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Intercropping indices of fodder maize (*Zea mays*) and fodder cowpea (*Vigna unguiculata*) under various row proportions

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Abstract
A field experiment was conducted during the *Rabi* 2019-20 at Agronomy Farm, College of Agriculture, Dapoli, Dist. Ratnagiri (M.S.), with objectives to quantify effect of row proportion of fodder maize and fodder cowpea on growth, quality, yield and economics. The present investigation encompassing fodder maize and fodder cowpea intercropped with various patterns, revealed that the intercropping indices 4:2 row proportion recorded highest land equivalent ratio (1.35), relative yield total (0.676), maize equivalent yield (346.31), relative yield and relative crowding coefficient (4.53) over all other intercropping treatments. And 4:1 row proportion recorded highest competitive ratio (5.15) and aggressively index (4.51). Most of the cowpea values of aggressively index were negative which indicated dominance of maize. The study concluded that values of most of the intercropping indices were highest for 4:2 row proportion and hence, it will be most advantageous in terms of land utilization and net yield.

Keywords: Cowpea, Intercropping indices, Maize

Introduction
In dairy industry quality forage production is very important. Availability of green forage to animals is the key to success of dairy enterprises. With the help of good quality supply of green fodder health of livestock improved and milk production can be maintained. Both quality and quantity of fodder are influenced due to plant species stage of growth agronomic practices. Country faces a net deficit of 61.1 per cent green fodder and 21.9 per cent dry fodder. The heavy livestock pressure because of limited land resources in the country. The area under cultivated fodder is 8.33 million ha which is about 3.9 % of total geographical area. This limited area is not going to increase, rather it may decreases due to competition with the other food grain crops and horticulture crops which are needed to supply demand of increasing population of country. So, this gap between demand and supply can be reduced by increase in the yield of fodder per unit area per unit time. This can be achieved by using high yielding varieties and following management practices like intercropping or mixed cropping etc. Intercropping has been recognized as a beneficial system of crop production as well as is one ideal management practice for better utilization of resources and higher fodder production per unit area per unit time. Growing of two or more crop species simultaneously in the same field during a growing season is defined as intercropping. The mixed sowing of legumes with cereals not only improves the quality of fodder but also enhances the soil fertility by fixing atmospheric nitrogen. Maize is the most suitable fodder crop for making silage. Inclusion of legumes along with cereals has been reported to improve the forage quality since legumes are rich in protein. In Maharashtra state, pulses especially cowpea is the most favourite among the farmers because it can be used in different ways as food, fodder and organic manures. The green fodder of cowpea contains about 15-20 per cent crude protein and 50 per cent digestible carbohydrates at first stage of pod formation. It is also rich in vitamin A and vitamin B, calcium and phosphorus. Cowpea provides palatable, nutritious and good balanced concentrate in rations for poultry, cattle, sheep and other animals. Cowpea is strictly a warm weather crop but in India it is cultivated during Kharif and summer crop. It requires same climatic condition as corn, but need more heat to mature. The growing of fodder crops in mixture with legumes enhanced fodder palatability and digestibility.

To improve the quality of cereal fodders mixing of legumes in cereals is a better choice. Keeping this points in view, the proposed research was planned to be conducted at Agronomy Farm, College of Agriculture, Dapoli during *Rabi* season of 2019.

Material and Methods

A field experiment on effect of row proportion in maize + cowpea intercropping system. The experiment was laid out in randomized block design with nine treatments and three replications. The treatments consisted of sole maize, sole cowpea and seven planting ratios on row basis i.e. 1:1, 2:1, 3:1, 4:1, 2:2, 3:2, 4:2 in replacement series of intercropping system. In all, it is consisted of seven treatments of maize and cowpea intercropping and two sole stands of maize and cowpea, thereby leading to the total number of nine treatments.

For fodder maize variety African tall and for fodder cowpea variety DFC-1 were used for sowing. The fodder maize and fodder cowpea were sown on 18th November 2019. The gross and net plot size were 6.60m × 4.20 m and 6.00m × 4.00m respectively.

During the course of investigation, observations on growth and yield contributing characters were recorded. Besides this, at harvest, the content of nitrogen, phosphorus and potassium in straw and soil were estimated. Quality of fodder maize and fodder cowpea in terms of ash content, crude protein and crude fibre as affected by different treatments was studied. Yield and yield attributes of various crops, indices such as LER, MEY, RCC, A, CR, RYT and RYL of the intercropping system were also computed.

The analysis of initial soil sample indicated that, the soil of the experimental plot was categorized under acidic soil. And it was sandy loam in texture, slightly acidic in reaction (pH 5.58) and very high in organic carbon content (1.2%). The soil was found to be low in available nitrogen (236.7 kg ha^{-1}) and available phosphorus (9.61 kg ha^{-1}) but it was found high in available potassium (250.51kg ha^{-1}).

The perusal of meteorological observations implied that the mean maximum temperature ranged from 29.4°C to 33.3 °C and mean minimum temperature from 12.7°C to 20.6°C during the crop season in the year 2019-20. The bright sunshine hours ranged from 6.1 to 9.5 hrs. The daily mean evaporation during crop season was 3.47 mm. The relative humidity during entire crop season ranged between 89 to 94 % during morning and 51.4 to 60 % during afternoon. The meteorological data revealed that the weather of *Rabi* season was favourable for the growth and development of fodder maize and fodder cowpea without incidence of any major pest or diseases during crop growth period.

Result and Discussion

Indices observed in intercropping treatment

Relative yield

The data regarding relative yield of fodder maize and fodder cowpea as affected by various treatments are presented in Table 1. The data were not statistically analyzed, hence interferences were drawn from mean values. The relative yield of maize recorded higher under T_9 treatment i.e. maize + cowpea 4:2 row proportion than all remaining intercropping treatments. Among all the intercropping system, maximum relative yield of maize was recorded under 4:2 ratio followed by 3:1, 4:1 and 2:1 ratio. In cowpea, relative yield was found higher under 2:2 row ratio followed by 1:1 and 4:2 row ratio in all the intercropping system.

This might be due to better utilization of resources so result in better yield and there positive influence on the economic parameters due to better mutual benefit of legume i.e. cowpea. Similar results reported by Sawant (1989) [9].

Land equivalent ratio (LER)

Data pertaining to LER given in Table 1 which indicate that land equivalent ratio (LER) is greater than unity in intercropping treatment. Maize + cowpea 4:2 row proportion recorded maximum land equivalent ratio over rest of other treatments.

It indicated that 4:2 row proportion strongly influenced the crop productivity and utilized the land area more efficiently compared to sole crop and other intercropping system. There was considerable increase in yield of companion crop therefore; higher values of LER were recorded. And all intercropping treatments show LER greater than one which means that this intercropping system is advantageous. Mishra (2014) [8] reported similar type of results.

Maize equivalent yield (q/ ha)

The data regarding maize equivalent yield (q/ ha) as affected by various treatments are presented in Table 1. Maize equivalent yield was higher in sole maize. This was closely followed by 4:2 row proportions. This was due to higher market price of fodder maize than market price of companion crop. Similar types of findings were also reported by Khonde *et al.* (2018) [6].

Aggressivity

Aggressivity index of maize and cowpea influenced by different treatments are given in Table 2. Aggressivity index of intercrop was negative indicating the dominance of maize in the intercropping system. In case of maize aggressivity index was higher in T_6 treatment i.e. Maize + Cowpea 4:1 row proportion followed by 3:1 and 4:2 ratios over rest of the other treatments. In intercrop cowpea aggressivity higher in 2:2 row proportion.

Aggressivity was the competitive relationship between maize and cowpea. Maximum aggressively was recorded in 4:1 row proportion in case of maize over rest of the treatments. Negative aggressively index of cowpea indicated that dominance of maize. Similar types of results were in agreement with findings of Chaudhari and Jana (2015) [3] and Manasa *et al*. (2018) [7].

Competitive ratio

Competitive ratio of maize with cowpea given in Table 2 showed that higher competitive ratio recorded for maize in 4:1 ratio followed by 3:1 and 4:2 ratios while for cowpea highest competitive ratio recorded in 2:2 row proportion. Higher the competitive ratio, higher will be the competitive ability of crop with its companion crop. Dhima *et al.* (2007) [4] and Jakhar *et al.* (2015) [5] reported similar type of results.

Relative yield total (RYT)

Data related to relative yield total are given in Table 2. From the data it was clear that relative yield total increases in intercropping treatments. Higher value of relative yield total recorded in Maize + Cowpea 4:2 row proportion over rest of the treatment.

Relative crowding coefficient (RCC)

Data regarding relative crowding coefficient influenced due to intercropping treatments are presented in Table 3. The relative crowding coefficient was higher in Maize + Cowpea 4:2 row proportion (T_9) over rest of other treatments.

It was indicated that this row proportion was more competitive for input resource use efficiency and it also indicate yield advantage. Chaudhari and Chadhuri (2016) [2] had reported similar type of results.

Relative yield loss (RYL)

Relative yield loss worked out for different intercropping treatments and given in Table 3. Data on relative yield loss of intercropping treatments indicated that for maize, maximum RYL recorded in 2:2 row proportion (-51.21) followed by 1:1 row proportion(-50.34). Singh and Bohra (2012) [10] and Banike *et al.* (2000) [1] reported similar type of findings.

Thus it can be concluded that productivity of unit land area is increased by intercropping rather than sole cropping. Fodder maize intercropped with fodder cowpea produced higher fodder yield as compared to sole cropping. The competitive indices also showed that intercropping had a major advantage over sole cropping. So for obtaining optimum and sustainable productivity fodder maize and fodder cowpea should be planted in 4:2 row proportion to increase land use efficiency and maximum profit.

Table 1: Maize – equivalent yield, land equivalent ratio and relative yield as influenced by maize + cowpea intercropping systems

Treatment		Maize-Equivalent Yield (q ha^{-1})	Land equivalent Ratio	Relative Yield	
				Maize	Cowpea
T_1	Sole Maize	366.41	1.00	1	-
T_2	Sole Cowpea	192.65	1.00	-	1
T_3	Maize + Cowpea (1:1)	256.26	1.12	0.50	0.62
T_4	Maize + Cowpea (2:1)	302.26	1.21	0.64	0.57
T_5	Maize + Cowpea (3:1)	324.31	1.25	0.71	0.54
T_6	Maize + Cowpea (4:1)	321.74	1.24	0.70	0.54
T_7	Maize + Cowpea (2:2)	255.19	1.13	0.49	0.64
T_8	Maize + Cowpea (3:2)	278.28	1.15	0.57	0.58
T_9	Maize + Cowpea (4:2)	346.31	1.35	0.75	0.60

Table 2: Indices as observed in various treatment combination

Treatment		RYT	Aggressivity		Competitive ratio	
			Maize	Cowpea	Maize	Cowpea
T_1	Sole Maize	0.500	1.00	0.00	1.00	0.00
T_2	Sole Cowpea	0.500	0.00	1.00	0.00	1.00
T_3	Maize + Cowpea (1:1)	0.557	-0.60	0.6	0.80	1.24
T_4	Maize + Cowpea (2:1)	0.603	2.40	-2.4	2.28	0.44
T_5	Maize + Cowpea (3:1)	0.622	3.98	-3.98	3.98	0.25
T_6	Maize + Cowpea (4:1)	0.621	4.51	-4.51	5.15	0.19
T_7	Maize + Cowpea (2:2)	0.561	-0.73	0.73	0.77	1.30
T_8	Maize + Cowpea (3:2)	0.573	1.11	-1.11	1.48	0.68
T_9	Maize + Cowpea (4:2)	0.676	2.99	-2.99	2.49	0.40

Table 3: Effect of different intercropping ratios on competitive coefficients:

Treatment		RCC	RYL		
			Maize	Cowpea	Total
T_1	Sole Maize	1	0.00	-	0.00
T_2	Sole Cowpea	1	-	0.00	0.00
T_3	Maize + Cowpea (1:1)	1.59	-50.34	-38.28	-88.62
T_4	Maize + Cowpea (2:1)	2.32	-36.16	-43.23	-79.40
T_5	Maize + Cowpea (3:1)	2.81	-29.07	-46.50	-75.57
T_6	Maize + Cowpea (4:1)	2.77	-30.05	-45.66	-75.70
T_7	Maize + Cowpea (2:2)	1.66	-51.21	-36.54	-87.74
T_8	Maize + Cowpea (3:2)	1.81	-43.02	-42.29	-85.31
T_9	Maize + Cowpea (4:2)	4.53	-25.43	-39.29	-64.73

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