Effect of enriched farm yard manure on growth and yield of sweet corn (*Zea mays* var.*Saccharata*)

Abstract

A field experiment was conducted during *Kharif*-2023 at Agricultural Research Station, Dhadesugur to study the effect of enriched farm yard manure on growth and yield of sweet corn. The experiment consisted of seven treatments *viz.*, T_1: 100% RDF T_2: 50% RDF + Enriched FYM with *Azospirillum* + PSB T_3: 50 % RDF + Enriched FYM with *Gluconobacter* + PSB T_4: 75% RDF + Enriched FYM with *Azospirillum* + PSB T_5: 75 % RDF + Enriched FYM with *Gluconobacter* + PSB T_6: 100 % RDF + Enriched FYM with *Azospirillum* + PSB T_7: 100 % RDF + Enriched FYM with *Gluconobacter* + PSB. The results revealed that among different treatments, growth parameters such as plant height (204.4 cm), number of leaves (13.6), leaf area (5033 cm^2), leaf area index (3.82), and dry matter production and its accumulation in different plant parts (243.9 g $plant^{-1}$) were significantly higher with application of 100% RDF + enriched FYM with *Gluconobacter* + PSB which in turn resulted in significantly higher fresh cob yield (175.6 q ha^{-1}) and green fodder yield (224.8 q ha^{-1}). Further, the same treatment recorded significantly higher gross returns (₹1,98,080 ha^{-1}) net return (₹ 1,46,230 ha^{-1}) and benefit-cost ratio (3.89).

Key words: Sweet corn, RDF, *Gluconobacter*, *Azospirillum*, PSB.

1. Introduction

Sweet corn (*Zea mays* var. *Saccharata*) is a modern maize variety that stands out as one of the most popular types of maize, primarily used for human consumption. Originally from Peru, it is now widely cultivated across the Americas. This variety has been selectively bred to enhance its natural sugar levels, making it highly favoured. As a result, sweet corn, also known as "sugar corn," is a hybrid maize variety specifically developed for its increased sweetness.

Biofertilizers play a crucial role in enhancing soil fertility by fixing atmospheric nitrogen, both in collaboration with plant roots and independently, solubilizing insoluble phosphates, and producing plant growth-promoting substances in the soil. They are being actively promoted to utilize the natural biological system for nutrient mobilization. Biofertilizers are also more cost-effective, eco-friendly, and renewable sources of nutrient supply. In addition to providing nutrients, they contribute organic matter to the soil, helping to prevent its degradation.

Gluconobacter, a genus of Gram-negative, rod-shaped acetic acid bacteria from the Acetobacteraceae family, is recognized for its ability to oxidize alcohols and sugars into acids. In agriculture, these bacteria improve nutrient availability and uptake by solubilizing phosphorus and other essential nutrients in the soil, thereby promoting plant growth and increasing crop yields. Organic fertilizers enriched with *Gluconobacter*, such as farmyard manure (FYM), significantly enhance soil fertility and health by boosting the availability of key nutrients like nitrogen, phosphorus, and potassium (NPK), leading to improved plant productivity.

Phosphorus-solubilizing bacteria (PSB) play a vital role in transforming chemically fixed and applied phosphorus into a form that plants can absorb, resulting in better crop yields (Gull *et al*., 2004). PSB represent 1 to 50 percent of the total microbial population in soil, depending on their phosphorus-solubilizing potential (Chen *et al.,* 2006). The beneficial effects of combined inoculation with *Gluconobacter* and PSB are attributed to the synergistic interactions between phosphate-solubilizing microorganisms and free-living organisms, which lead to enhanced nutrient availability (Khatkar *et al.,* 2007).

Enriching manures with beneficial microbial inoculants, such as free-living nitrogen fixers and phosphate solubilizers, helps enhance the nutritional quality of the manures. The fortification of farmyard manure with zinc sulphate and beneficial microbial cultures not only boosts its nutrient content but also leads to improved crop growth and yields. Microbial enrichment of organic manures further enhances phosphate solubilization, nitrogen fixation, and overall plant growth and development. Organisms like *Azospirillum,* phosphorus-solubilizing bacteria (PSB), *Azotobacter,* and *Gluconobacter* are commonly recommended for this purpose.

Incorporating these microbes into organic manures like vermicompost, neem cake, and compost tends to yield better results compared to using organic manure alone. The addition of beneficial microbial cultures to organic manures enhances nitrogen and phosphorus content through nitrogen fixation and phosphate solubilization. Therefore, combining organic matter with microbial inoculants offers an optimal nutrition strategy for crops, providing an economical and ecologically efficient nutrient management technique.

2.Materials and Methods

A field experiment was conducted during *kharif* 2023 at Agricultural Research Station, Dhadesugur, UAS, Raichur Karnataka (15º 6´ N, 76º 8´ E, altitude 358 m). The soil of the experimental site belongs to *Vertisols* (medium black soil). Regarding chemical properties, the soil was alkaline in reaction (pH-8.15), low in EC (0.30dS m^{-1}) and low in organic carbon content (0.47%). The soil was low in available nitrogen (275.2 kg ha^{-1}), high in available phosphorus (28.31 kg ha^{-1}) and high in available potassium (345.6 kg ha^{-1}). The experiment was laid out in randomized complete block design (RCBD) with three replications. There were seven treatments consisting of T_1: 100% RDF T_2: 50% RDF + Enriched FYM with *Azospirillum* + PSB T_3: 50% RDF + Enriched FYM with *Glucenobacter* + PSB T_4: 75% RDF + Enriched FYM with *Azospirillum* + PSB T_5: 75% RDF + Enriched FYM with *Glucenobacter* + PSB T_6: 100% RDF + Enriched FYM with *Azospirillum* + PSB T_7: 100% RDF + Enriched FYM with *Glucenobacter* + PSB. The sweet corn variety Sugar-75 was selected for the study. Seeds were sown by adopting line sowing method at spacing of 60 ×20 cm on 19th July 2023 and harvested on 28th September 2023.

From randomly selected five plants, selecting main shoot and recording plant height from ground level to the tip of the fully opened leaf and number of leaves per plant were counted at 20 days interval. Five plants were randomly selected and uprooted from destructive rows of plot at 20 days interval. The samples were separated into leaf, stem and reproductive parts and were oven dried at 70 °C to a constant dry weight to determine the total dry matter production. The cobs were removed from net plot of all the plants and taken the total fresh cob yield per plot and expressed in kg per plot and using this fresh cob yield was worked out and expressed in quintal per hectare (q ha^{-1}). The green fodder yield per plot was used to calculate green fodder yield per ha and expressed in quintal per hectare (q ha^{-1}). The economics was worked out based on the prevailing market price for the existing year. Data analysis and interpretation was done using Fisher's method of analysis of variance (ANOVA) technique as given by Panse and Sukhatme (1967).

3. Result and discussion

3.1 Effect of enriched FYM on growth attributes

3.1.1Plant height

Plant height and number of leaves per plant was significantly influenced by application of 100% RDF + enriched FYM with *Gluconobacter* + PSB(Table 1).However, treatment receiving the application of 100% RDF + Enriched FYM with *Azospirillum* + PSB (29.7, 75.1, 168.8 and 190.4 cm, respectively), 75% RDF +Enriched FYM with *Gluconobacter* + PSB (291.1, 72.1, 167.0 and 188.3 cm, respectively) and 75% RDF + Enriched FYM with *Azospirillum* + PSB (28.7, 69.2, 164.4 and 186.3 cm, respectively) were on par with each other. Whereas, application of 50% RDF + Enriched FYM with *Azospirillum* + PSB recorded significantly least plant height and leaf area per plant at different growth stages.

Plant height was significantly higher at 20, 40, 60 DAS and at harvest due to application of 100% RDF + enriched FYM with *Gluconobacter* + PSB. Application of higher levels of nitrogen and enriched farm yard manure resulted in increased availability of major nutrients *viz*., nitrogen, phosphorus and potassium which had favorable effect on cell multiplication and elongation, thereby causing an increase in the stem internodal length which reflected in increased plant height. Further, 50% RDF + Enriched FYM with *Azospirillum* + PSB (22.4, 52.0, 135.5 and 157.4 cm, respectively) recorded significantly lower plant height over other treatments. This might be due to lower available nutrients. These results are on line with the findings of Ramesha (2010) and Baradhan and Kumar (2017).

3.1.2 Number of leaves per plant, leaf area and leaf area index

Among different treatments, results observed that, application of 100% RDF + Enriched FYM with *Gluconobacter* + PSB (Table1 and 1a) recorded significantly a greater number of leaves per plant, larger leaf area per plant and leaf area index. However, application of 100% RDF + Enriched FYM with *Azospirillum* + PSB,75% RDF + Enriched FYM with *Gluconobacter* + PSB, and 75% RDF + Enriched FYM with *Azospirillum* + PSB were on par with each other. Whereas, application of 50% RDF + Enriched FYM with *Azospirillum* + PSB recorded significantly least number of leaves per plant, larger leaf area per plant and leaf area index at different growth stages. The increased number of leaves per plant, leaf area and leaf area index might be due to timely supply of nutrients particularly nitrogen which is required for vegetative growth of plant. The FYM as a source of organic manure might have helped in development of the physical properties of soil like porosity, aeration and water holding capacity. The soil application of biofertilizers might have helped to increase the biological nitrogen fixation and availability of phosphorus required for strong vegetative growth. The minimum number of leaves, leaf area and leaf area index in 50% RDF + Enriched FYM with *Azospirillum* + PSB treatment is obvious, might be due to least availability of nutrients needed for production of a greater number of leaves. Similar results were also reported by Pawar and Barkule (2017).

3.1.3 Dry matter production

Results observed that, the maximum amount of dry matter production was noticed in the treatment with the application of 100% RDF + Enriched FYM with *Gluconobacter* + PSB (Fig.1). Whereas least dry matter production was recorded in the treatment with the application of 50% RDF + Enriched FYM with *Azospirillum* + PSB compared to other treatments. However, 100% RDF + Enriched FYM with *Azospirillum* + PSB which is on par with 75% RDF + Enriched FYM with *Gluconobacter* + PSB and 75% RDF + Enriched FYM with *Azospirillum* + PSB.

The higher dry matter accumulation in sweet corn was observed with the application of 100% RDF + Enriched FYM with *Gluconobacter* + PSB is due to enhanced nutrient availability and improved plant growth promotion facilitated by specific microbial interactions and adequate nutrients supply. Higher total dry matter production in these treatments might be due to the higher dry matter accumulation of individual plant parts like leaves, stem and reproductive parts. Apart from this, combined application of enriched FYM with *Gluconobacter*, PSB and Zn along with 100 per cent RDF resulted in increased availability of nutrients (available N, P, K, and Zn) as they are responsible for profuse growth & development leading to higher plant height, leaf area & number of leaves. Similar findings obtained by Akashreddy (2020) and Ramesha (2010). Application of 50% RDF + Enriched FYM with *Azospirillum* + PSB compared to other treatments This might be due to decreased dry matter accumulation and its distribution in leaves, stem and reproductive parts.

3.2 Effect of enriched FYM on grain and stover yield

Results revealed that, significantly the maximum fresh cob yield and green fodder yield was obtained with application of 100% RDF + Enriched FYM with *Gluconobacter* + PSB over the rest of the treatments (Table 2). While 50% RDF + Enriched FYM with *Azospirillum* + PSB recorded significantly lowest cob yield and fodder yield. 100% RDF + Enriched FYM with *Azospirillum* + PSB,75% RDF + Enriched FYM with *Gluconobacter* + PSB and 75% RDF + Enriched FYM with *Azospirillum* + PSB were on par with each other.

The significantly maximum fresh cob yield and green fodder yield achieved with the application of 100% RDF + Enriched FYM with *Gluconobacter* + PSB can be attributed to the optimal and balanced supply of essential nutrients, particularly nitrogen, phosphorus, and potassium provided by this combination. *Gluconobacter* plays a vital role in solubilizing phosphates and fixing atmospheric nitrogen, making these nutrients more available to the plants. Enriched FYM enhances soil structure, boosts organic matter content, and promotes microbial activity, improving nutrient availability and uptake by the roots. This leads to better root growth and development, enhancing the plant's ability to absorb water and nutrients, resulting in overall improved plant health and vigour. The improved nutrient uptake and root development enhance growth parameters such as plant height, leaf area index, and dry matter production, as well as yield-contributing factors like the number of kernels per cob, number of cobs per plant, and cob weight, thereby increasing the fresh cob yield and green fodder yield. Comparable outcomes were noted by Jagathjothi *et al*. (2008), Lavanya *et al.* (2023) and Devasena and Innazent (2024). On the other hand, the significantly lowest cob yield and fodder yield recorded with 50% RDF + Enriched FYM with *Azospirillum* + PSB (128.9 q ha^{-1}) can be attributed to insufficient nutrient supply due to the reduced fertilizer dose. Despite the presence of beneficial microbes, the lower nutrient availability likely limited plant growth and yield.

3.3 Effect of biofertilizer enriched FYM on economics

The cost incurred for the cultivation of sweet corn differed with different treatments. Treatment with the application of 100% RDF + Enriched FYM with *Gluconobacter* + PSB (T_7) recorded higher cost of cultivation (₹ 50,850 ha^{-1}) and the same amount of cost incurred for the treatment T_6 (100% RDF + Enriched FYM with *Azospirillum* + PSB). Application of 50% RDF + Enriched FYM with *Gluconobacter* + PSB (T_3) incurred lower cost of cultivation (₹ 47,382 ha^{-1}) and the same amount of cost was incurred for the treatment T_2 (50% RDF + Enriched FYM with *Azospirillum* + PSB) (Table 2). Significantly higher gross return (₹ 1,98,080 ha^{-1}) was recorded with application 100% RDF + Enriched FYM with *Gluconobacter* + PSB and which was followed by the application of 100% RDF + Enriched FYM with *Azospirillum* + PSB (₹ 1,87,610 ha^{-1}). Application of 50% RDF + Enriched FYM with *Azospirillum* + PSB recorded lower gross returns (₹ 1,44,920 ha^{-1}). Application of 100% RDF + Enriched FYM with *Gluconobacter* + PSB recorded higher net returns and BC ratio (₹ 1,47,230 ha^{-1} and3.90). However, lower net returns and benefit cost ratio (₹ 96,785 $ha^{-1}$and 3.06) was shown byapplication of 50% RDF + Enriched FYM with *Azospirillum* + PSB.

Application of 100% RDF + Enriched FYM with *Gluconobacter* + PSB yielded the highest economic returns due to its optimal nutrient supply and enhanced nutrient uptake, which resulted in higher crop yields and better financial returns. In contrast, the 50% RDF + Enriched FYM with *Azospirillum* + PSB treatment recorded lower net returns due to reduced nutrient application, which led to lower yields and, consequently, reduced financial returns. Similar results obtained by Anilkumar *et al*. (2017) and they stated that application of enriched FYM resulted in higher net returns compared to the recommended package of practices in sorghum. Shahin *et al*. (2022) reported maximum net returns were registered with application of 100% RDF which was significantly higher over all other nutrient management treatments.

4 Conclusion

The study concludes that the application of 100% RDF + Enriched FYM with *Gluconobacter* + PSB resulted in a notably higher fresh cob yield, green fodder yield, net returns and benefit-cost ratio indicating superior economic efficiency. Incorporating the microbes into organic manures like vermicompost, neem cake, and compost tends to yield better results compared to using organic manure alone. The addition of beneficial microbial cultures to organic manures enhances nitrogen and phosphorus content through nitrogen fixation and phosphate solubilization.

Table 1: Growth parameters of sweet corn at different growth stages as influenced by the application of enriched farm yard manure with biofertilizer

Treatments	Plant height (cm)				Number of leaves per plant			
	20 DAS	40 DAS	60 DAS	At harvest	20 DAS	40 DAS	60 DAS	At harvest
T_1	26.2	62.6	151.7	172.5	4.90	7.67	12.0	10.6
T_2	22.4	52.0	135.5	157.4	4.10	6.96	10.9	9.22
T_3	23.7	58.8	148.2	171.5	4.70	7.63	12.0	10.4

T_4	28.7	69.2	164.4	186.3	5.46	8.31	13.2	11.9
T_5	29.1	72.1	167.0	188.3	5.48	8.40	13.3	12.1
T_6	29.7	75.1	168.8	190.4	5.51	8.45	13.2	12.2
T_7	32.5	81.4	181.5	204.4	6.04	9.12	14.5	13.6
S.Em. ±	**0.8**	**2.1**	**4.2**	**4.5**	**0.17**	**0.20**	**0.35**	**0.40**
C.D. (P=0.05)	**2.5**	**6.2**	**12.6**	**13.7**	**0.51**	**0.62**	**1.04**	**1.22**

Table 1a: Growth parameters of sweet corn at different growth stages as influenced by the application of enriched farm yard manure with biofertilizers

Treatments	**Leaf area (cm^2 $plant^{-1}$)**				**Leaf area index (LAI)**			
	20 DAS	**40 DAS**	**60 DAS**	**At harvest**	**20 DAS**	**40 DAS**	**60 DAS**	**At harvest**
T_1	391.8	2137	4262	3813	0.33	1.78	3.55	3.18
T_2	317.5	1858	3713	3216	0.26	1.55	3.09	2.68
T_3	377.4	2090	4133	3666	0.31	1.74	3.44	3.06
T_4	450.6	2344	4683	4252	0.38	1.95	3.90	3.54
T_5	457.3	2400	4849	4428	0.38	2.00	4.04	3.69
T_6	465.7	2450	4953	4583	0.39	2.04	4.13	3.82
T_7	523.5	2675	5376	5033	0.44	2.23	4.48	4.19
S.Em. ±	**16.7**	**66**	**133**	**142**	**0.01**	**0.06**	**0.11**	**0.12**
C.D. (P=0.05)	**51.5**	**205**	**410**	**437**	**0.04**	**0.17**	**0.34**	**0.36**

Table 2: Yield and economics of sweet corn at different growth stages as influenced by the application of enriched farm yard manure with biofertilizer

Treatments	**Fresh cob yield q ha^{-1}**	**Green fodderyield q ha^{-1}**	**Cost of cultivation (₹ ha^{-1})**	**Gross returns (₹ ha^{-1})**	**Net returns (₹ ha^{-1})**	**B:C**
T_1	140.5	171.1	46350	157610	116260	3.40
T_2	128.9	160.2	47382	144920	97538	3.06
T_3	143.5	177.8	47382	161280	113898	3.40
T_4	150.7	199.0	49116	170600	121484	3.47

T_5	159.9	203.3	49116	180230	131114	3.67
T_6	165.9	217.1	50850	187610	136760	3.69
T_7	175.6	224.8	50850	198080	147230	3.90
S.Em. ±	**3.0**	**2.4**	**-**	**2498.3**	**2498.3**	**0.06**
C.D. (P=0.05)	**9.1**	**7.3**	**NA**	**7698.1**	**7698.1**	**0.18**

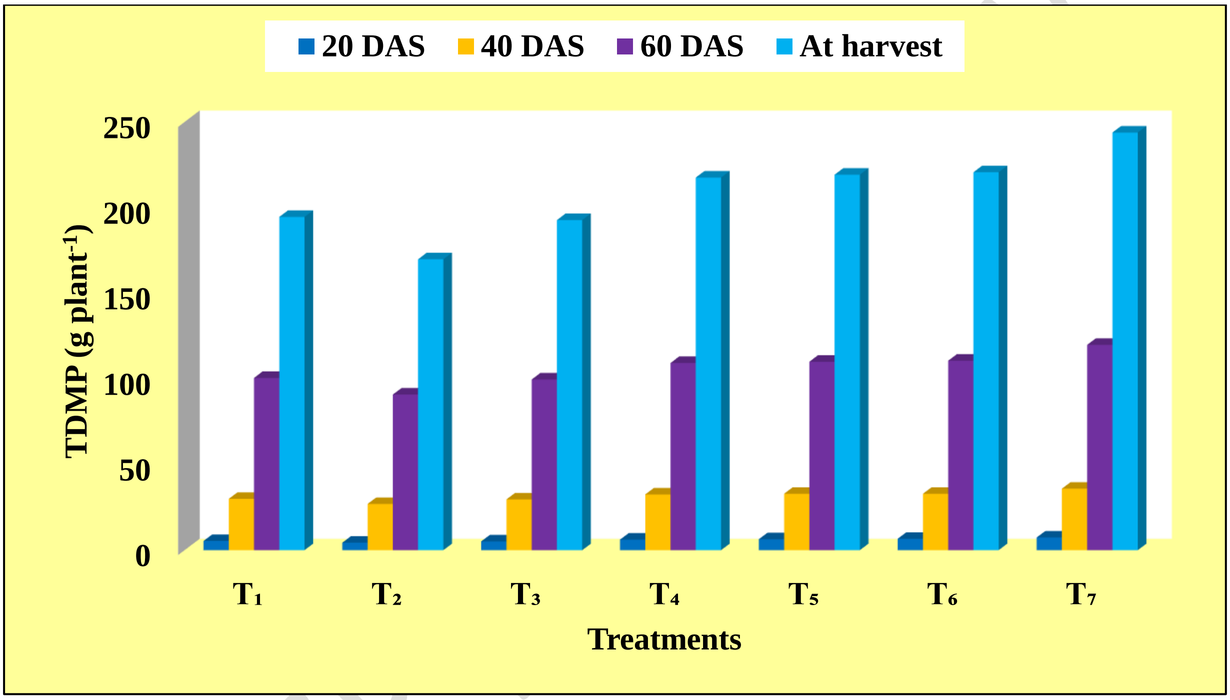

Fig. 1: Effect of enriched FYM with biofertilizer on total dry matter production (gplant^{-1}) of sweet corn at different growth stages

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