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Research Communication

Designing crop geometry in maize (*Zea mays*)–legume intercropping systems for higher system productivity and profitability in Eastern plateau region of India

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ABSTRACT

A field study on intercropping maize [*Zea mays* L.] with green gram [*Vigna radiata* L.] and cowpea [*Vigna unguiculata* L.] was undertaken in randomized complete block design at the ICAR-Indian Agricultural Research Institute, Jharkhand during the wet (*kharif*) season in 2022 to determine the impact of crop geometry in maize legume intercropping systems for higher system productivity and profitability. Though crop yields for individual crops of maize, green gram and cowpea were found to be the highest for sole crop, but yield of intercropping system in terms of maize equivalent yield was found to be the highest for the additive crop stand of maize + cowpea (10.05 t/ha) followed by that additive crop stand of maize + green gram (9.82 t/ha). Higher system productivity (91.3 kg/ha/day), system profitability (₹1690.1 /ha/day), land equivalent coefficient (0.70), area time-equivalent ratio (1.37) and monetary advantage (₹69,987) were derived in additive crop stand of maize with cowpea; while, higher relative crowding coefficient (1.78), energy efficiency (14.4 MJ/ha) and energy productivity (0.93 kg/MJ) were in additive crop stand of maize with green gram. Thus, intercropping maize with green gram/cowpea at additive crop stands could ensure higher productivity and profitability than its pure crop stand of maize in this Eastern plateau region, India.

Key words: Additive stand, Maize-legume intercropping system, Productivity, Profitability replacement stand

Maize (*Zea mays* L.) is one of the most versatile crops having wider adaptability across diverse agro-climatic conditions because of its higher genetic yield potential. Globally, maize is known as queen of cereals because it has the highest genetic yield potential among the cereals. In India, maize is the third most important food crop after rice and wheat grown on 9.86 million ha area, contributing 31.5 million tonnes produce (DES, 2021). Intensifying cropping systems may be one of the viable options promoting system productivity. Moreover, different crops and intercropping stand geometries could also enhance resource use efficiency and profitability as well. Maize is a widely spaced crop and offers ample scope for adoption of intercropping and combination of maize legume in intercropping benefits the agricultural production system by many ways with enhancement of productivity from unit area (Maitra *et al.,* 2019). Intercropping maize with short duration legumes offers the potential to obtain high productivity and profitability at low water use without reducing its own yield. Other host of benefits accruing from legume-cereal intercrop include ability of legumes to combat erosion and thereby conserve soil resources, suppression of weeds and increase in yield of benefiting crops (Ijoyah *et al*., 2012). Therefore, the present study on legume based maize intercropping system was conducted during *kharif* season in 2022 at the ICAR-IARI, Jharkhand with the objective to determine comparative yield benefits with different crop stand arrangement for sustaining higher productivity and profitability.

The field experiment was conducted at the ICAR-Indian Agricultural Research Institute farm in Jharkhand, situated at latitude 24°16' N, longitude 24°28' N and 85°21' E to 85°36' E an elevation of 413 meters to 387.51 meters above sea level. The experimental soil was sandy loam, acidic in reaction (*p*H 5.4) containing organic carbon (0.29%), available nitrogen (128.4 kg/ha), available phosphorus (6.62 kg/ha) and available potassium (135.8 kg/ha).

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Experiment constitute nine treatments, viz. T_1, pure crop stand of maize with plant population of 83,333/ha; T_2, pure crop stand of green gram with plant population of 333,333/ha; T_3, pure crop stand of cowpea with plant population of 148,148/ha; T_4, additive crop stand of maize + green gram (1:2) with plant population of 83,333/ha (maize) and 170,000/ha (green gram); T_5, replacement crop stand-I of maize + green gram (1:1) with plant population of 52,000/ha (maize) and 170,000/ha (green gram); T_6, replacement crop stand-II of maize + green gram (1:3) with plant population of 52,000/ha (maize) and 255,000/ha (green gram); T_7, additive crop stand of maize + cowpea (1:2) with plant population of 83,333/ha (maize) and 106,666/ha (cowpea); T_8, replacement crop stand-I of maize + cowpea (1:1) with plant population of 52000/ha (maize) and 106,666/ha (cowpea); T_9, replacement crop stand-II of maize + cowpea (1:3) with plant population of 52,000/ha (maize) and 160,000/ha (cowpea) in a randomized complete block design with three replications. Seed rates for different crops were 20 kg/ha, 16 kg/ha, and 35 kg/ha for maize, green gram and cowpea pure crop stands respectively. Different cropping system indices, viz. maize-equivalent yield (MEY), system productivity (kg/ha/day), system profitability (₹/ha/day), relative crowding coefficient (RCC), area time equivalent ratio (ATER), land equivalent coefficient (LEC), energy efficiency (Ee) (MJ/ha), energy productivity (Ep) (kg/MJ) and monetary advantage index (MAI) were derived. All data on growth and yield parameters of the crops were subjected to standard analysis of variance (ANOVA). Treatment differences were compared at 5% level of significance (P<0.05) for deriving a logical inference of the study.

Grain yield of maize in additive crop stand of maize + cowpea (6.96 t/ha) and additive crop stand of maize + green gram (6.93 t/ha) was at par with pure crop stand of maize (7.03 t/ha), which was significantly higher than other treatments (Table 1.). Significant yield increase could be attributed to optimum plant population and comparable growth parameters in intercrop stands, which was in conformity with Manasa *et al*., 2020. Green gram produced significantly higher grain yield in pure crop stand of green gram (1.32 t/ha) followed by replacement crop stand-II of maize + green gram (0.96 t/ha) (Table 1.). The result corroborated with similar studies by Kheroar and Patra, 2014. While, significantly higher grain yield of cowpea was in pure crop stand of cowpea (1.29 t/ha) followed by replacement crop stand-II maize + cowpea (1.12 t/ha) (Table 1.). Similar obser-

Table 1. Effect of crop geometry and different intercropping systems on grain yields, maize equivalent yield, system productivity, system profitability, energy parameters, competition indices and monetary advantage index

Treatment	Grain yield (t/ha)			MEY (t/ha)	System productivity (kg/ha/day)	System profitability (₹/ha/day)	Energy efficiency (MJ/ha)	Energy productivity (kg/MJ)	LEC	RCC	ATER	MAI (₹)
	Maize	Green gram	Cowpea									
T_1	7.03	-	-	7.03	63.9	1,092.5	13.6	0.86	-	-	-	-
T_2	-	1.32	-	5.22	87.0	1,529.1	8.7	0.66	-	-	-	-
T_3	-	-	1.29	4.38	73.0	1,230.5	8.0	0.61	-	-	-	-
T_4	6.93	0.73	-	9.82	89.2	1,661.5	14.4	0.93	0.54	1.78	1.29	58,443
T_5	3.63	0.82	-	6.87	62.5	1,145.4	13.0	0.84	0.32	0.83	0.86	13,341
T_6	3.51	0.96	-	7.30	66.4	1,220.0	12.7	0.83	0.36	0.69	0.90	21,483
T_7	6.96	-	0.91	10.05	91.3	1,690.1	14.1	0.91	0.70	1.40	1.37	69,987
T_8	3.83	-	0.95	7.05	64.1	1,166.5	12.9	0.84	0.40	0.74	0.95	25,097
T_9	3.68	-	1.12	7.48	68.0	1,235.9	12.3	0.81	0.45	0.60	1.00	34,039
SEm±	0.11	0.03	0.01	0.26	2.80	69.99	0.59	0.03	-	-	-	-
CD (P=0.05)	0.33	0.11	0.06	0.78	8.41	209.83	1.76	0.10	-	-	-	-

T_1, pure crop stand of maize; T_2, pure crop stand of green gram; T_3, pure crop stand of cowpea; T_4, additive crop stand of maize + green gram; T_5, replacement crop stand-I of maize + green gram; T_6, replacement crop stand-II of maize + green gram; T_7, additive crop stand of maize + cowpea; T_8, replacement crop stand-I of maize + cowpea; T_9, replacement crop stand-II of maize + cowpea; MEY, maize equivalent yield; LEC, land equivalent coefficient; RCC, relative crowding coefficient; ATER, area time equivalent ratio; MAI, monetary advantage Index vation was reported by Manasa *et al*., 2020.

The highest MEY (10.05 t/ha) was recorded with the additive crop stand of maize + cowpea followed by that additive crop stand of maize + green gram (9.82 t/ha). The lowest MEY (4.38 t/ha) was recorded in pure crop stand of cowpea (Table 1). Similar observation was reported by Kaushal *et al*., 2015 and Gowda *et al*., 2022. The system productivity (91.3 kg/ha/day) was recorded higher with additive crop stand of maize + cowpea; while, it was lower (62.5 kg/ha/day) with replacement crop stand-I of maize + green gram (Table 1). The highest system profitability (₹1690.1 /ha/day) was recorded with additive crop stand of maize + cowpea, whereas, lowest system profitability (₹1092.5 /ha/day) was in pure crop stand of maize (Table 1).

The energy efficiency (14.4 MJ/ha) and energy productivity (0.93 kg/MJ) were highest in additive crop stand of maize +green gram; while, lowest (8.0 MJ/ha and 0.61 kg/MJ) were in pure crop stand of cowpea (Table 1). The land equivalent coefficient (0.70), monetary advantage index (₹69987) and area time equivalent ratio (1.37) were higher in additive crop stand of maize + cowpea. Although, relative crowding coefficient was higher (1.78) in additive crop stand of maize + green gram. Our result support the findings of Chhetri and Sinha, 2020 in maize intercropping.

Thus, the study could advocate intercropping maize with legumes at additive crop stands, preferably with cowpea for boosting farmer's income instead of traditionally growing maize alone in this Eastern plateau region of India.

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