International Journal of Environment and Climate Change

Volume 13, Issue 8, Page 1278-1286, 2023; Article no.IJECC.101015
ISSN: 2581-8627
(Past name: British Journal of Environment & Climate Change, Past ISSN: 2231–4784)

Impact on Maize (*Zea mays*) Crop Productivity and Yield Parameters with Intercropping of Cowpea (*Vigna unguiculata* L.) and Moong Bean (*Vigna radiata* L.)

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Authors' contributions

This work was carried out in collaboration among all authors. The author Pinki is responsible for the conceptualization and design of the study as well as data collecting, tabulation and manuscript preparation while the author AS helped in screening the data and selecting analysis tools, the author MN designed the analysis and performed the analysis. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJECC/2023/v13i82070

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/101015

Original Research Article

Received: 23/04/2023
Accepted: 05/06/2023
Published: 10/06/2023

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.,* (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 (1:3), (T_7) Maize + Moong bean (1:1), (T_8) Maize + Moong bean (1:2)

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and, (T_9) 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. (T_5) 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]. Cowpea's 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 METHODS

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 kgha^{-1}, available Phosphorus of 12 kgha^{-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°C ±5°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 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 T_5 performed well for all the traits. Plant height (cm) was maximum at harvest in T_5 (212.55) followed by T_4 (208.00) and T_6 (206.99) and minimum in T_1 (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 T_5 (14.00) followed by T_4 (12.22) and T_8 (12.11) and minimum in T_1 (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 T_5 (33.32) followed by T_4 (31.39) and T6 (28.38). Minimum reading was observed in T_7 (26.64). [14], found similar results. The leaf area was recorded high in sole Maize than intercrop. Maximum leaf area (cm^2) was observed in T_1 (723.5) followed by T_5 (716.4) and T_6 (713.7) whereas T_7 (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)
T$_1$-Sole Maize	200.33^{d} ± 0.72	11.78^{b} ± 0.57	27.35^{c} ± 0.84	723.5^{a} ±0.92
T$_4$-Maize + Cowpea (1:1)	208.00^{b} ± 1.70	12.22^{ab} ± 0.87	31.39^{ab} ± 0.94	711.31^{d} ± 0.91
T$_5$-Maize + Cowpea (1:2)	212.55^{a} ± 1.66	14.00^{a} ± 0.27	33.32^{a} ± 0.89	716.4^{b} ± 0.45
T$_6$-Maize + Cowpea (2:1)	206.99^{bc} ± 1.25	12.5^{ab} ± 0.13	28.38^{bc} ± 0.78	713.7^{c} ± 0.22
T$_7$-Maize + Moong bean (1:1)	204.77^{bc} ± 1.03	11.89^{b} ± 0.68	26.64^{c} ±0.80	701^{f} ± 0.72
T$_8$-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

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}
T$_1$-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
T$_4$-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
T$_5$-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
T$_6$-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
T$_7$-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
T$_8$-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
T$_9$-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	84de ± 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
T_1-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
T_4-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
T_5-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
T_6-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
T_7-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
T_8-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
T_9-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)
T_2- Sole cowpea	24.78^{a} ± 0.68	13.00^{a} ± 2.45	2451.13^{a} ± 20.22	26.67^{d} ± 2.49
T_3-Sole Moong bean	31.44^{a} ± 1.36	11.22^{b} ± 0.87	2245.23^{c} ± 15.58	50.00^{a} ± 3.74
T_4-Maize + Cowpea (1:1)	20.11^{d} ± 1.50	11.11^{b} ± 1.91	2384.93^{b} ± 14.07	23.00^{e} ± 2.44
T_5-Maize + Cowpea (1:2)	16.44^{e} ± 2.86	9.22^{c} ± 1.91	2228.80^{c} ± 15.42	18.83^{f} ± 3.27
T_6-Maize + Cowpea (2:1)	20.00^{d} ± 2.50	11.55^{b} ± 1.91	2349.70^{b} ± 12.31	22.00^{e} ± 2.44
T_7-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
T_8-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
T_9-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

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 T_5 was observed best for maximum yield and it attributing traits followed by T_4 and T_6 in most of the traits whereas T_1 performance is low. [17] found the matching results. The maximum number of cob plants^{-1} were found in the same T_5 (2.77) followed by T_4 (2.77) and T_8 (2.0). Similar findings were of [18]. Length of cob (cm) was observed maximum for T_5 (21.09) followed by T_4 (20.43) and T_6 (19.71). Cob diameter (cm) was observed maximum in T_5 (4.52) followed by T_4 (4.29) and T_6 (4.24). The maximum grains row^{-1} was noticed in the same T_5 (34) followed by both T_4 and T_6 (31.5). The minimum grains cob^{-1} was recorded in sole Maize T_1 (28.17). Maximum number of rows cob^{-1} (Table 3) were found maximum in T_5 (17.33) followed by T_4 (16.77) and T_6 (16.13). [19] also revealed that intercropping improved the length of cob, cob diameter, grains row^{-1}, number of rows. T_5 (9.42) revealed maximum tassel weight followed by T_4 (9.15) and T_6 (8.94). For grain cob^{-1} T_5 (573.44) found maximum cob followed by T_4 (531.11) and T_6 (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, T_5 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) T_5 revealed maximum (32.93), (20.7) and (9.42) respectively. Whereas T_4 (19.86) is significant for branch length and T_6 (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 T_5 (43.33) and minimum from T_1 (38.57**)** [22] did similar studies. The maximum grain yield in kgha^{-1} is recorded in T_5 (5915.83) followed by T_4 (5806) and T_6 (5768.17). Test weight (g) and dry weight (g) also found maximum for T_5 (43.33, 92.33) followed by T_4 (40.77, 90.44) and T_6 (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 T_5 (7622.1, 5915.83) followed by T_4 (7516, 5806) and T_6 (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 T_5 (45.67) followed by T_4 (43.83) and T_6 (45.67) and minimum in sole T_1 (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 gcm^{2}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 kg ha^{-1}, 11152.52 kgha^{-1} and 10969.55 kgha^{-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 [29], 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 [30]. Earlier scientists have observed the yield difference in legumes caused by population diversity in Maize-legume intercropping [31] 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 (T_5) Maize + Cowpea (1:2). However the Cowpea's treatments (T_4) Maize + Cowpea (2:1) and (T6) Maize + Cowpea (1:1) were statistically at par. In Maize-Moong intercrop the best treatment was (T_8) Maize + Moong bean (1:2). The treatments (T_7) Maize + Moong bean (2:1) and (T_9) Maize + Moong bean (1:1) were statistically at par. The highest LER and MEY (kg ha^{-1}) were recorded from T_5 (1.8) and (11663.36) kg ha^{-1} respectively. Therefore we suggest Maize-legume intercrop can be adopted under Punjab's conditions.

ACKNOWLEDGEMENT

The authors are thankful to Lovely Professional University, Phagwara, Punjab-144402, India.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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The peer review history for this paper can be accessed here:
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