

Impact on Maize (*Zea mays*) crop productivity and yield parameters with intercropping of Cowpea (*Vigna unguiculata* L.) and Moong bean (*Vigna radiata* L.)

ABSTRACT

The current study evaluated the impact of intercropping Cowpea and Moong bean on Maize yield and its constituent parts. Nine different treatments were used in the experiment viz., (T₁) sole Maize, (T₂) sole Cowpea, (T₃) sole Moong bean, (T₄) Maize + Cowpea (1:1), (T₅) Maize + Cowpea (1:2), (T₆) Maize + Cowpea (1:3), (T₇) Maize + Moong bean (1:1), (T₈) Maize + Moong bean (1:2) and, (T₉) Maize + Moong bean (2:1) in a randomized block design with three replications in Kharif season. The findings showed that intercropped plants had greater potential and produced higher values for the majority of the studied criteria, including plant height, chlorophyll meter reading (SPAD) number of cobs plant⁻¹, number of rows cob⁻¹, number of grains row⁻¹, 100-grain weight, and straw and grain yields. Intercrop's seed yields were less in intercropped treatments than sole Maize. (T₅) Maize + Cowpea (1:2) was best treatment having highest yield (5915.83 kg ha⁻¹), maximum LER (1.8) and MEY (kg ha⁻¹) (11663.36). This clearly demonstrated the advantages of intercropping Maize with legumes. This is because the leguminous crops can provide additional nutrients to the Maize crop through biological nitrogen fixation (BNF). Additionally legumes can improve the declined soil productivity by enhancing the overall soil conditions like chemical, biological, and physical. The increased availability of nitrogen and enhancement in soil physical, chemical and biological properties can improve Maize growth, leading to higher yield. Additionally it boosts soil conservation by providing more ground cover than mono-cropping.

Keywords: Cowpea, Moong bean, Intercropping, Growth, Yield

1. INTRODUCTION

Maize is one of the main cereals, and referred as the "Queen of Cereals" worldwide, after Rice and Wheat, it is the third most widely cultivated cereal in India and in Punjab. Maize is one of the main crops grown throughout the spring and Kharif season [1]. *Kharif* Maize is grown in the Punjab region because of its greater adaptability to environment, tolerance to high temperate and having higher yield potentials [2]. In 2019-20 the total production of Maize in Punjab was 410.5 tonnes in Punjab with an average yield of 3582 kg ha⁻¹ of land [3]. Rice-Wheat cropping pattern has left India facing major difficulties and stagnant productivity particularly in the northwest [4]. For agricultural intensification, intercropping has proven to be an essential practice for boosting land use effectiveness, elevating production, increasing the economic value and resistance to climate change effects [5]. For developing a sustainable food and forage production system cereal-legume intercropping is a widely supported technique with little external input and isolated land distribution [6].

The simultaneous cultivation of multiple crops can increase competition for the resources like water, nutrition and light between the primary crop and intercrop, potentially reducing the yields of one or both crops [7]. However, the component crop's physiological and morphological variations allow for their complementary utilization of the environment's

resources, resulting in a higher yield and more effective use of the land [8]. For example in cereal/legume intercropping systems, N fixation by legumes can be transferred to nearby cereals, which promotes their growth and development. Cowpea; being a member of legumes family, it fixes the biological nitrogen, enhance soil fertility by altering the physical, chemical, and biological characteristics of soil, it maintains soil productive and alive. Also it adds a significant amount of organic matter through root biomass which mobilise nutrients and provides protection to soil against erosion [9]. Cowpeas resistance to drought and easy cultivation makes it a desirable crop. Green gram is an annual legume can be grown in rotation with cereals and can fix up to 110 kg of nitrogen ha^{-1} , which could help it meet both its own nitrogen needs, it's associated and for the crop which is growing next. Maize is used as a component crop in the majority of intercropping. Cereal-legume intercropping is a more effectual and profitable cropping method than single cropping. It provides more ground cover than single cropping, which minimizes the quantity of nutrients that are removed from the soil and conserves it. [10]. Therefore, the goal of this study is to determine how crop production conditions in the central plains of Punjab influences the growth and yield of Maize by intercropping it with Cowpea and Moong bean.

2. MATERIALS AND METHOD

The experiment was conducted on a sandy loam field at Lovely Professional University, Phagwara, Punjab. It had pH of 7.8, EC (electrical conductivity) of 0.429 (dS/m), available Nitrogen of 260 kg ha^{-1} , available Phosphorus of 12 kg ha^{-1} and available Potassium of 130 kg ha^{-1} . The experimental site had a subtropical climate with warm summers, mild winters, and a wet season that averaged 711 mm of precipitation annually. Nine treatments were used in the experiment, which was conducted using a randomized block design (RBD) layout given below in Table 1 in 3 replications in *Kharif* 2022. Varieties were used; for Maize -P3396 Pioneer Hybrid Corn having a distinctive plant structure that enables it to respond to bigger populations and is a very high yielding hybrid suitable for Kharif and Rabi season, for Moong bean-Govind Kranti, for Cowpea-Baramasi (can be grown in any season). In this field trial we have applied intercropping practices for Maize-Cowpea and Maize-Moong bean, by following the package of practices of Punjab Agricultural University (PAU). The recommended dose of fertilizer used was 50 kg acre^{-1} N (applied in split doses), 24 kg acre^{-1} P_2O_5 , and 12 kg acre^{-1} K_2O . Five randomly selected plants from each plot were cut down above the ground level except root, sun dried for one to two days, then dried in a hot air oven at a temperature of $60^\circ\text{C} \pm 5^\circ\text{C}$ until a constant weight was achieved. The final unchanged weight was then recorded for each plant, and the average was computed and recorded. For determining plant height (cm) meter stick was used, number of leaves were calculated from the tagged plants, the chlorophyll index was recorded with the help of SPAD meter, stem girth recorded with the help of Vernier calliper, Cob length (cm) and cob girth (cm) were measured using measuring scales; leaf area (cm^2) was calculated using a leaf area metre; number of cobs plant^{-1} , number of rows cob^{-1} , number of grains row^{-1} , and number of grains cob^{-1} were measured manually; and taking an average of five plants. Crop Growth Rate (CGR), Net Assimilation Rate (NAR), Relative Growth Rate (RGR) and the above parameters were taken at the interval of 30 DAS, 60 DAS, and 90 DAS. 100 grain weight (g) (Test weight) was recorded by taking weight of 100 grains from five random cobs, weighing them in electronic weighing balance and taking an average of five plants. For grain yield (kg ha^{-1}) the cobs were dried to moisture level 12-14% and then weighed by using digital balance. For Stover yield (quintal ha^{-1}) the residual plant and husks of cobs were weighed combined after all the cobs have been removed from the plants in each individual treatment plot. At last the Maize equivalent yield (kg ha^{-1}) and Harvest index (%) which is the ratio of the economic yield of grains hectare⁻¹ to the ratio of the total biological yield (grain plus Stover) were calculated.

2.1 Statistical analysis

Data was analysed using the SPSS (version 22). ANOVA was performed on the data and results were reported as means standard deviation after adopting homogeneity of variance. Duncan's multiple range test (DMRT) mean separation approach was used with probability p 0.05 to determine the best effective treatment. The significance of the variation components was examined using the Fisher's LSD test as a post hoc test.

Table 1 Different treatments used in the experiment

Treatments	Descriptions
T ₁	Sole Maize
T ₂	Sole cowpea
T ₃	Sole moong bean
T ₄	Maize + Cowpea (1:1)
T ₅	Maize + Cowpea (1:2)
T ₆	Maize + Cowpea (2:1)
T ₇	Maize + Moong bean (1:1)
T ₈	Maize + Moong bean 1:2)
T ₉	Maize + Moong bean (2:1)

3. RESULTS AND DISCUSSION

3.1 Growth attributes- Plant height, number of leaves plant⁻¹, leaf area and chlorophyll index

In comparison with sole Maize, intercropped-Maize had a considerable impact on agronomical indices. The result tabulated in (Table 2) revealed that T₅ performed well for all the traits. Plant height (cm) was maximum at harvest in T₅ (212.55) followed by T₄ (208.00) and T₆ (206.99) and minimum in T₁ (200). Under the legume intercropping system, Maize plants have gained height which might be because of complimentary interaction of legumes. This is in agreement with finding of resulted by [11]. The number of leaves were maximum in T₅ (14.00) followed by T₄ (12.22) and T₈ (12.11) and minimum in T₁ (11.7 8). More of green leaves were produced in intercropped Maize with legumes in comparison to sole Maize [12]. Researchers also found that fodder Maize and Cowpea intercropped together produced more plant-1 leaves than crop grown alone. The results of this study are in agreement with [13]. The chlorophyll index of Maize was high initially in its vegetative growth and it reduced till it attained maturity. The maximum SPAD's reading was observed in T₅ (33.32) followed by T₄ (31.39) and T₆ (28.38). Minimum reading was observed in T₇ (26.64). [14], found similar results. The leaf area was recorded high in sole Maize than intercrop. Maximum leaf area (cm²) was observed in T₁ (723.5) followed by T₅ (716.4) and T₆ (713.7) whereas T₇ (701) had minimum leaf area. [15] attributed the highest leaf area observed in the sole crop due to superior growth of Maize plants, which experienced less competition from the intercrop by [16].

Table 2 Growth parameters (at harvest) viz. Plant height, number of leaves plant⁻¹, chlorophyll index and leaf area.

Treatments	Plant height (cm)	No. of leaves plant ⁻¹	Chlorophyll index	Leaf area (cm ²)
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T₁-Sole Maize	200.33 ^d ± 0.72	11.78 ^b ± 0.57	27.35 ^c ± 0.84	723.5 ^a ± 0.92
T₄-Maize + Cowpea (1:1)	208.00 ^b ± 1.70	12.22 ^{ab} ± 0.87	31.39 ^{ab} ± 0.94	711.31 ^d ± 0.91
T₅-Maize + Cowpea (1:2)	212.55 ^a ± 1.66	14.00 ^a ± 0.27	33.32 ^a ± 0.89	716.4 ^b ± 0.45
T₆-Maize + Cowpea (2:1)	206.99 ^{bc} ± 1.25	12.5 ^{ab} ± 0.13	28.38 ^{bc} ± 0.78	713.7 ^c ± 0.22
T₇-Maize + Moong bean (1:1)	204.77 ^{bc} ± 1.03	11.89 ^b ± 0.68	26.64 ^c ± 0.80	701 ^t ± 0.72
T₈-Maize + Moong bean (1:2)	205.33 ^{bc} ± 0.82	12.11 ^{ab} ± 0.78	27.83 ^c ± 1.07	710.05 ^d ± 0.48

3.2 Yield attributes

3.2.1 Number of cobs plant⁻¹, Length of cob, cob diameter, grains row⁻¹, number of rows, tassel weight and grain cob⁻¹

Traits viz., Number of cobs plant⁻¹, Length of cob (cm), cob diameter (cm), grains row⁻¹, number of rows, tassel weight (g) and grain cob⁻¹ tabulated in (Table 3) where T₅ was observed best for maximum yield and it attributing traits followed by T₄ and T₆ in most of the traits whereas T₁ performance is low. [17] found the matching results. The maximum number of cob plants⁻¹ were found in the same T₅ (2.77) followed by T₄ (2.77) and T₈ (2.0). Similar findings were of [18]. Length of cob (cm) was observed maximum for T₅ (21.09) followed by T₄ (20.43) and T₆ (19.71). Cob diameter (cm) was observed maximum in T₅ (4.52) followed by T₄ (4.29) and T₆ (4.24). The maximum grains row⁻¹ was noticed in the same T₅ (34) followed by both T₄ and T₆ (31.5). The minimum grains cob⁻¹ was recorded in sole Maize T₁ (28.17). Maximum number of rows cob⁻¹ (Table 3) were found maximum in T₅ (17.33) followed by T₄ (16.77) and T₆ (16.13). [19] also revealed that intercropping improved the length of cob, cob diameter, grains row⁻¹, number of rows. T₅ (9.42) revealed maximum tassel weight followed by T₄ (9.15) and T₆ (8.94). For grain cob⁻¹ T₅ (573.44) found maximum cob followed by T₄ (531.11) and T₆ (507.78).

3.2.2 Tassel primary branch length, Tassel length, Test weight, Dry weight, Stover yield, Grain yield and Harvest index

For all these traits, T₅ is significantly higher among sole Maize as well as Moong intercropping. Intercropped plants have gained more height and good length of tassel (cm) in comparison to sole maize. For tassel length (cm), tassel primary branch length (cm) and tassel weight (g) T₅ revealed maximum (32.93), (20.7) and (9.42) respectively. Whereas T₄ (19.86) is significant for branch length and T₆ (32.36) is significant for tassel length respectively. [20] found similar outcomes. [21] found in his studies that intercropping Cowpea with Maize helped in gaining height of plant therefore an increment in the length of tassel. Maximum test weight (g) was recorded in T₅ (43.33) and minimum from T₁ (38.57). [22] did similar studies. The maximum grain yield in kg ha⁻¹ is recorded in T₅ (5915.83) followed by T₄ (5806) and T₆ (5768.17). Test weight (g) and dry weight (g) also found maximum for T₅ (43.33, 92.33) followed by T₄ (40.77, 90.44) and T₆ (40.53, 88.11) respectively. This result is in agreement with the finding of [23]. Stover (kg ha⁻¹) and grain yield in (kg ha⁻¹) also revealed maximum in T₅ (7622.1, 5915.83) followed by T₄ (7516, 5806) and T₆ (7407.67, 5768.17) respectively. [20] previously observed that the due to biological nitrogen fixation by legumes enhances the leaf area and Stover yield also increases similarly. Harvest index (%) is maximum in T₅ (45.67) followed by T₄ (43.83) and T₆ (45.67) and minimum in sole T₁ (43.83). [21] found similar results. In all traits, intercropping resulted

good in yield and associated traits as compared to sole Maize. This finding is in agreement with finding of [24].

3.3 Physiological parameters- Net Assimilation Rate, Crop Growth Rate, Maize equivalent yield and Relative Growth Rate

Significant difference between intercropping treatments and their growth in terms of NAR, CGR, MEY and RGR are tabulated in Table 5. The NAR in $\text{gcm}^2\text{day}^{-1}$ rose up until the Maize flowering phase (60-90 DAS) was maximum in T_5 (2.269). Similar outcomes were discovered in the research of [25]. T_4 (2.070) produced the lowest NAR. T_5 (2.29) had the maximum CGR at 60-90 DAS followed by T_4 (2.26) and T_6 (2.25) and T_1 had minimum CGR (2.12). Canopies of their neighbouring plants were exposed to sunlight, which increased their NAR [26]. Maximum MsEY was noted in (T_5) followed by T_4 and T_6 i.e., $11663.36 \text{ kg ha}^{-1}$, $11152.52 \text{ kg ha}^{-1}$ and $10969.55 \text{ kg ha}^{-1}$ respectively. It is evident to that intercropping is beneficial [27]. The highest RGR of was obtained from the growth stage of sole-cropped Maize T_1 (0.0065) and T_5 had minimum (0.0065). This result is in the agreement with the [28].

3.4 Intercropping's impact on pulses yield metrics and yield estimation studies

The yield parameters of intercrops Cowpea and Moong bean viz., number of pods plant^{-1} , number of seed pod $^{-1}$, seed yield and test weight significantly reduced in the intercropped treatments and it was opposite in sole treatments tabulated in (Table 6). Cowpea's number of pods plant^{-1} (24.78), number of seed pod $^{-1}$ (13.00), seed yield kg ha^{-1} (2451.13), test weight (26.67) were maximum in pure stands in T_2 . While the minimum number of pods plant^{-1} (16.44), number of seed pod $^{-1}$ (9.22), seed yield (kg ha^{-1}) (2228.80), test weight (g) (18.83) recorded from T_5 . The yield of cowpea was higher in sole than in intercrop. This was in conformity of the work of [16]. The Moong bean's maximum number of pods plant^{-1} (31.44), number of seed pod $^{-1}$ (11.22b), seed yield (kg ha^{-1}) (2245.23), test weight (g) (50.00) were recorded from the T_3 . Similar result found by [31], While the minimum number of pods plant^{-1} (23.00), number of seed pod $^{-1}$ (7.00), seed yield (kg ha^{-1}) (1965.16), test weight (g) (40.00) were recorded from intercropped plot T_8 . More intraspecific and interspecific competition for growth resources like water, light, nutrients, space may be the cause of the decreased number of pods plant^{-1} at greater plant densities, which may have resulted in fewer functional branches. While in sole plots the intercrop received good space, improved light availability, nutrients that lead plant to produce more branches and it directly influenced the growth and yield of plants. This outcome was consistent with [29]. Earlier scientists have observed the yield difference in legumes caused by population diversity in Maize-legume intercropping. [30] had similar findings suggested that decrease in effective branches could have resulted in a reduction in the number of pods plant^{-1} in the intercropped system.

4. CONCLUSION

Growing crops in continuity has degraded soil in terms of productivity. In intercropping two or more crops are grown together in a specific row ratio on the same plot of land. For India's growing population we need a sustainable production system like intercropping as it performs better in land use efficiency. We need to choose the intercrops carefully so that they do not create spatial and temporal competition. The deep root system of legumes does not interfere in nutrition absorption of other crop plus it provides Nitrogen to neighboring cereals by fixing it biologically, more ground cover helps in maintaining moisture. Additionally the Cowpea and Moong bean's peak nutrient demand is different than Maize. Three different cropping strategies were used; Monoculture of Maize, Cowpea, Moong bean, Maize-Cowpea

intercrop and Maize-Moong bean intercrop. If we compare sole crop in terms of agronomic, physiological, yield and competition parameters to the intercrop the best treatment was (T₅) Maize + Cowpea (1:2). However the Cowpea's treatments (T₄) Maize + Cowpea (2:1) and (T₆) Maize + Cowpea (1:1) were statistically at par. In Maize-Moong intercrop the best treatment was (T₈) Maize + Moong bean (1:2). The treatments (T₇) Maize + Moong bean (2:1) and (T₉) Maize + Moong bean (1:1) were statistically at par. The highest LER and MEY (kg ha⁻¹) were recorded from T₅ (1.8) and (11663.36) kg ha⁻¹ respectively. Therefore we suggest Maize-legume intercrop can be adopted under Punjab's conditions.

REFERENCES

1. Ignjatovic-Micic D, Vancetovic J, Trbovic D, Dumanovic Z, Kostadinovic M, Bozinovic S. Grain nutrient composition of *Maize* (*Zea mays* L.) drought-tolerant populations. *Journal of agricultural and food chemistry*. 2015;63(4):1251-60.
2. Anonymous. Maize-areas, production, yield during 2019-20. *Agriculture statistics at a glance-2021* (58-59).
3. Anonymous. Department of agriculture and farmer welfare, Punjab Economic Survey -2021. Government of Punjab.
4. Banjara TR, Bohra JS, Kumar S, Ram A, Pal V. Diversification *Rice–Wheat* cropping system improves growth, productivity and energetics of rice in the Indo-Gangetic Plains of India. *Agricultural Research*. 2021:1-0.
5. Xia H, Wang L, Xue Y, Kong W, Xue Y, Yu R, Xu H, Wang X, Wang J, Liu Z, Guo X. Impact of increasing *Maize* densities on agronomic performances and the community stability of productivity of maize/peanut intercropping systems. *Agronomy*. 2019 Mar 22;9(3):150.
6. Ayele HM. Evaluation of the effect of *Maize*-legume intercropping on soil moisture improvement in arid area of Bena-Tsemay district, South omo zone, Southern Ethiopia. *International Journal of Agricultural Research, Innovation and Technology*. 2020 Jul 7;10(1):80-6.
7. Gebru H. A review on the comparative advantages of intercropping to monocropping system. *Journal of Biology, Agriculture and Healthcare*. 2015;5(9):1-3.
8. Bacchi M, Monti M, Calvi A, Lo Presti E, Pellicanò A, Preiti G. Forage potential of cereal/legume intercrops: Agronomic performances, yield, quality forage and LER in two harvesting times in a Mediterranean environment. *Agronomy*. 2021 Jan 10;11(1):121.
9. Yadav T, Chopra NK, Chopra NK, Kumar R, Singh M, Datt C, Soni PG, Rathore DK, Kumar S. Influence of weed control methods on yield and quality of *Cowpea* fodder. *Indian Journal of Animal Nutrition*. 2016;33(1):70-4.
10. Ananthi T, Amanullah MM, Al-Tawaha AR. A review on *Maize*-legume intercropping for enhancing the productivity and soil fertility for sustainable agriculture in India. *Advances in environmental biology*. 2017 May 1;11(5):49-64.
11. Song C, Sarpong CK, Zhang X, Wang W, Wang L, Gan Y, Yong T, Chang X, Wang Y, Yang W. Mycorrhizosphere bacteria and plant-plant interactions facilitate *Maize* P acquisition in an intercropping system. *Journal of Cleaner Production*. 2021 Sep 10;314:127993.
12. Javanmard A, Majdi M, Hamzepour N, Nasiri Y. Evaluation of forage production using *Maize*-legume intercropping and biofertilizer under low-input conditions. *Philippine Agricultural Scientist*. 2017 Mar 1;100(1).

13. Alla WH, Shalaby EM, Dawood RA, Zohry AA. Effect of *Cowpea* (*Vigna sinensis* L.) with *Maize* (*Zea mays* L.) intercropping on yield and its components. *International Journal of Agricultural and Biosystems Engineering*. 2015 Jan 26;8(11):1258-64.
14. Saady HS. *Maize–Cowpea* intercropping as an ecological approach for nitrogen-use rationalization and weed suppression. *Archives of Agronomy and Soil Science*. 2015 Jan 2;61(1):1-4.
15. Pierre JF, Latournerie-Moreno L, Garruña R, Jacobsen KL, Laboski CA, Us-Santamaría R, Ruiz-Sánchez E. Effect of *Maize–Legume* Intercropping on Maize Physio-Agronomic Parameters and Beneficial Insect Abundance. *Sustainability*. 2022 Sep 29;14(19):12385.
16. Undie UL, Uwah DF, Attoe EE. Growth and development of late season maize/soybean intercropping in response to nitrogen and crop arrangement in the forest agro-ecology of South Southern Nigeria. *International Journal of Agricultural Research*. 2012;7(1):1-6.
17. Temesgen J, Kufa T, Wondimu Z. Effect of plant density of hybrid maize and common bean varieties on the productivity of intercropping system at Jimma, South West Ethiopia.
18. Pandey P, Bhambri MC. Growth response of *Maize* to different crop arrangements and nutrient managements under maize (*Zea mays* L.) and *Soybean* (*Glycine max* L.) intercropping system. *Plant Archives*. 2017;17(2):967-72.
19. Suárez JC, Anzola JA, Contreras AT, Salas DL, Vanegas JI, Urban MO, Beebe SE, Rao IM. Influence of simultaneous intercropping of *Maize*-bean with input of inorganic or organic fertilizer on growth, development, and dry matter partitioning to yield components of two lines of common bean. *Agronomy*. 2022 May 18;12(5):1216.
20. Zhang WP, Gao SN, Li ZX, Xu HS, Yang H, Yang X, Fan HX, Su Y, Fornara D, Li L. Shifts from complementarity to selection effects maintain high productivity in *Maize*/legume intercropping systems. *Journal of Applied Ecology*. 2021 Nov;58(11):2603-13.
21. Chhetri B, Sinha AC. Advantage of *Maize* (*Zea mays*)-based intercropping system to different nutrient management practices. *Indian Journal of Agronomy*. 2020;65(1):25-32.
22. Jat PC, Rathore SS, Sharma RK. Effect of integrated nitrogen management and intercropping systems on yield attributes and yield of *Maize*. *Indian Journal of Hill Farming*. 2014;27(1):52-6.
23. Subramanian KS, Bharathi C, Jegan A. Response of *Maize* to mycorrhizal colonization at varying levels of zinc and phosphorus. *Biology and fertility of soils*. 2008 Nov;45:133-44.
24. Choudhary VK, Kumar PS. Productivity, water use and energy profitability of staggered maize–legume intercropping in the eastern Himalayan Region of India. *Proceedings of the National Academy of Sciences, India Section B: Biological Sciences*. 2016 Sep;86:547-57.
25. Kim J, Song Y, Kim DW, Fiaz M, Kwon CH. Evaluating different interrow distance between corn and *Soybean* for optimum growth, production and nutritive value of intercropped forages. *Journal of Animal Science and Technology*. 2018 Dec;60(1):1-6.
26. Begam A, Mondal R, Dutta S, Banerjee H. Impact of cereal+ legume intercropping systems on productivity and soil health-a review. *International Journal of Bio-resource and Stress Management*. 2020;11(3):274-86.
27. Sridhar HS. Competitive functions, pest dynamics and bio-economic analysis in traditional *Maize* and legumes intercropping systems under rainfed situation of South India. *Indian Journal of Traditional Knowledge (IJTK)*. 2021 Aug 18;20(3):827-37.

28. Pandey P, Bhambri MC. Growth response of maize to different crop arrangements and nutrient managements under *Maize* (*Zea mays* L.) and *Soybean* (*Glycine max* L.) intercropping system. *Plant Archives*. 2017;17(2):967-72.
29. Tofa AI, Ademulegun T, Solomon R, Shehu H, Kamai N, Omoigui L. *Maize–Soybean* intercropping for sustainable intensification of cereal–legume cropping systems in northern Nigeria. *Experimental Agriculture*. 2019 Feb;55(1):73-87.
30. Ezung NK, Rajkhowa DJ, Yanthan B. Evaluation of *Maize* based legume intercropping systems. *Journal of Krishi Vigyan*. 2022;10(2):150-5.
31. Kumari S, Kumar R, Chouhan S, Chaudhary PL. Influence of Various Organic Amendments on Growth and Yield Attributes of Mung Bean (*Vigna radiata* L.). *International Journal of Plant & Soil Science*. 2023 May 13;35(12):124-30. <https://doi.org/10.9734/ijpss/2023/v35i122975>

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Table 3. Number of cobs plant⁻¹, Length of cob, cob diameter, grains row⁻¹, number of rows, tassel weight and grain cob⁻¹

Treatments	Number of cobs plant ⁻¹	Length of cob (cm)	cob diameter (cm)	grains row ⁻¹	no of rows cob ⁻¹	tassel weight (g)	Grains cob ⁻¹
T₁-Sole Maize	1.56 ^b ± 0.42	14.52 ^e ± 0.37	4.13 ^b ± 0.10	28.17 ^c ± 0.24	14.3 ^d ± 0.43	8.31 ^f ± 0.03	430.5 ^e ± 2.68
T₄-Maize + Cowpea (1:1)	2.11 ^{ab} ± 0.16	20.43 ^{ab} ± 1.38	4.29 ^{ab} ± 0.10	31.5 ^{ab} ± 1.09	16.77 ^{ab} ± 0.75	9.15 ^b ± 0.06	531.11 ^b ± 2.08
T₅-Maize + Cowpea (1:2)	2.77 ^a ± 0.16	21.09 ^a ± 0.32	4.52 ^a ± 0.02	34 ^{ab} ± 0.82	17.33 ^a ± 0.10	9.42 ^a ± 0.02	573.44 ^a ± 3.55
T₆-Maize + Cowpea (2:1)	1.89 ^b ± 0.16	19.71 ^{abc} ± 0.65	4.24 ^{ab} ± 0.22	31.5 ^{ab} ± 1.08	16.13 ^{abc} ± 0.88	8.94 ^c ± 0.04	507.78 ^c ± 2.08
T₇-Maize + Moong bean (1:1)	1.78 ^b ± 0.16	17.28 ^{cd} ± 0.48	4.18 ^{ab} ± 0.13	30.17 ^{bc} ± 1.31	15.6 ^{bcd} ± 0.73	8.63 ^d ± 0.09	453.33 ^d ± 3.69
T₈-Maize + Moong bean (1:2)	2 ^{ab} ± 0.27	18.33 ^{bcd} ± 1.19	4.21 ^{ab} ± 0.06	30.67 ^{bc} ± 0.94	16.23 ^{abc} ± 0.22	8.81 ^c ± 0.08	454.89 ^d ± 3.82
T₉-Maize + Moong bean (2:1)	1.67 ^b ± 0.27	16.33 ^{de} ± 0.72	4.15 ^{ab} ± 0.09	28.83 ^{bc} ± 0.85	14.94 ^{cd} ± 0.50	8.47 ^e ± 0.06	431.78 ^e ± 2.64

Table 4. Tassel primary branch length, Tassel length, Test weight, Dry weight, Stover yield, Grain yield and Harvest index

Treatments	Tassel primary branch length (cm)	Tassel length (cm)	Test weight (g)	Dry weight (g)	stover yield (kg ha ⁻¹)	Grain yield (kg ha ⁻¹)	Harvest index (%)
T ₁ -Sole Maize	16.77 ^e ± 0.06	31.41 ^d ± 0.41	38.57 ^c ± 0.42	80.66 ^f ± 0.72	6592.77 ^f ± 36.66	5442.83 ^f ± 29.55	43.83 ^b ± 0.067353
T ₄ -Maize + Cowpea (1:1)	19.86 ^b ± 0.04	31.84 ^c ± 0.09	40.77 ^b ± 0.54	90.44 ^{ab} ± 0.95	7516 ^b ± 33.79	5806 ^b ± 19.25	44.2 ^b ± 0.138329
T ₅ -Maize + Cowpea (1:2)	20.7 ^a ± 0.44	32.93 ^a ± 0.06	43.33 ^a ± 0.58	92.33 ^a ± 0.98	7622.1 ^a ± 36.55	5915.83 ^a ± 33.25	45.67 ^a ± 0.692866
T ₆ -Maize + Cowpea (2:1)	19.41 ^b ± 0.09	32.36 ^b ± 0.08	40.53 ^b ± 0.50	88.11 ^{bc} ± 1.37	7407.67 ^c ± 22.31	5768.17 ^{bc} ± 15.69	44.18 ^b ± 0.215684
T ₇ -Maize + Moong bean (1:1)	18.65 ^c ± 0.07	32.18 ^{bc} ± 0.07	39.63 ^{bc} ± 0.45	84 ^{de} ± 0.27	7256.8 ^{de} ± 41.99	5662.67 ^d ± 37.96	44.04 ^b ± 0.397526
T ₈ -Maize + Moong bean (1:2)	18.78 ^c ± 0.07	31.78 ^{cd} ± 0.05	40.1 ^{bc} ± 0.94	86.66 ^{cd} ± 0.54	7324.67 ^{cd} ± 22.60	5712 ^{cd} ± 10.23	44.06 ^b ± 0.211129
T ₉ -Maize + Moong bean (2:1)	17.35 ^d ± 0.05	31.86 ^c ± 0.04	39.6 ^{bc} ± 0.43	82.11 ^{ef} ± 1.29	7164.67 ^e ± 20.07	5546.33 ^e ± 39.20	44 ^b ± 0.093255

Table 5. Land Equivalent Ratio, Net Assimilation Rate, Crop Growth Rate, Maize equivalent yield and Relative Growth Rate

Treatments	LER	LER	NAR 60-90 DAS	CGR at 60-90 DAS	MEY (kg ha ⁻¹)	RGR at 60-90 DAS
T₁-Sole Maize	1 ^d ± 0.00	1 ^d ± 0.00	0.001 ^c ± 2.8677 ^E -05	2.12 ^b ± 0.0503	5542.8 ^e ± 128.24	0.0065 ^{bc} ± 0.000186
T₄-Maize + Cowpea (1:1)	1.5 ^b ± 0.01	2.19 ^{ab} ± 0.01	0.0013 ^{bc} ± 1.4157 ^E -05	2.26 ^a ± 0.0267	11152.52 ^b ± 98.92	0.0062 ^{bc} ± 0.000082
T₅-Maize + Cowpea (1:2)	1.8 ^a ± 0.00	2.22 ^a ± 0.00	0.0013 ^b ± 1.4869 ^E -05	2.29 ^a ± 0.0268	11663.36 ^a ± 221.61	0.0061 ^c ± 0.000089
T₆-Maize + Cowpea (2:1)	1.47 ^{bc} ± 0.01	2.16 ^{bc} ± 0.01	0.0013 ^{bc} ± 2.1593 ^E -05	2.25 ^{ab} ± 0.0339	10969.55 ^b ± 134.18	0.0063 ^{bc} ± 0.000101
T₇-Maize + Moong bean (1:1)	1.31 ^c ± 0.00	2.11 ^c ± 0.00	0.0013 ^{bc} ± 4.7444 ^E -05	2.22 ^{ab} ± 0.0777	8165.19 ± 57.53	0.0064 ^{bc} ± 0.000230
T₈-Maize + Moong bean (1:2)	1.65 ^c ± 0.03	2.16 ^{bc} ± 0.03	0.0013 ^{bc} ± 4.9187 ^E -05	2.24 ^{ab} ± 0.0755	8499.47 ^c ± 129.99	0.0064 ^{bc} ± 0.000202
T₉-Maize + Moong bean (2:1)	1.34 ^c ± 0.033	2.11 ^c ± 0.033	0.0013 ^{bc} ± 2.9728 ^E -05	2.21 ^{ab} ± 0.0537	7886.26 ^d ± 15.6	0.0065 ^b ± 0.000140

Table 6. Number of pods plant⁻¹, number of seed pod⁻¹, seed yield and test weight of Cowpea and Moong bean.

Treatments	No. of pods plant ⁻¹	No. of Seeds pod ⁻¹	Seed yield (Kg ha ⁻¹)	Test weight (g)
T₂- Sole cowpea	24.78 ^a ± 0.68	13.00 ^a ± 2.45	2451.13 ^a ± 20.22	26.67 ^d ± 2.49
T₃-Sole Moong bean	31.44 ^a ± 1.36	11.22 ^b ± 0.87	2245.23 ^c ± 15.58	50.00 ^a ± 3.74
T₄-Maize + Cowpea (1:1)	20.11 ^d ± 1.50	11.11 ^b ± 1.91	2384.93 ^b ± 14.07	23.00 ^e ± 2.44
T₅-Maize + Cowpea (1:2)	16.44 ^e ± 2.86	9.22 ^c ± 1.91	2228.80 ^c ± 15.42	18.83 ^f ± 3.27
T₆-Maize + Cowpea (2:1)	20.00 ^d ± 2.50	11.55 ^b ± 1.91	2349.70 ^b ± 12.31	22.00 ^e ± 2.44
T₇-Maize + Moong bean (1:1)	28.78 ^b ± 2.08	9.00 ^c ± 2.68	2137.03 ^d ± 13.63	46.33 ^b ± 5.25
T₈-Maize + Moong bean (1:2)	23.00 ^c ± 2.45	7.00 ^d ± 1.63	1965.16 ^e ± 16.24	40.00 ^c ± 2.45
T₉-Maize + Moong bean (2:1)	28.11 ^b ± 4.60	9.00 ^c ± 1.63	2118.30 ^d ± 27.33	45.13 ^b ± 4.09