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Effect of organic manures and biofertilizers on growth parameters of lemongrass (*Cymbopogon flexuosus* N.)

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Abstract
The present field experiment entitled "Effect of organic manures and biofertilizers on growth and yield of lemongrass (*Cymbopogon flexuosus* N.)" was conducted during the year 2025–2026 at Nursery No. 4, College of Horticulture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli. The experiment was laid out in (RBD) comprising eleven treatments with three replications. The results revealed significant differences among the treatments for all the growth and yield parameters. Among the treatment combinations, T_{10} (Vermicompost @ 5 t ha^{-1} + FYM @ 10 t ha^{-1} + *Azotobacter* @ 12 kg ha^{-1} + *Azospirillum* @ 12 kg ha^{-1}) recorded superior performance with respect to plant height (158.27 cm), number of leaves (293.53), number of tillers (55.53), leaf length (119.73 cm) at 180 days after transplanting (DAT). Thus, the integrated application of vermicompost, FYM, *Azotobacter*, and *Azospirillum* as was found to be the most effective nutrient management practice for enhancing the growth and herbage yield of lemongrass.

Keywords: Lemongrass, Growth, Organic manures, Biofertilizers

Introduction

Lemongrass (*Cymbopogon flexuosus* N.) is an aromatic grass belonging to the family Poaceae. It is native to India and is widely distributed in semi-temperate and tropical regions of Asia, America and Africa. The major chemical constituents present in the roots, stems and leaves include geraniol (30.5%), citronellol (24.1%), neral (10.3%), and geranial (13.6%). In India, lemongrass is cultivated along Western Ghats (Maharashtra, Kerala), *Karnataka* and Tamil Nadu states besides foot-hills of Arunachal Pradesh and Sikkim. The total cultivation area is approximately 4000 ha, yielding about 250 tonnes annually. Remarkably, lemongrass accounts for nearly 61 % of the area dedicated to aromatic crop cultivation in India. Lemongrass responded very positively to the application of organic manure. Vermicompost, farm yard manure and green manuring were found to be effective to enhance the root formation, elongation of stem and production of biomass in lemongrass. Studies have also been reported that bio-fertilizer such as Azotobacter spp. offers an attractive way to replace chemical fertilizer, resulting a significant increase in plant height, root length, and dry matter production (Mirzaei *et al.*, 2020) [1].

2. Materials and Methods

The experiment was conducted at the Department of Plantation, Spices, Medicinal and Aromatic Crops, College of Horticulture, Dapoli, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Dist. Ratnagiri (M.S.). The study was laid out in a Randomized Block Design (RBD) comprising 11 treatments with three replications. The experimental layout consisted of 33 plots, with 11 plots in each replication and 30 plants per plot, accounting for 990 plants in total. Healthy rooted slips of lemongrass cv. Krishna were planted at a spacing of 60 × 60 cm in plots measuring 3.6 × 3.0 m. Vermicompost and farmyard manure (FYM), along with the biofertilizers *Azotobacter* and *Azospirillum*, were applied as basal inputs as per the respective treatment combinations (Table 1).

To assess the individual and combined effects of organic manures and biofertilizers on the vegetative growth of lemongrass, ten healthy plants were randomly selected from each treatment in every replication and used for recording observations. The recorded data were subjected to analysis of variance (ANOVA) following the standard statistical procedure described by Panse *et al.* (1995) [2].

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Table 1. Treatment details

Code	Treatments
T_1	Recommended dose of fertilizer (100:45:30 NPK kg/ha)
T_2	Vermicompost @10 t/ha
T_3	Vermicompost @10 t/ha + A*zotobacter* @12 kg/ha
T_4	Vermicompost @10 t/ha) + *Azospirillum* @12 kg/ha
T_5	Vermicompost @5 t/ha + FYM @10 t/ha + *Azospirillum* @10 kg/ha
T_6	Vermicompost @5 t/ha + FYM @10t/ ha + *Azospirillum* @12 kg/ha
T_7	Vermicompost @2.5 t/ha + FYM @5 t/ha + *Azospirillum* @10 kg/ha
T_8	Vermicompost @2.5 t/ha + FYM @5 t/ha + *Azospirillum* @12 kg/ha
T_9	Vermicompost @2.5 t/ha + FYM @5 t/ha + *Azotobacter* @10 kg/ha + *Azospirillum* @10 kg/ha
T_{10}	Vermicompost @5 t/ha + FYM @10 t/ha + *Azotobacter* @12 kg/ha + *Azospirillum* @12 kg/ha
T_{11}	Absolute Control

3. Results and Discussion

The growth and yield of lemongrass are greatly influenced by the application of organic manures and biofertilizers, as they provide essential nutrients required for vital physiological and biochemical processes. Adequate nutrient availability enhances growth traits such as plant height, number of leaves and number of tillers, which subsequently contribute to greater herbage yield. Integrated application of organic manures and biofertilizers improves nutrient availability and uptake, promotes vigorous vegetative growth and supports enhanced herbage production, making balanced nutrient management important for improving lemongrass productivity.

Plant height (cm)

Plant height is one of the most important growth parameters indicating the vegetative vigour and overall growth performance of lemongrass. The data presented in Table 2 revealed significant differences among the treatments at 180 DAT and 210 DAT, indicating the influence of different combinations of organic manures and biofertilizers on plant height of lemongrass.

The treatment T_{10} comprising VC (5 t/ha) + FYM (10 t/ha) + *Azotobacter* (12 kg/ha) + *Azospirillum* (12 kg/ha) consistently recorded the highest plant height at 120 DAT and 180 DAT. The highest plant height of 173.63 and 158.27 cm was recorded in treatment T_{10} at 120 DAT and 180 DAT, respectively, whereas the lowest plant height of 145.61 and 119.15 cm was registered in treatment T_{11} (absolute control) at 120 DAT and 180 DAT, respectively. These findings align with the findings by Punam *et al.* (2012) [3], Anjali (2019) [4] and Attri (2021) [5].

Table 2. Effect of organic manures and biofertilizers on plant height (cm) of lemongrass

Sr.No.	Treatment detail	Plant height (cm)	
		120 DAT	180 DAT
T_1	RDF (100:45:30 NPK kg/ha)	157.57	132.77
T_2	VC@10t/ha	132.00	95.57
T_3	VC@10t/ha+*Azotobacter*@12 kg/ha	134.70	97.70
T_4	VC@10t/ha+*Azospirillum*12 kg/ha	138.67	101.57
T_5	VC@5t/ha+FYM@10t/ha+*Azospirillum*@10 kg/ha	151.40	124.40
T_6	VC@5t/ha+FYM@10t/ha+*Azopsirillum*@12 kg/ha	152.63	127.47
T_7	VC@2.5t/ha+FYM@5t/ha+*Azopsirillum*@10 kg/ha	137.33	115.30
T_8	VC@2.5t/ha+FYM@5t/ha+*Azopsirillum*@12 kg/ha	136.23	117.77
T_9	VC@2.5t/ha+FYM@5t/ha+*Azotobacter*@10 kg/ha+*Azospirillum*@10 kg/ha	169.07	146.83
T_{10}	VC@5t/ha+FYM@10t/ha+*Azotobacter*@12 kg/ha+*Azospirillum*@12 kg/ha	173.63	158.27
T_{11}	Absolute Control	118.43	93.00
	Mean	145.61	119.15
	Range	118.43-173.63	93.00-158.27
	S.Em. (±)	2.76	0.63
	C.D.@ 5%	8.14	1.86
	F test	SIG	SIG

2. Number of leaves per plant

The number of leaves per plant is an important morphological trait indicating the vegetative vigour and growth of lemongrass. A greater number of leaves increases the photosynthetic surface area and enhances assimilate production. It also reflects better nutrient uptake and physiological activity, thereby contributing to higher herbage yield and essential oil production.

The number of leaves increased progressively and significantly among the treatments receiving organic manures and biofertilizers during the experiment, with the data presented in Table 3. The significantly highest number of leaves was recorded in treatment T_{10}, comprising VC @ 5 t/ha + FYM @ 10 t/ha + *Azotobacter* @ 12 kg/ha + *Azospirillum* @ 12 kg/ha, with values of 251.57 and 293.53 at 120 DAT and 180 DAT, respectively. The treatment T_{10} was significantly superior to all other treatments. In contrast, the lowest number of leaves, 143.67 and 170.17 at 120 DAT and 180 DAT, respectively, was recorded in treatment T_{11} (absolute control). These findings are supported by Shimi (2011) [6] in vetiver; Anjali (2019) [4] and Attri (2021) [5] in lemongrass; Shreya (2022) [7] in lemongrass; Dora *et al.* (2024) [8] in citronella.

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Table 3. Effect of organic manures and biofertilizers on number of leaves of lemongrass

Sr. No.	Treatment detail	Number of leaves	
		120 DAT	180 DAT
T_1	RDF (100:45:30 NPK kg/ha)	238.10	265.13
T_2	VC@10t/ha	178.37	198.33
T_3	VC@10t/ha+*Azotobacter*@12 kg/ha	185.30	217.07
T_4	VC@10t/ha+*Azospirillum*12 kg/ha	190.70	221.23
T_5	VC@5t/ha+FYM@10t/ha+*Azospirillum*@10 kg/ha	222.93	248.43
T_6	VC@5t/ha+FYM@10t/ha+*Azopsirillum*@12 kg/ha	227.73	252.47
T_7	VC@2.5t/ha+FYM@5t/ha+*Azopsirillum*@10 kg/ha	202.53	232.37
T_8	VC@2.5t/ha+FYM@5t/ha+*Azopsirillum*@12 kg/ha	205.77	239.57
T_9	VC@2.5t/ha+FYM@5t/ha+*Azotobacter*@10 kg/ha+*Azospirillum*@10 kg/ha	241.83	283.13
T_{10}	VC@5t/ha+FYM@10t/ha+*Azotobacter*@12 kg/ha+*Azospirillum*@12 kg/ha	251.57	293.53
T_{11}	Absolute Control	143.67	170.17
	Mean	208.05	238.31
	Range	143.67-251.57	170.17-293.53
	S.Em. (±)	1.35	0.98
	C.D.@ 5%	3.98	2.89
	F test	SIG	SIG

3. Number of tillers per plant

Number of tillers per plant is an important growth parameter of lemongrass and is closely associated with vegetative growth and herbage productivity. The number of tillers increased progressively and significantly among the treatments involving organic manures and biofertilizers at 120 DAT and 180 DAT, with the data presented in Table 4. The significantly highest number of tillers was recorded in treatment T_{10}, comprising VC @ 5 t/ha + FYM @ 10 t/ha + *Azotobacter* @ 12 kg/ha + *Azospirillum* @ 12 kg/ha, with values of 45.67 and 55.53 at 120 DAT and 180 DAT, respectively. The treatment T_{10} was significantly superior to all other treatments. Meanwhile the lowest number of tillers, 29.63 and 32.20 at 120 DAT and 180 DAT, respectively, was recorded in treatment T_{11} (absolute control). Similar results were reported by Punam *et al.* (2012) [3], Shahi *et al.* (2012) [9], El-Gendy *et al*. (2013, Anjali (2019) [4], Attri (2021) [5] in lemongrass and Dora *et al.* (2024) [8] in citronella.

Table 4. Effect of organic manures and biofertilizers on number of tillers of lemongrass

Sr. No.	Treatment detail	Number of tillers	
		120 DAT	180 DAT
T_1	RDF (100:45:30 NPK kg/ha)	42.63	49.73
T_2	VC@10t/ha	31.10	35.93
T_3	VC@10t/ha+*Azotobacter*@12 kg/ha	32.37	37.23
T_4	VC@10t/ha+*Azospirillum*12 kg/ha	33.70	39.17
T_5	VC@5t/ha+FYM@10t/ha+*Azospirillum*@10 kg/ha	35.77	44.10
T_6	VC@5t/ha+FYM@10t/ha+*Azopsirillum*@12 kg/ha	36.77	45.30
T_7	VC@2.5t/ha+FYM@5t/ha+*Azopsirillum*@10 kg/ha	34.00	41.13
T_8	VC@2.5t/ha+FYM@5t/ha+*Azopsirillum*@12 kg/ha	34.70	41.97
T_9	VC@2.5t/ha+FYM@5t/ha+*Azotobacter*@10 kg/ha+*Azospirillum*@10 kg/ha	40.40	52.83
T_{10}	VC@5t/ha+FYM@10t/ha+*Azotobacter*@12 kg/ha+*Azospirillum*@12 kg/ha	45.67	55.53
T_{11}	Absolute Control	29.63	32.20
	Mean	36.07	43.19
	Range	29.63-45.67	32.20-55.53
	S.Em. (±)	0.58	0.62
	C.D.@ 5%	1.71	1.82
	F test	SIG	SIG

4. Leaf length (cm)

Leaf length is an important growth parameter in lemongrass, as it contributes to photosynthetic activity and biomass production. The application of organic manures and biofertilizers resulted in a progressive increase in leaf length (cm) of lemongrass. The data pertaining to leaf length (cm) at 120 DAT and 180 DAT showed significant differences among the various treatments, as presented in Table 5. Among the treatments, T_{10}, comprising VC @ 5 t/ha + FYM @ 10 t/ha + *Azotobacter* @ 12 kg/ha + *Azospirillum* @ 12 kg/ha, recorded the significantly highest leaf length of 145.97 and 119.73 cm at 120 DAT and 180 DAT, respectively. Whereas, the minimum leaf length of 83.50 and 88.20 cm at 120 DAT and 180 DAT, respectively, was recorded in treatment T_{11} (absolute control). Similar results were reported by Punam *et al.* (2012) [3], Shahi *et al.* (2012) [9], El-Gendy *et al*. (2013, Anjali (2019) [4], Attri (2021) [5] in lemongrass and Dora *et al.* (2024) [8] in citronella.

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Table 5. Effect of organic manures and biofertilizers on leaf length (cm) of lemongrass

Sr. No.	Treatment detail	Leaf length (cm)	
		120 DAT	180 DAT
T_1	RDF (100:45:30 NPK kg/ha)	125.13	102.93
T_2	VC@10t/ha	94.48	88.23
T_3	VC@10t/ha+*Azotobacter*@12 kg/ha	96.80	87.30
T_4	VC@10t/ha+*Azospirillum*12 kg/ha	103.53	97.57
T_5	VC@5t/ha+FYM@10t/ha+*Azospirillum*@10 kg/ha	113.90	106.33
T_6	VC@5t/ha+FYM@10t/ha+*Azopsirillum*@12 kg/ha	120.87	105.97
T_7	VC@2.5t/ha+FYM@5t/ha+*Azopsirillum*@10 kg/ha	104.73	102.33
T_8	VC@2.5t/ha+FYM@5t/ha+*Azopsirillum*@12 kg/ha	107.13	104.93
T_9	VC@2.5t/ha+FYM@5t/ha+*Azotobacter*@10 kg/ha+*Azospirillum*@10 kg/ha	137.47	113.13
T_{10}	VC@5t/ha+FYM@10t/ha+*Azotobacter*@12 kg/ha+*Azospirillum*@12 kg/ha	145.97	119.73
T_{11}	Absolute Control	83.50	88.20
	Mean	112.14	101.52
	Range	83.50-145.97	88.20-119.73
	S.Em. (±)	2.60	2.82
	C.D.@ 5%	7.67	8.33
	F test	SIG	SIG

Conclusion

The study concluded that the integrated application of organic manures and biofertilizers significantly influenced the growth and yield of lemongrass. Among the treatments, T_{10} comprising VC (5 t/ha) + FYM (10 t/ha) + *Azotobacter* (12 kg/ha) + *Azospirillum* (12 kg/ha) recorded superior performance with respect to plant height, number of leaves, tiller production, leaf length. The combined application of vermicompost, FYM and biofertilizers improved nutrient availability and soil conditions, which supported better crop growth and productivity. T_{10} also recorded favourable economic returns. Hence, the integrated use of organic manures and biofertilizers can be considered an effective, sustainable and eco-friendly nutrient management approach for enhancing the growth, yield of lemongrass.

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