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Evaluation of intercropping indices of groundnut and cowpea with mustard (*Brassica juncea* L.) in red lateritic soils of western costal region

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Abstract
A field experiment on "Intercropping of groundnut and cowpea with mustard (*Brassica juncea* L.)" was conducted during *rabi*, 2018-19 at Agronomy Farm, College of Agriculture, Dapoli (M.S.) with objectives to quantify the effect of intercropping on main as well as intercrops in terms of their growth, yield, quality, N,P,K uptake and economics of intercropping systems. Conclusionary finding are abstracted below. The intercrops like groundnut and cowpea being leguminous crops, improved the growth performance of mustard. However, growth performance of both the intercrops was better under their sole stands. The yield attributes and yield of mustard was improved due to intercropping system. In general, within the intercropping systems, when mustard was grown with groundnut, yield performance of mustard was better, followed by mustard + cowpea. Maximum values of nitrogen, phosphorous and potassium content in grain and straw of mustard and quality parameters were recorded in case of mustard + groundnut in 3:1 proportion. However, total uptake of these nutrients was higher at sole cropping. For the production of higher total biomass, mustard equivalent yield (MEY) and to earn more net profit, mustard + groundnut intercropping system should followed in 1:1 row proportion.

Keywords: Intercropping, Groundnut, Cowpea, Mustard in Konkan

Introduction
Rapeseed-mustard is the third important oilseed crop in the world after soybean (*Glycine max*) and oil palm (*Elaeis guineensis* Jacq.). Among the seven edible oilseeds cultivated in India, rapeseed-mustard (*Brassica* spp.) contributes 28.6% in the total production of oilseeds. It is the second most important edible oilseed after groundnut sharing 27.8% in the India's oilseed economy. The share of oilseeds is 14.1% out of the total cropped area in India, rapeseed-mustard accounts for 3% of it. The global production of rapeseed-mustard and its oil is around 38-42 and 12-14 mt, respectively. India contributes 28.3% and 19.8% in world acreage and production. India produces around 6.7mt of rapeseed-mustard next to China (11-12mt) and Europe (10-13mt) with significant contribution in world rapeseed-mustard industry.

Intercropping is recommended to be used in many parts of the world for food or fibres productions, because of its overall high productivity, effective control of pests and diseases, good ecological services and economic profitability. In an intercropping system, there are often two or more crop species grown in the same field for a certain period of time, even though the crops are not necessarily sown or harvested simultaneously. In practice, most intercropping systems involve only two crops, as inclusion of more crops results in higher labour costs. Mostly, intercropping is practiced with the aim of maximum plant competition rather than plant competition for maximum crop yield.

The success of intercropping systems is due to an enhanced temporal and spatial complementarity of resource capture, for which both above-ground and belowground parts of crops play an important role. Even though two crops compete for soil N as they both need it for the growth, the competition drives legumes to fix atmospheric N_2 in symbiosis with *Rhizobium*. This actually results in complementary utilization of N by the crops, which is of particular importance in soils where inorganic N is limited or over-fertilized. However, negative intercropping productivity due to interspecific competition has also been reported, especially when the fields are managed inappropriate. Therefore, only reasonable use of competitive and facilitative interactions between crops in intercropping systems can enhance crop productivity and nutrient use efficiency. Keeping these points in view, the proposed research was planned to be conducted at Agronomy Farm, College of Agriculture, Dapoli during *rabi* season of 2018.

Material and methods

The experiment was laid out in randomized block design with thirteen treatments and three replications. The treatment consisted of mustard as a main/base crop and groundnut cowpea as intercrops planted in five planting ratios on row basis, i.e. 1:1, 1:2, 1:3, 2:1, and 3:1 in a replacement series of intercropping system. In addition to this, for better comparison of the performance of the intercrops in the intercropping system their respective sole crop treatments were also included. In all, it consisted of ten treatments of mustard intercropping and three sole stands of mustard, groundnut and cowpea, thereby leading to the total number of thirteen treatments.

The mustard and intercrops were sown on 16th November 2018. The mustard variety Varuna, groundnut variety Konkan Tapora and cowpea variety Konkan Sadabhar were used for sowing. Seeds were sown by dibbling method. The gross and net plot size were 4.80 m x 3.30 m and 4.20 m x 3.00 m respectively.

During the course of present investigation, observations on growth and yield contributing characters were recorded. Growth functions, i.e. AGR of height and dry matter production per day were also studied. Besides this, at harvest, the content of nitrogen, phosphorus and potassium in grain/kernel and straw/haulm were estimated separately for each crop and uptake of nitrogen and protein accumulation were computed from these data. Quality of mustard and intercrop grains in terms of oil content (in mustard and groundnut only) and protein content as affected by different treatments was studied. Yield and yield attributes of various crops, indices such as LER, CEY, RCC, A, CR, RYT, CPR and RYL of the intercropping system were also computed. Chemical analysis of main crop and intercrop plants was carried out at harvest to determine the nutrient content (per cent) and nutrient uptake (kg ha^{-1}).

The analysis of initial soil sample indicated that, the soil of the experimental plot was classified as lateritic, derived from mixed parent material which contains higher exchangeable mg^{2+} as compared to lateritic soils derived from basalt. Mineralogically, these soils have kaolinite as a predominant clay mineral associated with same quantity of illite.

The perusal of meteorological observations implied that the mean maximum temperatures ranged from 28^0C to 38^0C and mean minimum temperatures from 10^0C to 23^0C during the crop season in the year 2018-19. The relative humidity during entire crop season ranged from 72 to 95 % during morning and 40 to 72 % during afternoon. The bright sunshine hours ranged from 3.4 to 9.7 hrs. The daily mean evaporation during crop season was 4.86 mm. The meteorological data revealed that the weather of *rabi* season was favourable for the growth and development of mustard and intercrops without incidence of any major pests or diseases during crop growth period.

Results

1. Indices observed in intercropping treatment

1.1 Relative yield

The data regarding relative yield of mustard and intercrops as affected by various treatments are presented in Table 29. The data were not statistically analyzed, hence, interferences were drawn from mean values. The relative yield of mustard recorded under 3:1 ratio of mustard + groundnut system was higher than all remaining intercropping treatments. Among all the intercropping system, maximum relative yield was recorded under 3:1 ratio followed by 2:1 and 1:1 ratios in that order, except in mustard + groundnut and mustard + cowpea system, where relative mustard yield was same under 1:3 ratio. As regards intercrops, relative yield was higher under 1:3 ratio followed by 2:1 and 1:1 ratios in all the intercropping system.

1.2 Land equivalent ratio (LER)

Data regarding comparative coefficient as affected by different treatments are presented in Table 29. The data were not statistically analyzed, hence, interferences were drawn from mean values.

Under the almost all intercropping treatment, LER was more than one. Mustard + groundnut 1:1 ratio recorded the highest LER than all other intercropping treatments. In different planting patterns, 1:1 ratio recorded more LER followed by 2:1 and 3:1 ratios, respectively.

1.3 Mustard grain equivalent ratio (q/ha)

The data regarding mustard grain equivalent yield as affected by different treatments are presented in Table 1.

The data were not statistically analyzed, hence, interferences were drawn from mean values. The maximum grain equivalent yield was recoded under mustard + groundnut in 1:1 and 1:3 proportion and Mustard + cowpea 2:1 proportion recorded higher mustard grain equivalent yield than sole mustard.in different intercropping system, mustard grain equivalent yield recorded under 1:1 ratio was higher followed by 1:2 and 1:3 ratios, in that order

2 Crop equivalent yield

1. Mustard equivalent yield

Data depicted in Table 30 indicated that mustard + groundnut on 3:1 ratio registered higher mustard equivalent yield, which was closely followed by mustard + cowpea 3:1 ratio.

2. Groundnut equivalent yield

Data presented in Table 30 indicated that treatment sole groundnut recorded maximum groundnut equivalent yield, which was followed by treatment mustard + groundnut 1:3 ratio, mustard + groundnut 1:2 ratio.

3. Cowpea equivalent yield

Data presented in Table 30 indicated that treatment sole cowpea recorded maximum cowpea equivalent yield, which was followed by treatment mustard + cowpea 1:3 ratio, mustard + cowpea 1:2 ratio.

4. Aggressivity (A)

As regards to aggressivity index it was observed that aggressivity index was maximum in T_{12} i.e. mustard + groundnut 3:1 ratio (49.75) in case of mustard over all the treatment combinations. Aggressivity index of intercrop was negative indicating the dominance of mustard in the intercropping system.

5. Competitive ratio

The competitive ratio of mustard with intercrops recorded due to different treatment combination indicated that higher competitive ratio of mustard (8.71) was recorded in T_{12} (i.e. mustard + groundnut under 3:1 ratio) treatment combination.

Relative yield total (RYT)

It is clear from the values of relative yield total (RYT) of intercropping treatments given in Table 30, that the RYT values were improved with increase in mustard proportion in

intercropping. Therefore, the higher RYT value was recorded under treatment T_{12} mustard + groundnut 3:1 row ratio.

Crop performance ratio

Data pertaining in Table 31. As regards to crop performance ratio of mustard it is observed that performance of mustard was improved in T_4 (mustard + groundnut in 1:1 ratio) where it is lower in T_{11} (mustard + cowpea in 1:3 ratio). Similarly, performance of the intercrop was better due to mustard + groundnut in 3:1 ratio as compared to remaining treatment combinations.

Relative crowding coefficient (RCC)

Relative crowding coefficient was worked out for different intercropping treatments and the mean value are presented in Table 31. Relative crowding coefficient for mustard crop was recorded maximum at 1:1 proportion of mustard + groundnut. Groundnut in combination with mustard recorded maximum RCC under 3:1 row proportion indicating its more yield than other treatments.

Relative yield loss (RYL)

Data presented in Table 31. Indicated that present relative yield loss of intercropping treatments, as regards mustard maximum % RYL was -73.26 was observed in treatment mustard + cowpea in 1:3 ratio and -72.99 in treatment mustard + groundnut in 1:3 row proportion.

Discussion

Indices of intercropping system

Data indicate that relative yield of mustard was highest (0.78) in case of mustard + groundnut in 3:1 proportion. It was also noticed that in all the intercropping systems these parameters showed increasing trend with increasing proportion of intercrop in intercropping system. This may be attributed to better utilization of resources and their ultimate reflection in the economic parameters due to greater mutual benefit of legumes with the increasing proportion in the intercropping system. Similar types of results have been reported by Sawant (1989) [11] in case of oilseed + pulse intercropping.

The land equivalent ratio (LER) values in different intercropping systems were greater than unity, indicating the yield advantage was achieved from intercropping system. The higher LER (1.15) was recorded under mustard + groundnut intercropping system in 1:1 proportion, closely followed by mustard + cowpea in 1:1 row ratio. There was considerable increase in the yield of companion crops, therefore, higher LER values were recorded in above referred treatment combinations. Similar observations were made by Jadhav *et al.* (1992) [5], Singh and Arya (1999) [13], Pooranch and and Sujata (2000) [9], Mishra (2014) [8], Choudhuri and Jana (2015) [4] and Bhuva *et al.* (2017) [3]

Higher MEY (29.55 qha^{-1}) was obtained in mustard + groundnut in 1:1 row ratio. This was closely followed by sole groundnut and mustard + groundnut in 1:3 proportion. This was due to the higher market price of groundnut that coupled with better utilization of resources of the component crop in intercropping system. Singh and Arya (1997) [13], Ramamoorthy *et al*. (2003) [10], Mishra (2014) [8] and Jakhar *et al*. (2015) [6] had reported similar type results.

Relative crowding coefficient values of both the crops were found to be greater than unity indicating that, each species gave more yield than expected yield. This is due to mutual co-operation as reported by Maitra *et al*. (2001) [7], Ahlawat *et al*. (2005) [1], Sharma (2009) [12] and Choudhuri and Jana (2015) [4]. The highest RCC value was obtained under treatment T_4 (mustard + groundnut in 1:1 row proportion) followed by treatment T_{12} (mustard + groundnut 3:1 row proportion).

As regards to Aggressivity index, it was observed that Aggressivity index was maximum in T_{12} i.e. mustard + groundnut 3:1 ratio (49.75) in case of mustard over all the treatment combinations. Negative Aggressivity index of intercrop, indicated the dominance of mustard in the intercropping system. Negative Aggressivity index of groundnut in treatment T_{12} indicated the dominance of mustard in that intercropping combination. Similar types of findings were also reported by Ahlawat *et al*. (2005) [1] and Choudhuri and Jana (2015) [4].

The competitive ratio of mustard with intercrops recorded due to different treatment combination indicated that higher competitive ratio of mustard (8.71) was recorded in T_{12} (i.e. mustard + groundnut under 3:1 ratio) treatment combination, while, it was higher at treatment T_8 for groundnut and at treatment T_7 for cowpea. Higher the competitive ratio, higher will be the competitive ability of crop with its companion crop. Choudhuri and Jana (2015) [4] and Jakhar *et al*. (2015) [6] reported similar type of findings.

Data on relative yield loss of intercropping treatments indicated that for mustard, maximum RYL (-73.26%) was observed in treatment mustard + cowpea in 1:3 ratio followed by mustard + groundnut in 1:3 row proportion (-72.99%). Banike *et al.* (2000) [2] reported similar type of findings.

Table 1: Relative Yield and LER of the Cropping System

Treatments		Relative yield (RY)		LER	Mustard equivalent yield (q/ha)
		Mustard	Inter-crop		
T1	Sole Mustard	1.00	-	1.00	23.21
T2	Sole Groundnut	-	1.00	1.00	28.84
T3	Sole Cowpea	-	1.00	1.00	21.50
T4	Mustard + Groundnut (1:1)	0.59	0.56	1.15	29.54
T5	Mustard + Cowpea (1:1)	0.57	0.57	1.14	25.18
T6	Mustard + Groundnut (1:2)	0.37	0.68	1.05	27.85
T7	Mustard + Cowpea (1:2)	0.36	0.66	1.02	22.50
T8	Mustard + Groundnut (1:3)	0.28	0.77	1.05	28.29
T9	Mustard + Cowpea (1:3)	0.28	0.77	1.05	22.56
T10	Mustard + Groundnut (2:1)	0.69	0.38	1.07	26.64
T11	Mustard + Cowpea (2:1)	0.68	0.40	1.08	24.03
T12	Mustard + Groundnut (3:1)	0.78	0.29	1.07	26.23
T13	Mustard + Cowpea (3:1)	0.76	0.33	1.09	24.50

Table 2: Indices as observed in various treatment combination

Tr. No.	Area			Total	CEY			RYT	Aggressivity			Competitive ratio		
	M	G	C		M	G	C		M	G	C	M	G	C
T1	1.00	0.00	0.00	1.00	23.21	0.00	0.00	0.500	1.00	0.00	0.00	1.00	0.00	0.00
T2	0.00	1.00	0.00	1.00	0.00	28.84	0.00	0.500	0.00	1.00	0.00	0.00	1.00	0.00
T3	0.00	0.00	1.00	1.00	0.00	0.00	21.50	0.500	0.00	0.00	1.00	0.00	0.00	1..00
T4	0.50	0.50	0.00	1.00	13.66	15.89	0.00	0.579	0.93	-0.93	0.00	1.25	0.80	0.00
T5	0.50	0.00	0.50	1.00	12.93	0.00	12.25	0.554	0.31	0.00	-0.31	0.48	0.00	2.10
T6	0.33	0.67	0.00	1.00	8.42	19.42	0.00	0.512	-32.36	32.36	0.00	0.33	3.06	0.00
T7	0.33	0.00	0.67	1.00	8.27	0.00	14.23	0.515	-33.3	0.00	33.37	0.12	0.00	8.15
T8	0.25	0.75	0.00	1.00	6.27	22.02	0.00	0.515	-50.27	50.27	0.00	0.14	6.98	0.00
T9	0.25	0.00	0.75	1.00	6.21	0.00	16.35	0.516	-50.59	0.00	50.59	0.52	0.00	1.93
T10	0.67	0.33	0.00	1.00	15.82	10.82	0.00	0.536	32.74	-32.74	0.00	4.28	0.23	0.00
T11	0.67	0.00	0.33	1.00	15.61	0.00	8.42	0.524	32.67	0.00	-32.67	1.71	0.00	0.58
T12	0.75	0.25	0.00	1.00	17.88	8.35	0.00	0.546	49.75	-49.75	0.00	8.71	0.11	0.00
T13	0.75	0.00	0.25	1.00	17.59	0.00	6.91	0.524	49.59	0.00	-49.59	3.70	0.00	0.27

Table 3: Effect of different intercropping ratios on competitive coefficients

Tr. No.	CPR			RCC			RYL			Total
	M	G	C	M	G	C	M	G	C	
T1	1.00	0.00	0.00	1.00	1.00	1.00	0.00	-	-	-
T2	0.00	1.00	0.00	0.00	1.00	1.00	-	0.00	-	-84.20
T3	0.00	0.00	1.00	0.00	1.00	1.00	-	-	0.00	-89.19
T4	6.34	3.96	0.00	1.43	1.32	0.00	-41.17	-43.03	0.00	-97.54
T5	6.00	0.00	5.61	1.26	0.00	1.23	-44.28	0.00	-44.90	-97.00
T6	5.93	3.44	0.00	1.16	0.96	0.00	-63.71	-33.83	0.00	-96.95
T7	5.82	0.00	5.12	1.12	0.00	1.02	-64.36	0.00	-32.64	-96.90
T8	5.82	3.53	0.00	1.11	1.06	0.00	-72.99	-23.96	0.00	-92.73
T9	5.76	0.00	5.19	1.09	0.00	1.08	-73.26	0.00	-23.63	-95.24
T10	5.48	4.13	0.00	1.05	1.31	0.00	-31.86	-60.86	0.00	-90.85
T11	5.41	0.00	5.79	1.01	0.00	1.22	-32.75	0.00	-62.48	-95.27
T12	5.54	4.47	0.00	1.12	1.42	0.00	-22.96	-67.89	0.00	-84.20
T13	5.44	0.00	5.90	1.04	0.00	1.22	-24.22	0.00	-71.05	-89.19

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