ISSN 0258-7122 (Print), 2408-8293 (Online)
Bangladesh J. Agril. Res. 48(2): 195-208, June 2023

PRODUCTIVITY AND PROFITABILITY OF INTERCROPPING GARLIC WITH GROUNDNUT IN THE CHAR LAND OF TANGAIL

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Abstract

The experiment was carried out at the farmers' field of On-Farm Research Division, Bangladesh Agricultural Research Institute (BARI), Tangail during two consecutive years 2019-20 and 2020-21 to find out the suitable intercropping system for increasing crop productivity and profitability of groundnut + garlic intercropping system. The treatments were viz. T_1=groundnut (100%) + one row garlic (33%) in between two rows of groundnut, T_2=groundnut (100%) + two rows of garlic (67%) in between two rows of groundnut, T_3= groundnut (100%) + three rows of garlic (100%) in between two rows of groundnut, T_4= Sole groundnut (100%) and T_5= Sole garlic (100%). Groundnut var. BARI Chinabadam-9 and garlic var. BARI Rashun-2 were used in this trial. The experiment was laid out in a randomized complete block design with six dispersed replications. Among three intercropped treatments, groundnut (100%) + two rows of garlic (67%) within two rows of groundnut showed higher groundnut equivalent yield (5.40 t ha^{-1}) and garlic equivalent yield (6.48 t ha^{-1}) which provided the yield advantages of 106 and 26 % over the respective sole crops. The highest land equivalent ratio (1.43), gross return (Tk 3,23,800 ha^{-1}) and benefit cost ratio (2.93) were achieved in groundnut (100%) + two rows of garlic (67%) within two rows of groundnut compared to other intercropping and sole cropping systems. The higher values of all competition functions were also exhibited in groundnut (100 %) + two rows of garlic (67 %) in between two rows of groundnut (T_2). Thus, it is stated that two rows of garlic in between two rows of groundnut could be the most productive and profitable combination for the farmers of Tangail regions.

Keywords: Intercropping systems, economic, equivalent yield, groundnut and garlic**.**

Introduction

Bangladesh is an agriculture-based country and about 11.52 % gross domestic product (GDP) comes from agriculture in Bangladesh (AIS, 2023). The main challenge of the new millennium is to increase yield of per unit area by at least 50 % through manipulating the limited land resource.

Groundnut (*Arachis hypogaea* L.) is the third most important legume crop in Bangladesh which grown on 34,956 ha of land and produces 66,745 metric tons of nut with an average yield of 1.91 t ha^{-1} (BBS, 2021). It is used as edible oil, make cake, biscuit and bakery in the food industries. Recently the area of groundnut is being decreased due to the competition with *rabi* crops like wheat, potato, *boro rice* and mustard (Alom *et. al*., 2009). Moreover, most of the char land of

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Bangladesh become inundated in *kharif* season which also one of the causes the decline of groundnut production area.

On the other hand, garlic (*Allium sativum* L.) is one of the important spices crops in Bangladesh. In Bangladesh, it ranks third next to onion and chilli. It is grown all over the country in the *rabi* season and consumed by most of the people in Bangladesh. It is cultivated in 72,889 ha land and produces 5,01,612 metric ton with an average yield of 6.08 t ha^{-1} (BBS 2021). Now a days, intercropping plays an important role in increasing the productivity and stability of yield in order to improve resource utilization and environmental factors (Alizadeh *et al*., 2010). Consequently, it is a time demanding technology for cultivation of crops. So, intercropping of garlic with groundnut will help to retain spices crops and ensure highest productivity per unit area as well as supply of oil in our food menu. Groundnut var. BARI Chinabadam-9 is short in stature and it does not occupy more space in the field. Groundnut and garlic are row seeded crops while they are grown in the same season. The growth of groundnut is very slow in the winter season. So, during this time for utilization the space between two rows of groundnut, garlic can be cultivated as intercrop. Groundnut and garlic in intercropping systems may increase their production and fulfill the demand of groundnut and garlic. With this view, the present study was undertaken to find out the suitable intercrop combination of garlic with groundnut for higher productivity and profitability.

Materials and Methods

The study was carried out at the farmers' field under the supervision of On-Farm Research Division, Bangladesh Agricultural Research Institute (BARI), Tangail during two consecutive years 2019-20 and 2020-21 to find out the suitable intercropping system for increasing crop productivity and profitability of groundnut and garlic intercropping system. The experimental site belongs to Active Brahmaputra-Jamuna Floodplain Agro-ecological Zone (AEZ-7) of Tangail. The land was medium high and the soil of the study area was sandy loam in texture with well drainage system with acidic to slightly alkaline in reaction having pH range of 4.6 to 7.9. Organic matter content is low to medium. General fertility level including N, P, K, S, Zn and B was low to medium. Maximum rainfall was received during the months of April to September. The crop received (140.5 mm) rain from October to March. Monthly mean maximum and minimum air temperature (31.9 and 19.3^{o}C), total rainfall (2018 mm) and relative humidity (82.7 %) were prevailing during the study period.

The treatments were viz. T_1 = groundnut (100%) + one row garlic (33%) in between two rows of groundnut, T_2 = groundnut (100%) + two rows of garlic (67%) in between two rows of groundnut, T_3 = groundnut (100%) + three rows of garlic (100%) in between two rows of groundnut, T_4 = Sole groundnut (100%) and T_5 = Sole garlic (100%). Groundnut var. BARI Chinabadam-9 and garlic var.

BARI Rashun-2 were used in this trial. The experiment was laid out in a randomized complete block design with six dispersed replications. The unit plot size was 8.0 m × 5.0 m. Groundnut was the main crop and garlic as the intercrop in the study. Garlic was intercropped in between two rows groundnut @ 33, 67 and 100% population. The groundnut and garlic were planted on 14 November, 2019 and 17 November 2020 in line with seed rate of 100 kg ha^{-1} and 400 kg ha^{-1}, respectively. The plant spacing was 40 cm × 15 cm for groundnut and 10 cm × 10 cm for garlic. The sole crop of groundnut and intercrops were fertilized @ 47-38-25-14-1.0 kg ha^{-1} of NPKSB with 5 t ha^{-1} cowdung where half of nitrogen and other fertilizers were used as basal. Remaining N was top dressed at flowering stage and covered with soil for proper establishment of crop. Other intercultural operation such as weeding, fertilizer application, earthing up and crop protection measure were done properly. The garlic was harvested on 23 March, 2020 and 25 March, 2021 and groundnut harvested on 03 May, 2020 and 10 May, 2021 at physiological maturity. The crops were threshed and dried properly to take the clove and nut yield, respectively. The yield contributing characters of garlic and groundnut were recorded from 10 randomly selected plants in both the years. The following parameters were recorded for intercrop aspects:

Harvest index (HI) was calculated as per following equation (Rahman *et al*., 1989).

$$\text{HI (\%)} = \frac{\text{Grain yield}}{\text{Biological yield}} \times 100$$

Yield of individual crop was converted into equivalent yield on the basis of the prevailing market price of individual crop (Prasad and Srivastava, 1991).

$$\text{Groundnut equivalent yield (GEY)} = \text{Yield of intercrop groundnut} + \frac{\text{Yiga} \times \text{Pga}}{\text{Pg}}$$

and

$$\text{Garlic equivalent yield (GaEY)} = \text{Yield of intercrop garlic} + \frac{\text{Yig} \times \text{Pg}}{\text{Pga}}$$

Where, Yiga= Yield of intercrop garlic, Pga= Price of garlic, Pg= Price of groundnut and Yig= Yield of intercrop groundnut

In intercropping systems, relative yield was quantified by (Jokinen, 1991).

Relative Yield of Groundnut (RYg) = $\frac{\text{Yig}}{\text{Ysg}}$, Relative Yield of Garlic (RYga) = $\frac{\text{Yiga}}{\text{Ysga}}$ and Relative yield total (RYT) = RYg + RYga

Where Yig= Yield of intercrop groundnut, Ysg= Sole yield of groundnut, Yiga= Yield of intercrop garlic and Ysga= Sole yield of garlic.

Various competitive function like land equivalent ratio (LER), area time equivalent ratio (ATER), system productivity index (SPI), replacement value of intercropping (RVI), monetary advantage index (MAI), aggressivity index (A), competitive ratio (CR) and relative crowding coefficient (RCC) were worked out by using standard procedures to find out the benefit of intercropping and the effect of competition between the treatments. The competition functions were calculated by using the following formula:

(a) LER values were calculated by adding the partial LER for each crop and it was calculated by the following formula (Mead and Willey, 1980)

$$LER=\frac{Yig}{Ysg}+\frac{Yiga}{Ysga}$$

Where, Yig=Yield of intercrop groundnut, Ysg=Yield of sole groundnut, Y_{iga}=Yield of intercrop garlic and Y_{sga}=Yield of sole garlic

(b) Adetiloye *et. al*. (1983) uses the concept of land equivalent coefficient (LEC) defined as the product of land equivalent ratio in the intercrop. It was developed to assess the interaction and productive potential in crop mixtures.

(c) $$LEC=\frac{Yig}{Ysg}+\frac{Yiga}{Ysga}$$

where, Ysg= Sole yield of groundnut, Ysga= Sole yield of garlic, Yig= Intercrop yield of groundnut and Yiga= Intercrop yield of garlic

(d) The area time equivalent ratio (ATER) was calculated by the formula proposed by Hiebsch (1978) as follows:

$$ATER=\left[\frac{Yig}{Ysg}\times Tg+\frac{Yiga}{Ysga}\times Tga\right]\div T$$, Where Y_{ig}= Yield of groundnut in intercropping, Y_{sg}=yield of groundnut in sole cropping, Y_{iga}= yield of garlic in intercropping, Y_{sga}= yield of garlic in sole cropping, T_g= Duration of groundnut, T_{ga}= Duration of garlic and T= Total duration of intercropping system.

(e) The replacement value of intercropping (RVI) was calculated according to Moseley (1994) as follows: $RVI=\frac{Yig\times Pg+Yiga\times Pga}{Ysg\times Pg-Csg}$ Where Y_{ig} & Y_{iga} are the yield of groundnut and garlic intercrops, P_g & P_{ga} are the respective market price of these crops, Y_{sg} & C_{sg} are the yield and input cost of the groundnut in sole stand.

(f) The monetary advantage index (MAI) which gives an indication of the economic advantage of the intercropping system was calculated according to Ghosh (2004) as follows:

$$MAI=\frac{\text{Monetary value of combined intercrops yield}\times(LER-1)}{LER}$$

(g) Relative crowing coefficient (K), which is a measure of the relative dominance of one species over the other in a mixture (Willey and Rao, 1980) was calculated as follows:

$K_{groundnut}$ ×, $K_{garlic,}$ where $K_{groundnut} = \frac{Yig \times Zgap}{(Ysg\text{-}Yig) \times Zgp}$, and

$K_{garlic} = \frac{Yiga \times Zgp}{(Ysga\text{-}Yiga) \times Zmp}$ where Z_{gp} and Z_{gap} were the proportion of groundnut and garlic in the mixture, respectively.

(h) Aggressivity (A) index is a measure of competitive relationships between two crops in inter cropping system. This was expressed according to Dhima *et al*. (2007) as follows:

$A_{groundnut} = \frac{Yig}{Ysg \times Zgp} - \frac{Yiga}{Ysga \times Zgap}$ and $A_{garlic} = \frac{Yiga}{Ysga \times Zgap} - \frac{Yig}{Ysg \times Zgp}$. Aggressivity value would be zero when the component species were equally competitive and in all the other cases value of one species would be positive (dominant) and the other would be negative (undominated).

(i) Competitive Ratio (CR): The competitive ratio for groundnut and garlic in mixture was calculated by the formula proposed by (Willey and Rao, 1980).

$CR_{groundnut} = \frac{LERgroundnut}{LER\ garlic} \times \frac{Zgap}{Zgp}$ and $CR_{garlic} = \frac{LERgarlic}{LER\ groundnut} \times \frac{Zgp}{Zgap}$

(j) The system productivity index (SPI) was calculated as described by Odo (1991)

SPI= $(\frac{Ysg}{Ysga} \times Yiga)$ +Yig, Where Ysg and Ysga= Mean yield of groundnut and garlic in sole cropping, Yig and Yiga= Mean yield of groundnut and garlic in intercropping.

Pooled analysis was done as because there was no significant difference yield and yield contributing characters between two years. The collected data on different parameters were statistically analyzed with the help of computer package MSTAT-C and mean comparison among the treatments was made by LSD test at 5% level of significance (Gomez and Gomez, 1984).

Economic analysis was done on the basis of prevailing market price of the commodities. The inputs used included seed, fertilizer, labour and insecticides. The two years average results were analyzed for economic benefits using the methodology prescribed by CIMMYT (1988).

$$\text{Benefit Cost Ratio (BCR)} = \frac{\text{Gross return}}{\text{Total cost}}$$

Results and Discussion

Yield and yield attributes of groundnut

The yield and yield contributing characters of groundnut was significantly different due to intercropping system (Table 1). The considerable variation was found in branches plant^{-1}, kernel plant^{-1} and nut yield per hectare while plant height, shelling percent and 100-kernel weight were found insignificant (Table 1). The highest nut yield was recorded in monoculture (T_4) compared to intercropping systems might be due to no intercrop competition for light, nutrients, moisture and space. These nut yield differences were mainly due to higher kernel number plant^{-1}, and numerically higher 100-kernel weight and shelling percent of groundnut. The nut yield of groundnut was reduced 18 to 42 % in intercropping system than sole crop of groundnut though the plant population of groundnut was constant regardless of treatment. The nut yield was reduced probably due to intercrop competition between groundnut and garlic. This result corroborates with the findings of Khan *et al*., (2017) who reported that less groundnut yield was obtained from intercropping system. In Groundnut (100%) + two rows of garlic (67%) in between two rows of groundnut had higher nut yield due to rows planting system fovoured the growth of intercropped groundnut and judicious use of growth resources compared to others. These results are in conformity with the findings of Islam *et al*., (2016). Higher harvest index (HI) of groundnut was observed in T_4 (Sole groundnut) with intercropping system. It was possibly owing to use of more assimilates to the reproductive organs and had higher values in $T_4 > T_2$ $T_1 > T_3$ (Table 1).

Table 1. Nut yield, yield attributes and harvest index of groundnut intercropping with garlic during 2019-20 and 2020-21 (Pooled)

Treatments	Plant height (cm)	Branch plant^{-1} (no.)	Kernel plant^{-1} (no.)	100 kernels wt. (g)	Shelling (%)	Nut yield (t ha^{-1})	% yield decreased over sole	Harvest index (%)
T_1	36.6	7.3	15.3	49.2	66.4	2.15	18	58
T_2	36.0	7.1	15.2	48.8	66.7	1.98	24	59
T_3	35.4	6.8	13.1	48.4	64.4	1.52	42	55
T_4	38.2	7.9	17.4	49.6	66.8	2.62	-	60
LSD ($_{0.05}$)	ns	1.01	2.14	ns	ns	0.32	-	-
CV (%)	6.77	5.84	6.90	5.32	8.33	7.62	-	-

Note: - T_1= Groundnut (100%) + One row of garlic (33%) in between two rows of groundnut, T_2= Groundnut (100%) + two rows of garlic (67%) in between two rows of groundnut, T_3= Groundnut (100%) + three rows of garlic (100%) in between two rows of groundnut and T_4=Sole groundnut

Yield and yield attributes of garlic

The bulb yields of garlic were significantly influenced by groundnut + garlic intercropping systems (Table 2). Higher bulb yield (5.14 t ha^{-1}) was recorded from T_5 (sole garlic) which was statistically identical to T_2 treatment. Lower bulb yield (2.24 t ha^{-1}) was obtained from T_3 which was at par to T_2. The lower bulb yield might be due to lower yield attributes. Higher bulb yield of garlic was observed in monoculture compared to intercropping systems might be due to no intercrop competition for light, nutrients, moisture and space. This result corroborates with the findings of Khan *et al*., (2017). Garlic gave 20 to 56 % lower bulb yield in intercropping treatments as compared to their corresponding monoculture. The bulb yield of garlic was reduced probably due to intercrop competition between garlic and groundnut. However, additional yield from garlic not only compensated the deficit but also gave extra income. This finding is in conformity with Islam *et al*., (2016). The harvest index (HI) of garlic differs by the intercropping systems; it had higher values in $T_5 > T_2 > T_1 > T_3$ (Table 2).

Table 2. Bulb yield, yield attributes and harvest index of garlic intercropping with groundnut in Tangail during 2019-20 and 2020-21 (Pooled)

Treatments	Plant height (cm)	leaf $plant^{-1}$ (no.)	Cloves $bulb^{-1}$ (no.)	Bulb wt. (g)	Yield of garlic (t ha^{-1})	% yield decreased over sole	Harvest index (%)
T_1	68.25	9.10	19.66	11.15	2.43	53	78
T_2	66.34	8.76	18.70	10.93	4.10	20	82
T_3	61.15	7.88	15.28	9.72	2.24	56	75
T_5	71.39	9.35	20.45	11.56	5.14	-	84
LSD ($_{0.05}$)	ns	ns	2.83	ns	1.97	-	-
CV (%)	11.5	6.73	7.32	7.44	6.42	-	-

Note: - T_1= Groundnut (100%) + One row of garlic (33%) in between two rows of groundnut, T_2= Groundnut (100%) + Two rows of garlic (67%) in between two rows of groundnut, T_3= Groundnut (100%) + Three rows of garlic (100%) in between two rows of groundnut and T_5=Sole garlic.

Equivalent yield and partial relative yield

All the intercropping systems gave much higher groundnut equivalent yield than that of sole crop. The treatment T_2 gave the highest groundnut equivalent yield among the combinations, similar trend was followed in same treatment for garlic equivalent yield over sole (Table 3). It's indicated that higher bulb yield and consequently more efficient use of land and available resources under intercropping than sole cropping. The highest groundnut equivalent yield (5.40 t ha^{-1}) as well as garlic equivalent yield (6.48 t ha^{-1}) were recorded from T_2 (Groundnut 100% + two rows of garlic (67%) in between two rows of groundnut

which covered the yield advantages of 24 and 20 % over their respective sole crops. Such yield advantage might be due to combined yield of both the crops. The results are in agreement with the finding of Islam et. *al.*, (2016). The partial relative yields of intercropped groundnut varied from 0.58 to 0.82 and intercropped garlic ranged from 0.44 to 0.80 (Table 3). Groundnut yield was reduced (18 to 42 %) among the intercropping system but garlic yield was drastically reduced (20 to 56 %). The yield was reduced due to lower plant population. The result showed that treatment T_2 well accommodative in competitiveness in groundnut + garlic intercropping system (Table 3).

Table 3. Equivalent yields and relative yields of groundnut intercropping with garlic during 2019-20 and 2020-21(average)

Treatment	Yield (tha^{-1})		Equivalent Yield ($t\ ha^{-1}$)		Partial relative yield ($t\ ha^{-1}$)	
	Groundnut	Garlic	Groundnut	Garlic	Groundnut	Garlic
T_1	2.15	2.43	4.18	5.01	0.82 (18)	0.47 (53)
T_2	1.98	4.10	5.40	6.48	0.76 (24)	0.80 (20)
T_3	1.52	2.24	3.39	4.06	0.58 (42)	0.44 (56)
T_4	2.62	-	2.62	-	1.00	-
T_5	-	5.14	-	5.14	-	1.00

Note: - T_1= Groundnut (100%) + One row of garlic (33%) in between two paired rows of groundnut, T_2= Groundnut (100%) + Two rows of garlic (67%) in between two rows of groundnut, T_3= Groundnut (100%) + Three rows of garlic (100%) in between two rows of groundnut, T_4=Sole groundnut and T_5=Sole garlic.

Economic return of intercropping garlic with groundnut

On the basis of two years average result, the highest gross margin (Tk. 213202 ha^{-1}) was obtained in groundnut (100%) + two rows of garlic (67 %) in between two rows of groundnut (T_2) which gave an additional income of Tk. 151502 and Tk. 54452 ha^{-1} over sole groundnut and garlic, respectively (Table 4). Total cultivation cost was lower in sole crop and higher in intercropping treatments might be due to inclusion of component crops. Intercropping of garlic brought about an increase in return per taka investment. It was evident that intercropping was beneficial and recorded higher benefit cost ratio (BCR) with respect to monoculture of groundnut and garlic. Among the intercropping systems groundnut (100%) + two rows of garlic (67 %) in between two rows of groundnut (T_2) was obtained the highest benefit cost ratio of 2.93 which further indicated the superiority to T_2 over other treatments. These results are in agreement with the findings of Islam *et al*. (2016). Only one treatment T_2 showed higher BCR but other treatments failed to showed higher profitability.

Table 4. Yield of component crops and economics of groundnut and garlic intercropping system during 2019-20 and 2020-21 (average of two years)

Treatment	Yield (tha^{-1})		Gross return ($Tk.\ ha^{-1}$)	Total cost ($Tk.\ ha^{-1}$)	Gross margin ($Tk.\ ha^{-1}$)	BCR
	Groundnut	Garlic				
T_1	2.15	2.43	250500	99490	151010	2.52
T_2	1.98	4.10	323800	110598	213202	2.93
T_3	1.52	2.24	203200	115580	87620	1. 76
T_4	2.62	-	157200	95500	61700	1.65
T_5	-	5.14	257000	98250	158750	2.62

Note: - T_1= Groundnut (100%) + One row of garlic (33%) in between two rows of groundnut, T_2= Groundnut (100%) + Two rows of garlic (67%) in between two rows of groundnut, T_3= Groundnut (100%) + Three rows of garlic (100%) in between two rows of groundnut, T_4=Sole groundnut and T_5=Sole garlic.

Price: - Groundnut=Tk. 60.00 kg^{-1} and Garlic= Tk. 50.00 kg^{-1}

Effect of intercropping on different competitive functions

Land equivalent ratio (LER)

The data on LER of different intercropping systems were found greater than unity indicating higher land use efficiency of intercropping systems over the respective monoculture. The range of yield advantage over sole cropping of groundnut or garlic was between 0.02 to 56%. However, the total LER value (1.56) was highest in groundnut (100%) + two rows of garlic (67%) in between two rows of groundnut (T_2) where groundnut and garlic achieved 76 and 80% of their sole yields, respectively indicating higher biological and economic efficiency over monoculture (Table 5). It also expressed that by intercropping garlic with groundnut, a farmer can produce 4.10 tons garlic and 1.98 tons groundnut in one hectare of land instead of growing those separately as sole crops.

Land Equivalent Coefficient (LEC)

Land equivalent coefficient (LEC) measure mixture productivity which also measures intercrop interaction proved to be a superior index for the evaluation of mixture performance. Increasing garlic plant density per unit area 33 to 100 % had the lowest LEC. LEC was found 0.61 (by growing 100 % Groundnut + 67% garlic intercropping system), 0.39 (by growing 100 % Groundnut + 33 % garlic intercropping system)) and 0.28 by growing 100 % Groundnut + 100% garlic intercropping system (Table 5). These results probably due to yielding ability of 100 % Groundnut + 67% garlic (T_2) was more constant through the coordination of the interaction for above and/or below ground competition than other intercropping treatments by increasing adverse effect of increasing garlic population. These results show that competitive pressure between 100 %

Groundnut + 67% garlic (T_2) was lower than other treatments when grown together in the same field indicating a substantial land use advantage of intercropping. These results are in the same context of those obtained by Metwally *et al.* (2018).

Area Time Equivalent Ratio (ATER)

The area time equivalent ratio (ATER) included the duration of the intercrops in intercropping systems in the field and also evaluated the crop yield per day basis. ATER values were found greater than unity in T_1 and T_2 treatments in intercropping systems (Table 5). Groundnut (100%) + garlic (67%) in between two lines of groundnut intercropping system (T_2) showed higher ATER value (1.44) which was about 17 and 45% higher than that of ATER values obtained from T_1 and T_3 which indicating higher yield per day (Table 5). So, the intercropping system was found to be advantageous in comparison to sole crop. This was achieved due to the development of temporal as well as spatial complementary.

Replacement Value of Intercropping (RVI)

Replacement value of intercropping (RVI) is one of the better measures of economic advantage of intercropping systems. Maximum value (5.25) of RVI was obtained in groundnut (100 %) + garlic (67 %) in between groundnut lines (T_2) intercropping system (Table 5). This implies that, farmers who practice intercropping of two rows of garlic in between groundnut lines (T_2) could make 425 % more profit than the farmers who are involved in groundnut or garlic monoculture.

System Productivity Index (SPI)

The system productivity index (SPI) which standardized the yield of the secondary crop (garlic) in terms of the primary crop (groundnut) and also identified the combinations that utilized the growth resources most effectively and maintained a stable yield performance (Tajudeen, 2010). SPI values ranged from 2.78 to 4.10. The results showed that groundnut 100% + garlic (67 %) in intercropping system (T_2) gave the higher SPI value (4.10) than other intercropping systems. Decreasing garlic plant density per unit area from 100 to 67 % of sole garlic planting had higher SPI than intercropping system groundnut (100%) + garlic (33%) or groundnut (100%) + garlic (100%). (Table 5). The results could be attributed to decrease in number of garlic plants from 6,66,667 to 4,46,667 per hectare had positive effect on groundnut productivity per unit area through reducing competitive pressure between the intercrops for basic growth resources.

Monetary Advantage Index (MAI)

The monetary advantage index (MAI) values were positive in all intercropping systems (Table 5). The highest MAI (Tk. 97.37 ha^{-1}) was obtained in groundnut

(100 %) + garlic (67%) in between groundnut lines (T_2), which implied that the planting pattern was highly economical and advantageous for the mixtures. 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 5. Land equivalent ratio (LER), land equivalent coefficient (LEC), area time equivalent ratio (ATER), replacement value of intercropping (RVI), system productivity index (SPI) and monetary advantage index (MAI) of groundnut and garlic intercropping system during 2019-20 and 2020-21(average)

Treatment	LER	LEC	ATER	RVI	SPI	MAI (Tk ha^{-1})
T_1	1.29	0.39	1.23	4.06	3.39	45.17
T_2	1.56	0.61	1.44	5.25	4.10	97.37
T_3	1.02	0.28	0.99	3.29	2.78	10.94
T_4	1.00	-	-	-	-	-
T_5	1.00	-	-	-	-	-

Note: - T_1= Groundnut (100%) + One row of garlic (33%) in between two rows of groundnut, T_2= Groundnut (100%) + Two rows of garlic (67%) in between two rows of groundnut, T_3= Groundnut (100%) + Three rows of garlic (100%) in between two rows of groundnut, T_4=Sole groundnut and T_5=Sole garlic.

Aggressivity (A)

The value of aggressivity determined the competitive ability of the component crops in an intercropping system. Regardless of the intercropping system, there was a positive sign for garlic and a negative sign for groundnut indicating that garlic was dominant while groundnut appeared as dominated crop (Table 6). Results showed positive aggressivity for garlic at groundnut (100%) + garlic (33%) and groundnut (100%) + garlic (67%) in between groundnut lines planting pattern while it proved less competitive and was dominated by garlic at groundnut (100 %) + garlic (100 %) in between groundnut lines intercropping system. Intercropping of 3 lines garlic (100 %) in between two groundnut lines showed minimum competitive ability between the component crops.

Table 6. Aggressivity index (A), relative crowding coefficient (K) and competitive ratio (CR) of groundnut and garlic intercropping system during 2019-20 and 2020-21(average)

Treatment	Aggressivity (A)		Relative Crowding Coefficient (K)		Total Relative Crowding Coefficient (K)	Competitive ratio (CR)		
	Groundnut	Garlic	Groundnut (Kg)	Garlic (Kga)		Groundnut	Garlic	Difference
T_1	-1.61	0.61	1.51	2.72	4.11	0.68	1.48	0.80
T_2	-0.44	0.44	4.11	5.89	12.19	0.76	1.31	0.55
T_3	0.10	-0.10	1.38	0.93	1.28	1.21	0.83	0.38
T_4	-	-	-	-	-	-	-	-
T_5	-	-	-	-	-	-	-	-

Note: - T_1= Groundnut (100%) + One row of garlic (33%) in between two rows of groundnut, T_2= Groundnut (100%) + Two rows of garlic (67%) in between two rows of groundnut, T_3= Groundnut (100%) + Three rows of garlic (100%) in between two rows of groundnut, T_4=Sole groundnut and T_5=Sole garlic.

Relative Crowding Coefficient (K)

Total Relative crowding coefficient (K) of groundnut and garlic was more than unity indicating greater non-competitive interference than the competitive one. The intercropped garlic had higher relative crowding coefficient values than the intercropped groundnut. Positive relative crowding coefficient values were obtained in all intercropping systems (Table 6). Intercropping of groundnut (100 %) + two rows of garlic (67%) in between two groundnut lines had the higher relative crowing coefficient (K) value (12.19) compared to other intercropping system.

Competitive Ratio (CR)

The competitive ratio values showed variation among the intercropping indicating differential competitive ability of component crops as influenced by intercrops of garlic at different populations (Table 6). Garlic showed higher values of CR (0.83-1.48) than groundnut (0.68-1.21) in all intercropping combinations indicating garlic as the best competitor than groundnut. Garlic exhibited better competitive ability in groundnut (100%) + two rows of garlic (67%) in between two groundnut lines (T_2) intercropping system probably garlic plant was highly responsive to intercrops of groundnut. Lower values of CR indicated similarities of competitiveness but higher value of difference in CR indicated dissimilarities of competitiveness between the crops grown in the mixture. Consequently, groundnut (100%) + one row garlic (33 %) in between two groundnut lines intercropping system with higher difference of CR (0.80) exhibited dissimilarities in competitiveness between the component crops (Table 6). However, groundnut

(100%) + three rows of garlic (100%) in between groundnut lines (T_3) intercropping system with lower difference of CR (0.38) showed merely similar competitiveness between the component crops. These results are in agreement with the findings of Islam et al. (2016).

Conclusion

From two years average result indicating that intercropping groundnut with garlic gave maximum productivity as well as economic return than monoculture of component crops. The equivalent yields, relative yields, land equivalent ratio (LER) values and economic return were also found highest in treatment T_2 (two rows of garlic in between two lines of groundnut) in groundnut + garlic intercropping system. Thus, it could be concluded that a planting pattern comprising two rows of garlic in between two lines of groundnut intercropping system, i.e., groundnut (100%) + two rows of of garlic (67%) in between two rows of groundnut could be adopted for better productivity and to get maximum profit. So, the farmers of Tangail regions could be suggested to cultivate groundnut with garlic as intercropped instead of sole crops.

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