PRODUCTION POTENTIAL OF DIFFERENT VARIETIES OF HYBRID MAIZE (Zea mays L.) WITH GROUNDNUT (Arachis hypogaea L.) UNDER INTERCROPPING SYSTEM

M.S. ALOM¹, N.K. PAUL² AND M.A. QUAYYUM³

Abstract

The experiment was carried out at the Regional Agricultural Research Station, Bangladesh Agricultural Research Institute (BARI), Jessore to evaluate the performance of different varieties of hybrid maize under intercropping systems with groundnut in Rabi seasons for higher productivity and profitability. Four sole crops of hybrid maize varieties viz., BHM-1, BHM-3, Pacific-11, and Pacific-984, one sole crop of groundnut (var. Jhingabadam) and eight intercropping systems of maize + groundnut under two planting methods viz., normal and paired row made 13 treatments, were used for two consecutive years (2004 and 2005). Treatments were arranged in a randomized complete block design with four replications. Among the intercropped treatments, four rows groundnut in between paired rows of hybrid maize var. Pacific 11 showed higher total dry matter (TDM), leaf area index (LAI), crop growth rate (CGR), gross return, net return and benefit cost ratio (BCR) than the other planting systems tested in the experiment.

Keywords : Production potential, hybrid maize, groundnut, intercropping system.

Introduction

In Bangladesh, the condition of maize has been gaining popularity in recent years. It is now becoming an important cereal crop for its high productivity and diversity. Maize area, production and demands are increasing rapidly. In 1992-93, the area, production, and yields were 2834 ha, 3000 metric tons and 1.06 t/ha, respectively (BBS, 2002). By 2004-2005, the area increased 24 times (66,802 ha), production 119 times (356000 tons), and yield more than 5 times (BBS, 2005).

An estimate shows that at the present rate of consumption, the country would need more than one million tons of maize by 2012 (Mian et al., 2001). Maize is one of the most efficient crops which can give high biological yield as well as grain yield due to its photosynthetic mechanism. The agro-climatic condition of Bangladesh is favourable for its cultivation round the year. However, the average yield of maize in the country is considerably low. The national average yield is

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only 5.33 t/ha (BBS, 2005), whereas the newly released varieties have the potential to produce more than 8.0 t/ha. For fulfillment of the requirement of maize in Bangladesh, Bangladesh Agricultural Research Institute (BARI) has already released some hybrid maize varieties, such as BHM-1, BHM-2, and BHM-3, which are higher yielder with yield potential of about 9-10 tons/hha.

Groundnut (*Arachis hypogaea* L.) is the third most important legume crops in Bangladesh of which it was grown on 27073 ha with a production of 34240 tons in 2002-2003 (BBS, 2005). It is used as edible oil, to 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 (Biswa et al., 1997). Moreover, most of the char areas of Bangladesh become inundated in the Kharif season, which causes the decline of groundnut area. In Kharif season, only some high lands are used for groundnut cultivation.

In order to introduce maize and avoid competition from other crops, there is a need for developing technology like intercropping. Roy and Shahani (1970) have shown the potential of legume as a suitable crop for intercropping with maize. It is reported that the use of early maturing varieties, alternate row arrangement, spacing, and plant population are some of the tools that may promote the yield of the intercrop (Harrer and Harwood, 1974). Increase grain production per unit area of land has been reported elsewhere (Quayyum et al., 1987; Akanda et al., 1982) by intercropping grain legumes with maize. The temporal way of increasing food production includes adoption of modern varieties, practicing of improved cultural techniques and following the appropriate cropping systems. Intercropping system is one of the important approach of cropping systems and emerged as an important tool for increasing crop production. Combination of groundnut (Jhinghabadam) and hybrid maize in intercropping systems may increase the production to fulfill the demand for maize and groundnut. Changing the planting arrangements of the main and component crops is an important agronomic approach in intercropping systems but has not been extensively studied. However, information relating to intercropping of groundnut in hybrid maize during Rabi season is inadequate. In this context, the experiment was conducted to study the performance of different varieties of hybrid maize under intercropping systems with groundnut for higher productivity and profitability.

**Materials and Method**

The experiment was conducted at the Regional Agricultural Research Station, BARI, Jessore during two consecutive Rabi seasons of 2003-04 and 2004-05. There were 13 treatments, viz., 4 sole crops of hybrid maize (*Zea mays* L.), one sole crop of groundnut (*Arachis hypogaea* L.) and 8 intercropping systems of
maize + groundnut under two planting systems viz, normal and paired row. The treatments were as follows:

T₁ = Two rows of groundnut in between normal rows of hybrid maize (var. BHM-1)
T₂ = Two rows of groundnut in between normal rows of hybrid maize (var. BHM-3)
T₃ = Two rows of groundnut in between normal rows of hybrid maize (var. Pacific-11)
T₄ = Two rows of groundnut in between normal rows of hybrid maize (var. Pacific-984)
T₅ = Four rows of groundnut in between paired rows of hybrid maize (var. BHM-1)
T₆ = Four rows of groundnut in between paired rows of hybrid maize (var. BHM-3)
T₇ = Four rows of groundnut in between paired rows of hybrid maize (var. Pacific-11)
T₈ = Four rows of groundnut in between paired rows of hybrid maize (var. Pacific-984)
T₉ = Sole hybrid maize (var. BHM-1)
T₁₀ = Sole hybrid maize (var. BHM-3)
T₁₁ = Sole hybrid maize (var. Pacific-11)
T₁₂ = Sole hybrid maize (var. Pacific-984)
T₁₃ = Sole groundnut (var. Jhingabadam).

The experiment was laid out in a randomized complete block design with four replications in Rabi season. The unit plot size was 4.5 m x 6.0 m. Four maize (Zea mays L.) varieties, BARI Hybrid Maize-1 (BHM-1), BARI Hybrid Maize-3 (BHM-3), Pacific-11, and Pacific-984 were used. Groundnut variety Jhingabadam was tested in the experiment. Maize was sown at 75 cm apart rows with 25 cm between the plants both in sole (T₉, T₁₀, T₁₁, and T₁₂) and intercrop situation in normal row of maize (T₁, T₂, T₃, and T₄). On the other hand, maize was sown in paired rows 37.5 cm apart and 150 cm between two pairs with 25 cm between the plants (T₅, T₆, T₇, and T₈). The spacing maintained for sole groundnut was 30 cm × 10 cm. In case of intercrop situation, the population density of maize remained as that of the sole plot of maize, but it varied for groundnut. Germination of the seeds was above 95 percent in both the years. Sowing of both the crops was done on 13 November in 2003 and 2004. Fertilizer was applied for maize at the rate of 250-120-120-40-5-2 kg of N, P₂O₅, K₂O, S, Zn and B/ha from urea, triple superphosphate, muriate of potash, gypsum, zinc sulphate, and boric acid, respectively. Half amount of N and full dose of other fertilizers were incorporated into the soil at the time of final land preparation. The remaining urea was top dressed in two equal splits at 35 and 65 days after
sowing (DAS) only in maize rows as band placement. For groundnut sole crop, fertilizer was applied at the rate of 12-32-43-31-4-2 kg of N, P₂O₅, K₂O, S, Zn, and B/ha from urea, triple superphosphate, muriate of potash, gypsum, zinc sulphate, and boric acid. Half amount of urea and full dose of other fertilizers were applied at the time of final land preparation. Additional fertilizers were not applied for groundnut in intercrop situation. Three irrigations were applied at 30, 60, and 90 DAS. Mulching and hand weedings were done as and when necessary to keep the field reasonably weed free. Dasban was sprayed at 20-day intervals as precautionary measure against insects attack. Dithane M-45 was sprayed at 15-day intervals at the later stages of groundnut as precautionary measure to prevent from tikka disease. An effective area of 3.0 m x 4.5 m was harvested from each plot. Grain, pod and straw yields at harvest were converted into t/ha after proper drying.

The growth of maize and groundnut was recorded at 30-day intervals and at the final harvest. At each harvest, 5 plants¹ treatment, variety¹, replication¹ were selected. The plants were cut at the ground level and dry weights of these plants were recorded after oven drying at 70°C for 72 hours till they reached constant weight. Leaves of sample plants were separated manually. Leaves were oven-dried and weights were taken. One thousand of leaf cuts of 1 cm diameter were oven-dried along with the leaf samples for leaf area determination. The leaf area was measured at 30, 60, 90, 120 DAS and at the final harvest for maize and at 30, 60, 120, 150 DAS and at final harvest for groundnut. Crop growth rate (CGR) was determined from the dry weights of different plant parts between two successive harvests (Redford, 1967). Maize was harvested at physiological maturity at 15% moisture content, threshed and winnowed to determine the grain yield. Ten maize plants were selected randomly for recording data on yield attributes. Groundnut was also harvested at physiological maturity, threshed, and dried properly to determine the pod yield. Ten plants were selected randomly for the pod yield and yield components. The gross returns, cost of cultivation, gross margin, and net return was computed from different treatments on the basis of prevailing market price of maize grain, groundnut pod and both the crop-straw and biomass. Benefit cost ratio (BCR) of different treatments was computed as follows (Shah et al., 1991):

\[
BCR = \frac{\text{Gross return (Tk./ha)}}{\text{Total cost of production (Tk./ha)}}
\]

The data recorded for different characters were compiled and tabulated in proper way for statistical analysis. The significance of comparison was tested with ‘F’ test and whenever the variance ratio was found significant, means were
compared by Duncan Multiple Range Test (DMRT). The data were analyzed statistically following computer package MSTAT-C and DMRT was used to determine the significant differences among the treatment means.

**Results and Discussion**

**Plant growth parameter:**

Leaf area index (LAI) was significantly influenced by all the intercropping systems in maize and groundnut at different harvesting times in both the years (Fig. 1 and 2). These results are in conformity with the findings of Shivay *et al.* (2002). The LAI of maize and groundnut reached a maximum at 120 and 150 DAS, respectively, with the increasing number of leaves per plant and expansion of individual leaf. At the later stage of growth, LAI reduced slowly in maize but sharply in groundnut. LAI of maize decreased due to intercropping, but there was no remarkable difference between the sole and intercrop maize in both the years. The maximum LAI (4.97 in 2003-04 and 5.88 in 2004-05) was obtained from sole hybrid maize (var. BHM-3). Similar results were reported by Oljaca *et al.* (2000) who reported that sole maize produced higher LAI values than any other mixtures. On the other hand, LAI was also found maximum in sole groundnut (4.32 in both the years). This finding was in agreement with that of Ghosh (2002) and in contradiction with Oljaca *et al.* (2000). They reported that LAI values of beans as sole crop produced significantly lower leaf area than the mixtures. Number of leaves per plant decreased in the intercropping system, which might reduced the LAI of groundnut (Singh *et al.*, 2000).

Total dry matter (TDM) of different varieties of hybrid maize and groundnut increased with advancement of time irrespective of treatments (Figs. 1 and 2). Dry matter accumulation of hybrid maize varieties increased slowly and attained plateau at around 120 DAS and then the pattern of curves remained similar until the final harvest. The highest dry matter accumulation of hybrid maize (var. BHM-3) in monoculture was due to better utilization of solar radiation and CO$_2$ as there was no competition with intercrop and better nitrogen uptake and less weed infestation. Similar results were reported by Talukder *et al.* (2003) and Alam *et al.* (2005). Sole groundnut produced higher dry matter than any other intercropped groundnut. Intercropped groundnut with lower density faced different levels of shading from different planting geometry of maize and subsequently accumulated lower dry matter (Kephart *et al.*, 1992).

Irrespective of intercropping systems, CGR of maize increased progressively with the advancement of time and reached peak at 90-120 DAS and then declined (Fig. 1). The sole and intercropped maize varieties showed similar trend of CGR. The rapid decline in COR of maize varieties after 90-120 DAS might be due to rapid cessation of effective leaf area. There was a trend for higher CGR in sole
Fig. 1. Leaf area index, total dry matter and crop growth rate of maize in maize+groundnut intercropping systems over time in 2003-04 (A) and 2004-05 (B).

LSD (0.05) values are 0.02, 0.12, 0.11, 0.43 & 0.55 in A and 0.02, 0.28, 0.78, 0.63 & 0.54 in B for LAI; 0.65, 7.19, 119.22 & 115.86 in A and 0.84, 15.97, 52.23, 214.21 & 160.11 in B for TDM at 30, 60, 90, 120 & 150 DAS, respectively, and 0.24, 1.06, 4.09 & 4.84 in A and 0.55, 1.79, 6.88 & 8.61 in B for CGR at 30-60, 60-90, 90-120 & 120-150 DAS, respectively.
Fig. 2. Leaf area index, total dry matter and crop growth rate of groundnut in maize + groundnut intercropping systems over time in 2003-04 (A) and 2004-05 (B).

LSD (0.05) values are 0.01, 0.03, 0.13, 0.26, 0.34 & 0.19 in A and 0.04, 0.09, 0.03, 0.26, 0.34 & 0.29 in B for LAI; 0.89, 1.66, 12.31, 18.55, 53.01 & 37.59 in A and 1.01, 7.56, 9.31, 32.04, 32.36
& 31.54 in B for TDM at 30, 60, 90, 120, 150 & 170 DAS, respectively, and 0.07, 0.37, 0.61, 1.70 & NS in A and 0.17, 0.31, 1.26, 1.80 & 1.72 in B for CGR at 30-60, 60-90, 90-120, 120-150 & 150-170 DAS, respectively.

cropping compared to the intercropped in both the years due to less competition among the plants for air and solar radiation. El-Shaer et al. (1979) and Kumar et al. (1995) also reported similar results. CGR of groundnut increased steadily upto 120-150 DAS and thereafter, declined quickly till the final harvest (Fig. 2). These results are in agreement with the findings of Misa et al. (1994) in peanut. CGR of groundnut in the intercropped situation was much lower than sole groundnut. Such lower CGR of groundnut might be due to reduction of leaf area and availability of lower light to underneath groundnut canopy.

**Grain yield of maize**

Higher grain yield of maize was observed in T11 (sole maize var. Pacific-11) which was statistically at par with T3, T4, T7, T8, T10, and T12 in 2003-04 and T2, T3, T4, T6, T7, T8, T10, and T12 in 2004-05 (Table 1). It showed that Pacific-11 variety of hybrid maize was higher yielder in monoculture (T11) and its respective intercrops because of more number of cobs/ plant and higher 1000-grain weight or cumulative effect of yield attributes. Lower yield was obtained from T5, which was statistically identical with T1, T2, T6, T8, T9, and T10 in 2003-04 and T1 and T9 in 2004-05. Higher yield of maize was observed in monoculture compared to their respective intercrop situation might be due to no intercrop competition for light, nutrients, moisture, and space. This corroborates with the findings of Quayyum et al. (1987), Karim et al. (1990), and Uddin et al. (2003). The maize yield under intercropping treatment (both normal and paired row) was lower than that of respective monoculture, though the population of maize was constant regardless of treatment. The reduction of maize yield was probably due to intercrop competition between maize and groundnut. However, additional yield from groundnut not only compensated the deficit, but also gave extra income. This finding is in conformity with that of Quayyum and Maniruzzaman (1995), Uddin et al. (2003) and Pandey et al. (2003). The yield reduction of maize was more when intercropped in paired row system (4.47-6.50% in 2003-04 and 3.69-9.50% in 2004-05) than normal row system (1.78-3.83% in 2003-04 and 0.53-4.08% in 2004-05), which might be due to more interplant competition for growth resources. Similar results were reported by Karim et al. (1990).
Table 1. Grain and stover yield of different varieties of hybrid maize, and pod yield and biomass yield of groundnut in maize + groundnut intercropping systems in 2003-04 and 2004-05.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Maize</th>
<th>Groundnut</th>
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<tbody>
<tr>
<td></td>
<td>Grain yield (t/ha)</td>
<td>Stover yield (t/ha)</td>
</tr>
<tr>
<td>T1</td>
<td>7.98 bc</td>
<td>9.42 cd</td>
</tr>
<tr>
<td>T2</td>
<td>8.28 be</td>
<td>10.28abc</td>
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<td>T3</td>
<td>9.05 ab</td>
<td>10.89 a</td>
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<td>T4</td>
<td>8.83 ab</td>
<td>10.82 a</td>
</tr>
<tr>
<td>T5</td>
<td>7.62 c</td>
<td>8.57 d</td>
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<td>T6</td>
<td>8.13 bc</td>
<td>10.18abc</td>
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<td>T7</td>
<td>8.97 ab</td>
<td>10.68 ab</td>
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<td>T8</td>
<td>8.53 abc</td>
<td>10.62abc</td>
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<td>T9</td>
<td>8.15 bc</td>
<td>9.47 bcd</td>
</tr>
<tr>
<td>T10</td>
<td>8.61 abc</td>
<td>10.57abc</td>
</tr>
<tr>
<td>T11</td>
<td>9.39 a</td>
<td>11.31 a</td>
</tr>
<tr>
<td>T12</td>
<td>8.99 ab</td>
<td>11.28 a</td>
</tr>
<tr>
<td>T13</td>
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</table>

F-test ** ** ** ** ** ** ** **
CV (%) 5.84 4.60 5.07 9.00 9.01 7.44 9.54 9.12

Mean values in a column having the dissimilar letter/letters indicate significant differences at 0.05 (*) and 0.01 (**) level of significance (DMRT)

Stover yield of maize

Stover yield of maize was influenced by maize + groundnut intercropping system in both the years (Table 1). Higher stover yield of maize was obtained from T10 (sole maize var. BHM-3), which was statistically at par with T2 in 2003-04 and all the treatments except T1 and T3 in 2004-05. It was noted that the variety BHM-3 had the ability for quick growth compared to other varieties. So, monoculture of BHM-3 (T10) had higher stover yield and so did its intercropped treatments (T2 and T6) in both the years. It might be due to varietal character and higher plant height compared to other varieties. In intercropping situations, stover yield was reduced compared to sole maize and it might be due to interplant competition among the different varieties of maize and groundnut. The lowest stover yield was obtained from T5 followed by that of T1 and T9. The variety BHM-1 gave lower stover yielder in monoculture and also in its respective intercrop treatments among the varieties of maize. It might be due to varietal character and higher plant height.
Pod yield of groundnut

Pod yield of groundnut was significantly affected by maize + groundnut intercropping systems in both the years (Table 1). The highest pod yield was recorded in T13 (monoculture groundnut) in both the years. The pod yield differed mainly due to the highest number of plants/m², number of pods/plant and 100-pod weight. Ghosh (2002), Sarkar and Pal (2004) and Razzaque et al. (2007) also reported higher pod yield of groundnut in monoculture. The pod yield of groundnut in intercropping situation was considerably reduced. This corroborates with the findings of Karim et al. (1990), Ghosh (2002), Sarkar and Pal (2004) and Razzaque et al. (2007). The reduction of pod yield might be due to shading effect of maize on the groundnut. Similar results were reported by Patra et al. (1990). It was noted that yield reduction in groundnut was observed more in T1 to T4 than T5 to T8 treatments. It reveals that paired rows planting system of maize favoured the growth of intercropped groundnut. Similar findings were observed by Islam et al. (2006). Among the intercropping treatments, T7 (4 rows of groundnut in between 2 paired rows of hybrid maize var. Pacific 11) had higher pod yield of groundnut. It might be due to paired row planting system of maize var. Pacific 11 which favoured the growth of intercropped groundnut and judicious use of growth resources compared to other intercropped combinations. The results are in conformity with the findings of Islam et al. (2006) who reported that paired row planting system of maize favoured the growth of intercropped bush bean.

Biomass yield of groundnut

Biomass yield of groundnut was significantly influenced by maize + groundnut intercropping systems in both the years (Table 1). The highest biomass yield was obtained from sole groundnut due to maximum plants/m², highest number of branches/plant and no intercrop competition. Reduced biomass yield of groundnut under different intercropping situations was due to lower plant population (67% in T1 to T4 and 53% in T5 to T8) compared with sole crop of groundnut (100%) and also shading effect of maize. The lowest biomass yield was recorded in T1 because of short plant height and lower number of branches/plant in both the years.

Cost benefit analysis

Data pertaining to monetary return of maize + groundnut intercropping system indicated that higher total gross return was obtained from T7 (four rows of groundnut in between two paired rows of hybrid maize var. Pacific 11) than sole crop of maize varieties or groundnut in consecutive two years (Table 2). Several authors (Santalla et al., 2001 and Razzaque et al., 2007) also reported higher monetary advantages from different intercropping systems than their respective sole crops. Total gross return increased 43.77% in 2003-04 and 35.18% in 2004-05 in T7 (four rows of groundnut in between two paired rows of hybrid maize var. Pacific 11) over respective sole cropping of maize.
Table 2. Cost benefit analysis of sole maize, sole groundnut and intercropped maize with groundnut in 2003-04 and 2004-05.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>2003-04</th>
<th>2004-05</th>
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<tbody>
<tr>
<td></td>
<td>Gross return (Tk./ha)</td>
<td>Cost cultivation (Tk./ha)</td>
</tr>
<tr>
<td></td>
<td>Maize</td>
<td>Groundnut</td>
</tr>
<tr>
<td>T1</td>
<td>65860</td>
<td>23380</td>
</tr>
<tr>
<td>T2</td>
<td>69013</td>
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<td>T3</td>
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<td>73113</td>
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<td>62888</td>
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<td>T6</td>
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<td>T7</td>
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<td>T12</td>
<td>74465</td>
<td>74465</td>
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<tr>
<td>T13</td>
<td>-</td>
<td>63000</td>
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Price: Maize: 8.00 Tk./kg, Groundnut : 25.00 Tk./kg, Stover/biomass: 0.25 Tk./kg.
The data showed that the highest total cost of cultivation of Tk. 31423/ha in 2003-04 and Tk. 34336/ha in 2004-05 was incurred in T4 (two rows of groundnut in between two rows of hybrid maize var. Pacific-984) (Table 2). The lowest total cost of cultivation was observed in T3 (sole groundnut). The cost of cultivation increased in the intercropping systems compared with respective sole crop of maize varieties or groundnut. It might be due to additional inputs and management require for groundnut in the intercropping treatments. These results are in agreement with those of Quayyum and Maniruzzaman (1995) and Patel and Rajagopal (2001) under cereal + legume intercropping system.

The net returns obtained from different intercropping treatments were appreciably higher than from a sole maize and groundnut stand in both the years (Table 2). Two year’s results revealed that the highest total net return was obtained from T7 (four rows of groundnut in between two paired rows of hybrid maize var. Pacific 11). It might be due to better utilization of different growth resources in hybrid maize (var. pacific II) + groundnut intercropping system. The net return could be increased considerably on maize intercropped with blackgram as reported by Quayyum and Maniruzzaman (1995). Many investigators also reported higher net return obtained in ntercropping system than sole crop (Quayyum et al., 1987; Biswas et al., 1997; Sarkar and Pal, 2004 and Razzaque et al., 2007).

Cost and benefit analysis is an important tool for evaluating the economic feasibility of intercropping systems. Data showed that T7 (four rows of groundnut in between two paired rows of hybrid maize var. Pacific 11) gave the highest benefit cost ratio (BCR) of 3.79 in 2003-04 and 3.91 in 2004-05 followed by T6 (four rows of groundnut in between two paired rows of hybrid maize var. BHM-3) of 3.56 in 2003-04 and 3.79 in 2004-05. Similar findings were reported by Sharma (1994). Maize hybrid variety as sole crop gave reasonable good yield and economic return but due to sustaining of soil fertility as well as ensures productivity from hybrid maize, intercropping with legumes is one of the way which could help in yield stability. In this situation, four rows of groundnut in between two paired rows of hybrid maize var. Pacific 11(T7) would be better option in Rabi season.

References


