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Influence of microbial consortia on growth and yield attributes of zucchini (*Cucurbeta pepo* L.)

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Abstract
This study was accomplished at reaserch field, College of Horticulture, VNMKV, Parbhani during *winter* season 2024. Experiment was laid out in Randomized Block Design with three replication and eight treatments. The application of microbial consortia resulted in significantly increase in growth, yield of zucchini. The plant height (30, 45, 60 DAS-22.53, 51.71, 75.60), number of leaves (30, 45, 60 DAS-8.87, 22.07, 33.47), no. of fruits (7.47), fruit length (21.53), TSS (3.65) and moisture percentage (94.56) were found significantly maximum in treatment no T_8: 100% NPK fertilizer + Application of microbial consortia as compared to control. The Significantly higher fruit yield (71.80 t ha^{-1}), dry matter (4.96 t ha^{-1}) in zucchini with treatment T_8 i.e. 100% NPK fertilizer + Application of microbial consortia found superior over other treatments. The results of this experiment suggested that the application of microbial consortia have a great potential to increase the growth and yield of zucchini (*Cucurbita pepo* L.).

Keywords: Zucchini, microbial consortia, NPK, fruit, growth, yield, hectare

Introduction
Soil microorganisms are fundamental to the functioning of terrestrial ecosystems as they play crucial roles in biogeochemical cycles including the decomposition of organic matter, mineral nutrient release and energy transformation (Zhou & Lei 2007) [19]. The growth and development of terrestrial plants are heavily influenced by the diverse microbial communities present in the soil. These microbes support plant health by producing growth-stimulating compounds, increasing nutrient availability, and providing defense against soil borne diseases (Ahemad & Kibret, 2014) [1]. The rhizosphere the narrow region of soil surrounding plant roots acts as a vital zone for nutrient and chemical exchange between plants and the soil environment (Peiffer *et al*. 2013) [11]. Microorganisms in this zone are often considered an extension of the plant's genetic potential due to their substantial impact on plant physiology and development. Root microbe interactions within the rhizosphere can also influence interactions among neighboring plants (Berendsen *et al*. 2012, Philippot *et al*. 2013) [2, 12]. Given their significant role in enhancing plant productivity, soil health and nutrient cycling, rhizosphere associated microorganisms have become a central focus in recent scientific investigations (Pii *et al*. 2015, Lv *et al*. 2019) [13, 7].
Zucchini (*Cucurbita pepo* L.) is a member of the Cucurbitaceae family and is commonly referred to as vegetable marrow or field pumpkin depending on the region. This crop is highly valued for its fast growth rate and substantial yield and it is among the few annual bush type cucurbits cultivated for human consumption. Originating from North America and northeastern Mexico, zucchini exhibits significant genetic variation and is well adapted to both tropical and subtropical environments. Harvesting typically occurs when the fruits are still in an immature physiological stage (Kathiravan *et al*. 2006) [5]. Zucchini fruits are available in a range of colors including green, light green and yellow. The plant displays a trailing growth habit with short internodes and can produce fruits in rapid succession. Botanically classified as a *pepo*, the fruit reaches harvestable maturity within 50 to 60 days of sowing. While zucchini is predominantly monoecious bearing both male and female flowers recent studies have reported the presence of androecious variants as well (Bhattacharjee *et al*. 2023) [3].

Materials and Methods

The experiment was conducted at the reaserch field, College of Horticulture, Vasantrao Naik Marathwada Krishi Vidyapeeth (VNMKV), Parbhani entitled with the Influence of microbial consortia on growth and yield attributes of zucchini (*Cucurbeta pepo* L.). The study adopted a Randomized Block Design with a plot size of 2.4 x 2.4 m^2. The crop geometry was maintained with a row-to-row spacing of 60 cm and plant-to-plant spacing of 60 cm. Zucchini is used as a test crop for experiment. Microbial consortia contains *Azotobacter*, *Bacillus megaterium* and *Fraturia aurantia* and applied @ 2.5 lit/ha. Experiment consists of three replication and eight treatments were T_1: Control (No microbial consortia + No NPK Fertilizer), T_2: Application of microbial consortia, T_3: 50% NPK fertilizer, T_4: 75% NPK fertilizer, T_5: 100% NPK fertilizer, T_6: 50% NPK fertilizer + Application of microbial consortia, T_7: 75% NPK fertilizer + Application of microbial consortia, T_8: 100% NPK fertilizer + Application of microbial consortia. The analysis followed to standardized procedures, with statistical evaluation and data interpretation carried out following the methodologies suggested by Panse and Sukhatme (1985) [9] in "*Statistical Methods for Agricultural Workers*". The total soluble solids (TSS) of fresh fruits were measured at room temperature using a digital refractometer. Fruit length and the number of fruits per plant were recorded at each harvest and mean values were calculated. Fruit yield and dry matter yield per hectare were estimated based on the corresponding yields obtained per plant for each treatment.

Results and Discussion

Plant Height

The results are presented in Table 1 and shown in fig 1 on plant height of zucchini is affected by microbial consortia. Plant height was measured at different growth stages (30 DAS, 45 DAS and 60 DAS) of zucchini crop. Significantly highest plant height at 30 DAS, 45 DAS and 60 DAS was recorded as 22.53 cm, 51.71 cm and 75.60 cm in the treatment T_8 (100% NPK fertilizer + Application of microbial consortia), which was at par with T_5 (100% NPK fertilizer). The lowest plant height was recorded in T_1 (absolute control) (16.85, 41.70, 60.47 cm). Similar results were reported by Sahu *et al*. (2022) [14] who observed combined application of inorganic chemical fertilizers with a biofertilizer consortium (*Azotobacter*, *Azospirillum*, and PSB) led to enhanced vegetative growth in cucumber. Similarly, Kumar *et al*. (2024) [6] found that seed inoculation of maize with zinc and iron solubilizing bacteria significantly improved plant height during both the tasseling and harvest stages.

Table 1: Effect of microbial consortia on plant height and no of leaves at different growth stages of the zucchini.

Treatments	Plant Height (cm)			Number of leaves		
	30 DAS	45 DAS	60 DAS	30 DAS	45 DAS	60 DAS
T_1: Control (No microbial consortia + No NPK Fertilizer)	16.85	41.70	60.47	5.33	15.33	24.20
T_2: Application of microbial consortia	18.13	42.48	61.45	6.07	16.77	25.20
T_3: 50% NPK fertilizer	19.20	40.05	62.33	6.33	16.80	25.33
T_4: 75% NPK fertilizer	19.43	43.91	65.00	7.40	18.33	25.47
T_5: 100% NPK fertilizer	21.47	48.60	73.07	8.20	21.00	31.33
T_6: 50% NPK fertilizer + Application of microbial consortia	19.61	46.20	63.08	6.80	17.87	26.07
T_7: 75% NPK fertilizer + Application of microbial consortia	21.20	48.15	71.03	7.80	20.00	30.53
T_8: 100% NPK fertilizer + Application of microbial consortia	22.53	51.71	75.60	8.87	22.07	33.47
SE(m)±	0.42	1.09	1.34	0.32	0.43	0.71
C.D at 5%	1.28	3.29	4.06	0.98	1.31	2.16

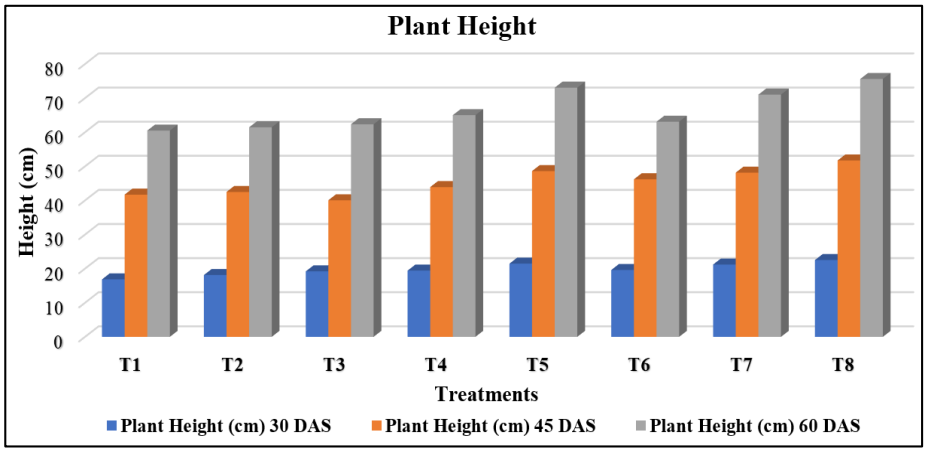

Fig 1: Effect of microbial consortia on plant height at different growth stages of the zucchini

Number of leaves per plant

No of leaves was measured at different growth stages (30, 45 and 60 DAS) of zucchini crop. The data presented in Table 1 and shown in fig 2 shows that the no. of leaves increased significantly due to microbial consortia over the control. Significantly highest no of leaves at 30, 45 and 60 DAS was recorded as 8.87, 22.07 and 33.47 in the treatment T_8 (100% NPK fertilizer + Application of microbial consortia) which was at par with T_5 (100% NPK fertilizer) with values of 8.20, 21.00 and 31.33. The lowest number of leaves were (5.33, 15.33 and 24.20) recorded in treatment T_1 (control). Madhukar *et al*. (2021) [8] found similar results that the number of leaves, plant height and other physiological parameters were significantly increased by the biofertilizer inoculation.

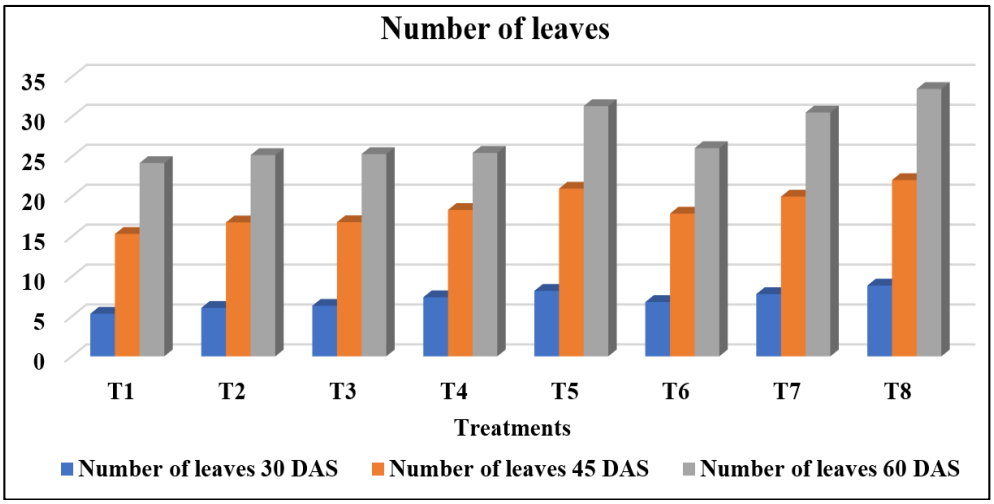

Fig 2: Effect of microbial consortia on plant height at different growth stages of the zucchini

Fruit Length

The data showing fruit length of zucchini is significantly affected due to application of microbial consortia as presented in Table 2. Statistically maximum fruit length was recorded in T_8 (100% NPK fertilizer + Application of microbial consortia) with fruit length of 21.53 cm which was at par with treatment T_5, T_7, T_6, T_4, T_3. With values of 21.10 cm, 20.67, 20.17, 19.13 and 20.13 cm. The lowest fruit length was recorded in T_1 (absolute control). Tomar *et al*. (2024) [18] found similar results that the application of chemical fertilizer, vermicompost and *Azospirillum* @ 1 kg/ha was the most effective in increasing fruit length (40.11 cm), fruit diameter (7.51 cm) as compared to other treatments.

Table 2: Effect of microbial consortia on number of fruits and fruit length of the zucchini.

Treatments	Number of fruits (per plant)	Fruit Length (cm)
T_1: Control (No microbial consortia + No NPK Fertilizer)	4.73	19.60
T_2: Application of microbial consortia	5.40	19.80
T_3: 50% NPK fertilizer	6.13	20.13
T_4: 75% NPK fertilizer	6.33	19.13
T_5: 100% NPK fertilizer	7.33	21.10
T_6: 50% NPK fertilizer + Application of microbial consortia	6.07	20.27
T_7: 75% NPK fertilizer + Application of microbial consortia	6.80	20.67
T_8: 100% NPK fertilizer + Application of microbial consortia	7.47	21.53
SE(m)±	0.12	0.88
C.D at 5%	0.37	2.66

Number of Fruits per plant

Results noticed in Table 2 which is related to number of fruits per plant in zucchini. Highest number of fruits was recorded in the treatment T_8 consisting of (100% NPK fertilizer + Application of microbial consortia) with 7.47 fruits per plant which was at par with T_5 contains (100% NPK fertilizer) with 7.33 fruits per plant. Lowest number of fruits per plant were recorded in treatment no T_1 (Absolute control) with 4.73 fruits per plant. Similar findings found by Kalita *et al*. (2023) [4] that the application of organic nutrients and microbial consortia (*Azotobacter* and PSB) significantly increase the growth, no of fruits per vein and quality of cucumber. Sonkamble *et al*. (2022) [16] found that number of fruits per vine were found maximum with Vermicompost @ 13.5 t ha^{-1} + soil application of *Azotobacter* + PSB @ 5 kg ha^{-1} as compared to other treatments in cucumber.

Fruit yield and Dry matter yield

Fruit yield and Dry matter yield (t ha^{-1}) shown in Table. 3 and in fig 3. Yield was affected significantly due to different treatments of microbial consortia in combination with RDF (inorganic fertilizers). The application of T_8: 100% NPK fertilizer + Application of microbial consortia recorded significantly highest fruit yield (71.80 t ha^{-1}.) and dry matter yield (41.96 t ha^{-1}) and this treatment was found statistically superior than all the treatments in zucchini. The lowest fruit yield and dry matter yield of zucchini was recorded by T1 absolute control (45.62 t ha^{-1}), (3.86 t ha^{-1}). Pawar *et al*. (2017) [10] found that the combined application of *Trichoderma viride* and zinc solubilizing microbial inoculant with RDF resulted in increase in dry matter yield of cotton. Kalita *et al*. (2023) [4] founded that the application of organic nutrients and microbial consortia (*Azotobacter* and PSB) in various combinations, significantly improved the growth, yield, cucumber.

Table 3: Effect of microbial consortia on fruit yield and dry matter yield of zucchini.

Treatments	Yield/hector (t ha^{-1})	Dry Matter (t ha^{-1})	TSS (ºBrix)	Moisture%
T_1: Control (No microbial consortia + No NPK Fertilizer)	45.62	3.86	2.53	91.04
T_2: Application of microbial consortia	51.57	4.03	2.57	91.18
T_3: 50% NPK fertilizer	52.18	4.24	2.67	91.91
T_4: 75% NPK fertilizer	56.02	4.49	2.68	92.17
T_5: 100% NPK fertilizer	64.78	4.78	3.03	93.64
T_6: 50% NPK fertilizer + Application of microbial consortia	53.77	4.36	2.86	92.53
T_7: 75% NPK fertilizer + Application of microbial consortia	62.06	4.65	3.23	93.63
T_8: 100% NPK fertilizer + Application of microbial consortia	71.80	4.96	3.65	94.56
SE(m)±	1.29	0.07	0.25	0.55
C.D at 5%	3.91	0.21	0.77	1.66

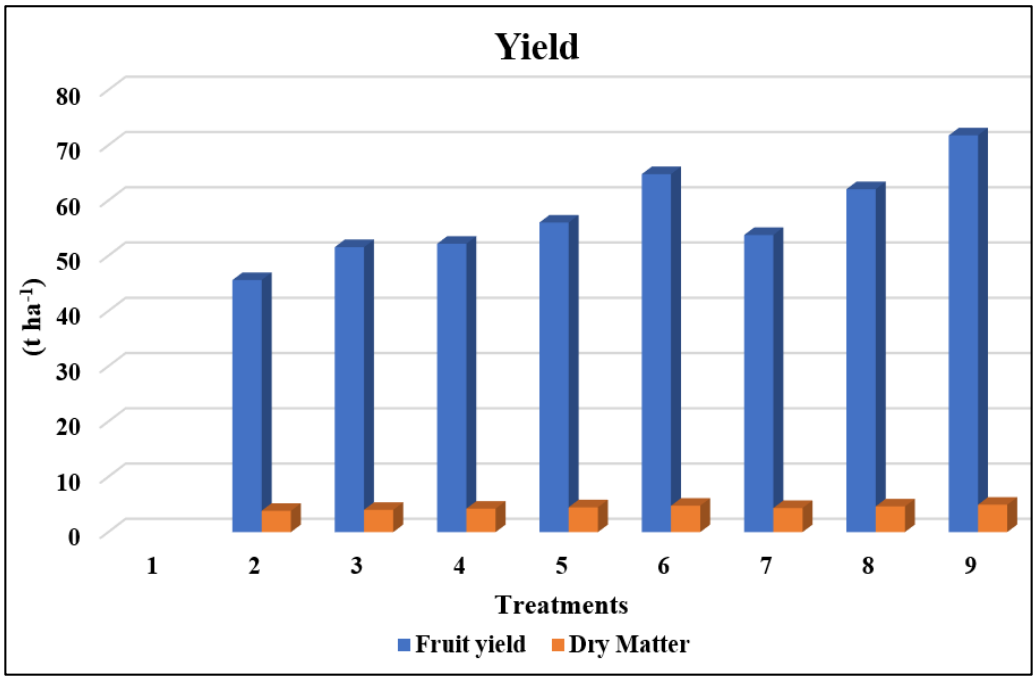

Fig 3: Effect of microbial consortia on fruit yield and dry matter yield of zucchini.

TSS and Moisture percentage

TSS and moisture percentage found highest in treatment T_8: 100% NPK fertilizer + Application of microbial consortia with values of 3.65 ^{O}Brix and 94.56% and this treatment was found at par with T_5 (100% NPK fertilizer) with values of 3.03 ^{O}Brix and 93.64% as shown in Table 3. The lowest TSS and moisture percentage of zucchini was recorded by T1 absolute control (2.53, 91.04%). Thriveni *et al*. (2015) [17] This study observed that plants treated with 100% NPK, vermicompost and biofertilizers exhibited significant benefits as higher amount of total soluble solids (TSS) (2.10°Brix) of bitter gourd. Similar findings were also found by Sekhar *et al*. (2025) [15] founded highest percentage of TSS with treatments containing microbial consortia.

Conclusion

From this study it can be concluded that the application of microbial consortia with RDF had ability to increase the growth and yield of crop. The growth attributes of zucchini plant increase with treatment receiving the 100% NPK fertilizer + Application of microbial consortia. Similarly, fruit yield and dry matter yield the same treatment 100% NPK fertilizer + Application of microbial consortia performed significantly better Thus, it may be concluded that application of microbial consortia with RDF may be used for improving quality. growth attributes and yield attributes of zucchini crop.

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