Original Research Article

Maize Yield Response to Organic Fertilizers and Biofertilizers in a Sub-Tropical Zone of Eastern Himalayan Region of Arunachal Pradesh

Abstract

A Field experiment was conducted at theDepartment of Agriculture at Himalayan University, Jullang, Arunachal Pradesh, to assess the impact of composts and biofertilizers on plant growth.The available nutrient status was medium in N,High in P and medium in K.Thetreatements considered of T_1- Control 100 % RDF, T_2 - Vermicompost + *Phosphorus solubilizing bacteria* ,T_3 – Poultry manure + *Azotobacter*, T_4 – Compost + *Phosphorus solubilizing bacteria* + Azotobacter , T_5 – compost+ *Phosphorus solubilizing bacteria* , T_6 – Poultry manure + *Azotobacter*, T_7 – Vermicompost + *Phosphorus solubilizing bacteria*+ *Azotobacter*.The highest cob plant^{-1} recorded highest in treatment receiving Vermicompost + *Phosphorus solubilizing bacteria* + *Azotobacter*(T_7)i.e 1.93. highest cob lengthrecorded 13.80 cm receiving treatment Vermicompost + *Phosphorus Solubilizing Bacteria* + *Azotobacter* (T_7).The highest number of cob grain^{-1} is 394.47 receiving Vermicompost + *Phosphorus solubilizing bacteria* + *Azotobacter* (T_7) and 12.03 g of test weight were obtained with treatment (T_7) receiving Vermicompost + *Phosphorus solubilizing bacteria*+ *Azotobacter*.???

Keywords: Maize, Vermicompost, *PSB*,*Azotobacter*, Compost,DAS.

1. ~~1. Introduction~~INTODUCTION

Maize is one of the most important cereal crops of the world in terms of its global production. It ranks second to wheat and equal to rice. Globally, 67 percent of maize is used for livestock feed, 25 percent for human consumption and industrial purposes, while 5 percent is used for seed purposes to sow next crop [1](Jiskani, 2004). During its vegetative growth the maize plant consumes large quantities of water which it utilizes very rationally to form its organic mass. During intensive growth an adult maize plant evaporates about 2-4 kilograms of water daily [2](Ustimenko and Bakumovsky, 1983). As corn plant grows, its demand for water increases with increasing leaf area which reaches a maximum near the tasseling stage. The period of time shortly before pollination through grain fill, when the kernels begin to dent, is a critical period during which adequate moisture is important to corn yield (Neild and Newman, 1991).

Maize consumption in India can broadly be divided into three categories *viz*. Feed, food and Industrial non-food products (mainly starch). The most important use and demand driver of maize is poultry and cattle feed which accounts 63 % of total maize consumption and nearly

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8 per cent of maize is consumed by humans. The major consumption states in India are Karnataka, Andhra Pradesh, Punjab, Gujarat, Haryana, Telangana, Tamil Nadu, Bihar, West Bengal (Subedi *et al., 2005*). There are many drivers of maize demand in India, the most important being (1) growing demand from poultry sector, consuming more than half of the domestic production; (2) growing urbanization, leading to increased demand for processed foods like corn flakes, bakery products (3) growing organised dairy sector, requiring more of fine cereals or maize-based concentrates, and (4) rising international price due to diversion of maize grain towards biofuel production.

In the country, more than three-fourths of the maize is grown in Karnataka, Madhya Pradesh, Maharashtra, Rajasthan, Bihar, Uttar Pradesh, Telangana, Gujarat and Tamil Nadu (Marambe and Sangakkara, 1997). Maize cultivation is done in two production environments namely traditional maize growing areas (Bihar, Madhya Pradesh, Rajasthan, and Uttar Pradesh) and non-traditional maize areas, (Karnataka and Andhra Pradesh). In traditional areas, the crop is primarily grown as a subsistence crop to meet food needs. In contrast, maize in the non-traditional areas is grown for commercial purposes i.e., mainly to meet the feed requirements of the booming poultry sector.Since 1990s, a regional shift in maize production has taken place in India in big way, as southern states emerged as the largest maize-producing states, while maize area started tapering in the traditional major maize-growing states. In 2019-20, the highest maize yield was observed in Guntur district. In terms of maize production, the major districts were Guntur (5.03 lakh tonnes), West Godavari (4.40 lakh tonnes), Srikakulam (2.61 lakh tonnes), Vizianagaram (2.45 lakh tonnes) and Kurnool (2.37 lakh tonnes).???

2. MATERIIAL AND METHODS~~2.~~ **Materials and Methods**

Study area. The experiment was conducted during the *rabi*season of 2022 at the Himalayan University, Itanagar. The farm is located in Jullang, University campus. The Crop Research Farm is situated at 27.14^0 N latitude and 93.62^0 E longitudes and at an altitude of 320 m above mean sea level. The site comes under the Eastern Himalayan region and the agro climatic zone is under sub-Tropical zone of Arunachal Pradesh.

Soil analysis. The soil of the experimental field constituting a part of central Gangetic alluvium is neutral and deep. Pre-sowing soil samples were taken from a depth of 15 cm with the help of an auger. The composite samples were used for the chemical and mechanical analysis. The soil was sandy loam in texture with high acidic content and also rich in organic

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matter. The mechanical, chemical and physio-chemical properties of the soil of experimental field

Table 1. Initial soil properties of field experiment

~~List 1.~~	
Soil properties	**Status**
Sand (%)	53.47 %
Silt (%)	37.65 %
Clay (%)	23.98 %
Textural class	???
Organic carbon	5.2%
pH	5.10
EC	0.6 dS/m
Available Nitrogen	290 Kg/ha
Available Phosphorus	35.50 Kg/ha
Available Potassium	157.9 Kg/ha

Treatments. The experiment was laid out in a Randomized Block Design (RBD) in the year of 2022.The treatments includes T_1 - Control 100 % RDF, T_2 - Vermicompost + *Phosphorus solubilizing bacteria* ,T_3 – Poultry manure + *Azotobacter*, T_4 – Compost + *Phosphorus solubilizing bacteria* + *Azotobacter* , T_5 –compost+ *Phosphorus solubilizing bacteria* , T_6 – Poultry manure + *Azotobacter*, T_7 – Vermicompost + *Phosphorus solubilizing bacteria*+ *Azotobacter*.

3. ~~3.~~RESULT AND DISCUSSIONResult and Discussion

Table 1. Effect of organic fertilizers and biofertilizerson no.ofcobs plant^{-1} of *rabi*maize

	Treatments	**Number of cobs plant $^{-1}$**
T_1	Control	1.20
T_2	Vermicompost + *Phosphorus Solubilizing Bacteria*	1.73
T_3	Poultry manure + *Azotobacter*	1.47
T_4	Compost + *Phosphorus Solubilizing Bacteria* + *Azotobacter*	1.73
T_5	Compost + *Phosphorus Solubilizing Bacteria*	1.60

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The analysis methods...
The harvest date of the crop concerned (maize)

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T_6	Poultry manure + *Phosphorus Solubilizing Bacteria*	1.60
T_7	Vermicompost + *Phosphorus Solubilizing Bacteria* + *Azotobacter*	1.93
	F test	S
	SEd (±)	0.06
	CD (P= 0.05)	0.12

Table 2. Effect of organic fertilizers and biofertilizers on cobs length (cm) of *rabi* maize

	Treatments	Cobs length (cm)
T_1	Control	11.47
T_2	Vermicompost + *Phosphorus Solubilizing Bacteria*	12.95
T_3	Poultry manure + *Azotobacter*	11.93
T_4	Compost + *Phosphorus Solubilizing Bacteria* + *Azotobacter*	12.75
T_5	Compost + *Phosphorus Solubilizing Bacteria*	12.40
T_6	Poultry manure + *Phosphorus Solubilizing Bacteria*	12.20
T_7	Vermicompost + *Phosphorus Solubilizing Bacteria* + *Azotobacter*	13.80
	F test	S
	SEd (±)	0.21
	CD (P= 0.05)	0.47

Table 3. Effect of organic fertilizers and biofertilizers on cobs grain of *rabi* maize

	Treatments	Cobs grain
T_1	Control	339.73
T_2	Vermicompost + *Phosphorus Solubilizing Bacteria*	390.87
T_3	Poultry manure + *Azotobacter*	360.67
T_4	Compost + *Phosphorus Solubilizing Bacteria*	381.40

	+ *Azotobacter*	
T_5	Compost + *Phosphorus Solubilizing Bacteria*	383.93
T_6	Poultry manure + *Phosphorus Solubilizing Bacteria*	379.93
T_7	Vermicompost + *Phosphorus Solubilizing Bacteria* + *Azotobacter*	394.47
	F test	S
	SEd (±)	4.54
	CD (P= 0.05)	9.88

Table 4.Effect of organic fertilizers and biofertilizers on test weight (g) of *rabi* maize

	Treatments	Test weight (g)
T_1	Control	7.87
T_2	Vermicompost + *Phosphorus Solubilizing Bacteria*	10.79
T_3	Poultry manure + *Azotobacter*	9.81
T_4	Compost + *Phosphorus Solubilizing Bacteria* + *Azotobacter*	10.57
T_5	Compost + *Phosphorus Solubilizing Bacteria*	10.42
T_6	Poultry manure + *Phosphorus Solubilizing Bacteria*	10.24
T_7	Vermicompost + *Phosphorus Solubilizing Bacteria* + *Azotobacter*	12.03
	F test	S
	SEd (±)	0.24
	CD (P= 0.05)	0.53

Table 5. Effect of organic fertilizers and biofertilizers on grain yield of *rabi* maize

	Treatments	Grain yield (t $ha^{-1)}$
T_1	Control	3.73
T_2	Vermicompost + *Phosphorus Solubilizing Bacteria*	4.73
T_3	Poultry manure + *Azotobacter*	4.07
T_4	Compost + *Phosphorus Solubilizing Bacteria* + *Azotobacter*	4.47
T_5	Compost + *Phosphorus Solubilizing Bacteria*	4.40

T_6	Poultry manure + *Phosphorous solubilizing Bacteria*	4.30
T_7	Vermicompost + *Phosphorus Solubilizing Bacteria* + *Azotobacter*	5.03
	F test	S
	SEd (±)	0.14
	CD (P= 0.05)	0.31

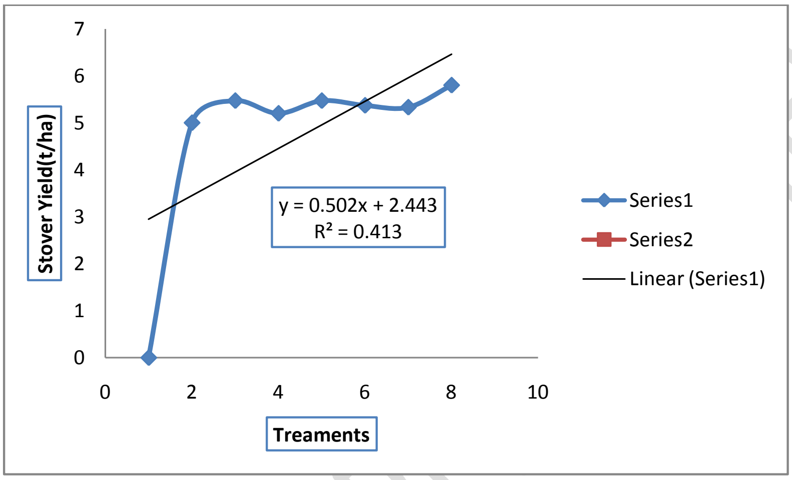

Fig.1. Linear relationship of Stover yield (t/kg) with Treatments

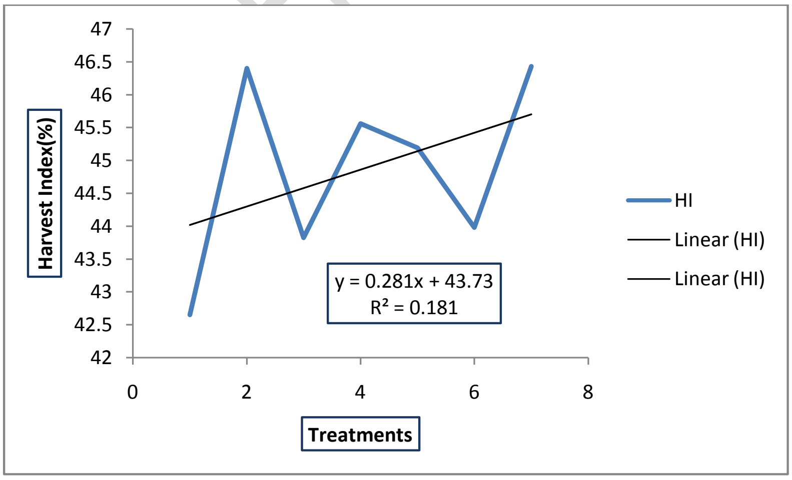

Fig.2. Linear relationship of Harvest Index (%) with Treatments

The number of cobs plant^{-1}, recorded at harvest is presented in Tables . The data shows that there was significant effect of different treatments on the number of cobs plant^{-1}.

maximum number of cobs plant^{-1}was found to be statistically significant in treatment T_7 (Vermicompost + *Phosphorus Solubilizing Bacteria* + *Azotobacter*) *i,e.,* 1.93and T_2 (Vermicompost + *Phosphorus Solubilizing Bacteria*) *i,e.,* 1.73 was found to be statistically at par with T_7 (Vermicompost + *Phosphorus Solubilizing Bacteria* + *Azotobacter*). Lowest no. of cobs plant $^{-1}$ was observed in treatment T_1 (Control) *i,e.,* 1.20 .

The probable reason for recording higher No. of cobs plant^{-1} under treatment T_7 (Vermicompost + *Phosphorus Solubilizing Bacteria* + *Azotobacter*) is due to the use of Vermicompost increased the total N uptake in the above ground biomass of maize Joshi *et al*. (2015) and the maximum number of cobs plant^{-1} and biological yield was seen in the combination of *Azotobacter* and *Phosphorus solubilizing bacteria* Costa *et al.* (2002).

At harvest, the significant and highest cob length was recorded in treatments T_7 (Vermicompost + *Phosphorus Solubilizing Bacteria* + *Azotobacter*) *i,e.,* 13.80 cm and T_2 (Vermicompost + *Phosphorus Solubilizing Bacteria*) *i,e.,* 12.20 cm was found to be statistically at par with T_7 (Vermicompost + *Phosphorus Solubilizing Bacteria* + *Azotobacter*). Lowest cob length (cm) was observed in treatment T_1 (Control) *i,e.,* 11.47 cm.

The probable reason for recording higher cob length (cm) under treatment T_7 (Vermicompost + *Phosphorus Solubilizing Bacteria* + *Azotobacter*) is due to the vermicompost was sustainable model for increasing water storage, producing greater economic benefit and maintaining SOC balance for maize production Khalil *et al*. 2005 and use of *Azotobacter* and *Phosphorus solubilizing bacteria* biofertilizer increases the yield parameters, diameter of cob, volume of cob and number of rows per cob Valenzuela *et al*. (2002).

The significant and highest grains cob^{-1} was recorded and observed in treatment T_7 (Vermicompost + *Phosphorus Solubilizing Bacteria* + *Azotobacter*) *i,e.,* 394.47 and T_2 (Vermicompost + *Phosphorus Solubilizing Bacteria*) *i,e.,* 390.87 was found to be statistically at par with T_7 (Vermicompost + *Phosphorus Solubilizing Bacteria* + *Azotobacter*). Lowest grain cob^{-1} was observed in treatment T_1 (Control) *i,e.,* 339.73.

The probable reason for recording higher grains cob^{-1} under treatment T_7 (Vermicompost + *Phosphorus Solubilizing Bacteria* + *Azotobacter*) was because of the balanced nutrient through *Azotobacter* and *Phosphorus solubilizing bacteria* improved the growth parameter and root density like number of the grains per cob, diameter of cobs, test weight etc Valenzuela *et al*. 2002.

The significant and highest test weight (g) was recorded in treatment T_7 (Vermicompost + *Phosphorus Solubilizing Bacteria* + *Azotobacter*) *i,e.,* 12.03 g and T_2 (Vermicompost + *Phosphorus Solubilizing Bacteria*) *i,e.,* 10.79 g was found to be statistically at par with T_7 (Vermicompost + *Phosphorus Solubilizing Bacteria* + *Azotobacter*). Lowest test weight (g) was observed in treatment T_1 (Control) *i,e.*, 7.87 g .

The probable reason for recording higher test weight (g) under treatment T_7 (vermicompost with PSB) was because of vermicompost significantly affected extracellular enzyme production, and N fertilizer application significantly affected the composition of the soil microbial community and use of *Phosphorus solubilizing bacteria* was recorded highest in Test weight, grain yield, cob weight .Lekasi*et al*. (2001) and uptake of nitrogen by the crop is significantly increases in pod tests with the seeds were inoculated with *Azotobacter* spp. Scherer (1997).

The significant and highest grain yield was recorded in treatment T_7 (Vermicompost + *Phosphorus Solubilizing Bacteria* + *Azotobacter*) *i,e.,* 5.03 t ha^{-1} and T_2 (Vermicompost + *Phosphorus Solubilizing Bacteria*) *i,e.,* 4.73 t ha^{-1}, T_4(Compost + *Phosphorus Solubilizing Bacteria* + *Azotobacter*) *i,e.,* 4.47 t ha^{-1}, T_5 (Compost + *Phosphorous solubilizing Bacteria*) *i,e.,* 4.40 t ha^{-1}, T_6 (Poultry manure + *Phosphorous solubilizing Bacteria*) *i,e.,* 4.30 t ha^{-1}, T_3 (Poultry manure+ *Azotobacter*) *i,e.,* 4.07 t ha^{-1}. Lowest grain yield (t ha^{-1}) was observed in treatment T_1 (control) *i,e.,* 3.73 t ha^{-1} .

The probable reason for recording higher grain yield (t ha^{-1}) under treatment T_7 (Vermicompost + *Phosphorus Solubilizing Bacteria* + *Azotobacter*) is due to phosphorous application because phosphorous was directly related to the vegetative and reproductive phases of the crop and attributes complex phenomenon of phosphorous utilization in plant metabolism. It also helped in the efficient absorption and utilisation of the other required plant nutrients which ultimately increased the grain yield Singh *et al.* (2011)and it was found that the *Azotobacter* improves the protein yield of the maize, and it increased the uptake of N significantly improves the grain and stover yield (Meena *et al.*,2013).

The significant and highest stover yield was recorded in treatment T_7 (Vermicompost+ *Phosphorus Solubilizing Bacteria* + *Azotobacter*) 5.80 t $ha^{-1}$and T_2 (Vermicompost + *Phosphorus Solubilizing Bacteria*) *i,e.,* 5.47 t ha^{-1}, T_4(Compost + *Phosphorus Solubilizing Bacteria* + *Azotobacter*) *i,e.,* 5.47 t ha^{-1}, T_5 (Compost + *Phosphorus Solubilizing Bacteria*) *i,e.,* 5.37 t $ha^{-1,}$ T_6 (Poultry manure + *Phosphorus Solubilizing Bacteria*) *i,e,.* 5.33 t ha^{-1}, T_3 (Poultry manure + *Azotobacter)i.e.,* 5.20 t ha^{-1}. Lowest stover yield (t ha^{-1}) was observed in treatment T_1 (Control) *i,e.,* 5.00 t ha^{-1} .

The probable reason for recording higher stover yield ha^{-1} under treatment T_7 (Vermicompost + *Phosphorus Solubilizing Bacteria* + *Azotobacter*) is due to synergistic action of organisms which increased the phosphorous uptake Singh *et al*., 2010 and vermicompost significantly improved soil temperature and moisture regimes in maize crop and improved soil properties and highly increases maize productivity and nitrogen use efficiency Torbert *et al.*(2001).

Because of the free living, N-fixing, aerobic, *Azotobacter* could replace the application of nitrogen fertilizer to maize. Maize after inoculation with *Azotobacter* was influenced significantly and resulted in a higher nitrogen concentration in grain and stover along with a higher yield(Alley *et al*., 1997).

The significant and highestharvest index was recorded in T_7 (Vermicompost+ *Phosphorus Solubilizing Bacteria* + *Azotobacter*)*i,e.,* 46.43 t ha^{-1} and T_2 (Vermicompost + *Phosphorus Solubilizing Bacteria*) *i,e.,* 46.40 t ha^{-1}, T_4(Compost + *Phosphorus Solubilizing Bacteria* + *Azotobacter*) *i.e.,* 45.56 t ha^{-1}, T_5 (Compost + *Phosphorus Solubilizing Bacteria*) *i,e.,* 45.19 t $ha^{-1,}$ T_6 (Poultry manure + *Phosphorus Solubilizing Bacteria*) *i,e,.* 43.98 t ha^{-1}, T_3 (Poultry manure + *Azotobacter)i.e.,* 43.82 t ha^{-1}. Lowest harvest index (%) was observed in treatment T_1 (Control) *i,e,.* 42.65.

The probable reason for recording higher harvest index (%) under treatment T_7 (Vermicompost + *Solubilizing Bacteria* + *Azotobacter*) is due to the increased temperature and moisture principally during early growth vermicompost increase the harvest index in maize Zaremaneshe*t* al. (2017) and the synergistic action of organisms which increased the phosphorous uptake Singh *et al*., 2011 and seedling treated with *Azotobacter* inoculants responded greatly and was significantly increases stem diameter, fresh and dry weight of seedling and it is eco-friendly El-Douby *et al.* (2000).

4. 4. Conclusion

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Considering the salient findings in perspective, the study revealed that application of Vermicompost with *Phosphorus Solubilizing Bacteria* and *Azotobacter* (T_7) was found to be best combination for maximizing the yield parameters (no.of cobs plant^{-1},cobs length,cobs grain,test weight,grain yield,stover yield and harvest index) of maize. Treatments with Vermicompostand *Phosphorus Solubilizing Bacteria* was also observed best in yield parameters.

5. ACKNOWLEDGEMENTS

Akcnowledgements of financial support, advice or other kind of assistance should be given at the end of the text under the heading "Acknowledgements". The names of funding organizations should be written in full.

6. References*References*should be numbered in the order of appearancein the text (see the author instructions)

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