Original Research Article

"Influence of Biofertilizers and Organic liquid nutrients on Growth, Yield and Economics of Maize (*Zea Mays* L.)"

ABSTRACT

A field experiment was conducted during *Zaid* 2022 at Crop Research Farm, Department of Agronomy, Sam Higginbottom University of Agriculture, Technology And Sciences Prayagraj (U.P) to determine the "Influence of biofertilizers and organic liquid nutrients on growth, yield and economics of maize (*Zea Mays* L.). The results showed that treatment 8 [Azotobacter (12.5 g/kg) + Azospirillum (12.5 g/kg) + *Panchagavya* (4%) recorded significantly higher plant height (172.43 cm), higher plant dry weight (135.93 g), maximum number of cobs/plant (1.53), maximum rows/cob (16.00), maximum seeds/row (26.76), higher seed index (24.83 g), higher seed yield (6.33 t/ha), higher stover yield (19.80 t/ha), maximum gross returns (144,420.60 INR/ha), maximum net returns (102,245.60 INR/ha) and highest benefit cost ratio (2.42) was also recorded in treatment 8 [Azotobacter (12.5 g/kg) + Azospirillum (12.5 g/kg) + *Panchaga-vya* (4%)] as compared to other treatments.

Keywords: *Biofertilizers, Growth, Organic liquid nutrients, Yield and Economics.*

Introduction:

Maize (*Zea mays* L.) is also called as 'Queen of Cereals' due to its highest production potential and adaptability to wide range of environment. After wheat and rice, maize is the world's third most important cereal crop. Being a C4 plant, maize is capable of utilizing solar radiation more efficiently compared to other cereals. Maize is grown throughout the year in all states of the country for various purposes including fodder for animals, food grain, sweet corn, baby corn, green cobs and popcorn, corn flour is consumed widely in Indian cooking. Among the cereals in India, maize occupies the third most important food crops after rice and wheat. In order to obtain more agricultural production, either more lands should be cultivated, which is not applicable in most cases, or higher yield must be produced in the currently cultivated land.

India cultivable area under maize was 9.86 m ha with production of 31.51 m t and productivity of 3.19 t/ha. In Uttar Pradesh maize was cultivated in 0.77 m ha area with production of 1.80 m t and productivity of 2.33 t/ha which accounts 7.85% total cultivable area and productivity of 5.72% of maize in India **(GOI, 2012).**

The decline in the crop yield due to imbalanced use of chemical fertilizers, which results in deficiency of nutrients in the soil. When compared to solid organic nutrients, liquid organic nutrients disperse in water easily and are rapidly absorbed by plants. Interestingly plants can overcome temporary, acute nutrient shortages with absorption of nutrients about twenty times faster through the leaves when compare to soil application **(Chandra *et al.*, 2019)**. The Untamed and excessive use of toxic chemicals has shown ugly consequences expressing erratic pattern in the environment in general and the soil system in particular, which has drastically changed the soil biota and reduced the crop yield. The nutrients required by the plants can be supplied through organic foliar spray. It has potential in modifying the soil physical properties and improving crop yields. The usage of fermented organic formulations with supportive beneficial microorganisms as foliar nourishment has come into the picture of modern agriculture for giving rise to good quality food **(Debbarma and Abraham, 2015)**.

Combinations of plant and animal by-products have better impacts on crop production. Liquid nutrients preparations are obtained by active fermentation of animal and plant residues over specific duration which are of low cost and also biodegradable. Organic liquid manures play a key role in promoting growth and providing immunity to the plant system. The liquid nutrients are used to promote the vigour and quality production in a sustainable way. The use of organic liquid products such as *Jeevamrutha* and *Panchagavya* results in higher growth, yield and quality of crops in more sustainable and cost-effective way **(Chandra *et al.*, 2019)**.

Use of bio-fertilizers in crop not only fixes the biological nitrogen but also solubilizes the insoluble phosphates in soil and thus improves fertilizer use efficiency. Azotobacter is applied to seeds, seed germination is improved to a considerable extent. Azotobacter was the first and is the most common biofertilizer for some plants such as maize, wheat, sorghum and rice which produces some plant growth promoting metabolites, enzymes and hormones (auxin, cytokinin and gibberellin) in addition to fixing air nitrogen and it is a free-living nitrogen fixing bacteria which is reported to fix 20-60 kg N/ha/year **(Thamatam and Mehera, 2022).** Azospirillum species belong facultative endophytic diazotrophoic group that contribute nitrogen economy and promotes plant growth hormones synthesis. Among several bio agent Azospirillum is known to fix atmospheric nitrogen and increased about 10-15 % grain yield in maize (**Patil *et al.*, 2001**).

The increasing concern for environmental safety and global demand for pesticide residue free food has evoked keen interest in crop production using eco-friendly products which are easily biodegradable and do not leave any harmful toxic residues besides conserving nature. In modern farming liquid manure play a crucial role in sustainable yield increase as well as reduce the fertilizer dose. The *Panchagavya*, Jeevamrut are ecofriendly liquid organic preparation made from cow products i.e., cow dung, urine, milk, curd, ghee, legume flour and jaggary etc. results in higher growth, yield & quality of crops (**Chongre *et al.*, 2019**). *Panchagavya* may be good source of essential nutrients, vitamins, growth promoting substances and beneficial microorganisms **(Debbarma and Abraham, 2017)**. *Jeevamrutha* enhances microbial activity in soil and helps in improvement of soil fertility. *Panchgavya* has played a si -gnificant role in drought tolerance and providing resistance to *pests* and diseases, resulting in increased overall yields (**Tharmaraj *et al.*, 2011**). Vermiwash contains 0.5% N, 0.39% P and 0.46% K and it contains major micro nutrients and organic molecules that are useful for plants. Keeping these points in view, the present investigation entitiled "**Influence of biofertilizers and organic liquid nutrients on growth and yield of Maize (*Zea mays* L.)**"

MATERIALS AND METHODS:

The experiment was conducted during *zaid* season of 2022 at Crop Research Farm, Department of Agronomy, Sam Higginbottom University of Agriculture Technology And Sciences, Prayagraj (U.P). The soil of the field constituting a part of central gangetic alluvium is neutral and deep. The soil of the experimental field was sandy loam in texture, nearly neutral in soil reaction (pH 7.8), low level of organic carbon (0.48%), available N (225 Kg/ha), P (19.03 kg/ha), and K (238.1 kg/ha). The experiment was laid out in randomized block design with 10 treatments each replicated thrice. The treatments consists of biofertilizers *viz.,* Azotobacter, Azospirillum and three organic liquid nutrients (*Jeevamrutha, Panchagavya, Vermiwash*). The treatment combinations are T1- Azotobacter (25 g/kg) + *Jeevamrutha* (4%), T2 - Azotobacter (25 g/kg) + *Panchagavya* (4%), T3 – Azotobacter (25 g/kg) + Vermiwash (4%), T4 – Azospirillum (25 g/kg) + *Jeevamrutha* (4%), T5 – Azospirillum (25 g/kg) + *Panchagavya* (4 %), T6 – Azospirillum (25 g/kg) + Vermiwash (4%), T7 – Azotobacter (12.5 g/kg) +Azospirill um (12.5 g/kg) + *Jeevamrutha* (4%), T8 – Azotobacter (12.5 g/kg) + Azospirillum (12.5 g/kg) + *Panchagavya* (4%), T9- Azotobacter (12.5g/kg) + Azospirillum (12.5 g/k) + Vermiwash (4%), T10 – control. Data recorded on different aspects of crop, *viz.*, growth and yield were subjected to statistical analysis by analysis of variance method of **Gomez and Gomez** (1976).

RESULT AND DISSCUSSION

Growth Parameters

Plant height (cm)

The data revealed (Table 1) that significant and higher plant height (172.54cm) was observed in treatment 8 [Azotobacter (12.5g/kg) + Azospirillum (12.5g/kg) + *Panchagavya* (4%)]. However , treatment 7 [Azotobacter (12.5g/kg) + Azospirillum (12.5g/kg) + *jeevamrutha* (4%) were found to be statistically at par with the treatment 8 [Azotobacter (12.5g/kg) + Azospirillum (12.5g/kg) + *Jeevamrutha* (4%)]. The Significant and highest plant height was observed in seed treatment with biofertilizers (Azotobacter 12.5g/kg and Azospirillum 12.5g/kg) might be due to it increasing nutrients uptaking by plant, improving soil properties such as organic content and increasing available N in general, plant height is influenced by water and nutrients availability through increasing number of nodes middle nodes length. Similar findings were reported by **Naserirad *et al.* (2011)**. Further increase in plant height the foliar spray of *Panchagavya* 4% might be due to liquid bio-enhancer avail favourable influence of nitrogen to produce larger cells with thinner cell walls and its contribution in cell division and cell elongation, which promoted vegetative growth similar results were reported by **Patel *et al.* (2021)** in pearl millet.

Plant dry weight (g)

Results revealed (Table1) that treatment 8 [Azotobacter (12.5g/kg) + Azospirillum (12.5g/kg) + *Panchagavya* (4%)] recorded significantly higher plant dry weight (135.93). However, treatment 7 [Azotobacter (12.5g/kg) + Azospirillum (12.5g/kg) + *Jeevamrutha* (4%)] were found to be stastically at par with treatment 8 [Azotobacter (12.5g/kg) + Azospirillum (12.5g/kg) + *Panchagavya* (4%)]. Significant and maximum plant dry weight was observed with seed treatment Azospirillum might be due to improve the soil through microbial activity which might have facilitate better crop growth. Similar results was reported by **Reddy *et al.* (2021)** in Finger millet. Further increase in plant dry weight with application of *panchagavya* 4% might be due to the supply of all micro and macronutrients and growth enzymes present in the *panchagavya* which favoured rapid cell division and multiplication with respect to *Panchagavy -a*, ammonia and nitrite oxidizers were found to colonize the leaves and increased the uptake and total N. Simlar results was reported by **Sreethu and singh (2020)**.

Crop Growth Rate (g/m^2/day)

The data revealed (Table 1) that during 80-100 DAS, treatment 8 [Azotobacter (12.5 g/kg) +Az

-ospirillum (12.5 g/kg) + *Panchagavya* (4%)] (Table1). significantly higher crop growth rate (9 .45 g/$m^{2/}$day). However, treatment 9 [Azotobacter (12.5g/kg) + Azospirillum (12.5g/kg) + Vermiwash (4%)] was found to be statistically at par with treatment 9 [Azotobacter (12.5g/kg) + Azospirillum (12.5g/kg) + *Panchagavya* (4%)]. The significant and higher crop growth rate was with application of biofertilizers (Azotobacter 12.5g/kg and Azospirillum 12.5g/kg) might be due to they improved nutrient assimilation rate is the main reason for crop growth rate. Similar results was reported by **Soleymanifard *et al*. (2013).**

Relative Growth Rate (g/g/day)

The data recorded (Table 1) that during 80-100 DAS, no significance difference among the all the treatments. However, highest relative growth rate (0.0114 g/g/day) was observed in treatm -ent 10 [Control].

Yield attributes:

Number of cobs/plant

The data revelead (Table2) that highest no. of cobs/plant (1.53) was observed in treatment 8 [Azotobacter (12.5 g/kg) + Azospirillum (12.5 g/kg) + *Panchagavya* (4%)]. Though, there is no significance difference among the treatmen

Number of rows/cobs

The data showed (Table 2) that treatment 8 [Azotobacter (12.5 g/kg) + Azospirillum (12.5 g/kg) + *Panchagavya* (4%)] recorded significantly maximum number of rows/cob (16.00). However, treatment 1 [Azotobacter (25g/kg) + Jeevamrutha (4%)] and treatment [Azotobacter (12.5g/kg) +Azospirillum (12.5g/kg) + *Jeevamrutha* (4%)] found to be statistically at par with treatment 8 [Azotobacter (12.5g/kg) + Azospirillum (12.5g/kg) + *Panchagavya* (4%)]. Significant and maxi -mum number of rows/cob was observed with application of *Panchagavya* 4% might be due to better nutrient availability and its favourably effects on soil physical and biological properties resulting yield attributes and yield. Similar results was reported by **Rao *et al.* (2017).**

Number of seeds/row

The significant and maximum seeds/row (26.76) was observed in treatment-8 [Azotobacter (12.5 g/kg) + Azospirillum (12.5 g/kg) + *Panchagavya* (4%)]. However, treatment 7 [Azotobacter

(12.5g/kg) + Azospirillum (12.5g/kg) + *Jeevamrutha* (4%)], and treatment 5 [Azospirillum (25g/kg) + *Panchagavya* (4%)] found to be statistically at par with treatment 8 [Azotobacter (1 2.5g/kg) + Azospirillum (12.5g/kg) + *Panchagavya* (4%)] (Table2). Significant and maximum seeds/row was observed with seed inoculation of biofertilizers (Azotobacter 12.5g/kg and Azospirillum 12.5g/kg) might be due to living bacteria within the root zone promote plant growth, it's reproductively and nutrient uptake by releasing auxins and gibberellins; and increased sink portion, resulted increased number of grain/ rows. Similar result was reported by **Naseri *et al*. (2013).**

Seed index (g):

Significant and higher number of seed index (24.83 g) was observed in treatment 8 [Azotobacter (12.5g/kg) + Azospirillum (12.5g/kg) + *Panchagavya* (4%)]. However, all treatments except treatment 9 [Azotobacter (12.5g/kg) + Azospirillum (12.5g/kg) + Vermiwash (4%)] and [Azotobacter (25g/kg) + Vermiwash (4%)] found to be statistically at par with treatment 8 [Azotobacter (12.5g/kg) + Azospirillum (12.5g/kg) + *Panchagavya* (4%)] (Table2). Significant and maximum seed index was observed with the application of biofertilizers (Azotobacter 12.5g/kg and Azospirill -um 12.5g/kg) might be due to transforming more photosynthetic matter from source. Similar results was reported by **Naserirad *et al.* (2011).** Further increase in seed index with application of *Panchagavya* 4%might be due steady and continuous supply of N through bio-enhancer throughout the entire crop growth period due to gradual transformation and mineralization of organics, solubilization of water insoluble P compounds by organic acids released in greater extent and P availability to crop coupled with higher native K availability might have played a key role in ensuring superior yield attributes. Similar results was reported by **Patel *et al*. (2014)** in finger millet.

Seed yield (t/ha):

Significant and higher seed yield (6.33 t/ha) was observed in the treatment 8 [Azotobacter (12.5g/kg) + Azospirillum (12.5g/kg) + *Panchagavya* (4%)]. However, treatment 7 [Azotobacter (12.5g/kg) + Azospirillum (12.5g/kg) + *Jeevamrutha* (4%)] found to be statistically at par with treatment 8 [Azot -bacter (12.5g/kg) + Azospirillum (12.5g/kg) + *Panchagavya* (4%)] (Table2). Significantly and maximum seed yield was observed with application of biofertilizers (Azotobacter 12.5g/kg and Azospirillum 12.5g/kg) might be due to secreting growth regulating and prompting in attars such as oxine, giberline by Azospirillum and secreting oxine, gibberline and cytokenine by Azotobacter and assisting these bacteria with maize rhizome are most important interacting to improving growth hand

grain yield. Similar results was reported by **Lucangeli and Bottini (1997)**. Further increase in seed yield with application of *Panchagavya* 4% might be due to readily supplied nutrients and growth hormones *Viz.* IAA and GA3 present in *panchagavya* which might have stimulated the production of growth regulators in cell system. Similar results was reported by **Sreethu and Singh (2020)**.

Stover yield (t/ha)

The data revealed (Table 2) that treatment 8 [Azotobacter (12.5g/kg) + Azospirillum (12.5g/kg) + *Panchagavya* (4%)] recorded higher stover yield (19.80 t/ha). However, treatment 9 [Azotobacter (12.5g/kg) + Azospirillum (12.5g/kg) + Vermiwash (4%)] found to be statistically at par with treatment 8 [Azotobacter (12.5g/kg) + Azospirillum (12.5g/kg) + *Panchagavya* (4%)]. Significant and higher stover yield was observed with application of *Panchagavya* 4% might be due to cytokinin which plays a vital role in vegetative plant parts with nutrient partitioning while in reproductive parts, high levels of nutrient mobilization. Increase in yield was also be due to fact that cow dung in *Panchagavya* act as a medium for the growth of beneficial microbes and cow urine provides nitrogen which is essential for crop growth. Similar results was reported by **Salin P *et al*. (2019).**

Harvest Index (%)

The data recorded (Table 2) that highest harvest index (29.40) was recorded in that treatment 1 [Az -otobacter (25g/kg) + *Jeevamrutha* (4%)]. There was no significance difference among the treatme-

Economics:

The result showed (Table 3) that Maximum gross returns (144,420.60 INR/ha), maximum net returns (102,245.60 INR/ha) and highest benefit cost ratio (2.42) was recorded in treatment 8 [Azotobacter (12.5g/kg) + Azospirillum (12.5g/kg) + *Panchagavya* (4%)]. Higher gross return, net return and B:C ratio was obtained with application of *Panchagavya* 4% might be due to its nature of providing balanced supply of all essential nutrients, which balances the crop needs, source uptake result in grain yield. Similar results was reported by **Sindhu *et al.* (2022)**.

Table 1: Influence of biofertilizers and organic liquid nutrients on growth parameters of maize.

S. No	Treatments	Plant Height (cm)	Plant Dry Weight (g)	CGR ($g/m^2/day$)	RGR (g/g/day)
1	Azotobacter (25g/kg) + *Jeevamrutha* (4%)	159.40	114.99	5.90	0.0075
2	Azotobacter (25g/kg) + *Panchagavya*(4%)	161.80	116.37	5.04	0.0062
3	Azotobacter (25g/kg) + Vermiwash (4%)	150.33	112.43	5.83	0.0075
4	Azospirillum (25g/kg) + *Jeevamrutha* (4%)	159.73	113.42	5.74	0.0073
5	Azospirillum (25g/kg) + *Panchagavya* (4%)	170.23	114.52	5.38	0.0068
6	Azospirillum (25g/kg) + Vermiwash (4%)	166.83	111.74	5.54	0.0070
7	Azotobacter (12.5g/kg) + Azospirillum (12.5g/kg) + *Jeevamrutha* (4%)	170.87	129.50	8.16	0.0093
8	Azotobacter (12.5g/kg) + Azospirillum (12.5g/kg) + *Panchagavya*(4%)	172.43	135.93	9.45	0.0104
9	Azotobacter (12.5g/kg) + Azospirillum (12.5g/kg) + Vermiwash (4%)	163.43	123.99	9.04	0.0110
10	Control	160.47	95.00	7.12	0.0114
	F-Test	S	S	S	NS
	SEm (±)	3.35	2.41	0.99	0.001
	CD (5%)	9.96	7.17	2.94	-

Table 2: Influence of biofertilizers and organic liquid nutrients on yield attributes and yield of maize

S. No	Treatments	Number of cobs/plant	Number of rows/cob	Number of seeds/row	Seed Index (g)	Seed yield (t/ha)	Stover yield (t/ha)	Harvest Index (%)
1	Azotobacter (25g/kg) + *Jeevamrutha* (4%)	1.03	14.89	20.64	24.68	5.60	13.01	29.40
2	Azotobacter (25g/kg) + *Panchagavya*(4%)	1.33	12.98	24.10	24.27	4.94	14.90	24.80
3	Azotobacter (25g/kg) + Vermiwash (4%)	1.33	12.42	22.22	21.71	4.83	14.00	26.74
4	Azospirillum (25g/kg) + *Jeevamrutha* (4%)	1.20	12.89	22.44	22.77	4.77	14.83	24.26
5	Azospirillum (25g/kg) + *Panchagavya* (4%)	1.27	12.34	25.35	22.47	4.44	14.60	23.28
6	Azospirillum (25g/kg) + Vermiwash (4%)	1.40	12.21	23.38	22.71	4.38	15.13	22.31
7	Azotobacter (12.5g/kg) + Azospirillum (12.5g/kg) + *Jeevamrutha* (4%)	1.27	14.23	25.80	24.66	5.87	15.02	24.24
8	Azotobacter (12.5g/kg) + Azospirillum (12.5g/kg) + *Panchagavya*(4%)	1.53	16.00	26.76	24.83	6.33	19.80	28.12
9	Azotobacter (12.5g/kg) + Azospirillum (12.5g/kg) + Vermiwash (4%)	1.27	12.86	20.41	20.41	4.74	17.51	21.48
10	Control	1.37	12.99	24.40	24.40	4.07	14.36	22.12
	F-Test	NS	S	S	S	S	S	NS
	SEm (±)	1.63	0.50	0.38	0.77	0.44	0.56	1.92
	CD (5%)	-	1.50	1.33	2.30	1.31	2.30	-

Table 3. Influence of biofertilizers and organic liquid nutrients on economics of maize

Treatment	Cost of cultivation (INR/ha)	Gross return (INR/ha)	Net return (INR/ha)	B:C Ratio
1. Azotobacter (25g/kg) + *Jeevamrutha* (4%)	41225.00	122,881.60	81567.60	1.98
2. Azotobacter (25g/kg) + *Panchagavya* (4%)	42025.00	111,892.80	69867.80	1.65
3. Azotobacter (25g/kg) + Vermiwash (4%)	42225.00	108,764.60	66,539.60	1.57
4. Azospirillum (25g/kg) + *Jeevamrutha* (4%)	41250.00	101712.80	60463.00	1.46
5. Azospirillum (25g/kg) + *Panchgavya* (4%)	42050.00	101712.80	59,662.80	1.41
6. Azospirillum (25g/kg) + Vermiwash (4%)	42250.00	101065.60	58,815.60	1.39
7. Azotobacter (12.5g/kg) + Azospirillum (12.5g/kg) + *Jeevamrutha* (4%)	41375.00	130,189.00	88,814.40	2.10
8. Azotobacter (12.5g/kg) + *Azospirillum* (12.5g/kg) + *Panchagavya* (4%)	42175.00	144,420.60	102,245.60	2.42
9. Azotobacter (12.5g/kg) + Azospirillum (12.5g/kg) + Vermiwash (4%)	42375.00	110.508.80	68133.8.80	1.60
10. Control	39900.00	94213.40	54,313.00	1.36

CONCLUSION

Based on the above findings it can concluded that application of Azotobacter (12.5g/kg) and Azospirillum (12.5g/kg) along with application of *Panchagavya* (4%) had performed better growth parameters and yield attributes of maize and also proven profitabl

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