www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2021; 10(11): 834-837

www.thepharmajournal.com
Received: 15-09-2021
Accepted: 30-10-2021

Peiwang
M.Sc. Scholar, Department of Agronomy, NAI, SHUATS, Prayagraj, Uttar Pradesh, India

Joy Dawson
Professor and Head of Department, Department of Agronomy, NAI, SHUATS, Prayagraj, Uttar Pradesh, India

Corresponding Author:
Peiwang
M.Sc. Scholar, Department of Agronomy, NAI, SHUATS, Prayagraj, Uttar Pradesh, India

Study on intercropping in maize (*Zea mays* L.) with Legumes

Peiwang and Joy Dawson

Abstract
A field experiment was conducted at Crop Research Farm (CRF), SHUATS, Prayagraj, Uttar Pradesh, during the *Zaid* season of 2021 with 9 treatments replicated thrice in randomized block design, to study intercropping in maize (*Zea mays* L.) with legumes. The result revealed that treatment T_1 (Maize sole) was found to be maximum for no. of cobs plant^{-1} (2.87), grains cob^{-1} (345.43), test weight (238.67 g), grain yield (8900 kg ha^{-1}) and stover yield (20100 kg ha^{-1}). Land equivalent ratio (1.43) and maize equivalent yield (11639.33 kg ha^{-1}) were found to be highest in treatment T_6 (Maize + Green gram 2:2). The highest gross returns (₹ 157803.10 ha^{-1}), net returns (₹ 116043.10 ha^{-1}) and B:C ratio (3.78) were recorded in treatment T_6 (Maize + Green gram 2:2).

Keywords: Intercropping, land equivalent ratio, maize equivalent yield, maize, legumes

Introduction
Maize (*Zea mays* L.) is the third major cereal crop after Wheat and Rice and belongs to Gramineae family. Among the cereals Maize rank 5th in total area and 3rd in total production and productivity in India. In India, the crop occupies 9.19 m ha with a production of 24.17mt and average productivity is 2632 kg/ha (2014-15). It is a miracle crop as it has very high yield potential. There is no other cereal on the earth which has such yield potential and that is why it is called "Queen of cereals". Maize (*Zea mays* L.) is the world's leading cereal grain crop and one of the most versatile emerging crops having wider adaptability.

Intercropping is an ancient practice, placed on the fringes of a 'modern agriculture' dominated by large areas of monocultured, resource-consuming and high-yielding crops (Vandermeer, 2010; Zhang *et al.*, 2010; Li *et al.*, 2013) [24, 27, 9]. However, intercropping may be a means to address some of the major problems associated with modern farming, including moderate yield, pest and pathogen accumulation, soil degradation and environmental deterioration (Vandermeer, 1989) [23], thereby helping to deliver sustainable and productive agriculture (Lithourgidis *et al.*, 2011) [10]. Intercropping has been recognized potentially beneficial system to increase crop production per unit time and area, which can provide substantial yield advantages compared to sole cropping. These advantages may be especially important because they are achieved not by means of costly inputs, but by the simple expedient of growing crops together (Willey, 1979) [25]. The main objective of intercropping is to improve the productivity per unit land area per unit time with equitable and judicious utilization of land resources and farming inputs including labour without reducing base crop yield (Marer *et al.*, 2007) [16].

Cereal–legume intercropping grown for both the green fodder and seeds are valued for the important role they play in sustainable agriculture (Andersen *et al.*, 2007) [1]. One of the explanations for this improvement is that the maize canopy is not able to intercept all the solar radiation during the growth period. Hence, the remaining radiation is captured by the culture growing under the maize, resulting in better use of this resource (Prasad & Brook 2005) [18] and blocking the light from reaching the undesirable plants (weeds). Chen *et al.*, (2004) [3] found that intercropping maize with legumes was beneficial in yield increment because of improved soil fertility and less competition for water and nutrients between maize and weeds as the latter are suppressed by the leguminous crop. Furthermore, intercropping cereals with legumes have huge capacity to replenish soil mineral nitrogen through its ability to biologically fix atmospheric nitrogen (Mandal *et al.*, 1991; Maitra *et al.*, 2000; Giller, 2001) [14, 11, 6].

Materials and Methods

The experiment was carried out at Crop Research Farm, Department of Agronomy, Naini Agricultural Institute, SHUATS, Prayagraj (U.P.).

The area is situated on the south of Allahabad on the right hand of rivers Yamuna at Rewa Road at a distance of about 7 km of Allahabad city. Allahabad has sub-humid sub-tropical climate with the monsoon commencing from July and withdrawing by the end of September. The rainfall is unevenly distributed and most of it is received between July and September.

Apart from this, a few winter and summer showers are also received. The soil of the experimental field was sandy loam in texture with pH 7.4, low in organic carbon 0.62%, available P 29.3 kg/ha and available K 257.5 kg/ha. This experiment was conducted in year 2020-21 during the Zaid season and maize variety 'SWARAJ', green gram variety 'PDM 139' and cowpea variety 'ANKUR HARI' was sown on 07th April, 2021.

The experiment consisted of 9 treatments namely T_1: Maize sole, T_2: Green gram sole, T_3: Cowpea sole, T_4: Maize + Green gram (2:1), T_5: Maize + Cowpea (2:1), T_6: Maize + Green gram (2:2), T_7: Maize + Cowpea (2:2), T_8: Maize + Green gram (1:2) and T_9: Maize + Cowpea (1:2) replicated thrice in randomized block design. A fertilizer dose of 120-40-40 kg/ha N-P-K was applied to maize sole plots and maize + legumes plots, whereas, in green gram and cowpea sole plots a fertilizer dose of 20-40-40 kg/ha N-P-K was applied. Half of nitrogen was applied through urea as basal dressing at sowing and rest half of nitrogen was top-dressed at 30 DAS. Full dose of phosphorus and potassium was applied through single super phosphate and muriate of potash respectively, at the time of sowing.

Other agronomic management practices were followed as per the standard recommendation. Green gram was harvested on 18th of June, cowpea on 26th of June and maize was harvested on 7th of July. The data on growth parameters, yield attributes and yield were recorded in different treatments. All the data were statistically analysed.

Results and Discussion

Yield attributes and yield of maize

Number of cobs per plant

The data as presented in Table 1 showed that highest number of cobs plant^{-1} (2.87) was found in treatment T_1 (Maize sole) though with non-significant difference. The lowest number of cobs per plant was recorded in treatment T_4 (Maize + Green gram 2:1).

Number of grains per cob

Number of grains cob^{-1} is an important yield contributing parameter and has a direct bearing on the final grain yield of maize. There was a significant difference within the treatments for number of grains cob^{-1}. Treatment T_1 (Maize sole) recorded significant and highest number of grains cobs^{-1} (345.43). However, treatments T_6 (Maize + Green gram 2:2) was found to be statistically at par with treatment T_1 (Maize sole). The increase in number of grains cob^{-1} of maize was also reported in maize soybean intercropping system by Zhang and Li (1987) [26] and Rana *et al.*, (2001).

Test weight

Highest test weight (238.67 g) was recorded in treatment T_1 (Maize sole) though with non-significant difference. This lowest value was recorded in treatment T_9 (Maize + Cowpea 1:2). Kalra and Ganger (1980) [7] also reported the higher test weight of maize under pure stand.

Grain yield and stover yield

The data showed that significant and highest grain yield (8900 kg ha^{-1}) and stover yield (20100 kg ha^{-1}) were recorded in treatment T_1 (Maize sole). However, treatment T_6 (Maize + Green gram 2:2) was found to be statistically at par with treatment T_1 (Maize sole).

The reduction in seed yield of maize under intercropping treatments could be assigned to lower values of almost all yield attributes *viz*., number of cobs per plant, number of grains per cob and 1000 grain weight under intercropping treatments resulting from poor plant growth due to competition effect between maize and intercrops for resources like sun light, space, moisture and plant nutrients. Reduction in seed yield of maize owing to legume intercropping was also reported by Chalka and Nepalia 2005 [2], Marer *et al.*, 2007 [16], Sheoran *et al.*, 2010 [22], Chaudhary *et al.*, 2012 [4], Mandal *et al.*, 2014 [15], Nyasasi and Kisetu 2014 [17], Kaushal *et al.*, 2015 [8].

Intercropping indices

Land equivalent ratio

The data as presented in Table 2 showed that significant and highest (1.43) land equivalent ratio was recorded in Treatment T_6 (Maize + Green gram 2:2). However, treatment T_7 (Maize + Cowpea 2:2) was statistically at par with treatment T_6 (Maize + Green gram 2:2). The data showed that all the intercropping systems recorded land equivalent ratio greater than 1 which indicates higher land use efficiency of intercropping over sole crop. In terms of land utilization, 2:2 ratio proved to be more advantageous. Such results were also reported by Saban *et al.*, 2007 and Dahmardeh *et al.*, 2010 [20, 5]. Land equivalent ratio and other competitive functions were favourably influenced with intercropped maize + green gram and maize + cowpea. Sharma and Behera 2009 [21].

Maize equivalent yield

The data showed that all the intercropping systems recorded maize grain equivalent yield higher than sole maize. Treatment T_6 (Maize + Green gram 2:2) showed significant and highest maize grain equivalent yield (11639.33 kg ha^{-1}). However, treatments T_7 (Maize + Cowpea 2:2) and T_8 (Maize + Green gram 1:2) were statistically at par with T_6 (Maize + Green gram 2:2).

The difference in maize grain equivalent yield was mainly as a consequence of differences in the yield of maize, additional component crop yield and price of individual component crops. Higher maize equivalent yield under intercropping systems was attributed to yield advantages achieved in intercropping system Marer *et al.*, 2007 [16].

Aggressivity

Aggressivity values were positive (+ve) in maize which obviously indicated that maize was the dominant crop, whereas the associated intercrops appeared to be the dominated ones having negative (-ve) values. Being a C_4 plant, maize appeared to be more competitive and the subsidiary intercrops were found to be less competitive with respect to utilization of available resources.

Economics

Gross return, Net return and B:C Ratio

Observations regarding the economics of treatments are given in table 3.

The highest gross returns (₹ 157803.10 ha^{-1}), net returns (₹ 116043.10 ha^{-1}) and B:C ratio (3.78) were recorded in treatment T_6 (Maize + Green gram 2:2).

The highest net return was obtained when maize was intercropped with green gram at 2:2 ratio. This might be due to the spatial as well as temporal complementarity which resulted in substantial yield advantages from intercropping. Similar results were also obtained by Mandal *et al.,* (1986, 1990 and 1991) [12, 13, 14]. Higher monetary advantages were always obtained when maize was intercropped with leguminous crops. Maize + green gram (2:2) intercropping gave rise to the highest monetary advantage. Similar observation was also made by Refey and Prasad 1992 [19].

Table 1: Effect of intercropping on yield attributes and yield of maize

Treatments	No. of cobs plant^{-1} at	No. of grains cob^{-1}	Test weight (g)	Grain yield (kg ha^{1})	Stover yield (kg ha^{1})
Maize sole	2.87	345.43	238.67	8900.00	20100.00
Green gram sole	-	-	-	-	-
Cowpea sole	-	-	-	-	-
Maize + Green gram (2:1)	2.47	339.37	237.00	8000.00	17933.33
Maize + Cowpea (2:1)	2.53	339.40	236.67	7966.67	18106.67
Maize + Green gram (2:2)	2.67	343.73	237.00	8733.33	19966.67
Maize + Cowpea (2:2)	2.60	342.97	236.67	8633.33	19900.00
Maize + Green gram (1:2)	2.53	341.67	236.33	8500.00	19833.33
Maize + Cowpea (1:2)	2.60	339.17	235.67	8333.33	19333.33
F test	NS	S	NS	S	S
SEd (±)	0.12	1.25	1.44	193.55	277.64
CD (P=0.05)	-	2.73	-	421.70	604.92

Table 2: Effect of intercropping in maize with legumes on land equivalent ratio, maize equivalent yield and aggressivity

			Aggressivity	
Treatments	Land equivalent ratio	Maize equivalent yield (kg ha^{-1})	Maize	Legumes
Maize sole	1.00	8900.00	-	-
Green gram sole	1.00	-	-	-
Cowpea sole	1.00	-	-	-
Maize + Green gram (2:1)	1.31	10730.00	0.04	-0.04
Maize + Cowpea (2:1)	1.28	10300.00	0.06	-0.06
Maize + Green gram (2:2)	1.43	11639.33	0.27	-0.27
Maize + Cowpea (2:2)	1.40	11230.33	0.27	-0.27
Maize + Green gram (1:2)	1.37	11260.00	0.74	-0.74
Maize + Cowpea (1:2)	1.33	10713.33	0.74	-0.74
F test	S	S		
SEd (±)	0.03	217.29		
CD (P=0.05)	0.06	473.43	NA	NA

Table 3: Economics of different treatment combinations

Treatments	Gross return (₹ ha^{-1})	Net return (₹ ha^{-1})	B:C ratio
Maize sole	129200.00	88440.00	3.17
Green gram sole	69100.00	26340.00	1.62
Cowpea sole	63826.44	19066.44	1.43
Maize + Green gram (2:1)	144537.80	103117.80	3.49
Maize + Cowpea (2:1)	140906.48	98826.48	3.35
Maize + Green gram (2:2)	157803.10	116043.10	3.78
Maize + Cowpea (2:2)	153745.96	110985.96	3.59
Maize + Green gram (1:2)	153798.00	111698.00	3.65
Maize + Cowpea (1:2)	147596.62	106156.62	3.39

*data on economics are not subjected to statistical analysis

References

1. Andersen MK, Hauggaard NH, Høgh-Jensen HJ ES. Competition for and utilisation of sulfur in sole and intercrops of peas and barley. Nutrient Cycling in Agroecosystems 2007;77:143-153.
2. Chalka MK, Nepalia V. Production potential and economics of maize (*Zea mays*) intercropped with legumes as influenced by weed control. Indian Journal of Agronomy 2005;50(2):119-122.
3. Chen C, Westcott M, Neill K, Wichman D, Knox M. Row configuration and nitrogen application for barley–pea intercropping in Montana. Journal of Agronomy and Crop Science 2004;96:1730-1738.
4. Choudhary VK, Dixit A, Sureshkumar P, Bhagwati R. Production potential, soil moisture and temperature as influenced by maize-legume intercropping. International Journal of Science and Nature 2012;3(1):41-46.
5. Dahmardeh M, Ghanbari A, Syasar B, Ramroudi M. The role of intercropping maize (*Zea mays* L.) and Cowpea (*Vigna unguiculata* L.) on yield and soil chemical properties. African Journal of Agricultural Research 2010;5:631-636.

6. Giller KE. Nitrogen Fixation in Tropical Cropping Systems. 2nd Ed., CABI, Wallingford 2000,423.
7. Kalra GS, Ganger B. Economics of intercropping of different legumes with maize at different levels of N under rainfed conditions. Indian Journal of Agronomy 1980;25:181-185.
8. Kaushal S, Rameshwar, Saini JP, Punam, Sankhyan NK. Performance of maize (*Zea mays*)-based intercropping systems and their residual effect on wheat (*Triticum aestivum*) + lentil (*Lens culinaris*) intercropping system under organic conditions. Indian Journal of Agronomy 2015;60(2):224-229.
9. Li L, Zhang LZ, Zhang FZ. Crop mixtures and the mechanisms of overyielding. In: Levin SA, ed. Encyclopedia of biodiversity, 2nd edn, 2. Waltham, MA, USA: Academic Press 2013,382–395.
10. Lithourgidis AS, Dordas CA, Damalas CA, Vlachostergios DN. Annual intercrops: an alternative pathway for sustainable agriculture. Australian Journal of Crop Science 2011;5:396-410.
11. Maitra S, Ghosh DC, Sounda G, Jana PK, Roy DK. Productivity, competition and economics of intercropping legumes in finger millet (*Eleusine coracana*) at different fertility levels, Indian Journal of Agricultural Sciences 2000;70(12):824-828.
12. Mandal BK, Dasgupta S, Ray PK. Yield of wheat, mustard and chickpea grown as sole and intercrops with four moisture regimes. Indian Journal of Agricultural Science 1986;56(8):577-583.
13. Mandal BK, Mahapatra SK. Barely, lentil and flax yield under different intercropping systems. Agronomy Journal 1990;82:1066-1068.
14. Mandal BK, Dhara MC, Mandal BB, Bhunia SR, Dandapat A. Nodulation in some legumes grown as pure and intercrops. Indian Agriculturist 1991;35(1):15-19.
15. Mandal MK, Banerjee M, Banerjee H, Alipatra A, Malik GC. Productivity of maize based intercropping system during kharif season under red and lateritic tract of West Bengal. An international quarterly journal of environmental sciences 2014;9(1):31-35.
16. Marer SB, Lingaraju BS, Shashidhara GB. Productivity and economics of maize and pigeon pea intercropping under rainfed condition in northern transitional zone of Karnataka. Karnataka Journal of Agricultural Sciences 2007;20(1):1-3.
17. Nyasasi BT, Kisetu E. Determination of land productivity under maize-cowpea intercropping system in agro-ecological zone of mount Uluguru in Morogoro, Tanzania. Global Journal of Agriculture Science 2014;2(2):147-157.
18. Prasad RB, Brook RM. Effect of varying maize densities on intercropped maize and soybean in Nepal. Experimental Agriculture 2005;41:365-382.
19. Refey A, Prasad NK. Biological potential and economic feasibility of maize (*Zea mays*) + pigeonpea (*Cajanus cajan*) intercropping system in dry lands. Indian Journal of Agricultural Science 1992;62:110-113.
20. Saban Y, Mehmt A, Mustafa E. Identification of Advantages of Maize-Legume Intercropping over Solitary Cropping through Competition Indices in the East Mediterranean Region. Turkish Journal of Agriculture and Forestry 2007;32:111-119.
21. Sharma AR, Behera UK. Recycling of legume residues for nitrogen economy and higher productivity in maize (*Zea mays*)-wheat (*Triticum aestivum*) cropping system, Nutrient Cycling in Cropping Systems 2009;83(3):197-210.
22. Sheoran P, Sardana V, Singh S, Bhushan B. Bio-economic evaluation of rainfed maize (*Zea mays*)-based intercropping systems with blackgram (*Vigna mungo*) under different spatial arrangements. Indian Journal of Agricultural Sciences 2010;80(3):244–7,56-59.
23. Vandermeer JH. The ecology of intercropping. Cambridge, UK: Cambridge University Press 1989.
24. Vandermeer J. The ecology of agroecosystems. Sudbury, MA, USA: Bartlett and Jones 2010.
25. Willey RW. Intercropping its importance and research needs. Part l. Competition and yield advantage. Field Crop Abstracts 1979;32:110.
26. Zhang XL, Li BH. A study on the complementary and competitive effects induced by intercropping and mixed cropping of maize and soybeans on fertile land. Scientia Agricultura Sinica 1987;20(2):34-42.
27. Zhang F, Shen J, Zhang J, Zuo Y, Li L, Chen X. Rhizosphere processes and management for improving nutrient use efficiency and crop productivity: implications for China. Advances in Agronomy 2010;107:1-32.