Determining the best Lentil (*Lens culinaris*) and Mustard (*Brassica campestris*) Intercrop Combination to Improve Biomass Yield and Economic Returns on the Yield in Southern Region of Bangladesh

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Abstract— *An intercropping experiment on mustard with lentil was conducted during rabi season of 2013-14 and 2014-15 at the Regional Agricultural Research Station, Rahmatpur, Barisal to find out suitable intercrop combination for higher profitability and economic return. Sole lentil (100%), sole mustard (100%) and five intercrop combinations {one row of lentil and one row of mustard (1:1), one row of mustard in between two rows of lentil (2:1), one row of mustard in between three rows of lentil (3:1), one row of mustard in between four rows of lentil (4:1) and two rows of mustard in between four rows of lentil (4:2)} were evaluated in the present study. Significantly the highest lentil (1.91 t/ha) and mustard yield (1.48 t/ha) were obtained from their respective sole crops. Lentil yield was reduced (17-34%) due to intercropping, but it was compensated by the mustard yield. Moreover, land equivalent ratios (LER) of the intercrop treatments were higher than those of sole crops. The highest (2.29t/ha) lentil equivalent yield (LEY) was obtained from T_5 treatment (One row of lentil + Three rows of mustard). This treatment also gave the highest LER (1.65), gross return (Tk 182400/ha), net return (Tk. 103200/ha) and benefit cost ratio (2.29).*

Keywords— Corroboration, Lentil (*Lens culinaris*), Mustard (Brassica campestris), Intercropping and Equivalent yield.

I. INTRODUCTION

Intercropping is a traditional practice in Bangladesh. It increases total productivity per unit area through maximum utilization of land, labor and growth resources. Growing two or more crops in combination is called intercropping where intra and inter specific competition occurs (Spilter, 1983). The success of intercropping thus depends mostly on the complementary or competitive behaviors (Nazir *et al*., 1988, Chandrasekhar *et al.*,1988) of the component crops. Competitiveness of component crops depends to a large degree on each crops response to the limiting factors (Fukai and Trenbath, 1993). Therefore, intercropping is considered to be very efficient technique in maximizing the production per unit area and it gives higher resource use efficiency (Hashem and Moniruzzaman, 1986; Quayyum *et al.*,1999). It also increases land equivalent ratio (LER) to varying degrees (Mehta and De, 1980; Hashem *et al.*,1990). Lentil and mustard two most important crops in Bangladesh are usually grown as sole and intercrop. Lentil is one of most valuable cash crop grown for domestic as well as export purpose. By adopting appropriate planting geometry in the intercropping system,the total productivity can be increased (Umrani *et al*., 1984). Successful intercropping system gives higher cash return total production per unit area and diversifies production system than growing sole crop (Kurata 1966; Khaliq *et al.*,1997) and provides greater resource use efficiency (Pathic&Mulla, 1979). Several workers also reported higher economic advantage in intercropping than sole cropping (Mandal*et al.*,2004; Khaliq *et al.*,1997; Hossain and Bari, 1996). Proper row arrangement of lentil and mustard under intercropping system can ensure higher productivity and economic return. The review of research work done so far indicated that growth of mustard as intercrop is more beneficial than growing lentil alone in many situations (Aravazhi *et al*., 1997; Natarajan, 1992, Sadashiv, 2004). However, literature relating optimum plant population of mustard for intercropping with lentil is meager. Hence this experiment was undertaken to find out the optimum plant population of mustard in association with lentil for achieving higher productivity.

II. MATERIALS AND METHODS

The experiment was conducted during the rabi season of 2013-14 and 2014-15 at the Regional Agricultural Research Station, Rahmatpur, Barisal. The soil was sandy loam having pH 7.5 of Agro Ecological Zone 12. The soil was low in organic matter (1.34 %) and deficient in total nitrogen (0.05%), available phosphorus (12 µg/g soil), exchangeable potassium (0.09 meq/100 g soil) and available sulphur (2.2 µg/g soil). The unit plot size was 4m x 4 m. Five treatment combinations viz., T_1= Sole lentil (30 cm x 20 cm), T_2 = Sole mustard (30 cm x 20 cm), T_3 =1 row lentil + 1 row of mustard,T_4=1 Row mustard between every two rows of lentil (2:1), T_5 =1 row of mustard between every 3 rows of lentil (3:1) ,and T_6 =1 row mustard between every four rows of lentil (4:1), T_7 =2 rows of mustard between every 4 rows of lentil (4:2). The experiment was tested in a randomized complete block design with three replications. The seeds of lentil (BARI Mosur 6) and were mustard (BARI Sarisha 15) sown on November 19, 2014. Lentil sole and intercrop plots had received a uniform application of 50-90-40-102 kg NPKS /ha and sole mustard plot had received 250-175-90-160 kg NPKS /ha through urea, triple super phosphate (TSP), muriate of potash (MoP) and gypsum. In lentil and intercrop plots, all fertilizers were applied as basal. But in case of sole mustard plot, one half of urea and full amount of TSP, MoP and gypsum were applied as basal and remaining half ureawere applied before flowering at 30 days after sowing (DAS). Cow dung (5 t/ha) were applied as basal in all the plots. Intercultural operations like weeding, irrigation and plant protection measures were provided to both the crops as and when necessary. Lentil was harvested on 11 March 2015 (120 Days after sowing). Lentil and mustard were harvested as whole plot basis. At harvest, 10 randomly selected plants of each crop from each plot were uprooted for the assessment of yield components. The collected data were analyzed statistically and the means were adjudged using LSD. Economic analysis and benefit cost ratio (BCR) were also computed.

III. RESULTS AND DISCUSSION

3.1 Yield and yield attributes of lentil

Treatments had significant effects on pods and siliqua per plant, seeds per fruit, yield per plant (Table 2 and Table 3). Plant height does not show significant variation among the treatments. Significantly the maximum number of pods per plant (117.80 and 121.63) was observed in T_1 treatment followed by T_3 and T_5 treatment. The least number of pods per plant (66.43 and 69.33) was obtained from T_7 treatment. Shading due to higher population probably resulted in less number of fruits/plant in T_4 treatment. Significantly the maximum 1000 seeds weight (23.5 and 24 g) were obtained from sole lentil which was statistically similar to T_3 treatment and lowest 1000 seeds weight (18.27 and18.15g) were found in T_7 treatment and Significantly the maximum yield (1.91 and 1.99 tha^{-1}) was obtained from sole lentil and lowest was obtained from T_7 (1.27 and 1.29tha^{-1}) treatment that might be due to competition in this treatment. The yield of lentil in intercropping situation was reduced by 17-34% at various treatments.

TABLE 1
YIELD AND YIELD ATTRIBUTES OF LENTIL AS AFFECTED BY INTERCROPPING WITH MUSTARD WITH MUSTARD DURING RABI SEASON OF 2013-14

Treatment	Plant height (cm)	No.of pod/plant	1000 seed weight (g)	Seed yield (tha^{-1})
T_1	41.93	117.80	23.50	1.91
T_3	34.27	84.07	22.67	1.46
T_4	37.80	92.67	20.00	1.52
T_5	33.67	106.70	20.33	1.61
T_6	34.33	76.53	19.33	1.40
T_7	39.13	66.43	18.17	1.27
LSD(0.05)	NS	9.82	5.262	0.56
CV%	8.91	7.10	12.68	2.87

TABLE 2

YIELD AND YIELD ATTRIBUTES OF LENTIL AS AFFECTED BY INTERCROPPING WITH MUSTARD DURING RABI SEASON OF 2014-15

Treatment	Plant height (cm)	No. of pod/plant	No. 1000 seed weight (g)	Seed Yield (tha^{-1})
T1	43.33	121.63	24.00	1.99
T3	36.07	82.83	21.00	1.43
T4	37.56	91.08	22.00	1.49
T5	40.29	108.35	20.34	1.72
T6	34.47	77.53	19.63	1.37
T7	33.45	69.33	18.15	1.29
LSD(0.05)	4.95	10.99	2.25	0.47
CV%	7.63	7.89	10.28	2.64

Where, T_1=Sole Lentil, T_3= One row of Lentil+One row of mustard, T_4=One row of mustard in between every two rows of lentil, T_5= One row of mustard in between alternate three rows of lentil, T_6=One row of mustard in between every four rows of lentil and T_7=Two rows of mustard in between every four rows of lentil

3.2 Yield and yield attributes of mustard

Plant height does not show significant variation among the treatments. But intercropping has significant effect on the yield and yield attributing characters of mustard. The highest no. of siliqua (119 and 117.33) per plant, 1000 seed weight (3.90 and 2.71g) was observed in T_2 treatment which was followed by T_3 treatment. Significantly highest yield (1.48 and 1.52 t/ha) of mustard was obtained from sole mustard and lowest from T_7 treatment (Table 3 and Table 4). The yield of mustard in intercropping situation was reduced by 13-41% at various treatments.

TABLE 3

YIELD AND YIELD ATTRIBUTES OF MUSTARD AS AFFECTED BY INTERCROPPING WITH LENTIL DURING RABI SEASON OF 2013-14

Treatment	Plant height (cm)	No. of siliqua/plant	1000 seed weight (g)	Yield (tha^{-1})
T_2	84.13	119.00	3.41	1.48
T_3	88.93	103.90	3.37	1.33
T_4	89.60	89.13	3.32	1.29
T_5	92.33	83.53	3.39	1.25
T_6	83.63	77.23	3.34	1.22
T_7	88.53	68.73	3.29	1.15
LSD (0.05)	NS	8.95	NS	0.06
CV%	10.75	5.63	1.21	2.73

TABLE 4

YIELD AND YIELD ATTRIBUTES OF MUSTARD AS AFFECTED BY INTERCROPPING WITH LENTIL DURING RABI SEASON OF 2014-15

Treatment	Plant height (cm)	No. of siliqua/plant	100 seed weight (g)	Yield (tha^{-1})
T_2	84.12	118.02	2.79	1.61
T_3	83.54	117.33	2.71	1.52
T_4	89.43	121.50	2.65	1.36
T_5	82.65	108.35	2.58	1.27
T_6	86.13	105.33	2.62	1.21
T_7	83.36	98.50	2.69	1.14
LSD(0.05)	NS	9.05	NS	0.75
CV%	9.17	6.19	1.13	2.52

Where, T_1=Sole Lentil, T_3= One row of Lentil+One row of mustard, T_4=One row of mustard in between every two rows of lentil, T_5= One row of mustard in between alternate three rows of lentil, T_6=One row of mustard in between every four rows of lentil and T_7=Two rows of mustard in between every four rows of lentil.

3.3 Economic analysis

Productivity of lentil + mustard intercropping system was evaluated on the basis of equivalent yield (Bandyopadhyay 1984). All the intercropped combinations showed the higher lentil equivalent yield over sole lentil except T_7 treatment (Table 5 and

Table 6). Among the intercrop treatments, the highest lentil equivalent yield (2.28 t/ha) was obtained from T_3 and the lowest (1.84t/ha) from T_7 treatment. Highest LER (1.65) was found in T_3 treatment followed by T_5. Intercropping showed higher gross return than sole cropping. Although higher cost of production was involved in intercropping system, highest gross return (Tk152400/ha) and net return (Tk103200/ha) was obtained from T_5 treatment. Moreover, the treatment T_3 contributed to the highest benefit cost ratio (2.29). The results revealed that mustard grown as intercrop with lentil is more profitable than sole lentil. The results also suggested that one row of mustard between three rows of lentil was the most suitable intercrop combination for achieving higher economic benefit.

TABLE 5
COST AND RETURN ANALYSIS OF LENTIL-MUSTARD INTERCROPPING SYSTEM DURING RABI SEASON OF 2013-14

Treatment	LER	Average LEY (t/ha)	Average Gross return (Tk)	Average Cost of prod^n(tk)	Average Net return (Tk)	BCR
T_1	1	1.95	91680	78000	13680	1.17
T_2	1	0.71	34080	31000	3080	1.09
T_3	1.65	2.09	100320	81800	18520	1.23
T_4	1.62	2.10	100800	80000	20800	1.26
T_5	1.54	2.23	107040	79200	27840	1.35
T_6	1.35	1.93	92640	78500	14140	1.18
T_7	1.24	1.80	86400	81300	5100	1.06

TABLE 6
COST AND RETURN ANALYSIS OF LENTIL-MUSTARD INTERCROPPING SYSTEM DURING RABI SEASON OF 2014-15

Treatment	LER	LEY (t/ha)	Gross return (Tk)	Cost of prod^n (tk)	Net return (Tk)	BCR
T_1	1	1.99	159200	78000	74800	2.04
T_2	1	0.74	59200	31000	28000	1.90
T_3	1.65	2.08	166400	81800	84600	2.03
T_4	1.62	2.17	173600	80000	93000	2.17
T_5	1.54	2.28	182400	79200	103200	2.30
T_6	1.35	2.01	160800	82000	78800	1.96
T_7	1.24	1.84	147200	82300	64900	1.78

Where, T_1=Sole Lentil, T_3= One row of Lentil+One row of mustard, T_4=One row of mustard in between every two rows of lentil, T_5= One row of mustard in between alternate three rows of lentil, T_6=One row of mustard in between every four rows of lentil and T_7=Two rows of mustard in between every four rows of lentil.

IV. CONCLUSION

From the study it was found that one row of mustard in between every three rows of lentil performed better than other. Compared to conventional monoculture oflentil, mustard-lentil intercropping had significant advantage in yield, economy, land utilization ratio and reducing soil nitrate-N accumulation, as well as better residual effect on the subsequent crop. Intercropping systems could reduce N fertilizer use and increase relative biomass of respected crops as a result of high photosynthetic efficiency of border rows and sufficient nitrate supply during symbiotic period. Noticeably, intercropping advantage was not inherent but began to emerge at legume formation stage. 3L:1M was the best intercropping system in this study, as it had the largest LER and BCR.

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