Effect of Organic Manures on Growth and Yield attributes of Citronella Java (*Cymbopogon winterianus*) under Moringa*(Moringa oleifera)*based agroforestry and open-field systems

Abstract

A field investigation was conducted to evaluate the effects of farmyard manure (FYM) vermicompost and neem-cake on the growth and yield of citronella java (*Cymbopogon winterianus*) under moringa-based agroforestry and open-field systems during 2022 and 2023. Growth parameters like plant height, number of leaves per plant and number of tillers per plant and yield attributing parameters like fresh weight (kg ha^{-1}), Dry Weight (kg ha^{-1}) and total herbage yield (t ha^{-1}). The findings highlight the superior performance of the treatment combining FYM, vermicompost, and neem cake (T13), particularly in shaded conditions provided by moringa trees, which created a favourable microclimate. This study demonstrates the significant role of integrated organic amendments in enhancing citronella productivity while fostering environmental sustainability. The findings offer valuable insights for farmers and policymakers, advocating for the adoption of sustainable practices in aromatic crop production through agroforestry systems

Keywords: *Agroforestry, Citronella Java, Moringa, and Organic manures*

Introduction

Sustainable agriculture seeks to balance productivity with environmental stewardship by promoting practices that enhance soil health, biodiversity, and economic viability. Agroforestry, the integration of trees with crops or livestock, is increasingly recognized as a sustainable farming system due to its ability to improve soil fertility, optimize resource use, and provide environmental benefits such as carbon sequestration and microclimate regulation (Nair, 2011). In such systems, medicinal and aromatic plants like Citronella Java (*Cymbopogon winterianus*), known for its high-value essential oil used in the cosmetic, pharmaceutical, and insect-repellent industries, offer significant economic potential (Singh *et al.*, 2015).

The integration of organic amendments like farmyard manure (FYM), vermicompost, and neem cake in agroforestry systems further enhances soil health by providing essential nutrients, improving soil structure, and stimulating beneficial microbial activity(Ram et al., 1998; Ruswandi et al., 2023). In combination with the resource benefits provided by tree species, such as Moringa oleifera, these organic inputs can create a synergistic environment that supports optimal growth conditions for crops like citronella (Singh et al., 2015; Prakasa Rao & Singh, 1991). Moringa oleifera Lam is an important tree whose pods, leaves, flowers, barks and roots have been advocated for traditional and medicinal uses for thousands of years and native to India (Yadav *et al.*, 2021, Yadav *et al.*, 2022, Yadav *et al.*, 2023, Yadav *et al.*, 2024).

Despite the recognized benefits of organic inputs and agroforestry systems, the specific effects of FYM, vermicompost, and neem cake on citronella's growth and yield under both shaded (moringa-based) and open-field conditions remain underexplored. Understanding these interactions is critical to optimizing the productivity and sustainability of citronella cultivation, particularly for resource-limited farmers seeking to adopt eco-friendly practices(Singh et al., 1998).

Although previous studies have highlighted the benefits of organic inputs and agroforestry systems in other crops, there is a lack of detailed research on how specific organic amendments, such as FYM, vermicompost, and neem cake, influence the growth and yield of citronella in shaded versus open-field conditions(Nandapure et al., 2020). This knowledge gap is particularly important for optimizing citronella cultivation, as farmers increasingly seek sustainable practices to improve productivity and minimize environmental impact

Materials and Methods

The study was conducted during the Kharif season of 2022-2023 at the central research farm of the Department of Agroforestry and Silviculture, College of Forestry, Sam Higginbottom University of Agriculture, Technology, and Science. The type of soil texture is sandy loam (Reddy *et al.,* 2021) The experimental site was in the Prayagraj district, positioned at a geographical latitude and longitude of 250 40’ N and 810 85’ E, with an altitude of 92 meters above sea level. This site was situated near the Yamuna Riverbank in the east and the indalpur village in the north.

The present study examined the effects of FYM, vermicompost, and neem cake on the growth and yield attributes of citronella, using a Randomized Block Design (RBD) to account for spatial variations and assess the independent and combined influences of these factors on citronella yield.Farmyard Manure (FYM) application was implemented 12 t ha^{-1} at distinct rates: 25%, 33.3%, 50%, 75%, and 100%**.** Vermicompost (VC) were applied 6t ha^{-1} at different rates: 25%, 33.3%, 50%, 75%, and 100%**.** Neem-cake (NC) were incorporated 4 t ha^{-1} at different rates: 25%, 33.3%, 50%, 75%, and 100%**.** With following treatment combinations T_0 -Control, T_1- 50% FYM+50% Neem cake, T_2- 50% FYM+50% Vermicompost, T_3- 50%NC+50% Vermicompost, T_4- 75% FYM+25% Vermicompost, T_5- 75% FYM+25% NC, T_6- 75% NC+25% Vermicompost, T_7- 75% NC+25% FYM, T_8- 75% VC+25% NC, T_9- 75% VC+25% FYM, T_{10}- 100% FYM, T_{11}- 100% Vermicompost, T_{12}- 100% Neem-cake, T_{13}- 33.3% FYM+33.3% VC+33.3% NC. Citronella, a perennial grass, is propagated vegetatively using slips, as it does not produce viable seeds. Mature clumps, typically yielding about 50 slips after a year, are carefully divided into slips with 1-3 tillers each. Before planting, fibrous roots and leaves are clipped off the slips. Planting was conducted in July using slips sourced from CIMAP, Lucknow, Uttar Pradesh. The field was ploughed 2-3 times and divided into 2 x 2 meter plots with irrigation channels beside each plot. Organic manures—FYM, vermicompost, and neem cake—were evenly applied across the field. Slips were planted vertically at 60 cm x 60 cm spacing with a 90 cm x 90 cm gap between rows, at a depth of 10 cm. Proper drainage was ensured to avoid waterlogging, which can stunt growth, and planting on slopes was preferred. If rain did not occur within 24 hours of planting, irrigation was provided immediately.

The growth attributes of the citronella were quantified at various time intervals following planting, specifically at 30,60, 90, 120, 150 and 180 DAS (Days after sowing), encompassing parameters such as plant height, no. of leaves per plant and no. of tiller per plant and yield attributes of the citronella were observed such as fresh weight of plant, dry weight of plant and total herbage yield during the consecutive years of 2022 and 2023.

The experimental data were analysed using the Randomized Block Design (RBD) to assess the effects of organic manures (FYM, vermicompost, and neem cake) and cultivation conditions (moringa-based agroforestry and open-field systems) on the growth and yield attributes of citronella (*Cymbopogon winterianus*).Analysis of variance (ANOVA) was performed to determine the significance of differences among treatments, with the main factors being Cultivation condition (shaded vs. open field). Organic manure type. Interaction between cultivation condition and manure type. The treatment means were compared using the least significant difference (LSD) test at a 5% level of significance. Statistical analyses were performed using SPSS. This approach ensured robust evaluation of treatment effects and their interactions on the measured parameters.

Results and Discussion:

<u>Plant height</u>

The effect of citronella treatments on plant height across different growth stages (30, 60, 90, 120, 150, and 180 DAS) under both open and shaded conditions is presented in Tables 1 and 2.Treatment T13 consistently resulted in the highest plant height at all stages, highlighting its superior efficacy in promoting growth. At 30 DAS, T13 showed a marked improvement over the control (T0), indicating its ability to stimulate early-stage growth. By 60 and 90 DAS, the advantage of T13 became more pronounced, particularly under shaded conditions, which generally supported greater growth compared to open environments. Treatments such as T11 and T12 also demonstrated notable results, though they fell short of T13's performance.

At 120 DAS, the growth pattern remained consistent, with T13 continuing to outperform, while other treatments like T5, T6, and T9 exhibited competitive growth. By 150 DAS, plant heights across treatments stabilized, but T13 maintained its leading position, reflecting its sustained effectiveness in later growth stages. Finally, at 180 DAS, the height gains began to plateau, but T13's dominance persisted under both open and shaded conditions, significantly outperforming the control and other treatments.

Overall, the application of organic manure treatments positively influenced plant height, with T13 emerging as the most effective treatment throughout the study period. The shaded conditions further enhanced the growth, suggesting that citronella responds well to partial shade, which likely optimizes its physiological processes for height gain. These results underscore the importance of treatment selection and environmental conditions in maximizing citronella growth.

Number of leaves/Plant

The effect of citronella treatments on the number of leaves per plant was assessed across various growth stages (30, 60, 90, 120, 150, and 180 DAS) under open and shaded conditions. Treatment T13 consistently recorded the highest leaf count across all stages, indicating its superior efficacy in enhancing vegetative growth. At 30 DAS, T13 significantly outperformed the control (T0), reflecting its ability to promote early leaf initiation and development. By 60 and 90 DAS, the trend became more pronounced, with shaded conditions generally resulting in higher leaf numbers compared to open conditions, suggesting enhanced adaptability and growth potential under reduced light intensity. Treatments T11 and T12 also exhibited competitive performance during this period, albeit at slightly lower levels than T13.

At 120 DAS, T13 showed superior performance, with significant increases in leaf production under both shaded and open conditions. Treatments T5, T6, and T9 also exhibited improved leaf counts, contributing to vegetative biomass. By 150 DAS, the number of leaves had substantially increased across all treatments, with T13 maintaining its lead. Shaded conditions continued to promote higher leaf production, highlighting citronella's preference for partial shade. At 180 DAS, leaf production peaked, with T13 achieving the highest leaf count in both environments, significantly outperforming the control and other treatments.

The statistical analysis confirmed that the differences among treatments were significant (F-test: Significant) at all stages, demonstrating the efficacy of the applied organic manures. The consistent performance of T13 across all growth stages highlights its potential for maximizing foliage production, particularly under shaded conditions. These findings underscore the critical role of treatment selection and environmental optimization in enhancing the vegetative performance of citronella.

Number of Tiller/Plant

The number of tillers per plant in citronella was assessed at different growth stages (30, 60, 90, 120, 150, and 180 DAS) under open and shaded conditions. Treatment T13 consistently recorded the highest tiller count, demonstrating its superior ability to enhance tillering throughout the growth period. At 30 DAS, T13 significantly outperformed the control (T0), reflecting its effectiveness in promoting early tiller initiation. By 60 and 90 DAS, the tiller count showed a marked increase across all treatments, with shaded conditions generally producing higher tiller numbers compared to open conditions. Other treatments, such as T11 and T12, also exhibited notable performance, albeit less pronounced than T13.

At 120 DAS, T13 continued to lead in tiller production under both open and shaded environments, while treatments such as T5, T6, and T9 also contributed substantially to tiller growth. By 150 DAS, the trend of increasing tiller numbers remained consistent, with T13 maintaining its dominance, particularly in shaded conditions. At 180 DAS, tiller production reached its peak, with T13 achieving the maximum tiller count under both conditions, significantly surpassing the control (T0) and other treatments.

Statistical analysis indicated that the differences among treatments were significant (F-test: significant) at all growth stages, confirming the efficacy of the treatments in enhancing tillering. The superior performance of T13 across all stages underscores its potential for maximizing tiller production, especially in shaded environments, which consistently supported better tillering. These results highlight the importance of organic manure treatments and environmental optimization in promoting vegetative propagation in citronella.

<u>Fresh Weight</u>

The effect of different organic manures on the fresh weight of citronella java plants at harvest under open and shaded conditions in a moringa-based agroforestry system was significant. Across the treatments, T13 consistently recorded the highest fresh weight, indicating its superior ability to enhance biomass accumulation.

Under shaded conditions, the fresh weight was generally higher compared to open conditions, reflecting the favourable microenvironment created by the moringa canopy. Specifically, T13 achieved the maximum fresh weight in both conditions, demonstrating its effectiveness in optimizing plant growth in agroforestry settings. Treatments T11 and T12 also showed competitive results, although they were outperformed by T13.

The statistical analysis (F-test: Significant) confirmed that differences among treatments were substantial. These results suggest that the integration of organic manures, particularly T13, within moringa-based agroforestry systems can significantly improve the biomass productivity of citronella java, making it a promising strategy for sustainable agricultural practices.

Dry Weight

The application of different organic manures significantly influenced the dry weight of citronella java plants at harvest under open and shaded conditions within a moringa-based agroforestry system. Among the treatments, T13 consistently demonstrated the highest dry weight accumulation, highlighting its superior efficacy in enhancing the physiological and biomass attributes of citronella.

Dry weight under shaded conditions was generally higher than in open environments, likely due to the moderated microclimatic conditions provided by the moringa canopy, which optimized plant growth processes. Treatments such as T11 and T12 also recorded competitive dry weights but were consistently outperformed by T13. The control (T0) exhibited the lowest dry weight under both conditions, underscoring the necessity of organic manure application for improved biomass production.

Statistical analysis indicated that the differences among treatments were significant (F-test: Significant) at harvest. These findings demonstrate the potential of integrating high-performance organic manures, particularly T13, in moringa-based agroforestry systems to maximize the dry matter yield of citronella java. This underscores the importance of selecting appropriate amendments and leveraging agroforestry practices for sustainable and productive biomass management.

Total Herbage Yield

The application of different organic manures significantly impacted the total herbage yield of citronella java under open and shaded conditions in a moringa-based agroforestry system. Among all treatments, T13 consistently recorded the highest herbage yield, highlighting its superior efficacy in enhancing overall biomass production. Shaded conditions generally resulted in higher yields compared to open conditions, likely due to the favourable microclimatic effects of the moringa canopy, which improved moisture retention and moderated temperature fluctuations.

The statistical analysis (F-test: Significant) revealed substantial differences among treatments, confirming the effectiveness of organic manure applications. T13 demonstrated the most pronounced effect on herbage yield under both conditions, followed by T11 and T12, which showed competitive performance. The control (T0) consistently recorded the lowest yield, emphasizing the importance of organic amendments for optimal biomass accumulation.

These results underscore the potential of T_{13} as a high-performance organic input for enhancing herbage yield in citronella java, particularly when cultivated within agroforestry systems. The integration of organic manures with moringa-based shading practices offers a sustainable strategy to maximize biomass productivity, optimize resource use, and improve overall system efficiency.

Conclusion

The study highlights the significant benefits of integrating organic manures with agroforestry practices to boost citronella growth and yield. The treatment combining FYM, vermicompost, and neem cake (T13) consistently delivered superior results, yielding higher plant biomass and herbage compared to other treatments. The moringa-based agroforestry system further enhanced productivity by providing shaded conditions, demonstrating the synergy between organic inputs and agroforestry. This research offers valuable insights for resource-limited farmers, showing how eco-friendly practices can optimize agricultural output while improving long-term soil and environmental health. By showcasing the economic and ecological advantages of sustainable citronella cultivation, the study provides important guidance for advancing sustainable agricultural practices in regions where aromatic crops and agroforestry systems are viable.

Disclaimer (Artificial intelligence)

Author(s) hereby declares that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and NO text-to-image generators have been used during the writing or editing of this manuscript.

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Table.1Effect of different organic manures on plant height (cm) at 30, 60, 90, 120, 150 and 180 DAS of *citronella java*under open condition

Treatments	30 DAS		60 DAS		90 DAS		120 DAS		150 DAS		180 DAS	
	2022	2023	2022	2023	2022	2023	2022	2023	2022	2023	2022	2023
T_0	33.43	35.43	41.23	40.21	50.12	49.25	75.21	72.23	100.21	100.25	115.21	111.35
T_1	35.23	40.12	46.21	42.23	66.22	61.23	86.23	82.23	115.12	115.23	126.12	126.32
T_2	38.26	41.21	46.28	42.23	67.15	61.22	88.12	82.32	120.21	120.12	126.23	126.42
T_3	40.35	41.25	46.32	42.35	67.32	62.32	87.21	82.35	121.12	125.32	127.21	126.35
T_4	41.25	41.24	47.22	42.26	67.25	62.25	88.23	85.23	120.22	121.32	127.12	127.35
T_5	41.32	42.15	47.26	43.53	67.35	63.45	88.32	85.35	121.23	125.23	127.24	130.12
T_6	42.23	41.26	47.25	42.35	67.28	63.52	88.23	86.45	123.21	125.32	127.25	131.23
T_7	42.23	41.32	47.32	42.53	67.35	63.45	89.25	86.35	123.25	124.32	128.12	132.23
T_8	43.25	40.23	47.28	41.36	67.29	65.26	89.28	85.54	123.24	125.42	128.21	134.25
T_9	43.21	42.32	48.21	43.34	68.25	65.55	89.23	87.65	123.25	126.32	128.23	134.32
T_{10}	43.32	40.21	48.12	41.26	68.34	65.23	90.01	86.35	124.25	128.35	128.25	134.35
T_{11}	43.54	41.32	48.12	42.31	69.21	65.32	89.26	86.23	124.26	128.32	128.27	134.35
T_{12}	43.26	40.25	48.21	41.34	68.26	64.25	89.21	86.35	124.21	127.45	128.28	134.36
T_{13}	43.62	44.25	55.21	43.25	70.21	65.35	90.25	88.23	125.12	130.23	128.31	140.23
F-test	NS	NS	S	S	S	S	S	S	S	S	S	S

Table.2Effect of different organic manures on plant height (cm) at 30, 60, 90, 120, 150 and 180 DAS of *citronella java*under shade condition in moringa based agro-forestry system.

Treatments	30 DAS		60 DAS		90 DAS		120 DAS		150 DAS		180 DAS	
	2022	2023	2022	2023	2022	2023	2022	2023	2022	2023	2022	2023
T_0	38.45	38.65	45.42	43.12	70.43	71.43	100.23	101.31	120.26	125.13	135.26	132.12
T_1	40.35	41.26	52.26	51.13	80.36	81.13	115.35	114.63	128.45	123.12	142.32	131.15
T_2	41.10	42.26	54.23	52.16	81.13	82.13	116.26	113.43	134.52	125.13	145.85	131.35
T_3	40.95	41.54	50.45	53.31	80.92	83.46	111.24	115.63	134.85	128.11	145.95	134.12
T_4	42.25	41.26	52.35	52.55	82.26	83.43	112.24	115.13	129.56	124.13	147.26	131.45
T_5	41.81	42.15	51.50	53.52	81.82	84.16	114.82	115.61	134.20	127.46	145.25	131.45
T_6	41.52	42.62	51.28	53.45	81.54	86.32	114.53	116.13	134.65	128.13	147.26	133.66
T_7	41.35	42.35	51.33	54.33	81.36	85.16	115.52	113.61	137.56	128.45	142.26	135.11
T_8	42.88	41.26	52.75	53.43	82.88	83.64	115.26	115.13	131.26	128.65	145.64	136.63
T_9	43.01	43.62	53.21	52.33	83.01	84.46	116.01	115.16	132.23	128.48	145.26	135.13
T_{10}	43.20	41.31	53.22	54.33	83.23	85.46	116.20	116.13	136.45	129.16	139.65	135.54
T_{11}	43.38	42.32	53.32	56.23	83.24	85.45	116.23	115.16	131.65	128.12	141.26	135.13
T_{12}	40.21	41.23	50.24	55.51	80.24	86.43	115.23	116.13	135.26	128.45	145.65	135.47
T_{13}	43.58	45.12	54.56	58.65	84.59	90.45	117.56	125.56	140.58	135.26	150.58	150.25
F-test	S	S	S	S	S	S	S	S	S	S	S	S

Table.3Effect of different organic manures on No. of leaves/plant at 30, 60, 90, 120, 150 and 180 DAS of *citronella java*under open condition

Treatments	30 DAS		60 DAS		90 DAS		120 DAS		150 DAS		180 DAS	
	2022	2023	2022	2023	2022	2023	2022	2023	2022	2023	2022	2023
T_0	4.42	5.21	6.62	7.25	7.42	9.23	8.21	12.23	9.26	16.15	10.22	20.12
T_1	5.52	6.23	7.45	8.42	8.46	9.21	9.23	12.21	10.02	17.12	11.23	20.32

Treatments	30 DAS		60 DAS		90 DAS		120 DAS		150 DAS		180 DAS	
	2022	2023	2022	2023	2022	2023	2022	2023	2022	2023	2022	2023
T_0	5.45	6.15	7.78	10.25	8.45	14.54	9.44	18.26	10.32	12.54	18.62	25.16
T_1	6.54	7.45	8.78	8.48	9.46	10.22	10.12	13.13	11.34	14.65	15.45	20.32
T_2	6.32	6.32	7.12	8.23	8.54	9.12	9.26	12.24	10.35	17.24	11.26	22.31
T_3	6.62	7.25	8.12	8.23	9.21	9.35	10.22	12.32	11.52	17.25	12.26	22.16
T_4	6.42	7.32	7.29	8.32	8.42	9.34	9.24	12.35	10.23	18.23	11.32	23.24
T_5	7.12	7.35	8.23	8.35	9.25	9.45	10.26	12.42	11.32	18.34	12.25	24.58
T_6	7.46	6.23	8.26	8.42	9.28	9.54	10.28	13.45	11.23	17.37	12.24	24.52
T_7	7.46	7.45	8.35	8.41	9.26	9.65	10.62	13.46	11.32	17.45	12.25	25.32
T_8	7.45	7.54	8.45	8.26	9.32	9.45	10.42	15.21	11.62	18.24	12.24	25.62
T_9	8.54	8.32	9.26	10.21	10.21	11.12	11.21	15.24	12.63	18.45	13.22	24.65
T_{10}	7.43	8.35	8.24	10.12	9.28	11.23	10.21	15.45	12.42	18.35	13.25	24.51
T_{11}	7.48	8.65	8.54	10.13	9.31	11.32	10.32	15.46	12.52	18.65	13.24	26.84
T_{12}	8.42	8.25	8.65	10.32	9.45	11.25	10.26	15.54	12.52	18.35	13.26	25.65
T_{13}	8.42	8.65	9.12	10.25	10.32	11.34	11.32	15.64	13.32	18.67	13.85	28.45
F-test	S	S	S	S	S	S	S	S	S	S	S	S

Table.4Effect of different organic manures on No. of leaves/plant at 30, 60, 90, 120, 150 and 180 DAS of *citronella java*under shade condition in moringa based agro-forestry system.

Treatments	30 DAS		60 DAS		90 DAS		120 DAS		150 DAS		180 DAS	
	2022	2023	2022	2023	2022	2023	2022	2023	2022	2023	2022	2023
T 0	3.54	5.25	4.53	6.54	8.56	7.62	9.24	10.12	10.23	14.12	11.32	18.21
T 1	4.54	6.12	6.52	7.52	7.42	8.62	8.45	11.23	9.52	15.21	10.35	21.23
T 2	6.42	7.54	7.58	9.10	8.48	10.66	9.64	14.45	10.45	14.35	15.46	22.32
T 3	7.77	8.84	8.45	9.45	9.75	11.15	10.11	14.65	12.54	15.65	18.45	22.15
T 4	7.45	8.45	8.75	8.46	9.45	11.62	12.12	14.85	13.45	16.26	19.45	23.45
T 5	8.12	8.45	9.35	8.45	10.35	12.22	13.22	14.55	10.45	13.54	20.32	[illegible]
T 6	8.45	7.53	9.33	8.56	10.75	13.31	14.43	13.62	16.43	16.64	21.21	24.55
T 7	8.45	8.65	9.45	9.56	10.48	12.51	11.43	15.63	16.32	16.46	22.12	25.43
T 8	8.78	8.45	9.47	9.62	10.46	13.64	13.32	17.26	16.45	15.65	22.34	25.56
T 9	9.75	9.14	10.49	10.84	10.50	12.45	12.34	15.16	16.45	14.35	23.42	24.59
T 10	8.78	8.45	9.15	9.65	11.45	12.15	14.64	15.66	18.15	16.64	24.42	24.15
T 11	7.87	8.65	8.78	9.85	10.65	12.45	10.54	15.43	18.45	16.53	23.44	26.85
T 12	8.45	8.45	9.85	9.84	9.78	13.15	14.24	18.16	18.45	16.65	24.44	25.59
T 13	9.45	9.55	10.75	10.85	10.46	13.65	15.31	18.32	18.15	16.66	25.12	28.95
F-test	S	S	S	S	S	S	S	S	S	S	S	S

Table.5Effect of different organic manures on No. of tiller/plant at 30, 60, 90, 120, 150 and 180 DAS of *citronella java*under open condition

Treatments	30 DAS		60 DAS		90 DAS		120 DAS		150 DAS		180 DAS	
	2022	2023	2022	2023	2022	2023	2022	2023	2022	2023	2022	2023
T_0	5.45	6.12	7.45	7.84	9.57	10.56	10.13	14.56	15.45	18.54	24.44	20.55
T_2	5.53	7.25	7.45	8.52	8.26	9.23	9.54	11.26	10.42	15.26	11.45	21.15
T_3	5.65	7.26	7.54	8.65	8.32	9.26	9.35	12.25	10.54	15.25	11.65	21.25
T_4	5.73	7.45	7.62	8.35	8.84	10.12	9.53	12.35	10.63	16.21	11.25	21.26
T_5	6.65	7.45	8.26	8.65	9.45	10.32	10.24	12.45	11.35	15.32	12.45	22.24
T_6	6.52	7.15	8.71	8.45	9.56	10.26	10.35	12.65	11.45	16.24	12.54	22.45
T_7	5.58	7.24	7.23	8.62	8.52	10.28	9.62	12.63	10.53	16.41	11.52	22.35
T_8	6.26	8.24	8.62	9.21	9.35	10.56	10.26	12.62	11.34	15.42	12.45	23.45
T_9	6.35	8.45	8.58	9.12	9.65	11.21	10.24	13.21	11.43	15.24	12.43	23.41
T_{10}	6.45	8.42	8.65	9.67	9.34	11.26	10.23	12.23	11.65	15.41	12.34	24.45
T_{11}	6.75	8.64	8.63	9.32	9.43	11.45	10.52	12.41	11.45	15.53	12.42	23.54
T_{12}	6.36	8.35	8.54	9.81	9.75	11.65	10.85	12.43	11.65	15.60	12.75	24.21
T_{13}	7.24	8.84	9.53	9.92	10.21	12.12	11.25	13.23	12.42	16.21	13.68	25.21
F-test	S	S	S	S	S	S	S	S	S	S	S	S

Table.6Effect of different organic manures on No. of tiller/plant at 30, 60, 90, 120, 150 and 180 DAS of *citronella java*under shade condition in moringa based agro-forestry system.

T_1	6.44	7.15	7.58	8.64	8.12	10.25	10.21	12.13	12.64	14.65	15.45	22.13
T_2	7.45	8.95	8.47	9.64	9.21	10.26	10.34	12.16	15.45	14.35	18.14	18.65
T_3	7.64	8.15	8.35	9.65	9.25	10.56	10.64	12.64	13.44	15.65	17.34	19.65
T_4	7.53	8.95	8.65	9.65	9.87	10.46	10.34	12.53	14.56	16.26	18.64	18.64
T_5	8.53	8.46	9.65	9.64	10.45	10.64	11.24	12.34	18.44	15.34	21.45	21.23
T_6	8.54	8.40	9.75	9.65	10.54	10.46	11.54	12.15	14.46	16.64	19.64	21.33
T_7	7.51	8.45	8.35	9.67	9.84	10.48	10.34	12.46	14.46	16.46	20.55	21.66
T_8	8.85	9.64	9.65	9.64	10.64	11.56	11.64	12.62	14.54	15.65	18.45	22.32
T_9	8.54	9.46	9.87	9.84	10.84	12.30	11.37	13.13	14.65	14.35	19.45	23.13
T_{10}	8.65	9.45	9.87	9.87	10.25	11.63	11.75	12.33	14.54	16.64	18.74	25.26
T_{11}	8.44	9.64	9.58	9.35	10.64	11.45	11.45	12.42	18.95	16.53	19.46	23.26
T_{12}	8.43	8.40	9.56	9.84	10.35	11.64	11.74	12.32	17.54	16.65	18.69	24.12
T_{13}	9.41	9.94	10.85	10.23	11.24	12.66	12.46	13.12	19.45	16.66	20.45	25.15
F-test	S	S	S	S	S	S	S	S	S	S	S	S

Table.7Effect of different organic manures on Fresh weight of plant (kg plant^{-1}) at harvest of *citronella java*under open and shade condition in moringa based agro-forestry system.

Treatments	Open			Shade		
	2022	2023	Pooled	2022	2023	Pooled
T_0	9.10	12.56	11.40	10.23	14.45	11.78
T_1	10.12	13.26	12.75	12.23	17.45	13.79
T_2	10.22	15.56	14.91	14.25	17.45	13.84
T_3	11.21	14.56	15.21	15.85	17.64	14.43
T_4	12.32	15.47	15.02	14.56	18.74	15.53
T_5	13.22	16.56	15.61	14.65	18.85	16.04
T_6	12.52	15.56	14.54	13.52	17.84	15.18
T_7	14.22	18.46	17.36	16.25	21.45	17.84
T_8	10.22	16.26	15.76	15.26	18.75	14.49
T_9	12.23	17.84	16.00	14.15	19.85	16.04
T_{10}	12.26	18.48	17.37	16.25	21.45	16.86
T_{11}	12.65	19.45	18.86	18.26	21.54	17.10
T_{12}	12.23	17.45	16.85	16.25	19.54	15.89
T_{13}	15.56	22.45	20.66	18.86	24.45	20.01
F-test	S	S	S	S	S	S
C.D. (P=0.005)	0.74001	0.907	0.49822	0.46	0.8031	0.46131
SE(m)	0.24583	0.3013	0.1655	0.15	0.26678	0.15324
SE(d)	0.34765	0.4261	0.23406	0.21	0.37729	0.21672
C.V.	3.54653	3.12334	1.80578	1.78	2.40088	1.69861

Table.8Effect of different organic manures on dry weight of plant (kg plant^{-1}) at harvest of *citronella java*under open and shade condition in moringa based agro-

Treatments	Open			Shade		
	2022	2023	Pooled	2022	2023	Pooled
T_0	3.45	3.47	3.46	3.41	3.81	3.63
T_1	4.65	4.65	4.65	4.54	4.86	4.70
T_2	4.65	4.58	4.62	3.56	4.68	4.12
T_3	3.45	4.65	4.05	4.56	4.70	4.62
T_4	4.95	4.85	4.90	4.58	4.98	4.77

forestry system.

T_5	4.85	4.75	4.80	4.51	4.67	4.57
T_6	4.95	4.84	4.90	5.45	4.61	5.02
T_7	5.45	4.95	5.20	4.65	4.73	4.70
T_8	4.56	4.82	4.69	3.45	4.59	3.99
T_9	4.86	4.41	4.64	4.56	4.34	4.46
T_{10}	5.21	4.62	4.92	5.01	4.60	4.82
T_{11}	4.87	4.25	4.56	4.65	5.03	4.80
T_{12}	4.95	4.75	4.85	4.54	4.87	4.70
T_{13}	5.89	5.56	5.73	5.50	5.73	5.58
F-test	S	S	S	S	S	S
C.D. (P=0.005)	0.22701	0.24036	0.17002	0.19869	0.20192	0.14888
SE(m)	0.07541	0.07985	0.05648	0.066	0.06708	0.04946
SE(d)	0.10665	0.11292	0.07987	0.09334	0.09486	0.06994
C.V.	2.73987	2.97188	2.07675	2.5417	2.45663	1.86079

Table.9Effect of different organic manures on total herbage yield (t ha^{-1}) at harvest of *citronella java*under open and shade condition in moringa based agro-forestry system.

Treatments	Open			Shade		
	2022	**2023**	**Pooled**	**2022**	**2023**	**Pooled**
T_0	10.58	16.12	13.35	14.52	17.32	15.92
T_1	14.87	17.12	16.00	16.51	18.45	17.48
T_2	14.59	16.62	15.61	16.53	18.65	17.59
T_3	14.95	17.65	16.30	16.25	18.15	17.20
T_4	14.78	17.48	16.13	16.56	18.65	17.61
T_5	14.55	16.65	15.60	16.35	18.56	17.46
T_6	14.35	16.75	15.55	16.26	18.65	17.46
T_7	14.75	16.45	15.60	16.34	18.62	17.48

T_8	14.14	16.65	15.40	16.44	18.35	17.40
T_9	14.51	16.15	15.33	16.56	18.45	17.51
T_{10}	14.25	16.35	15.30	16.54	18.65	17.60
T_{11}	14.65	16.45	15.55	16.64	18.26	17.45
T_{12}	14.35	16.56	15.46	16.57	18.36	17.47
T_{13}	15.26	18.35	16.81	16.78	19.62	18.20
F-test	S	S	S	S	S	S
C.D. (P=0.005)	0.45678	0.79938	0.44315	0.55373	0.81278	0.53521
SE(m)	0.15174	0.26555	0.14721	0.18395	0.27	0.17779
SE(d)	0.16969	0.15876	0.0853	0.14892	0.16687	0.11237
C.V.	0.3612	0.71933	1.09257	0.67474	0.75607	1.36421