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INTERCROPPING OF MAIZE AND COWPEA FOR ENHANCING PRODUCTIVITY, PROFITABILITY AND LAND USE EFFICIENCY

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Abstract

A field experiment was conducted at agriculture farm, ICAR-Central Institute for Research on Goats (CIRG), Makhdoom, Mathura, Uttar Pradesh during *kharif* season of 2020. The treatments consist of sole maize, sole cowpea; and intercropping of maize + cowpea in 1:1, 2:1, 1:2, 2:2, 3:1, 1:3 and 3:3 row ratios. The results revealed that maximum total green fodder yield, maize and cowpea equivalent yield, Land Equivalent Ratio (LER), Monitory Advantage Index (MAI), net returns and Benefit: Cost ratio were recorded with 2:1 row ratio of maize + cowpea intercropping combination followed by 3:1 row ratio. The highest value of nitrogen and potassium content both in fodder maize and cowpea were recorded with 1:3 row ratios of maize + cowpea intercropping combination. Further, the highest phosphorus content in fodder maize was recorded with 3:1 row ratio of maize + cowpea intercropping combination whereas in case of cowpea the highest phosphorus content was recorded with 1:3 row ratio of maize + cowpea intercropping combination. Thus, it was found that two rows maize + one row of cowpea (2:1) intercropping combination perform best in terms of yield, land use efficiency and profitability of fodder maize and cowpea.

Introduction

Green fodder plays an important role in the optimum growth and development of animals, but at present, India faces a net deficit of 35.6% of green fodder (IGFRI Vision 2050). Therefore, to bridge this gap of fodder requirement and availability for enhancing the animal productivity, either the area to be increased under forage production or to increase the fodder productivity per unit area per unit time. The first approach is not viable due to competition with the other agriculture crops and preferential need for food crops. So, the only alternative to meet the fodder requirement is to increase the yield of fodder per unit area per unit time. Therefore, intercropping system which provides crop intensification both in time and space dimension can be used as a tool for the production of adequate green fodder (Reddy 2012).

Cereal-legume intercropping may be a feasible approach for enhancing forage yield, reducing risk production and provide greater financial stability (Tamta *et al*. 2019). The cereal and legume mixture are considered as an ideal system because cereals derived benefits from symbiotic nitrogen fixation governed by associated legume and provided a balanced diet source to livestock. Intercropping of botanically diverse forage crop species appears to be one of the feasible approaches for increasing the herbage yield, utilization of land more efficiently and economy in the use of nitrogen fertilizers (Tripathi 1989). Among the cereal fodder crops, maize (*Zea mays* L.) is an excellent fodder crop due to its high production potential, wider adaptability, succulence and palatability (Yadav *et al.* 2017). In legume fodder crops cowpea is also an important fodder crop due to its short duration, quick growth and higher production potential with higher protein content (Kumar *et al.,* 2016). Intercropping of maize and cowpea resulted in more N, P and K uptake (Ramanakumar and Bhanumurthy 2001, Srininivasraju *et al.* 1997) and net returns and benefit cost ratio (Ramachandra *et al.* 1993) of the system than sole cropping.

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The intercropping practices of cereals and legumes particularly in maize and cowpea have not been evaluated extensively in the region of Yamuna ravines of Uttar Pradesh, India. Also, the identification of suitable intercropping combination for this region helps the farmers for improving farm profitability and livestock productivity. Therefore, the present study was carried out to evaluate the suitable intercropping combination of maize and cowpea for enhancing forage yield, land use efficiency and net profitability in the region of Yamuna ravines of Uttar Pradesh, India.

Materials and Methods

The experiment was conducted at agriculture farm, ICAR-Central Institute for Research on Goats (CIRG), Makhdoom, Mathura, Uttar Pradesh, India during *kharif*, 2020 to study the effect of intercropping row ratios on yield, intercropping indices, nutrient content and economics of fodder maize + cowpea intercropping system. The mean weekly meteorological data recorded at the institute showed that the maximum and minimum temperatures during the crop growth period ranged between 34.0 to 39.9ºC and 19.6 to 28.6ºC, respectively. The mean relative humidity ranged between 51.7 to 86.8% and the total rainfall received during the crop growing season was 269.3 mm. The soil of the experimental field was nearly neutral in reaction (pH 7.3) with EC of 0.27 dS/m. The soil was low in organic carbon (0.22 %) and available nitrogen (241 kg/ha); and medium in available phosphorus (44 kg/ha) and potassium (168 kg/ha). The treatments consist of sole maize, sole cowpea, maize + cowpea intercropping in 1:1, 2:1, 1:2, 2:2, 3:1, 1:3 and 3:3 row ratios. The experiment was laid out in randomize block design with three replications. The field was allocated into 27 plots and each plot was 3.6 m × 6 m in size. All treatments were allocated in these small plots.

Maize variety African tall and cowpea variety Russian giant were sown as per the treatment on 20th July, 2020, by using the seed rate of 50 and 25 kg/ha in sole maize and sole cowpea, respectively. Further, the crops were sown with row to row spacing of 30 cm in both sole as well as in intercropping combinations. All other agronomic practices were carried out as per standard recommendations. The harvesting of both maize and cowpea crop was done at 68 DAS for fodder purposes. Harvesting for green fodder was taken from net plot then weighed and converted into t/ha to obtain green fodder yield. For calculating the crop equivalent yield, yield of one crop is converted into yield equivalent of other crop by using the ratio of prices of the two crops as given below:

$$\text{Maize equivalent yield (t/ha)} = \frac{\text{Cowpea yield (t/ha)} \times \text{Prices of cowpea}}{\text{Prices of maize}}$$

The intercropping indices were calculated by using the following formulas: Land equivalent ratios (LER) = La+Lb, La =Yab/Yaa, Lb = Yba/Ybb where, La and Lb are land equivalent ratio of maize and cowpea, respectively. Yaa and Ybb are yields as sole crop of a (maize) and b (cowpea) and Yab and Yba are yields as intercrops of maize and cowpea, respectively. Aggressivity of maize (Aab) = {(Yab/Yaa × Zab) - (Yba/Ybb × Zba)} and of cowpea (Aba) = {(Yba/Ybb × Zba) - (Yab/Yaa × Zab)}. Competitive ratio of maize (Cra) = (LERa/LERb) (Zba/Zab) and of cowpea (Crb) = (LERb/LERa) (Zab/Zba). Relative crowding coefficient of maize (Kab) = (Yab × Zba)/(Yaa-Yab) Zab and of cowpea (Kba) = (Yba× Zab)/(Ybb – Yba) Zba, where Zab, proportion of intercrop area allocated to maize and Zba, proportion of intercrop area allocated to cowpea. Monetary advantage index (MAI) = Net returns from combined produce (US$/ha) × (LER-1)/LER.

Analysis of nutrients was carried out by using the digested samples by following methods: nitrogen by using micro Kjeldahl method, phosphorus by yellow colour method and potassium by flame photometer method.

To find out the most profitable treatments, economics of different treatments was worked out as follows in terms of net return (US$/ha) and B: C ratio. Net return = Gross return (US$/ha) – Cost of cultivation (US$/ha) and B: C ratio = Gross return (US$/ha) /Cost of cultivation (US$/ha). All the data were subjected to statistical analysis by adopting appropriate method of analysis of variance as described by Gomez and Gomez (1984). The results are presented at 5% level of significance.

Results and Discussion

Intercropping combinations had significant effect on green fodder and their equivalent yield of maize and cowpea (Table 1). The maximum value of total green fodder yield (Maize + Cowpea) was recorded with 2:1 row ratios (38.0 t/ha) followed by 3:1 row ratios (37.6 t/ha). However, intercropping row ratios 2:1, 3:1, 2:2, 3:3 and 1:2 recorded at par values of green fodder yield. The increase in total green fodder yield in 2:1 row ratio was 11.1 and 33.3% over sole maize and sole cowpea, respectively. The increase in green fodder yield in the intercropping systems might be owing to better utilization of space and light interception coupled with nutrient contribution of leguminous fodder to cereal. Tamta *et al*. (2019) and Ramanakumar and Bhanumurthy (2001) also obtained highest green fodder yield of maize + cowpea intercropping in 2:1 row ratio. These results are also in agreement with the statement that inclusion of legume component in the cereal-legume association increased the green forage yield up to 35 to 45 per cent over monocrops due to reduced intercrop competition and better use of resources (Tripathi *et al*. 1997, Obuo *et al*. 1998, Pandita *et al*. 1998). Similarly, maximum maize (38.6 t/ha) and cowpea (36.2 t/ha) equivalent yield was also recorded with 2:1 row ratios of maize + cowpea intercropping followed by 3:1 row ratio. However, intercropping row ratios 2:1, 3:1, 2:2, 3:3, 1:1 and 1:2 recorded at par values of green fodder equivalent yield both in maize and cowpea. These results are in close confirmation with Dhonde *et al.* (2016) who reported that maize + cowpea (2:2) row ratio recorded significantly highest maize equivalent yield over rest of other treatments. However, maize + cowpea intercropping row ratios 3:1, 2:1, 2:2, 1:2, 3:3 and 1:1 were statistically at par with each other.

In fodder maize and cowpea intercropping system of all the intercropping treatments recorded land equivalent ratio (LER) value more than 1 (Table 2). This indicated yield advantage of mixing these crops in all these intercropping treatments. Further, highest value of LER (1.17) was recorded in 2:1 row ratio of maize + cowpea intercropping treatment followed by 3:1 row ratio. The value of 1.17 indicated that almost 17 % more land would be required to plant the sole crops to produce the same quantity of the yield of the intercropping pattern. The greater LER might be due to a greater resource use and resource complementarily nature of component crops. Sharma *et al*. (2008), Kumar *et al*. (2005) and Dhonde *et al.* (2016) also recorded significant variation in LER due to different intercropping treatments in cereal + legume intercropping system. The negative values of aggressivity for fodder cowpea indicated their poor competitiveness than the fodder maize, which has positive aggressivity in all the intercropping combinations. The higher values of aggressivity of fodder maize in 1:1 row ratio of maize + cowpea intercropping combination showed its greater dominance over other intercropping combinations. Higher values of competitive ratio of maize in 1:1 row ratio of maize + cowpea intercropping combination also indicated that it was most competitive to cowpea. Maize + cowpea (1:1) ratio recorded competitive ratio of 1.58 it means maize produced 1.58 times as much as expected yield and is

1.58 times as competitive. Takim (2012) also reported that aggressivity and competitive ratio significantly influenced by different intercropping combinations in maize + cowpea intercropping system. Further, all the intercropping combinations were advantageous than sole planting systems because the product of relative crowding coefficient of both the component crops was more than one due to their complimentary relationship. The higher values of relative crowding coefficient of

Table 1. Effects of different intercropping combinations on green fodder and their equivalent yield in fodder maize and cowpea.

Treatments	Green Fodder Yield (t/ha)			Equivalent yield (t/ha)	
	Maize	Cowpea	Total	Maize	Cowpea
Sole Maize	34.2	-	34.2	34.2	32.1
Sole Cowpea	-	28.5	28.5	30.4	28.5
Maize + Cowpea (1:1)	22.5	12.1	34.6	35.4	33.2
Maize + Cowpea (2:1)	29.3	8.7	38.0	38.6	36.2
Maize + Cowpea (1:2)	16.6	18.1	34.8	36.0	33.7
Maize + Cowpea (2:2)	22.7	12.7	35.4	36.2	34.0
Maize + Cowpea (3:1)	31.6	6.0	37.6	38.0	35.6
Maize + Cowpea (1:3)	12.5	20.2	32.7	34.0	31.9
Maize + Cowpea (3:3)	23.0	12.8	35.8	36.7	34.4
SEm±	1.0	0.7	1.1	1.1	1.0
CD at 5%	3.0	2.0	3.2	3.3	3.1

Table 2. Effects of different intercropping combinations on intercropping indices of maize + cowpea intercropping system

Treatments	LER	Aggressivity		Competitive ratio		RCC		MAI
		Maize	Cowpea	Maize	Cowpea	Maize	Cowpea	
Maize + Cowpea (1:1)	1.08	0.24	-0.24	1.58	0.65	1.99	0.75	1914
Maize + Cowpea (2:1)	1.17	0.12	-0.12	1.43	0.72	6.24	0.90	4254
Maize + Cowpea (1:2)	1.12	0.17	-0.17	1.53	0.66	1.90	0.88	2831
Maize + Cowpea (2:2)	1.11	0.11	-0.11	1.53	0.69	2.11	0.83	2626
Maize + Cowpea (3:1)	1.14	0.10	-0.10	1.48	0.68	12.30	0.81	3413
Maize + Cowpea (1:3)	1.08	0.13	-0.13	1.55	0.65	1.74	0.87	1680
Maize + Cowpea (3:3)	1.12	0.07	-0.07	1.50	0.67	2.06	0.82	2864

LER: Land Equivalent Ratio; RCC: Relative Crowding Coefficient; MAI: Monetary Advantage Index.

fodder maize were obtained from 3:1 row ratio (12.30) of fodder maize + cowpea intercropping combinations followed by 2:1 row ratio (6.24) indicated greater advantage from these intercropping combinations which was further evident from their respective higher values of product crowding coefficient (Maize crowding coefficient x Cowpea crowding coefficient) of 9.96 and 5.62, respectively. Similarly, highest monetary advantage index was obtained with 2:1 row

ratio (4254) of fodder maize + cowpea intercropping combinations followed by 3:1 row ratio (3413). Khonde *et al.* (2018) also reported that relative crowding coefficient and monetary advantage index significantly influenced by maize-cowpea intercropping combinations.

Nitrogen, phosphorus and potassium content of fodder maize and cowpea were significantly influenced by different intercropping combination (Table 3). The highest value of nitrogen content both in fodder maize (1.27 %) and cowpea (2.83 %) were recorded with 1 : 3 row ratio of maize + cowpea intercropping combination. However, 1:1, 1:2, 2:2 and 3:3 row ratio of maize + cowpea intercropping combination recorded at par value of nitrogen content with 1:3 row ratio. Similarly, highest value of potassium content both in fodder maize (1.57%) and cowpea (2.30%) were recorded with 1:3 row ratio of maize + cowpea intercropping combination followed by 1:2 row ratio. Further, highest phosphorus content in fodder maize (0.261 %) was recorded with 3:1 row ratio of maize + cowpea intercropping combination whereas in case of cowpea highest phosphorus content (0.399%) was recorded with 1:3 row ratio of maize + cowpea intercropping combination. Higher contents of N, P and K in intercropping as compared to sole cropping might

Table 3. Effects of different intercropping combinations on nutrient content of fodder maize and cowpea.

Treatments	Nitrogen (%)		Phosphorus (%)		Potassium (%)	
	Maize	Cowpea	Maize	Cowpea	Maize	Cowpea
Sole Maize	1.11	-	0.215	-	1.28	-
Sole Cowpea	-	2.58	-	0.321	-	1.87
Maize + Cowpea (1:1)	1.20	2.72	0.239	0.339	1.44	2.05
Maize + Cowpea (2:1)	1.16	2.64	0.254	0.347	1.41	1.99
Maize + Cowpea (1:2)	1.26	2.81	0.245	0.390	1.53	2.26
Maize + Cowpea (2:2)	1.20	2.74	0.242	0.374	1.46	2.10
Maize + Cowpea (3:1)	1.15	2.60	0.261	0.346	1.36	1.93
Maize + Cowpea (1:3)	1.27	2.83	0.251	0.399	1.57	2.30
Maize + Cowpea (3:3)	1.21	2.78	0.247	0.381	1.46	2.18
SEm±	0.03	0.06	0.008	0.013	0.05	0.07
CD at 5%	0.08	0.17	0.024	0.041	0.15	0.21

be attributed due to the fact that inclusion of a legume with cereal intercropping restores the soil fertility as it lessens the depletion of soil N, P and K compared to sole cropping of cereals. Tamta *et al.* (2019) also reported that N content in fodder maize + cowpea intercropping system significantly influenced by row ratios. Uptake of nitrogen, phosphorus and potassium in fodder maize and cowpea were also significantly influenced by different intercropping combination (Table 4). The highest total nitrogen uptake was recorded by sole cowpea (140.7 kg/ha) followed by 1:3 (139.6 kg/ha) and 1:2 (138.4 kg/ha) row ratio of fodder maize + cowpea intercropping combination. Further, highest total phosphorus (21.6 kg/ha) and potassium (128.7 kg/ha) uptake was recorded with 1:2 row ratio of fodder maize + cowpea intercropping. However, 1:1, 2:1, 2:2, 1:3 and 3:3 row ratio recorded at par values of total phosphorus and potassium uptake with 1:2 row ratio of fodder maize + cowpea intercropping. Ramanakumar and Bhanumurthy (2001) revealed that intercropping of maize and cowpea resulted in more N, P and K uptake of the system than sole cropping. Singh *et al.* (2008) also reported that total N, P and K uptake of the system was significantly superior in intercropping system to sole cropping.

Table 4. Effects of different intercropping combinations on nutrient uptake of fodder maize and cowpea.

Treatments	Nitrogen uptake (kg/ha)			Phosphorus uptake (kg/ha)			Potassium uptake (kg/ha)		
	Maize	Cowpea	Total	Maize	Cowpea	Total	Maize	Cowpea	Total
Sole Maize	74.8	-	74.8	14.5	-	14.5	86.3	-	86.3
Sole Cowpea	-	140.7	140.7	-	17.5	17.5	-	102.2	102.2
Maize + Cowpea (1:1)	54.5	60.0	114.5	10.9	7.6	18.5	65.5	45.5	111.0
Maize + Cowpea (2:1)	69.9	43.4	113.3	15.3	5.7	21.0	84.8	32.7	117.6
Maize + Cowpea (1:2)	41.4	97.0	138.4	8.1	13.5	21.6	50.4	78.3	128.7
Maize + Cowpea (2:2)	56.1	63.9	120.0	11.3	8.7	20.0	68.2	49.2	117.4
Maize + Cowpea (3:1)	75.1	29.0	104.1	17.1	3.9	21.0	89.0	21.6	110.5
Maize + Cowpea (1:3)	31.3	108.3	139.6	6.2	15.3	21.5	38.8	88.0	126.9
Maize + Cowpea (3:3)	56.8	65.6	122.5	11.6	9.0	20.6	68.1	51.7	119.8
SEm±	3.6	4.9	5.7	0.7	0.8	1.1	4.0	4.5	6.0
CD at 5%	11.0	14.8	17.1	2.2	2.5	3.3	12.2	13.6	17.9

The highest gross return (US$ 780.7/ha), net return (US$ 390.0/ha) and benefit: cost ratio (2.00) was obtained with 2:1 row ratio of maize + cowpea intercropping combination followed by 3:1 row ratio (Table 5). The 2:1 row ratio of maize + cowpea intercropping combination recorded 34.22 and 57.64% higher net return over sole maize and sole cowpea, respectively. It is obvious because of higher total green fodder yield of maize + cowpea intercropping system with 2:1 row ratio as compared to other intercropping combinations which consequently resulted in higher net return and benefit: cost ratio. Tamta *et al.* (2019) also reported that 2:1 row ratio of maize + cowpea intercropping recorded highest net return and benefit cost ratio.

Table 5. Effects of different intercropping combinations on economics of maize + cowpea intercropping system.

Treatments	Gross return (US$/ha)	Net return (US$/ha)	B:C ratio
Sole Maize	692.7	290.5	1.72
Sole Cowpea	615.1	247.4	1.67
Maize + Cowpea (1 : 1)	716.4	331.4	1.86
Maize + Cowpea (2 : 1)	780.7	390.0	2.00
Maize + Cowpea (1 : 2)	728.0	348.7	1.92
Maize + Cowpea (2 : 2)	733.4	348.5	1.91
Maize + Cowpea (3 : 1)	768.9	375.3	1.95
Maize + Cowpea (1 : 3)	688.3	311.9	1.83
Maize + Cowpea (3 : 3)	741.7	356.7	1.93

Results of this study stated that intercropping of maize and cowpea significantly influenced by different row ratios. Maximum value of green fodder yield, LER, MAI, net returns and B: C ratio was obtained with intercropping of two rows of maize + one row of cowpea (2:1) whereas the

maximum value of nitrogen and potassium content both in fodder maize and cowpea were recorded with intercropping of one row of maize + three rows of cowpea (1:3). Hence, this investigation recommended two row maize + one row cowpea (2:1) intercropping combination for obtaining maximum value of green fodder yield, profitability and land use efficiency of fodder maize and cowpea.

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