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Performance of Garden Pea Varieties as Intercrop with Maize in the Coastal Area of Bangladesh

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An experiment was conducted in the coastal saline area of Khulna, Bangladesh during *rabi* seasons of 2014-15, 2015-16 and 2016-17 to find out the performance of garden pea varieties as intercrops with hybrid maize. Three intercropping treatment combinations were investigated along with two sole crops. Treatment combinations were T_1: Two rows of garden pea variety (BARI Motorshuti-1) in between two rows of maize, T_2: Two rows of garden pea variety (BARI Motorshuti-3) in between two rows of maize, T_3: Two rows of local garden pea in between two rows of maize, T_4: Sole maize (BARI Hybrid Maize-9) (60 cm X 20 cm spacing) and T_5 = Sole garden pea with local variety (25 cm row spacing). There was no significant variation among the years in terms of growth and yield component characters of maize and garden pea varieties. Pooled data over the three years showed that the growth and yield component characters of maize varied significantly due to incorporation of different garden pea varieties, whereas significant variation was observed among the garden pea varieties in terms of plant height, thousand pod weight and pod yield. Incorporation of garden pea varieties as intercrop with maize increased maize equivalent yield (MEY). Maximum MEY was obtained from maize + BARI Motorshuti-3 (24.90 t ha^{-1}). Moreover, in T_2, percent yield reduction in maize (-8.66%) and garden pea (-17.04%) was lowest than other intercrop treatments consisting of other garden pea varieties. The values of all the competition functions and intercrop efficiency index showed superiority of maize + BARI Motorshuti-3 (T_2) intercropping than other garden pea varieties. Treatment T_2 also showed higher values of land equivalent ratio (1.74), gross return (Tk. 373500 ha^{-1}), gross margin (Tk. 238000 ha^{-1}) and BCR (2.76) as compared to other treatments.

(***Key words:*** *Benefit-cost ratio, Competition function, Gardenpea, Intercropping, Land equivalent ratio, Maize)*

Cropping system intensification through intercropping practice is particularly pertinent to Bangladesh due to shrinking of cultivable land and increase in population. Every year total cultivable land of the country is turning into non-agricultural land at the rate of 0.73% (Molla, 2016), while total population is projected to be 201.3 million by 2051 (El-Saharty *et al*., 2014). So, meeting food demand by maintaining soil health is a great challenge. In the face of current and future challenges to maintain productivity, profitability and sustainability, crop production may be enhanced by practicing crop rotation, relay cropping and intercropping of cereals with legumes (Ahmad *et al*., 2001). Intercropping is the simultaneous cultivation of two or more crops during the same season on the same piece of land at different population mixture pattern. It has been shown that intercropped systems have yield advantages over single crop (Awal *et al*., 2006; Zhang *et al*., 2007). It is believed that change in the architecture of plant species in the system provide better conditions for utilization of resources below soil surface (moisture, nutrients) and above ground canopy solar radiation interception in the intercropping system (Gong *et al*., 2014; Li *et al*., 1999, 2006; Xia *et al*., 2013). Intercropping also improves system productivity per unit area and time, and helps to promote equitable and judicious utilization of land resources and farming inputs including labour (Marer *et al*., 2007).

In Khulna region, which belongs to coastal saline area, cultivation of maize is getting popularity day by day due to its higher yield potentiality and their high economic return. Hybrid maize is a deep rooted crop and it requires high amount of chemical fertilizers for exploiting maximum yield potentiality. On the contrary, garden pea is a short duration shallow rooted legume crop and it needs comparatively less amount of fertilizers. Intercropping of short duration legume vegetable with maize does not hamper the growth and yield of maize,

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rather it improves the soil health as well as renders a handsome economic return (Islam *et al*., 2004; Singh *et al*., 2000). Intercropping of leguminous crops with maize is a common throughout developing countries and can be the ideal ones for sustainable production and food security to small scale farmers (Abera *et al*., 2005). However, selection of suitable intercrop variety is crucial for higher equivalent yield and economic return. Muoneke *et al*. (2012) reported that the cultivar which is most suitable for sole crop might not be suitable in intercropping due to change in microclimate within crop mixture. So, in the present study, we tried to find out a suitable garden pea variety for intercropping with maize with two rows of garden pea in between two rows of maize.

MATERIALS AND METHODS

Study area

The experiment was conducted at farmers' field in the coastal area of Khulna, Bangladesh during *rabi* 2014-15, 2015-16 and 2016-17. The area lies in south-western coastal saline area of Bangladesh, covering about 0.131 million hectares of land affected by various degrees of soil salinity. Soil salinity increases from *rabi* season (mid November to mid March) to *kharif*-I season (mid March to mid July) and decreases thereafter due to monsoon rainfall. Crop production during *rabi* season hence, becomes limited due to increasing soil salinity and lack of sufficient irrigation water. The experimental site is situated at 22° 47′ 57″ N and 89° 25′ 42″ E with an altitude of 3 m above sea level. Mean annual precipitation received is 2068 mm, most of which (90%) is received during May to October. Annual mean maximum temperature is 31.9°C and minimum temperature 22.4°C. The soil belongs to tidal floodplain land (Agro-ecological zone 13) with general pattern of grey, slightly calcareous, clay-loam to silty-clay in texture. In general, most of the top soils are acidic and sub-soils are neutral to slightly alkaline. General fertility level is high with low to medium organic matter content and very high CEC and K status.

Description of the treatments, intercultural operations, harvest and data collection

The experiment consisted of five treatments, *viz*. T_1: Maize (100%) + Garden pea (75%) (BARI Motorshuti-2), T_2: Maize (100%) + Garden pea (75%) (BARI Motorshuti-3), T_3: Maize (100%) + Garden pea (75%) (BARI Garden pea-1 as local variety), T_4: Sole maize and T_5: Sole Garden pea (BARI Motorshuti-1). Two rows of respective garden pea variety were sown at 25 cm row spacing in between every two rows of maize spaced at 60 cm x 20 cm. Previous studies proved that two rows of garden pea in between two rows of maize (1:2) performed better in terms of equivalent yield and profitability (Choudhary, 2015). The maize variety, BARI Hybrid Maize-9 was used in both sole and intercrop treatments, and garden pea varieties viz. BARI Motorshuti-2 and BARI Motorshuti-3 varieties were used in intercrop treatments and for sole treatment BARI Motorshuti-1 (Local) variety was used. Where, maize was the main crop which comprised 100% population and garden pea was grown as intercrop comprised 66% of the sole population. The garden pea varieties had dissimilar phenotypic characteristics and yield potentiality due to their genotypic variation (Table 1) (Azad *et al*., 2017).

Table 1. *Potential yield and phenotypic characteristics of garden pea varieties (BARI Motorshuti - 1, 2 and 3) used as intercrop with maize and sole crop at Khulna, Bangladesh during 2014-15, 2015-16 and 2016-17*

Characters	BARI Motorshuti-1	BARI Motorshuti-2	BARI Motorshuti-3
First harvest (days)	70-75	65-70	55-60
No. of Branch	1-2	2-3	2-3
Seeds per pod	4-7	5-8	4-7
Seed size	small	medium	larger
Green pod yield (t ha^{-1})	10-12	12-14	12-14

The experiment was laid out in randomized complete block design with four dispersed replications. The unit plot size was 8.0 × 5.0 m. The crops, maize and garden pea were sown on 24 November 2014, 26 November, 2015 and 27 November, 2016. The experimental plots were fertilized with 250-55-120-50-5-1 kg ha^{-1} of N-P-K-S-Zn-B and 45-30-45 kg NPK ha^{-1} for sole crop of maize and garden pea, respectively (BARC, 2012). Maize in intercropping treatments was fertilized with 250-55-120-50-5-1 kg N-P-K-S-Zn-B ha^{-1} in the form of urea, triple super phosphate (TSP), muriate of potash (MoP), gypsum, zinc sulphate and boric acid, respectively. Additionally, cow dung was applied @ 10 t ha^{-1} in each treatment. The full doses of

P, S, Zn, B, cow dung and one-third of N and K were applied during final land preparation. Remaining two-third of N was split equally and applied at 8-10 leaves stage after harvesting of garden pea and at tasseling stage beside maize rows. The land was irrigated three times. Mulching and hand weeding were done as and when required to keep the field reasonably weed free. Chlorpyrifos (Dursban 20 EC) was sprayed at 15-20 days intervals as precautionary measure against insects attack. Garden pea was harvested from 20 January to 5 February, 2015 and 24 January to 10 February, 2016 and 27 January to 16 February, 2017. Maize was harvested on 21 April 2015, 27 April 2016 and 29 April 2017. The yield contributing characters of garden pea and maize were recorded from 10 randomly selected plants in both the years. Maximum soil salinity level at the time of soil sample collection of the experimental field has been presented in Fig. 1. The range of soil salinity over the growing period during 2014-15 was between 2.45-6.13 dS m^{-1}, during 2015-16 it was between 2.51- 4.89 dS m^{-1} and was between 2.11-4.81 dS m^{-1} during 2016-17.

Calculations of competition functions

Different competition functions *viz*. aggressivity index (A), competitive ratio (CR) and relative crowding coefficient (RCC) were worked out by using following formulae to find out the benefit of intercropping (Banik *et al*., 2006; Dhima *et al*., 2007; Khan *et al*., 2018;

Aggressivity (A) index

$A_{maize} = Y_{im} / (Y_{sm} \times Z_{mp}) - Y_{ig} / (Y_{sg} \times Z_{gp})$ and

$A_{garden\ pea} = Y_{ig} / (Y_{sg} \times Z_{gp}) - Y_{im} / (Y_{sm} \times Z_{mp})$

where, Y_{im} & Y_{ig} are the yield of intercrops, Y_{sm} & Y_{sg} are yield of sole crops and Z_{mp} and Z_{gp} are the proportion of maize and garden pea in the mixture, respectively.

Competitive Ratio (CR)

$CR_{maize} = LER_{maize} / LER_{gardenpea} \times Z_{gp} / Z_{mp}$ and

$CR_{gardenpea} = LER_{gardenpea} / LER_{maize} \times Z_{mp} / Z_{gp}$

Relative crowding coefficient (RCC):

$RCC = RCC_{maize} \times RCC_{garden\ pea}$

Calculations of intercropping efficiency parameters

Different intercrop efficiency functions *viz*., harvest index (%), land equivalent ratio (LER), relative yield (RY), crop performance ratio (CPR), area time equivalent ratio (ATER), system productivity index (SPI), replacement value of intercropping (RVI), monetary advantage index (MAI), actual yield loss (AYL) and intercrop advantage (IA), etc. were calculated with following formulae (Caballero *et al*., 1995; Dhima *et al*., 2007; Khan *et al*., 2018; Ofori and Stern, 1987; Prasad and Srivastava, 1991; Willey, 1979).

Harvest index (HI, %)

$$HI = (\text{Economic yield} / \text{Biological yield}) \times 100$$

Equivalent yield

Maize equivalent yield (MEY) = $Y_{im} + ((Y_{ig} \times P_g) / P_m)$ and

Garden pea equivalent yield (GEY) = $Y_{ig} + ((Y_{im} \times P_m) / P_g)$

where, Y_{im} = Yield of maize as intercrop, Y_{ig} = Yield of garden pea as intercrop, P_g = Price of garden pea, P_m = Price of maize.

Land equivalent ratio (LER)

$$LER = Y_{im} / Y_{sm} + Y_{ig} / Y_{sg}$$

where, Y_{sm} = Yield of maize as solecrop, Y_{sg} = Yield of garden pea as solecrop,

Crop performance ratio (CPR)

$$CPR = (Y_{im} + Y_{ig}) \times (Z_{mp} \times Y_{sm}) + (Z_{gp} \times Y_{sg})$$

Area time equivalent ratio (ATER)

$$ATER = [(Y_{im} / Y_{sm}) \times T_m + (Y_{ig} / Y_{sg}) \times T_g] \div T$$

where, T_m = Duration of maize, T_g = Duration of garden pea and T = Total duration of intercropping system.

System productivity index (SPI)

$$SPI = (Y_{sm} / Y_{sg}) \times Y_{ig} + Y_{im}$$

Replacement value of intercropping (RVI)

$$RVI = (Y_{im} \times P_m + Y_{ig} \times P_g) / (Y_{sm} \times P_m - C_{sm})$$

where, Y_{sm} and C_{sm} are respectively the yield and input cost of the main crop in sole stand.

Monetary advantage index (MAI)

MAI = Monetary value of combined intercrops yield /LER × (LER - 1)

Actual yield loss (AYL)

$$AYL = AYL_m + AYL_g$$

$AYL_m = \{(Y_{im} / Z_{im}) \div (Y_{sm} / Z_{sm})\} - 1$ and

$AYL_g = \{(Y_{ig} / Z_{ig}) \div (Y_{sg} / Z_{sg})\} - 1$

where, Z_{im} & Z_{ig} are the proportion of intercrop maize and garden pea, respectively and Z_{sm} & Z_{sg} are the proportion of sole maize and garden pea, respectively.

Intercropping advantage (IA)

IA = AYL x Price of maize or garden pea

The unit price of maize and garden pea was 15 and 40 taka per kg, respectively, where 1 USD = 82 Taka.

Data analysis

Data on yield and yield components were collected and analyzed statistically using analysis of variance technique with the help of R software environment with required packages (R Core Team, 2018) and mean comparison among the treatments were done by least significant difference (LSD) test at 5% level of significance (Gomez and Gomez, 1984). At first analysis of variance were performed for each year separately and subsequently homogeneity of error variance test was done by Bartlett's Chi-square test. It appeared that there was no significant variation among the years for yield and yield component characters. So, data were pooled and analysis was done accordingly. Finally, benefit cost ratio was calculated based on prevailing local market price.

RESULTS AND DISCUSSION

Growth and yield component of maize in intercrop with garden pea varieties

Growth and yield components of maize varied significantly among the treatments (Table 2). Maximum plant height (267.67 cm), number of cobs per plant (1.86), cob length (25.38 cm), number of grains per cob (670.11) and thousand kernel weight (348.12 g) was recorded from sole maize (T_4). Among the intercrop treatments maize growth and yield component parameters were found highest from maize + BARI Motorshuti-3 (T_2) followed by maize with BARI Motorshuti-2 (T_1) and maize + BARI Motorshuti-1 (local) (T_3), respectively. It appears that garden pea variety BARI Motorshuti-3 facilitated the growth and yield components of maize than other varieties, which may be attributed to complementary effect of BARI Motorshuti-3 variety with maize. It was observed that BARI Motorshuti-3 covered the land surface uniformly, which impeded weed growth, conserved moisture and may have had more biological nitrogen fixation. On the other hand, variety BARI Motorshuti-1 and local cultivar were less dense in between the rows, where weed growth was more prominent and thereby competition of maize with weeds was higher. These results are in partial contradiction with (Khan *et al*., 2018), who reported maize growth and yield components were higher in intercrop situation rather than sole cropping, since there may be complementary effect between two crops. They also reported complementary effect of maize with garden pea by citing the work from Zhang and Li (1987) and Rana *et al*. (2001). However, Uddin *et al*. (2009) and Rahman *et al*. (2015) reported that maize growth and yield components were higher in sole cropping than intercropping with short duration vegetables viz. red amaranth, radish, spinach and potato.

Kernel yield of maize

Highest maize kernel yield and harvest index was recorded from sole maize than intercrop treatments (Table 2). In sole maize, kernel yield was 8.78 t ha^{-1} followed by maize intercrop with BARI Motorshuti-3

Table 2. *Growth, yield and yield contributing characters of BARI Hybrid Maize-9 as influenced by intercropping with different garden pea varieties at Khulna, Bangladesh during 2014-15, 2015-16 and 2016-17 (pooled data)*

Treatments	Plant height (cm)	No. of cobs plant^{-1}	Cob length (cm)	No. of grains cob^{-1}	1000- kernel wt. (g)	Maize yield (t ha^{-1})	Harvest index (%)
T_1	239.08c	1.48c	22.88c	641.36c	292.57c	7.68c	40.84c
T_2	245.83b	1.58b	24.10b	651.64b	309.80b	8.02b	41.78b
T_3	232.53d	1.33d	22.17d	625.38d	283.51d	7.16d	39.66d
T_4	267.67a	1.86a	25.38a	670.11a	348.12a	8.78a	42.65a
CV (%)	0.88	2.93	0.92	0.71	1.97	1.88	0.58
$LSD_{0.05}$	2.15	0.05	0.21	4.54	6.02	0.15	0.24

T_1 = Maize + BARI Motorshuti-2, T_2 = Maize + BARI Motorshuti-3, T_3 = Maize + Local garden pea (BARI Motorshuti-1), T_4 = Sole maize

(T_2) (8.02 t ha^{-1}) and maize with BARI Motorshuti-1 (7.68 t ha^{-1}). Whereas, the lowest maize yield (7.16 t ha^{-1}) was recorded from maize with local garden pea variety. Maximum yield advantage in sole maize was about 18.45% higher than intercropped with local garden pea variety, followed by maize with BARI Motorshuti-1 (12.53%) and lowest of 8.66% yield increase was recorded from maize with BARI Motorshuti-3 (T_2) (Fig. 2a). Harvest index was also found highest in sole maize (42.65%), which significantly differed with other treatments, followed by 41.78% with T_2 treatment (maize with BARI Motorshuti-3). Maize yield was higher in sole maize, which may be due to less competition at vegetative stage of maize for water, nutrients and light. Ransom (2013) reported that juvenile stage of maize is the most critical vegetative stage since at this stage nitrogen uptake begins to increase, so competition is likely in intercrop treatments. On the other, there are some supplementary effects of garden pea with maize in terms of nitrogen fixation, moisture conservation, weed suppression, etc. (Li *et al*., 1999).

Growth and yield component of garden pea in intercrop with maize

Growth, yield and yield components of garden pea varieties were significantly influenced by maize + garden pea intercropping systems (Table 3). All the garden pea varieties grown with maize were significantly shorter in height and had less thousand grain weight than sole garden pea crop. Plant height in sole garden pea was (49.57 cm) followed by intercrop treatments T_2 (42.93 cm), T_1 (41.56 cm) and T_3 (42.07 cm), respectively. However, there was no significant variation among intercropped garden pea in terms of plant height. There was no significant variation observed in number of pods per plant and number of seeds per pod among the treatments, but thousand seed weight significantly varied among the treatments. Sole garden pea had maximum thousand grain weight (306.55 g), followed by T_2 (291.18 g), T_3 (288.08 g) and T_1 (287.54 g), respectively. Pod yield of garden pea was found highest in sole crop (T_5) (7.63 t ha^{-1}), while significantly lower pod yield was obtained from intercrop treatments T_2 (6.33 t ha^{-1}), T_1 (5.89 t ha^{-1}) and T_3 (5.88 t ha^{-1}), respectively. However, there was no significant variation for pod yield among the intercrop treatments. Pod yield of garden pea decreased by 17.04%, 22.80% and 22.94% in T_2, T_1 and T_3 treatments, respectively (Fig. 2b). Harvest index of garden pea followed similar pattern as in pod yield. Highest harvest index was recorded from sole garden pea crop (27.10%) and followed by significantly decreasing order in T_2>T_1>T_3, respectively, though there were no significant difference observed among intercropped garden pea.

Lower garden pea yield in intercropped treatments was due to reduction in plant population and reduced solar radiation (Khan *et al*., 2018). They also reported reduced sunlight affected photosynthetic rate and thereby translocation of photosynthates from source to sink. Similar results were also reported by Patra *et al*. (2000) who found lower number of pods per plant, seeds per pod and decrease in yield of soybean, green gram, groundnut and black gram when intercropped with maize.

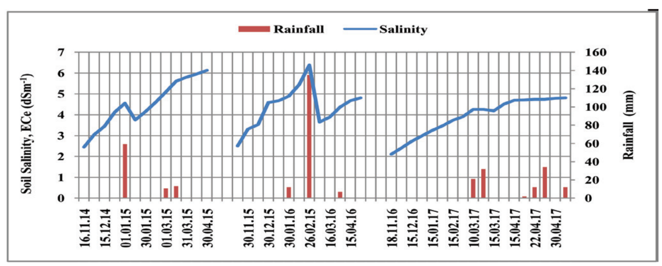

Fig. 1. *Soil salinity levels (EC_e)(saturated extract) and rainfall pattern during growing period of maize-garden pea intercropping*

Table 3. *Growth, yield attributes, pod yield and harvest index of garden pea as influenced by Inter cropping with maize at Khulna, Bangladesh during 2014-15, 2015-16 and 2016-17 (pooled data)*

Treatments	Plant height (cm)	No. of pods plant^{-1}	No. of seeds pod^{-1}	1000-seed wt. (g)	Garden pea pod yield (t ha^{-1})	Harvest index (%)
T_1	41.56b	12.30	3.51	287.54b	5.89b	24.59b
T_2	42.93b	11.87	3.47	291.18b	6.33b	24.69b
T_3	42.07b	11.77	3.34	288.08b	5.88b	24.32b
T_5	49.57a	13.17	3.50	306.55a	7.63a	27.10a

T_1 = Maize + BARI Motorshuti-2, T_2 = Maize + BARI Motorshuti-3, T_3 = Maize + local garden pea (BARI Motorshuti-1), T_5 = Sole garden pea (BARI Motorshuti-1)

Maize and garden pea equivalent yield

Maize and garden pea equivalent yield were recorded higher in all intercropping treatment than their corresponding sole crops yield (Table 4). The highest maize equivalent yield (24.90 t ha^{-1} yr^{-1}) as well as garden pea equivalent yield (9.34 t ha^{-1} yr^{-1}) were recorded from maize + BARI Garden pea-3 (T_2), which accounted yield advantages of about 183.60% and 22.41% over their respective sole crops. Such yield advantage might be due to combined yield of both the crops (Khan *et al*., 2018). Similarly, Chalka and Nepalia (2005) also reported significant increase in maize equivalent yield when intercropped with different legume crops.

Cost and return analysis

An increase in gross return and gross margin was found due to intercropping of garden pea with maize as compared with sole crop. Highest gross margin (Tk. 238,000 ha^{-1}) was recorded from maize + BARI Motorshuti-3 (T_2), which gave an additional income of Tk. 185,580 ha^{-1} over sole maize and Tk. 63,550 ha^{-1} over sole garden pea (Table 4). Total cultivation cost was lower in sole crop and higher in intercropping treatments might be due to inclusion of component crop. Intercropping of garden pea brought about an increase in return per taka investment. It was evident that intercropping was always beneficial and recorded higher benefit cost ratio (BCR) with respect to monoculture of maize and garden pea. Among the intercropping systems, maize with BARI Motorshuti-3 (T_2) recorded the highest benefit cost ratio of 2.76 which further indicated the superiority of intercropping BARI Motorshuti-3 with maize than other garden pea varieties. These results are in agreement with the findings of Bharati *et al*. (2007) who reported that maize based intercropping gave higher net return than sole crop of maize. Similarly, maize + legume intercropping was more productive and remunerative as compared to sole cropping as observed by Kamanga *et al*. (2010), which was in close agreement with the present findings.

Competition functions

Aggressivity (A)

The competitive ability of the component crops in an intercropping system is determined by its aggressivity index. Results showed that maize was dominated species in all intercrop treatments, whereas garden pea was dominant species in intercrop combinations (Table 5). However, smaller aggressivity values of both maize and garden pea in all intercrop treatments indicate that

Table 4. *Equivalent yield and cost benefit analysis of maize + garden pea intercropping systems at Khulna, Bangladesh (average of 2014-15, 2015-16 and 2016-17)*

Treatments	Equivalent yield (t ha^{-1} yr^{-1})		Gross return (Tk. ha^{-1})	Total variable cost (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})	BCR
	Maize	Garden pea				
T_1	23.39	8.77	350800	135500	215300	2.59
T_2	24.90	9.34	373500	135500	238000	2.76
T_3	22.84	8.57	342600	135500	207100	2.53
T_4	8.78	-	131700	79280	52420	1.66
T_5	-	7.63	305200	130750	174450	2.33

T_1= Maize + BARI Motorshuti-2, T_2 = Maize + BARI Motorshuti-3, T_3 = Maize + local garden pea (BARI Motorshuti-1), T_4 = Sole maize and T_5 = Sole garden pea (BARI Motorshuti-1)

Table 5. *Aggressivity index (A), competitive ratio (CR) and relative crowding coefficient (RCC) of maize and garden pea in maize + garden pea intercropping systems at Khulna, Bangladesh (average of 2014-15, 2015-16 and 2016-17)*

Treatments	Aggressivity index (A)		Competitive ratio (CR)			Relative Crowding Coefficient (RCC)		
	Maize	Garden pea	Maize	Garden pea	Difference	Maize	Garden pea	Product
T_1	-0.15	0.15	0.85	1.18	0.33	5.24	4.51	23.63
T_2	-0.19	0.19	0.83	1.21	0.39	7.91	6.49	51.33
T_3	-0.10	0.21	0.79	1.26	0.47	3.31	4.48	14.83

T_1 = Maize + BARI Motorshuti-2, T_2 = Maize + BARI Motorshuti-3, T_3 = Maize + local garden pea (BARI Motorshuti-1) lower difference in actual expected yield. Net aggressivity of both T_1 (maize + BARI Motorshuti-2) and T_2 (maize + BARI Motorshuti-3) treatments were zero except T_3 (maize + BARI Motorshuti-1) (+10), which indicates maize yield was compensated by garden pea. The domination of maize crop under intercrop situation can be justified by the fact that the initial growth of maize is suppressed by garden pea varieties up to 6-8 weeks, since during that period maize competes with garden pea crop but after garden pea harvest residual effect of biological nitrogen fixation and litter decomposition may have positive effect on subsequent maize growth. It is reported that generally non-legume crop is considered a suppressing crop in annual legume/non-legume intercrop system (Haynes, 1980; Wahla *et al*., 2009), for example, soybean/ wheat (Li *et al*., 2001), peanut/maize (Inal *et al*., 2007) and faba bean/barley (Strydhorst *et al*., 2008).

Competitive ratio (CR)

The competitive ratio values showed variation among the intercropping treatments indicating differential competitive ability of component crop as influenced by intercrops of garden pea (Table 5). Garden pea showed higher CR value (range: 1.18-1.21) than maize (range: 0.79-0.85) indicating garden pea as the best competitor than maize. Highest CR value was recorded in T_3 treatment (1.26 for garden pea) indicating that local garden pea is higher competitor than BARI released garden pea varieties. The difference of competitive ratio between maize and garden pea was lowest in maize with BARI Motorshuti-2 (0.33) (T_1), followed by moderate competitive ratio which was observed in maize with BARI Motorshuti-3 (0.39) (T_2). The results expressed that similar competitiveness with minimum CR between component crops provided complementary utilization of growth resources for better performance of intercropping with higher productivity, which is also reported by Islam *et al*., (2016).

Relative crowding coefficient (RCC)

Relative crowding coefficient (RCC) of maize and garden pea was far more than unity indicating greater non-competitive interference than the competitive one i.e. there were yield advantages gained in intercropping treatments, where T_2 treatment being the highest (51.33). The intercropped maize had higher relative crowding coefficient values *i.e.* more aggressive than the intercropped garden pea in all treatments (Table 5).

Crop performance ratio (CPR)

Partial CPR values of intercropping treatments indicate that garden pea varieties were better performer in intercrop situation than maize i.e. partial CPR values of garden pea varieties in all treatments were more than 1 (Table 6). Highest (2.02) crop performance ratio was found from T_2 treatment (maize + BARI Motorshuti-3), indicating T_2 can give higher yield than other treatments (Table 6).

Intercropping efficiency parameters

Land equivalent ratio (LER)

The values of land equivalent ratio (LER) in different intercropping treatments were found greater than unity indicating higher land use efficiency of intercropping treatments over the respective sole crop (Table 6). Yield advantages occurred in intercropping was mainly due to the development of both temporal and spatial complementarities (Khan *et al*., 2018).

Table 6. *Land equivalent ratio (LER), Crop performance ratio (CPR) of maize and garden pea in maize + garden pea intercropping systems at Khulna, Bangladesh (average of 2014-15, 2015-16 and 2016-17)*

Treatments	LER values			Crop performance ratio (CPR)		
	Maize	Garden pea	Total	Maize	Garden pea	Total
T_1	0.87	0.77	1.65	0.87	1.03	1.90
T_2	0.91	0.83	1.74	0.91	1.11	2.02
T_3	0.82	0.77	1.59	0.82	1.03	1.84
T_4	1.00	0.00	-	-	-	-
T_5	0.00	1.00	-	-	-	-

T_1 = Maize +BARI Motorshuti-2, T_2 = Maize + BARI Motorshuti-3, T_3 = Maize + local garden pea (BARI Motorshuti-1), T_4 = Sole maize and T_5 = Sole garden pea (BARI Motorshuti-1)

However, the total LER value was highest in maize + BARI Motorshuti-3 (1.74) (T_2), where maize and garden pea achieved 91% and 83% of their sole yields, respectively indicating higher biological and economic efficiency. It also expressed that by intercropping maize with BARI Motorshuti-3 variety, a farmer can produce 8.02 tons maize and 5.89 tons garden pea in one hectare of land instead of growing them separately as sole crop. Nurbakhsh *et al*. (2013) and Khan *et al*. (2018) also found similar results in intercropping of sesame and bean.

Area time equivalent ratio (ATER)

The area time equivalent ratio (ATER) evaluates duration of intercrops in field and their yield per day basis. Maize + BARI Motorshuti-3 (T_2) gave highest ATER value (1.25) which was about 6.4% and 5.6% % higher than that of ATER values obtained from T_1 (1.18) and T_3 (1.17), respectively which indicated higher yield per day in maize + BARI Motorshuti-3 (T_2) (Table 7). This was achieved due to the development of temporal as well as spatial complementary effect (Mohan *et al*., 2005).

System productivity index (SPI)

The system productivity index (SPI) helps to standardize the yield of the secondary crop (garden pea) in terms of the primary crop (maize) and also identify the combinations that utilized the growth resources most effectively and maintained a stable yield performance (Tajudeen, 2010). The results showed that maize + BARI Motorshuti-3 (T_2) intercropping system gave the highest SPI value (14.42) than other intercropping systems (Table 7). The values of SPI were higher and largely determined by maize intercrop yields as well as higher yield of BARI Motorshuti-3 variety than other intercrop garden pea variety.

Replacement value of intercropping (RVI)

The range of RVI values were between 2.51 to 7.13. The lowest RVI value was observed from sole maize (T_4) (2.51). Whereas, highest RVI value (7.13) was observed in maize + BARI Motorshuti-3 (T_2) intercropping system (Table 7), which implies that intercropping of Maize + BARI Motorshuti-3 was more profitable than sole crop of maize and other intercropping treatments. It was found that intercropping of BARI Motorshuti-3 variety with maize was about 184% more profitable than sole maize crop.

Monetary advantage index (MAI)

The monetary advantage index (MAI) values were positive in all intercropping treatments (Table 7). The highest MAI (Tk. 101458 ha^{-1}) was obtained in maize + BARI Motorshuti-3 (T_2) intercropping system, which indicates that intercropping of maize with BARI Motorshuti-3 garden pea variety was highly profitable and advantageous, which is due to higher LER value. The results are in agreement with the finding of Islam *et al*., (2016) who reported that higher MAI values found in turmeric-sesame intercropping systems compared to sole cropping system.

Table 7. *Area time equivalent ratio (ATER), System productivity index (SPI), Replacement value of intercropping (RVI) and Monetary advantage index (MAI) of maize and garden pea in maize + garden pea intercropping systems at Khulna, Bangladesh (average of 2014-15, 2015-16 and 2016-17)*

Treatments	ATER	SPI	RVI	MAI (Tk. ha^{-1})
T_1	1.18	12.82	6.69	84551
T_2	1.25	14.42	7.13	101458
T_3	1.17	13.08	6.54	76531

T_1 = Maize + BARI Motorshuti-2, T_2 = Maize + BARI Motorshuti-3, T_3 = Maize + local garden pea (BARI Motorshuti-1)

Table 8. *Actual yield loss and intercrop advantage of maize and garden pea in maize + garden pea intercropping systems at Khulna, Bangladesh (average of 2014-15, 2015-16 and 2016-17)*

Treatments	Actual yield loss			Intercrop advantage		
	Maize	Garden pea	Total	Maize	Garden pea	Total
T_1	-0.125	0.029	-0.096	-1.88	1.17	-0.71
T_2	-0.087	0.106	0.020	-1.30	4.25	2.95
T_3	-0.185	0.028	-0.157	-2.77	1.10	-1.67

T_1 = Maize + BARI Motorshuti-2, T_2 = Maize + BARI Motorshuti-3, T_3 = Maize + local garden pea (BARI Motorshuti-1)

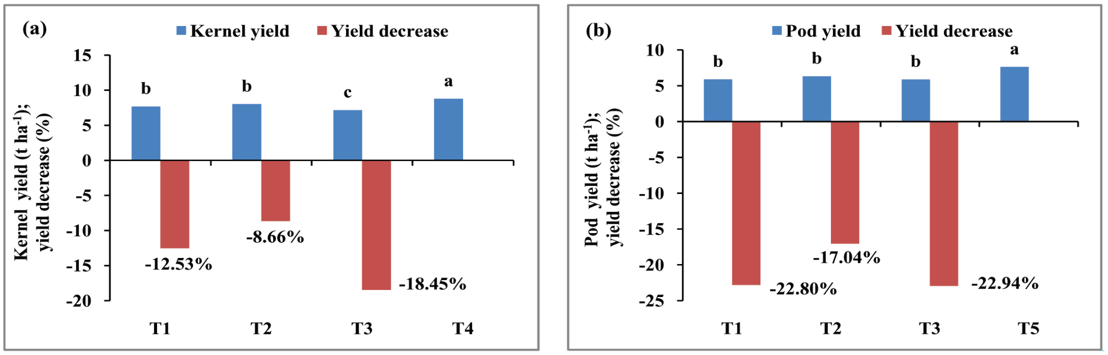

Fig. 2. *(a) Sole and intercropped maize kernel yield and corresponding yield decrease in comparison to sole crop, (b) Sole and intercropped garden pea pod yield and corresponding yield decrease in comparison to sole crop*

Actual yield loss (AYL) and intercropping advantage (IA)

Actual yield loss of maize had negative values in maize + garden pea intercropping when the maize was cultivated with garden pea. However, actual yield loss of maize was lowest (-0.087) in T_2 treatment. On the other hand, in intercrop situation, garden pea yield did not reduce though there was 75% of population in the intercrop mixture. Overall, actual yield loss was positive in T_2 treatment (0.02) *i.e.* total yield of maize and BARI Motorshuti-3 variety did not reduce over their individual sole cropping. T_2 treatment also showed intercrop advantage (2.95) than T_1 (-0.71) and T_3 (-1.67), which is due to higher yield potential of BARI Motorshuti-3 than other varieties (Table 7).

At the end of three consecutive years of experimentation on intercropping of different garden pea varieties in between maize variety at 1:2 ratio, it can be concluded that the productivity of unit land area was increased by intercropping rather than monocultures. Maize intercropped with garden pea produced higher maize equivalent yield than maize sole crop. The competitive functions also showed that intercropping had a major advantage over sole cropping. However, short duration and high yielding garden pea variety can produce significant economic benefit in intercrop. In the present study BARI Motorshuti-3 helped in producing highest maize equivalent yield and maximum economic return with positive competition effect in intercropping with maize (T_2) than comparatively other low yielding garden pea varieties.

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