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Fodder productivity and profitability of different maize and legume intercropping systems

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ABSTRACT

The current trend in global agriculture is to search for highly productive, sustainable and eco-friendly cropping systems. Intercropping of cereals with legumes is a recognized practice for economizing the use of nitrogenous fertilizers and increasing the productivity, quality, and profitability particularly in commercial grain crops but possibilities of fodder production in these intercropping systems is less explored. Availability of green fodder with improved quality to animals is the key to success of dairy enterprises and it is difficult to maintain the health and milk production of the livestock without supply of the quality green fodder. The growing of fodder crops in mixture with legumes has potential to improve palatability and digestibility of fodder (Kumar *et al.* 2018, Kumar *et al.* 2016). It is fact that about 65-70% of the total cost of livestock farming is attributed to feeding. However, green fodder production is a good way in order to curtail the cost on feed and fodder resources for sustainable livestock production. At present, the country is facing a net deficit of 35.6% green fodder, 10.95% dry crop residues and 44% concentrate feed ingredients. At the current level of growth in forage resources, there will be 18.4% deficit in green fodder and 13.2% deficit in dry fodder by the year 2050 (Anonymous 2015). The main objective of intercropping has been to maximize use of resources such as space, light and nutrients as well as to improve fodder quality and quantity. When legumes are used as intercrops, they provide beneficial effect on soil health by fixing atmospheric nitrogen, improving physical, chemical and biological properties. Hence, present study was undertaken in order to to assess the productivity, soil nutrient status and economics of different forage maize-legumes based intercropping systems.

Key words: Crop productivity, Farm profitability, Fodder, Fodder maize, Legumes, Intercropping

The present study was conducted in summer (*kharif*) 2017 to evaluate the fodder productivity and economics of maize with legumes under varying intercropping combinations. This experiment was laid out in randomized complete block design with 7 treatments consisting of 3 different forage crops, viz. maize, cowpea and guar sown in sole as well as in 1:1 and 2:1 intercropping combinations of forage cereal with legume crop components in three replications. All the growth parameters like plant height, leaf length, leaf width, number of leaves, number of tillers/ branches, stem girth and leaf:stem ratio were significantly higher in (1:1) row ratio of forage cereal/ millet intercropped with legume component at the time of harvest. Among the different forage crops, maximum green fodder yield (449.72 q/ha) and dry matter yield (94.89 q/ha) were obtained in maize+cowpea (2:1) and maize+guar (2:1), respectively. Total uptake of nitrogen and phosphorus was recorded highest with maize + cowpea/guar (2:1) intercropping combinations. Introduction of different forage crops in varying intercropping combinations, the soil nutrient status after harvesting was improved over sole treatment of forage cereal/millet crop. In terms of economics of different treatments, the highest net income (₹ 38747.27) and B:C ratio (1.78) were recorded with maize+cowpea (2:1) followed by (₹ 37724.21 and B:C 1.74) in maize+ cowpea (1:1) intercropping combinations. So, to realize higher productivity and farm profitability the planting of 2:1 row ratio is a viable option which may quite helpful to sustain the performance of livestock in terms of health and milk production.

MATERIALS AND METHODS

A field experiment was conducted at ICAR-NDRI, Karnal during *kharif* 2017. Karnal has semi-arid climate characterized by hot and dry summer and severe cold during winter season. The annual rainfall of the area is 650 mm, and 70% of which occurs during the main rainy season (June to September) and 30% during the summer season (February to April). The soil of experimental site was clay loam in texture with 7.2 pH (Jackson 1973),

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0.62% organic carbon (Walkley and Black 1934), EC (0.32 dS/m), (170 kg/ha) available N (Subbiah and Asija 1956), (22.5 kg/ha) available phosphorus (Olsen *et al.* 1954), and 1 N NH_4OAC extractable K (270 kg/ ha) values in the soil were estimated. The experiment was laid out in randomized complete block design (RCBD) with 7 treatments consisting of three different cereal-legume forage crops, viz. maize, cowpea and guar sown in sole as well as in 1:1 and 2:1 intercropping combination with three replications. The fodder maize (cultivar J-1006), cowpea (cultivar C-152) and guar (cultivar HG-02) were sown using seed rates of 60, 25 and 25 kg/ha, respectively during 29th standard meteorological week. For accommodating component crops in intercropping treatments replacement series was used. Five plants from the net plot area were randomly selected and tagged and growth parameters were recorded over tagged plants. Forage crops were harvested manually at the age of 65 days and fresh forage yield were recorded. The forage samples were ground to pass through 2 mm sieve. Nitrogen content in forage samples was estimated by Kjeldahl method (AOAC 2005) whereas phosphorus content was analysed employing vanadomolybdophosphoric acid yellow colour method (Prasad *et al.* 2006). Thereafter, the uptake of the N and P was calculated by multiplying their concentrations with respective forage yield. Available nitrogen and phosphorus in soil after final harvest were estimated using Kjeldahl method and Olsen's Method, respectively. The economics of each treatment combination were calculated by taking all the detailed farm expenses (cost of cultivation), cumulative income (Gross return), profit (Net return) and the benefit: cost ratio. All data recorded for different parameters were analysed with the help of analysis of variance (ANOVA) technique (Gomez and Gomez 1984). The least significant difference test was used in different treatments at 5% level of significance ($P < 0.05$).

RESULTS AND DISCUSSION

Plant height was significantly influenced by intercropping of forage cereal/ millet with legumes and the highest values were recorded in (1:1) intercropping ratio, whereas lowest was in their sole treatments (Table 1). There was also significant difference between intercropping treatments. Introduction of legume component (cowpea and guar) with forage maize either (1:1 or 2:1) also affected plant height of forage cereal component. However, within the intercropping ratio either with cowpea or guar there was no significant difference in height of forage cereal component. While intercropping with cowpea gave higher plant height in maize crop. Plant height of cowpea at harvest in its varying combinations with maize was significantly affected and maximum height was observed with maize+cowpea 1:1 row ratio. This might be due to trailing nature of cowpea. The height of maize plant under legume intercropping system was more might be due to competition of associated crops for light and resulted in increased plant height. Further, increase in plant height of cereal component might be due to the favourable microclimate created by legume crop and better availability of nitrogen to cereal crop plants and increase in plant height of cowpea might be due to better utilization of solar energy, space and nutrients from deep layer in the soil by cowpea. These results are in close conformity with the findings of Kumar and Balyan (2001).

Leaf length and width is an essential parameter to determine green fodder yield and quality. Leaf length and width of maize crop was affected considerably due to various intercropping systems and significantly higher value was observed in intercropping row ratio of (1:1). Within the intercropping ratio either 1:1 or 2:1 the observations were also significant. The lowest value of leaf length and width were recorded in their respective sole treatment. Within the intercropping ratio of forage maize + cowpea/ guar either (1:1 or 2:1) the average leaf length and width in maize were 03% higher in 1:1 row ratio. In case of legume component there was no significant impact of intercropping combinations. These results are also in accordance with Sahu and Ambawatia (2003).

Number of leaves of different forage crops at harvest was significantly affected by various intercropping combinations (Table 2). The significantly higher value of number of leaves was recorded in forage maize + cowpea (1:1) intercropping ratio followed by (2:1) row ratio and the lowest in sole crop. Intercropping has resulted in a greater number of leaves and hence better crop canopy in intercropping and efficient utilization of the solar radiation

Table 1 Effect of intercropping ratios on plant height, leaf length and leaf width of different forage crops

Treatment	Plant height (cm)			Leaf length (cm)			Leaf width (cm)		
	Maize	Cowpea	Guar	Maize	Cowpea	Guar	Maize	Cowpea	Guar
Sole maize	194.00			87.80			6.55		
Sole cowpea		188.89			10.96			6.64	
Sole guar			89.47			6.74			3.75
Maize+cowpea (1:1)	221.67	220.00		93.00	11.07		6.73	6.78	
Maize+guar (1:1)	219.00		95.27	92.00		6.82	6.71		3.90
Maize+cowpea (2:1)	205.67	213.00		89.20	11.11		6.62	6.71	
Maize+guar (2:1)	200.67		93.68	88.60		6.83	6.60		3.87
SEm ±	4.07	1.50	2.12	1.62	0.35	0.15	0.04	0.11	0.13
CD (P=0.05)	9.39	4.16	NS	3.73	NS	NS	0.10	NS	NS

Table 2 Effect of intercropping ratios on number of leaves, leaf to stem ratio and stem girth of different forage crops

Treatment	Number of leaves			Stem girth (cm)			L:S ratio		
	Maize	Cowpea	Guar	Maize	Cowpea	Guar	Maize	Cowpea	Guar
Sole maize	10.55			5.71			0.32		
Sole cowpea		80.47			3.09			0.49	
Sole guar			79.50			3.13			0.50
Maize+cowpea (1:1)	11.35	114.00		5.95	2.90		0.35	0.56	
Maize+guar (1:1)	11.33		93.33	5.94		2.76	0.36		0.56
Maize+cowpea (2:1)	11.16	102.33		5.85	3.00		0.33	0.54	
Maize+guar (2:1)	11.14		88.33	5.86		2.89	0.34		0.53
SEm ±	0.09	3.98	2.76	0.05	0.05	0.05	0.01	0.02	0.01
CD (P=0.05)	0.22	11.04	7.66	0.11	0.14	0.15	NS	0.05	0.03

available during the growing season. These results are also in accordance with Hamd Allah *et al.* (2014) and found that the higher number of leaves/plants were recorded in intercropped maize than their pure stand in intercropping combination of forage maize and cowpea crop.

Significantly higher value of stem girth was observed in 1:1 row ratio of intercropping combination of different cereal fodder crops as compared to their sole crop. However, highest value of stem girth was recorded in their respective sole treatments (Table 2). This might be due to fact that with the introduction of intercropping there was increment in plant height in competition to component crop, which might have caused reduction in stem girth of a plant. Leaf stem ratio is an important factor which is helpful in determining the digestibility and palatability of any fodder crop. Intercropping of forage cereal with forage legumes (cowpea and guar) in varying row ratio and their sole treatment has no significant influence on leaf stem ratio. These results are in line with the findings of Ram and Singh (2003).

The total green fodder yield of the different forage crops was significantly influenced by the intercropping ratios (Table 3). The highest total green fodder yield (449.00 q/ha) was registered in (2:1) intercropping ratio of maize+ cowpea followed by maize+ guar (2:1) row combination. It may be attributed to the fact that 2:1 intercropping ratio have more plant population of cereals/millets plant as compared to other planting ratios. In forage maize sole crop as well as its intercropping with cowpea/guar 2:1 row ratio, the total green fodder yield was increased in the tune of 2.77%, 1.11% over total green fodder yield of sole maize crop. The higher total green forage yields in intercropping combination of maize with cowpea in 2:1 row ratio might be attributed to complementary effect of cowpea, that supplemented nitrogen to maize and the better utilization of solar radiation, space and nutrients from the soil by maize + cowpea intercropping system. Moreover, the highest green fodder yield of intercropped cereal may be due to the highest values of plant height, leaf length, leaf width, number of leaves, and number of tillers/ branches and stem girth. Since these all growth parameters are important yield attributing factors resulted in increasing the green fodder yield as compared to the sole crop. Furthermore, increase in total green fodder in intercropping system might be owing to better utilization of space and light interception along with nutrient contribution of leguminous fodder to cereal crop component. Finding of Surve *et al.* (2011) confirmed the results of the present investigation. Significantly higher total dry matter yield (94.81 q/ha) was recorded in maize+ guar (2:1) followed by maize+ cowpea (2:1) intercropping treatment, however, these treatments were statistically at par to each other. Intercropping of legume crop component either

Table 3 Effect of intercropping combinations on green and dry fodder yield of different treatments

Treatment	Green fodder yield (q/ha)				Dry matter yield (q/ha)			
	Maize	Cowpea	Guar	Total	Maize	Cowpea	Guar	Total
Sole maize	436.87			436.87	94.09			94.09
Sole cowpea		299.63		299.63		58.13		58.13
Sole guar			283.95	283.95			60.31	60.31
Maize+cowpea (1:1)	264.80	164.50		429.30	57.13	31.82		88.96
Maize+guar (1:1)	263.83		155.00	418.83	56.93		32.85	89.79
Maize+cowpea (2:1)	322.33	126.67		449.00	69.51	24.53		94.04
Maize+guar (2:1)	322.07		119.67	441.73	69.44		25.37	94.81
SEm ±	2.17	1.27	1.12	2.45	0.53	0.28	0.23	0.53
CD (P=0.05)	5.01	3.53	3.11	5.34	1.23	0.77	0.64	1.16

cowpea or guar with maize, cowpea crop proved superior over component crop of guar in varying intercropping combinations. The increase in dry matter yield was also due to increase green forage yield in intercropping treatments. These findings are in agreement with results of Surve *et al.* (2007).

The total N uptake was significantly higher in maize+ guar (1:1) intercropping ratio over rest of the other treatments followed by in maize + cowpea (1:1) intercropping ratio (Table 4). Higher nitrogen uptake in intercropping treatments might be due to the contribution of higher symbiotic nitrogen supplied through root nodule by the legume intercrops which resulted in higher nitrogen content and dry matter accumulation leading to higher nitrogen uptake. Enhanced nitrogen uptake by intercropping system was observed by several workers and has often been claimed as the basis for yield advantage from intercropping system. This might be due to better exploitation of different soil layers for nutrients or due to phenomenon of mutual advance. These results are in conformity with findings of Singh *et al.* (2004). Likewise, maize + guar (1:1) intercropping combinations recorded significantly higher phosphorous uptake (25.11 kg/ha) over all intercropping treatments the second highest value was obtained in maize + cowpea (1:1) row ratio. Intercropping combinations of forage cereal with legume crop proved significantly higher phosphorous uptake over their respective sole treatment. More legume population in 1:1 row ratio, helped to fix more nitrogen and the enhanced nutrient sparing capacity of legume to cereal component. There is direct relationship in between available nitrogen and phosphorous content in plant. These results are also in accordance with Misra *et al.* (2001).

In general, the available nitrogen, phosphorus and potassium status of the soil was improved in intercropping of different row ratio because of more proportion of leguminous crop (Table 5). Sole treatment of forage maize crop recorded minimum residual nitrogen due to it's highly exhaustive nature. In case of forage maize sole crop as well as its intercropping with cowpea/guar in 1:1 and 2:1 row ratio, the final soil nitrogen status was improved to the tune of 15.41%, 14.58% intercropped in 1:1 ratio and 11.66%, 11.87% while intercropped in 2:1 intercropping ratio. The residual available nitrogen status of the soil after the harvest of the crops in sole treatment was the lowest which might be the result of high exhaustive nature of fodder cereal crop in sole cropping condition. The highest content of available soil nitrogen was recorded with legume treatment (sole cowpea or guar), which might be due to more nitrogen fixation and less dry matter accumulation of legume crop.

The practicability and usefulness of technology is judged ultimately in terms of net returns. Economics (₹/ha) of cultivation of different treatments are presented in Table 5. The highest net income (₹ 38747) and B:C (1.78) ratio was recorded in maize + cowpea (2:1) intercropping combination followed by in maize + cowpea (1:1) row

Table 4 Effect of intercropping combinations on nitrogen and phosphorous uptake of different forage crops

Treatment	N uptake (kg/ha)				P uptake (kg/ha)			
	Maize	Cowpea	Guar	Total	Maize	Cowpea	Guar	Total
Sole maize	125.48			125.48	18.83			18.83
Sole cowpea		151.06		151.06		19.63		19.63
Sole guar			162.20	162.20			20.67	20.67
Maize+ cowpea (1:1)	80.99	84.93		165.93	13.41	11.52		24.92
Maize+ guar (1:1)	81.11		89.60	170.71	13.14		11.97	25.11
Maize+ cowpea (2:1)	96.20	64.80		160.99	15.16	8.64		23.80
Maize+ guar (2:1)	95.92		68.83	164.75	14.95		8.89	23.85
SEm ±	0.97	0.85	0.89	1.23	0.28	0.40	0.38	0.52
CD (P=0.05)	2.24	2.35	2.48	2.67	0.65	1.11	1.05	1.14

Table 5 Effect of intercropping combinations on soil nutrient status and economics of different treatments

Treatment	Soil nutrient status			Economics			
	Nitrogen (kg/ha)	Phosphorus (kg/ha)	Potassium (kg/ha)	Cost of cultivation (₹/ha)	Gross return (₹/ha)	Net return (₹/ha)	B: C ratio
Sole maize	160.00	20.99	263.55	22041.59	54608.19	32566.60	1.48
Sole cowpea	186.00	20.97	274.28	21350.00	47940.56	26590.56	1.25
Sole guar	186.00	21.19	274.00	21300.00	42592.50	21292.50	1.00
Maize+ cowpea (1:1)	184.67	22.16	276.33	21695.79	59420.00	37724.21	1.74
Maize+ guar (1:1)	183.33	22.05	276.00	21670.79	56229.17	34558.37	1.59
Maize+ cowpea (2:1)	178.67	21.81	272.67	21811.06	60558.33	38747.27	1.78
Maize+ guar (2:1)	179.00	21.77	273.00	21794.39	58208.33	36413.94	1.67

ratio. This advantage was due to the increased total yield of the forage from two components and higher sale price of the legume fodders. In terms of economics, intercropping combinations of maize + legumes were superior over their respective sole treatments. These results are in close conformity with the findings of Surve *et al.* (2007).

Our study suggested that intercropping of maize and cowpea in 2:1 ratio had significant improvement on green fodder yield, dry matter yield and farm profitability along with comparable soil fertility over sole treatment as well as row proportion (1:1). Thus, it can be concluded that to realize higher productivity and farm profitability planting in 2:1 intercropping ratio is a viable option and may prove helpful in sustaining the performance of livestock in terms of health and milk production.

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