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Effect of microbial population on the plant parameters of sorghum in organic farming system

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Abstract
In order to investigate the dynamics of the microbial population and how it relates to sorghum plant growth and yield in an organic farming system, a field experiment was carried out at the Zonal Agricultural Research Station in Kalaburagi in 2017–18. The microbiological and biochemical characteristics of the soil improved in the treatments using organic manures. The results indicate that, when compared to the other treatments, the fully organic manures (100% NP) had a significantly higher population of both beneficial and general microbes, including bacteria (114.25 X 106 cfu/g), fungi (75.50 X 104 cfu/g), actinomycetes (54.50 X 104 cfu/g), azotobacter (17.50 X 104 cfu/g), Azospirillum (30.75 X 104 cfu/g), and phosphorus-soluting microorganism (PSM- 52.25 X 104 cfu/g). Additionally, the highest microbial biomass carbon (361.50 µg CO2-C g-1 soil for 24 hours), as well as the highest enzymatic activity (Dehydrogenase 35.75 µg TPF g-1 soil for 24 hours, Urease 221.63 µg NH4- N g-1 soil for 2 hours, and Phosphatase 92.13 µg PNP g-1 soil for 1 hour). The crop responded well to the different treatment combinations and found higher growth and yield parameters in the treatment applied as per recommended package of practices recorded (Plant height- 212.75 cm, Number of leaves-10.09/plant, Dry matter accumulation-91.32 g/plant, Grain weight per ear head-31.00 g Stover yield-5.06 t/ha, Grain yield- 1568 kg/ha) but however it was on par with the treatment applied with fully inorganic fertilizers (T_4) and the treatment given with 50 per cent organic manures and 50 per cent inorganic fertilizers (T_3) and treatment applied with fully organic manures of 100% N and P (T_2- in case of yield and yield parameters). Finally to find the comparative profits between the treatments, the economics of the crop was worked out and found that the treatment which was maintained fully organically with 75 per cent N and P (T_1) was superior among all the treatments with highest B:C ratio (2.84).

Keywords: Microbes, sorghum, organic farming, parameters, yield

Introduction

Sorghum (*Sorghum bicolor* L.) is commonly referred to by various names such as great millet, Indian millet, milo, durra, orshallu. It is a cereal grain plant belonging to the Poaceae family, and its seeds are edible and starchy. The origins of this plant are believed to be in Africa, where it serves as a significant staple crop. Sorghum comes in several varieties, including grain sorghums used for human consumption, grass sorghums cultivated for hay and livestock fodder, and broomcorn, which is utilized in the production of brooms and brushes.In India, sorghum is known by names like jowar, cholam, or jonna, while in West Africa, it is called Guinea corn, and in China, it goes by the name kaoliang. Sorghum holds particular importance in regions characterized by hot and arid climates due to its exceptional resilience to drought and high temperatures.

Sorghum is a robust grass that typically attains a height of 0.6 to 2.4 meters (2 to 8 feet), occasionally even reaching as tall as 4.6 meters (15 feet). The stalks and leaves of this plant are covered with a white waxy layer, and in certain varieties, the inner part or pith of the stalks is juicy and sweet. The leaves are approximately 5 cm (2 inches) wide and 76 cm (2.5 feet) long. The small flowers are arranged in panicles, with the density of these clusters varying from loose to compact, and each flower cluster contains between 800 and 3,000 kernels. The seeds exhibit considerable diversity in terms of color, shape, and size, but they are generally smaller than wheat grains.

Sorghum is considered to have lower feed quality compared to corn (maize). It is rich in carbohydrates, comprising 10 percent protein, 3.4 percent fat, and contains calcium, as well as small quantities of iron, vitamin B1, and niacin. For human consumption, this gluten-free grain is typically ground into a meal, which is then used to prepare porridge, flatbreads, and cakes.

The distinct strong flavor it possesses can be mitigated through processing. Furthermore, sorghum finds applications in the production of edible oil, starch, dextrose (a type of sugar), paste, and alcoholic beverages. Its stalks are utilized as fodder and in the construction of various materials.

Sweet sorghums, also known as sorgos, are primarily cultivated in the United States and southern Africa, primarily for forage and syrup production. They are occasionally employed in the production of ethyl alcohol for biofuel.

Organic farming, characterized as a comprehensive production management system that prioritizes and enhances the health of agro-ecosystems, including biodiversity, biological cycles, and soil biological activity, holds significant importance. Numerous studies have demonstrated that organic farming methods can yield higher crop yields compared to conventional methods. Notably, there is a marked difference in soil health indicators, such as higher nitrogen mineralization potential and greater microbial abundance and diversity, observed in organic farms. This enhanced soil health in organic farming leads to a noticeable reduction in insect and disease incidence. The emphasis on small-scale integrated farming systems has the potential to rejuvenate rural areas and stimulate their economies.

Materials and Methods

The current research was conducted at the Department of Agricultural Microbiology, College of Agriculture, Raichur, with the objective of evaluating the general and beneficial soil microflora, estimating soil microbial biomass carbon, and assessing soil biochemical properties in sorghum crop cultivated under organic farming systems at the Agricultural Research Station, Kalaburagi during the 2017-18 agricultural season. Additionally, the study aimed to investigate the impact of microbiological properties on the growth and yield attributes of sorghum. This chapter provides a comprehensive account of the methodologies, techniques, and materials employed in the research.

The fieldwork was conducted during the rabi season of 2017 at the Zonal Agricultural Research Station, Kalaburagi, situated in the northeastern dry zone of Karnataka, with coordinates spanning 16º 16' latitude and 77º 20' longitude, at an elevation of 389 meters above sea level. The soil at the experimental site was characterized as medium-deep black soil. Prior to the commencement of the experiment, the site was prepared by a single plowing followed by two harrowing operations to achieve fine tilth. The experimental setup was structured as a randomized complete block design (RCBD), and protective bunds were established around the plots to prevent soil and water contamination from adjacent areas. Sorghum seeds of the M 35-1 variety, known for its health and vigor, were sown with a plant-to-plant spacing of 45 x 10 cm.

Results and Discussion

The assessment of plant height at various growth stages of the crop revealed that the treatment adhering to the recommended package of agricultural practices consistently exhibited the tallest plant height when compared to the other treatments across all growth stages. This trend also exhibited an increase in plant height with the progression of the crop's age, with measurements of 52.50 cm at 30 days after sowing (DAS), 199.02 cm at 60 DAS, 204.13 cm at 90 DAS, and 212.75 cm at the time of harvest. In contrast, the treatment that involved the application of both beejamrutha and jeevamrutha exhibited the lowest plant height, registering 180.18 cm at the harvest stage (as presented in Table 1).

The results concerning the number of leaves per plant indicated that the treatment following the recommended package of agricultural practices exhibited the highest number of leaves at 60 days after sowing (DAS) as the crop matured. In contrast, the treatment involving the application of beejamrutha and jeevamrutha recorded a significantly lower number of leaves, specifically 1.24 leaves at the time of harvest (as shown in Table 2).

Regarding plant dry matter at various growth stages, the treatment adhering to the recommended agricultural practices consistently reported the highest values compared to the other treatments. Notably, the dry matter content increased with the crop's progression in age, with measurements of 3.72 g/plant at 30 DAS, 15.48 g/plant at 60 DAS, 74.46 g/plant at 90 DAS, and 91.32 g/plant at 120 DAS. Conversely, the treatment involving beejamrutha and jeevamrutha application recorded the lowest dry matter content (as presented in Table 3).

The treatment utilizing fully organic manures exhibited superior soil microbial properties. However, when it came to growth and yield parameters of the crop, it performed comparably to the treatment following the recommended package of practices. These findings align with previous studies. Maheshbabu *et al*. (2008) [9] reported significantly higher plant height (49.40 cm), number of branches per plant (6.07) at harvest, number of leaves per plant (21.53), and leaf area index (5.08) at 60 DAS when they applied 40 : 80 : 25 kg NPK per ha and 5 tons per ha FYM. They emphasized the need for combining organic manures with inorganic fertilizers, which notably enhances nutrient availability, thereby positively affecting plant growth parameters. Similar results were also observed by Babalad (1999) [13] in soybean, underscoring the importance of organic application alongside inorganic fertilizers. Likewise, Lakshmi (2014) [12] demonstrated that plant growth factors like plant height, dry matter production (DMP), leaf area index (LAI), root length, and root-shoot ratio of pigeonpea significantly improved with the application of 125% of the recommended dose of N, subsoiling at 45 cm depth, TNAU micro-nutrient mixture at 12.5 kg/ha, and the incorporation of Daincha as a green manure at 45 days after sowing.

The results indicate that the plots adhering to the recommended package of agricultural practices exhibited the highest grain weight per ear at 31.00 grams. However, it's worth noting that this performance was comparable to treatments T_3 and T_4. In contrast, the plots treated with beejamrutha and jeevamrutha displayed the lowest grain weight per ear at 24.63 grams (Table 4).

Similarly, the maximum test weight was observed in the plots that followed the recommended package of practices, registering 31.50 grams, and it was also on par with treatments T_3 and T_4. The minimum test weight was recorded in the plots treated with beejamrutha and jeevamrutha, at 23.00 grams (Table 5).

Regarding stover yield, the treatment following the recommended package of practices achieved the highest stover yield at 5.06 tons per hectare. Treatments T_4, T_3, and T_2 also performed comparably in this regard. The lowest stover yield was documented in the plots treated with beejamrutha and jeevamrutha, with a yield of 3.14 tons per hectare (Table 6).

The plots managed in accordance with the recommended agricultural practices recorded the highest seed yield at 1568 kilograms per hectare, possibly attributed to increased nutrient availability. Notably, this performance was on par with the plots where solely chemical fertilizers were applied, managed with a 50% organic and 50% inorganic input combination. Conversely, the lowest seed yield was observed in the plots treated with liquid organic manures, specifically beejamrutha and jeevamrutha, with a yield of 1366 kilograms per hectare.

Table 1: Effect of different farming systems on plant height of sorghum at different stages

Treatment	Plant height (cm)			
	30 DAS	60 DAS	90 DAS	120 DAS
T_1 - Fully organic (75% NP)	43.45	182.75	186.50	188.00
T_2 - Fully organic (100% NP)	47.28	185.75	190.25	193.75
T_3 - Integrated (50% organic + 50% inorganic)	49.81	195.88	202.50	210.50
T_4 - Fully inorganic	50.50	196.75	201.00	210.25
T_5 - Recommended Package of Practices	52.40	199.02	204.13	212.75
T_6 - Beejamrutha + Jeevamrutha	39.01	165.50	170.50	180.18
S.Em±	1.614	1.470	1.278	1.007
C.D. at 5%	4.87	4.43	3.85	3.04

DAS – Days after sowing
* Values are average of four replications

Table 2: Effect of different farming systems on number of leaves per plant at different growth stages of sorghum

Treatment	Number of leaves/plant			
	30 DAS	60 DAS	90 DAS	120 DAS
T_1 - Fully organic (75% NP)	5.95	8.30	8.33	1.68
T_2 - Fully organic (100% NP)	6.23	8.48	8.40	1.76
T_3 - Integrated (50% organic + 50% inorganic)	6.48	9.05	8.58	1.93
T_4 - Fully inorganic	6.65	9.10	8.65	2.00
T_5 - Recommended Package of Practices	7.41	10.09	8.75	2.20
T_6 - Beejamrutha + Jeevamrutha	5.29	7.61	7.13	1.24
S.Em±	0.243	0.371	0.232	0.099
C.D. at 5%	0.73	1.12	0.70	0.30

DAS – Days after sowing
* Values are average of four replications

Table 3: Effect of different farming systems on the dry matter accumulation per plant of sorghum at different growth stages

Treatment	Dry matter accumulation/plant			
	30 DAS	60 DAS	90 DAS	120 DAS
T_1 - Fully organic (75% NP)	2.86	10.38	67.26	79.00
T_2 - Fully organic (100% NP)	2.88	12.06	68.62	84.39
T_3 - Integrated (50% organic + 50% inorganic)	3.54	15.18	72.83	88.14
T_4 - Fully inorganic	3.65	15.36	73.79	89.37
T_5 - Recommended Package of Practices	3.72	15.48	74.46	91.32
T_6 - Beejamrutha + Jeevamrutha	2.53	11.58	59.50	71.54
S.Em±	0.155	0.939	2.624	2.796
C.D. at 5%	0.47	2.83	7.91	8.43

DAS – Days after sowing
* Values are average of four replications

Table 4: Effect of different farming systems on Grain weight/ear of sorghum

Treatment	Grain weight/ear
T_1 - Fully organic (75% NP)	25.00
T_2 - Fully organic (100% NP)	25.25
T_3 - Integrated (50% organic + 50% inorganic)	29.00
T_4 - Fully inorganic	30.50
T_5 - Recommended Package of Practices	31.00
T_6 - Beejamrutha + Jeevamrutha	24.63
S.Em±	0.90
C.D. at 5%	2.71

DAS – Days after sowing
* Values are average of four replications

Table 5: Effect of different farming systems on the test weight (1000 seed weight) of sorghum

Treatment	Test weight (g 1000 grains^{-1})
T_1 - Fully organic (75% NP)	24.38
T_2 - Fully organic (100% NP)	25.88
T_3 - Integrated (50% organic + 50% inorganic)	29.00
T_4 - Fully inorganic	30.00
T_5 - Recommended Package of Practices	31.50
T_6 - Beejamrutha + Jeevamrutha	23.00
S.Em±	0.77
C.D. at 5%	2.33

DAS – Days after sowing
* Values are average of four replications

Table 6: Effect of different farming systems on the stover yield (t ha^{-1}) of sorghum

Treatment	Stover yield (t ha^{-1})
T_1 - Fully organic (75% NP)	3.46
T_2 - Fully organic (100% NP)	4.35
T_3 - Integrated (50% organic + 50% inorganic)	4.57
T_4 - Fully inorganic	4.76
T_5 - Recommended Package of Practices	5.06
T_6 -Beejamrutha + Jeevamrutha	3.14
S.Em±	0.24
C.D. at 5%	0.72

DAS – Days after sowing
* Values are average of four replications

Conclusion

In terms of growth parameters, including plant height (measuring 199.02 cm at 60 days after sowing), the number of leaves (10.09 per plant at 60 DAS), and dry matter accumulation (91.32 g at harvest), it is evident that the lowest values were consistently obtained in the treatment involving the application of beejamrutha and jeevamrutha.

Turning to yield parameters, such as grain weight per ear, test weight (1000 seed weight), stover yield, and grain yield, the treatment that adhered to the recommended package of agricultural practices outperformed the other treatments. Specifically, it recorded the highest values for these parameters, with grain weight per ear at 31.00 g, test weight (1000 seed weight) at 31.50 g, stover yield at 5.06 tons per hectare, and grain yield at 1568 kilograms per hectare. This superior performance can be attributed to the increased availability of nutrients. However, it's worth noting that treatments managed fully with inorganic fertilizers, those receiving a 50% combination of organic manures and inorganic fertilizers, and those solely utilizing 100% organic manures yielded comparable results. On the contrary, the treatment involving beejamrutha and jeevamrutha consistently produced the lowest yields and yield parameters.

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