, grain yield and stover yield were also recorded.

RESULTS AND DISCUSSION

Growth attributes

Plant height (cm)

Except at 30 DAS, the plant height was significantly increased with the application of vermi-compost at 60 DAS and at harvest where it was observed that the maximum plant height (cm) was recorded with the application of 100 % RD of N through vermicompost. However at harvest, it was found to be *at par* with the application of 75 % RD of N through vermicompost (Table 1a). A similar finding was also reported by Mohadeseh ***et al.*** (2015) where he reported that the increase in levels of vermicompost showed corresponding increase in plant height. Between the two spacing, the highest plant height was recorded from 75 cm x 25 cm at all the growth stages, which might have resulted due to lesser inter crop competition for nutrients and moisture, resulting in higher nutrient uptake and growth. Sabo *et al.* (2016) also reported similar finding, who reported that 25 cm intra row spacing resulted in higher plant height as compared with 20 cm intra row spacing. The treatment interaction reveals that the maximum plant height was recorded from the combination of 100 % RD of N through vermicompost with the spacing of 75 cm x 25 cm at all the growth stages (Table 1b). This might be due to higher availability of nutrients and lesser inter crop competition resulting in higher uptake and growth.

Leaf Area Index

It was observed that the LAI of the maize plant was significantly increased with the application of different levels of nitrogen through vermicompost at all the growth stages where the maximum LAI was recorded with the application of 100 % RD of N through vermicompost (Table 2). This finds conformity with the finding of Jayaprakash *et al*. (2004), who reported that by increasing the levels of nitrogen through vermicompost, subsequent increase in LAI was also recorded. The crop with a spacing of 75 cm x 25 cm recorded higher LAI as compared to spacing 75 cm x 15 cm across all growth stages. A similar finding was also reported by Enujeke (2013), who reported that maize crop with 75 cm x 25 cm spacing recorded higher LAI as compared to 75 cm x15 cm. The interaction result reveals that the maximum LAI was recorded from the combination of 100 % RD of N through vermicompost with 75 cm x 25 cm spacing at all the growth stages (Table 2b). Wider spacing and higher level of vermicompost might have resulted in higher LAI.

Yield attributes

Number of grains cob^{-1}

The application of different levels of nitrogen through vermicompost significantly increased the number of grains where it was observed that with increase in the levels of nitrogen, the number of grains also tended to increase. The application of 100 % RD of N through vermicompost recorded the highest number of grains (464.43) (Table 3a). A similar findings was also reported by Mohadeseh ***et al.*** (2015) and Jayaprakash *et al*. (2003), who reported that the increase in application of vermicompost, significant corresponding effect was observed on the growth and yield parameters**.** It was also observed that the maximum number of grains was recorded with a spacing of 75 cm x 25 cm as compared to 75 cm x 15 cm spacing (Table 3a). Reddy *et al.*(2018) also reported similar finding, who reported that higher number of grains cob^{-1} was recorded from 60 cm x 25 cm as compared to 60 cm x 10 cm, 60 cm x 15 cm and 60 cm x 20 cm. The effect of interaction revealed that the maximum number of grains was obtained from the interaction of 100 % RD of N through vermicompost and 75 cm x 25 cm spacing (Table 3b). This might have resulted from higher availability of nitrogen coupled with lesser inter crop competition for nutrients and moisture.

Test weight (g)

Data pertaining to table 3 reveals that the application of different levels of nitrogen through vermicompost and spacing significantly increased the test weight. It was observed that the highest test weight of 80.54 g was recorded by the application of 100 % RD of N through vermicomposting (Table 3(a)). A similar finding was also reported by Vinod *et al*. (2018), where they found that application of 100% vermicompost resulted in recording the highest test weight (20.03 g). The observation on effect of spacing revealed that the highest test weight of 81.56 g was recorded from 75 cm x 25 cm spacing which was significantly higher as compared to 75 cm x 15 cm spacing which recorded a test weight of 62.92 g (Table 3(a)). Reddy *et al.* (2018) also reported similar finding, where higher test weight was recorded from 60 cm x 25 cm as compared to 60 cm x 10 cm, 60 cm x 15 cm and 60 cm x 20 cm. The treatment interaction reveals that the highest test weight was recorded from the combination of 100 % RD of N through vermicompost with 75 cm x 25 cm spacing (Table 3b). This might be due to well developed roots and less competition for nutrients and moisture among the crop plants.

Grain and stover yield (q)

The application of nitrogen through vermicompost significantly increased the grain and stover yield where it was observed that the increase in levels of nitrogen had a corresponding increase in grain and stover yield. Accordingly, it was recorded that the application of 100 % RD of N through vermicompost recorded the highest grain and stover yield (Table 3(a)) as compared to rest of the treatments. A similar finding was also reported by Kumar *et al*. (2007) and Sujatha *et al.* (2008), who reported that application of vermicompost @ 2.5 t ha^{-1} and 3.7 t ha^{-1} resulted in higher grain yield. The spacing also showed significant effect on the grain and stover yield where it was recorded that 75 cm x 25 cm spacing significantly recorded the highest grain and stover yield (27.98 q and 75.42 q) as compared to 75 cm x 15 cm spacing (Table 3(a)). Sabo *et al.* (2016) also reported similar findings, who reported that 25 cm intra row spacing resulted in the highest grain yield as compared to 20 cm and 30 cm. The treatment interaction revealed significant increase in grain and stover yield over the other interactions, where it was observed that the highest grain and stover yield of 26.29 q and 79.26 q was recorded from the combination of 100 % RD of N through vermicompost and 75 cm x 25 cm spacing (Table 3b). This might have resulted from higher availability of nutrients and wider spacing which might have facilitated better root growth, lesser crop competition resulting in better growth and yield.

Economic analysis

The economics for the different treatments were worked out in order to enable us to decide the suitable treatment combinations for more profitable maize cultivation under organic nutrient management. Among the different treatment combinations, the maximum net return was recorded by the application of 100 % RD of N through vermicompost and 75 cm x 25 cm spacing (Rs.109110.67) recorded lesser B:C ratio (2.47) as compared to combination of 75 % RD of N through vermicompost and 75 cm x 25 cm spacing which recorded a net return of Rs.94050.00 resulting in B:C ratio of 2.51 (Table 4).

From the observations of the investigation, it may be concluded that organic nitrogen management and spacing in maize resulted in significant variations in growth and yield of maize. In this experiment increasing the dose of nitrogen, applied through vermicompost, increased the growth and yield of maize which might be due to higher availability of nutrients and lesser crop competition. The results showed that application of 100 % RD through vermicompost had significant effect on the growth and yield parameters as compared to rest of the treatments. The effect of spacing was also observed to be significant where it was found that 75 cm x 25 cm spacing outperformed 75 cm x 15 cm spacing both in terms of growth as well as yield aspects. Then economic analysis revealed that though the combination of 100 % RD of N through vermicompost and 75 cm x 25 cm obtained higher yield and net return, the combination of 75 % RD of N through vermicompost and 75 cm x 25 cm spacing showed better B:C ratio(2.51) . Therefore, it may be concluded that application of 75 % RD of N through vermicompost and 75 cm x 25 cm spacing resulted in highest B:C ratio and may be considered for adoption by the farmers of Kiphire District.

Table 1a. Effect of different levels of vermicompost application and spacing on plant height (cm) of maize

Treatments	Days after sowing		
Nitrogen (kg ha^{-1})	30	60	At harvest
N_0	36.63	193.65	216.15
N_1	39.84	212.35	227.74
N_2	41.03	218.94	232.64
N_3	43.53	228.89	236.44
SEd(±)	2.67	4.00	2.80
CD (P=0.05)	-	8.58	6.01
Spacing (cm)			
S_1	38.32	197.66	220.25
S_2	42.19	229.26	236.23
SEd (±)	1.89	2.83	1.98
CD (P=0.05)	-	6.07	4.25

Table 1b. Interaction effect of different levels of vermicompost application and spacing on plant height (cm) in maize

Treatments	Days after sowing		
	30	60	At harvest
N_0 S_1	30.65	185.68	213.89
N_0 S_2	40.83	201.61	218.40
N_1 S_1	33.57	190.68	216.70
N_1 S_2	57.91	234.02	238.79
N_2 S_1	37.79	199.54	221.69
N_2 S_2	64.27	238.35	243.58
N_3 S_1	45.70	214.73	228.73
N_3 S_2	73.73	243.06	244.16
SEd(±)	2.89	5.66	3.96
CD (P=0.05)	6.19	12.13	8.50

N_0 - Control, N_1- Application of 50 % RD of N through vermicompost, N_2- Application of 75 % RD of N through vermicompost, N_3- Application of 100 % RD of N through vermicompost, S_1- 75 cm x15 cm, S_2- 75 cm x25 cm. NS- Non-significant

Table 2a. Effect of different levels of vermicompost application and spacing on LAI of maize

Treatments Nitrogen (kg ha^{-1})	Days after sowing 30	60	At harvest
N_0	0.41	1.51	1.33
N_1	0.49	1.75	1.68
N_2	0.53	2.11	1.68
N_3	0.59	2.59	2.29
SEd(±)	0.01	0.07	0.09
CD (P=0.05)	0.03	0.16	0.19
Spacing (cm)			
S_1	0.39	1.72	1.62
S_2	0.61	2.26	1.87
SEd (±)	0.01	0.05	0.06
CD (P=0.05)	0.02	0.11	0.13

Table 2b. Interaction effect of different levels of vermicompost application and spacing on LAI of maize

Treatments	Days after sowing 30	60	At harvest
N_0 S_1	0.35	1.37	1.32
N_0 S_2	0.46	1.65	1.35
N_1 S_1	0.38	1.63	1.55
N_1 S_2	0.59	1.87	1.82
N_2 S_1	0.40	1.94	1.85
N_2 S_2	0.65	2.27	1.51
N_3 S_1	0.42	1.93	1.76
N_3 S_2	0.75	3.25	2.82
SEd(±)	0.02	0.10	0.12
CD (P=0.05)	0.04	0.22	0.27

N_0 - Control, N_1- Application of 50 % RD of N through vermicompost, N_2- Application of 75 % RD of N through vermicompost, N_3- Application of 100 % RD of N through vermicompost, S_1- 75 cm x15 cm, S_2- 75 cm x 25 cm. NS- Non-significant

Table 3a. Effect of different levels of vermicompost application and spacing on yield parameters and yield of maize

Treatments Nitrogen (kg ha^{-1})	Grains cob^{-1}	Test weight(g)	Grain yield (q ha^{-1})	Stover yield (q ha^{-1})
N_0	404.17	64.13	19.66	57.66
N_1	418.21	74.33	21.67	66.82
N_2	446.01	69.96	24.30	69.90
N_3	464.43	80.54	25.78	75.42
SEd(±)	8.01	0.92	0.40	4.49
CD (P=0.05)	17.18	1.97	0.86	9.64
Spacing (cm)				
S_1	407.87	62.92	21.58	63.58
S_2	458.54	81.56	24.04	71.32
SEd (±)	5.66	0.65	0.28	3.18
CD (P=0.05)	12.15	1.39	0.61	6.81

Table 3b. Effect of different levels of vermicompost application and spacing on yield parameters and yield of maize

Treatments	Grains cob^{-1}	Test weight(g)	Grain yield (q ha^{-1})	Stover yield (q ha^{-1})
N_0 S_1	398.33	56.93	19.10	55.07
N_0 S_2	410.00	71.34	20.21	60.25
N_1 S_1	395.36	59.59	19.98	60.05
N_1 S_2	441.05	89.07	23.36	72.20
N_2 S_1	416.06	64.58	22.30	67.60
N_2 S_2	475.96	75.34	26.30	73.58
N_3 S_1	421.72	70.59	24.94	71.58
N_3 S_2	507.13	90.49	26.29	79.26
SEd(±)	11.33	1.30	0.56	6.35
CD (P=0.05)	24.30	2.78	1.21	-

Table 4. Effect of spacing and vermicompost on economics

Treatment	Cost of cultivation (Rs.)	Gross return (Rs.)	Net return (Rs.)	B:C ratio
N_0 S_1	27000.00	81233.33	54233.33	2.01
N_0 S_2	27000.00	84333.33	57333.33	2.12
N_1 S_1	34000.00	103433.33	69433.33	2.04
N_1 S_2	35000.00	116816.67	81816.67	2.34
N_2 S_1	36150.00	110083.33	73933.33	2.05
N_2 S_2	37450.00	131500.00	94050.00	2.51
N_3 S_1	40250.00	126383.33	86133.33	2.14
N_3 S_2	44256.00	153366.67	109110.67	2.47

N_0- Control, N_1- Application of 50 % RD of N through vermicompost, N_2- Application of 75 % RD of N through vermicompost, N_3- Application of 100 % RD of N through vermicompost, S_1- 75 cm x 15 cm, S_2- 75 cm x 25 cm. NS- Non-significant

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