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Evaluation of Pea *(Pisum sativum*L.*)* and Indian Mustard *(Brassica juncea L.*) Intercropping System on Growth, Yield and Competition Indices

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A B S T R A C T

A field experiment was carried out using two varieties of pea (Rachna and local cultivar Makhyatmubi) and one Indian mustard (NRCHB 101)intercropping systems to determine the competition among these and economics of each intercropping system. The intercropping systems were assessed on the basis of existing competition and economic indices such as land equivalent ratio (LER), relative crowding coefficient, aggressivity, competitive ratio (CR), relative crowding coefficient (RCC) and monetary advantage index (MAI). Yields of individual crop were higher when grown as sole crops compared with their intercropping. Competition ratio and aggressivity value were higher in the intercropping of Makhyatmubi with Indian mustard in row ratio of 1:1. Whereas Makhyatmubi intercropped with Indian mustard in row ratio of 2:1 gave the maximum Makhyatmubi Equivalent Yield (1830 kg/ha), Land Equivalent ratio (1.51), Relative Crowding Coefficient values (8.23) and Monetary Advantage Index (Rs.60883/ha) indicating a definite yield and monetary advantage.

Introduction

Intercropping is a crop management system involving the growing of two or more economic dissimilar crop species or varieties in distinct row combinations simultaneously on the same piece of land. Conceptually, intercropping system helps for risk avoidance from epidemic of insect-pest and disease, and overcome the effect of adverse environmental conditions in agro-climatologically unstable regions along with better utilization of solar radiation and inputs like fertilizer and water compared to crops in sole system. It means intercropping not only reduces the risk factors, but also increases the profit. In intercropping systems, differences may occur between the component crops in competitive ability for growth resources. Yield advantage occurs because growth resources such as light, water and nutrients are more efficiently absorbed and converted to biomass by the component crops over time and space. Normally, complementary use of resources occurs when

the component crops of an intercropping system use different resources or they use the same resources at different places or at different times. This results due to the variation in characteristics of component crops such as rates of vegetative growth, final canopy size, photosynthetic adaptation of canopies to prevailing light conditions and nature of root system, including rooting depth (Tsubo *et al*., 2001).

Selection of crops differing in competitive ability in time or space is essential for an efficient intercropping system as well as making decisions on planting time, density and arrangement. Thus, crop management decisions specify the design of intercropping systems, and its performance is governed largely by the availability and the competition for growth resources. It has also been found to be most useful (Adeniyi, 2011) because of its economic advantages resulting from nitrogen fixing activity of legumes intercropped with other crops. Legumes grown in intercropping are regarded as an alternative and sustainable way of introducing nitrogen into lower input agro-ecosystems (Fustec*et al*., 2010).

Therefore, keeping in view, the present investigation entitled "Pea *(Pisumsativum*L.*)*based intercropping system with Indian mustard *(Brassica juncea L.*) on growth, yield and competition indices" was carried out with the objectives to find out the suitable pea variety for intercropping with Indian mustard, their suitable combination of intercropping and the economics.

Materials and Methods

The experiment was conducted during *rabi* season of 2016-17 and repeated in 2017 – 2018 at the Research Farm of College of Agriculture, Central Agricultural University, Imphal. For the experiment two varieties of pea (Rachna and Makhyatmubi) and one Indian mustard (NRCHB 101) were used. The experiment consist of nine treatment viz., T_1 - Sole Rachna; T_2 - Sole Makhyatmubi; T_3 - Sole Indian mustard; T_4 - Rachna + Indian mustard (1:1); T_5 - Makhyatmubi + Indian mustard (1:1); T_6 - Rachna + Indian mustard (2:1); T_7 - Makhyatmubi + Indian mustard (2:1); T_8 - Rachna + Indian mustard (3:1); T_9 - Makhyatmubi + Indian mustard (3:1). The experiment was laid out in randomised block design with three replications. The soil of the experimental site is clay. The soil has pH (5.4), organic carbon (1.2%), available N (251.53 kg/ha), P_2O_5 (16.45 kg/ha) and K_2O (218.80 kg/ha). The crops were raised in rainfed condition. The seeds of pea and Indian mustard were sown in replacement series in all intercropping plots except sole. The seeds of both pea and rapeseed were treated with carbendazim @ 5g/kg seed just before sowing to protect from soil and seed borne diseases. The treated seeds of pea varieties Makhyatmubi, Rachna and Indian mustard variety NRC HB-101 were sown on 27th and 30th November, 2016 and 2017 and harvested on 28th March, 2017 and 1st April, 2018 respectively. Pea variety 'Makhyatmubi' was a susceptible to lodging local cultivar of Manipur. A uniform dose of N (20 kg/ha), P_2O_5 (60 kg/ha) and K_2O (40 kg/ha) was applied to all the plots as basal. All the other cultural practices were carried out during both the years. Data on growth and yield attributing characters were recorded and analysed statistically. The intercropping systems were assessed on the basis of existing competition and economic indices such as land equivalent ratio (LER), relative crowding coefficient (*K*), aggressivity (*A*), competitive ratio (CR), actual yield loss (AYL), intercropping advantage and monetary advantage index (MAI).

Makhyatmubi Equivalent Yield (MEY)

The Makhyatmubi Equivalent Yield was calculated from the ratio of price unit weight of the concerned crop (Rachna and Indian

mustard) by the price unit weight of Makhyatmubi (Verma and Modgal, 1983).

$$MEY = \frac{Y\ X\ Pi}{Pc}$$

Where, Y = Yield of a crop, which need conversion,
Pi = Price offered to a crop Y
Pc= Price offered to crop, in whose terms Y is being expressed.

Land Equivalent Ratio (LER)

Proposed by Willey (1979). It denotes the relative land area under sole crop required to give the same yield as obtained under mixed or an intercropping system at the same level of management.

$$LER = LERa + LERb = \frac{Yab}{Yaa} + \frac{Yba}{Ybb}$$

Where,

Yaa = Pure yield of main crop; Ybb = yield of intercrop; Yab and Yba = row proportion of main and intercrop respectively.

Competitive Ratio (CR)

Proposed by Willey *et al*. (1980). It is the ratio of individual LER of two component crops duly corrected for proportion in which they are grown. It is calculated separately for both the component crops, a and b.

$$A_{ab} = \frac{Yab}{Yaa\ xZab}\ x\ \frac{Yba}{Ybb\ x\ Zba}$$

Or, $CR_a = \frac{LERa}{LERb} x \frac{Zab}{Zba}$ and $CR_b = \frac{LERb}{LERa} x \frac{Zab}{Zba}$

Aggressivity

It is proposed by Mc. Gilchrist (1965). It is a simple measure of how much the relative yield increase in component "a" is obtained than that for component "b". "A" can be calculated for both crops independently in a system. Greater the numerical value of A, bigger is the difference in competitive ability and bigger difference between actual and expected yield.

$$A_{ab} = \frac{Yab}{Yaa\ xZab} - \frac{Yba}{Yaax\ Z\ ab}$$

$$A_{ba} = \frac{Yba}{Ybb\ xZba} - \frac{Yab}{Yaa\ x\ Zab}$$

Monetary advantage index (MAI)

It was calculated by using the formula of (Ghosh, 2004)

$$MAI = \frac{(\text{Value of intercrops})(LER - 1)}{LER}$$

Results and Discussion

Effect of intercropping on growth and yield attributes

Data in Table 1 shows the average growth and yield attributes of pea and mustard and their intercropping. The highest plant height of pea (97.93cm) was recorded in 1:1 row proportion of Makhyatmubi with Indian mustard which was significantly higher than sole of Makhyatmubi (78.8 cm) and statistically at par with 2:1 row proportion (85.40 cm) and 3:1 row proportion of Makhyatmubi with Indian mustrad (86.80cm). Significantly lowest plant height of Rachna was recorded when grown as sole (50.27cm). The result of giving higher pea height in intercropping of Makhyatmubi with Indian mustard in 1:1 systems than its monoculture might be due to competition for light. Sole Indian mustard recorded taller plants (105.60 cm) than other intercrop treatments. This might be due to high plant density and competition for light. Similar results were reported by Singh and Yadav (1992) and Kumar *et al.* (2006).

Number of pods per plant was significantly higher (8.73) when Rachna was intercropped with Indian mustard in 2;1 row ratio and it was closely followed by intercropping of Makhyatmubi with Indian mustard in 2:1 row ratio (8.27). Significantly lowest number of pods per plant was obtained from sole Makhyatmubi (5.82). It might be due to susceptible to lodging character of Makhyatmubi leading in poor development of pods.

Indian mustard produces significantly higher number of siliqua per plant when intercropped with Rachna in 1:1 row ratio (87.37). It might be due to advantage of additional nitrogen supplied by pea. In contrast the lowest (46.73) was recorded from the intercropping of Makhyatmubi with Indian mustard in 1:1 row ratio. It might be due to dominance of Indian mustard by Makhyatmubi thereby reducing the availability of sunlight for photosynthesis. Test weight of pea was significantly higher due to the seed size difference between Rachna and Makhyatmubi. Test weight of Indian mustard was found to be non-significant due to inherent character of the same variety.

Effect of intercropping on yield

Grain yield of pea and mustard were found to be highest in sole as compare to intercropping due to more plant population. Similar results were also reported by Singh and Singh (1998). Among the intercropping system significantly higher grain yield was recorded from Makhyatmubi with Indian mustard in 2:1 row ratio (1607.04 kg/ha) followed by Makhyatmubi with Indian mustard in 3:1 row ratio (1517.67). Among row proportions, the increase in the grain yield in 2:1 row proportion of Makhyatmubi with Indian mustard could be due to higher yield attributing parameters like pods per plant, test weight and number of seeds per pods because Makhyatmubi being a susceptible crop to lodging needs proper support for higher number of pods and seed development which they got proper support from Indian mustard. The decrease in the yield in intercropping was due to less competition for sunlight, space, water and nutrients for sole crop as compared to intercropping treatments.

Indian mustard as sole crop recorded significantly higher seed (1112.22 kg/ha) yield over intercropped Indian mustard. Similar results were also reported by Patel *et al.* (1991). The decrease in the yield in intercropping might be due to competition of crop plants for efficient utilization of natural resources and restricted growth of Indian mustard from initial stages to harvest resulting in yield competition for main and intercrops. Among the row proportions, 1:1 row proportion of Rachna with Indian mustard recorded significantly higher grain yield of Indian mustard due to higher yield attributes *viz,* number of pods per plant, seeds per pod, and 1000-grain weight. Similar results were also reported by Tiwari*et al.* (1992).

Effect of intercropping on indices

Makhyatmubi equivalent yield was recorded highest (1830 kg/ha) in 2:1 row proportion of Makhyatmubi with Indian mustard which was significantly higher than sole Makhyatmubi (1706 kg/ha). Lowest was found in sole Indian mustard (389 kg/ha). Highest makhyatmubi equivalent yield in 2:1 row proportion of Makhyatmubi with Indian mustard might be due to higher yield and higher market price of Makhyatmubi.

Intercropping of Pea with Indian mustard resulted in land equivalent ratio greater than 1, except in sole crops indicating its advantage or biological efficiency and suitability of the practice in quantitative term.

Table.1 Effect of pea based intercropping with Indian mustard on growth of pea and mustard (average for two years)

Treatment	Plant height (cm)		No. of pods/ plant	No. of siliqua/ plant	Test weight (g)		Grain yield kg/ha)	
	Pea	Mustard			Pea	Mustard	Pea	Mustard
T_1	50.27	-	10.60	-	228.67	-	1420.00	-
T_2	78.80	-	5.87	-	292.67	-	1705.92	-
T_3	-	105.60	-	86.93	-	6.37	-	1112.22
T_4	55.40	88.47	6.13	87.37	225.67	6.17	840.00	785.19
T_5	97.93	102.07	7.73	46.73	301.67	6.23	1436.11	571.85
T_6	56.60	84.80	8.73	85.27	222.33	6.23	1090.37	718.52
T_7	85.40	88.93	8.27	54.93	306.67	6.13	1607.04	637.04
T_8	57.60	91.33	7.07	69.07	222.33	6.33	1287.40	645.93
T_9	86.80	84.73	7.47	50.07	295.00	6.23	1517.67	533.70
S.Ed (±)	2.86	5.81	0.71	7.12	3.08	0.27	155.46	100.70
CD (P=0.05)	14.97	12.66	1.52	15.50	16.17	NS	333.45	219.33

T_1-Sole Rachna; T_2-Sole Makhyatmubi; T_3-Sole Indian mustard; T_4-Rachna+Indian mustard (1:1); T_5-Makhyatmubi+Indian mustard (1:1); T_6-Rachna+Indian mustard (2:1); T_7-Makhyatmubi+Indian mustard (2:1); T_8-Rachna+Indian mustard (3:1); T_9-Makhyatmubi+Indian mustard (3:1)

Table.2 Effect of pea based intercropping with Indian mustard on competition indices(average for two years)

Treatment	Makhyatmubi equivalent yield	Land Equivalent Ratio	Competitive Ratio	Aggressivity		Relative crowding coefficient (RCC)		Monetary advantage index
				Pea	Mustard	Pea	Mustard	
T_1	710	1.00	-	-	-	-	-	-
T_2	1706	1.00	-	-	-	-	-	-
T_3	389	1.00	-	-	-	-	-	-
T_4	695	1.31	0.85	-0.10	0.10	1.71	2.53	30138
T_5	1636	1.35	1.66	0.33	-0.33	5.66	1.09	43230
T_6	797	1.42	0.61	-0.26	0.26	2.27	4.10	23547
T_7	1830	1.51	0.88	-0.10	0.10	8.23	3.53	60883
T_8	870	1.49	0.53	-0.28	0.28	5.99	4.29	28378
T_9	1704	1.37	0.64	-0.18	0.18	3.13	3.00	45649
S.Ed (±)	121.44	0.11	-	-	-	-	-	-
CD (P=0.05)	257.46	0.23	-	-	-	-	-	-

T_1-Sole Rachna; T_2-Sole Makhyatmubi; T_3- Sole Indian mustard; T_4-Rachna + Indian mustard (1:1); T_5-Makhyatmubi+ Indian mustard (1:1); T_6 - Rachna+Indian mustard (2:1); T_7 - Makhyatmubi+Indian mustard (2:1); T_8-Rachna+Indian mustard (3:1); T_9 -Makhyatmubi +Indian mustard (3:1)

The obvious reason for yield advantage in intercropping system was due to the fact that the component crops have combined effect of better utilization of growth resources than sole cropping of companion crops and converting them more efficiently resulting in higher yields per unit area than that produced by the sole crops. Similar results were reported by Singh and Singh (1998). Competitive ratio was observed highest (1.66) in 1:1 row proportion of makhyatmubi with indian mustard and lowest (0.53) was found in 3:1 row proportion of Rachna with Indian mustard indicating more efficient combinations than other intercropping systems (Table 2). This might be due to the companion crop pea appeared less competitive than Indian mustard, giving lower value of competitive ratio.

Relative crowding coefficient of pea was recorded highest (8.23) in 2:1 row proportion of Makhyatmubi with Indian mustard and lowest (1.74) in 1:1 row proportion of Rachna with Indian mustard. For Indian mustard relative crowding coefficient was recorded highest (4.29) in 3:1 row proportion of Rachna with Indian mustard and lowest (1.09) in 1:1 row proportion of Makhyatmubi with Indian mustard. Similar results were also reported by Tuti *et al.*, (2012). Among intercroppings, Makhyatmubi + Indian mustard in 2:1 row ratio had a higher monetary advantage index (Rs 60883). The higher the MAI value the more profitable is the cropping system (Ghosh, 2004).

From the present investigation it can be concluded that intercropping of Makhyatmubi with Indian mustard in 2:1 row ratio was found to be beneficial.

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