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Research Article

Comparative Productivity and Profitability of Banana Intercropping with Vegetables

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Abstract

Productivity and profitability of vegetables intercropping in banana-based cropping system was analyzed in farmer's field of MLT site, Madhupur, Tangail in two consecutive years during 2020-21 and 2021-22 to find out a suitable intercrop combination of vegetables with banana for higher productivity and profitability. There were three intercrop-based treatments i.e., Banana + Potato, Banana +Cabbage+ Potato and Banana + Cauliflower + Potato along with Sole banana. Banana (Amrit Sagar), Cabbage (Parel), Cauliflower (Thirty-three) and Potato (Granola) were used as test materials. The experiment was laid out in a randomized complete block design with six dispersed replications. The unit plot size was 400 m^2. The results revealed that all the intercrops' treatments produced higher banana equivalent yield over the sole banana. However, among the intercrop combinations, Banana + Cauliflower + Potato provided the highest equivalent yield (101.89 tha^{-1} followed by Banana + cabbage + potato. Sole banana produced the lowest equivalent yield in both the cropping seasons. Higher gross margin (Tk.6,66,898 ha^{-1}) was also obtained from Banana + cauliflower + Potato treatment as well as higher BCR (3.79) than other intercrop treatments. So, the farmers of Madhupur Tracts (AEZ-28) and similar areas of Bangladesh could be suggested to cultivated cauliflower and potato as intercrop with banana instead of sole banana.

Keyword: Banana equivalent yield, Crop index, Intercrop and monetary advantage.

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Introduction

Bangladesh is an agricultural country and most of the inhabitants are involved in agriculture directly or indirectly for their livelihood. The country possesses very fertile land in which diversified crops grow very easily. Agriculture is the single largest producing sector and contributes about 11.38 % to the total Gross Domestic Product (GDP) in the economy of Bangladesh. The majority of the farmers are marginal and smallholders and their land size is on an average 0.05 to 2.49 acres and 1.50 to 2.49 acre, respectively (MOA, 2022). Demand for food has been increasing with the rapid population increase while land accessibility has been diminishing. Thus, the only way to increase agricultural production is to increase yield per unit area (Hirpa, 2014). Increasing food demand for the over population is creating challenge to the country for increasing productivity of the limited land. Now cultivation of long duration crops is discouraged and simultaneously short duration intercrops, relay crops and mixed crop are emphasized for cultivation to ensure food security for a large number of populations. Accordingly, intercropping is a time demanding technology for cultivation of long duration crops.

Banana (*Musa sapientum* L.) is a very popular fruit due to its low price and is used both as vegetable and as a dessert fruit. It is a rich source of carbohydrate and having plenty of vitamins particularly vitamin B. It is also a good source of potassium, phosphorus, calcium and magnesium. Banana powder is used as the first baby food. It helps in reducing risk of heart diseases when used regularly and is recommended for patients suffering from high blood pressure, arthritis, ulcer, gastroenteritis and kidney disorders. It is one of the cheapest, most plenteous and nutritious of all fruits which are available throughout the year. Among more than 118 minor crops in Bangladesh, banana is one of the top listed fruit crops, which is available throughout the year and consumption rate is higher than any other fruits which comprise about 16% of the total fruit production (BBS, 2022). It has great economic importance as well as nutritional value.

Bananas are largely grown in well drained high land, which is also suitable for growing other cash crops. The inter row space of banana remains underutilized in the early growing period. During this period, short duration crops may be grown as intercrops with banana. Intercropping with banana is more profitable without much investment than sole crop. The success of intercropping systems depends mostly on selection of component crops as well as agronomic modification of resources used. It is a wide spaced (1m × 1.25m) crop and life span ranges 390-395 days. It is a long duration crop grows slowly in first growth stage and establishment of full canopy takes several months. This privilege can be taken for growing potato, cabbage and cauliflower in between the rows as intercrops. These crops can easily be intercropped with banana at early growth stage for their short stature and quick growing habit. Intercropping has been considered advantageous in terms of economy of space,

saving on tillage, as well as utilization of available nutrients and moisture in unused space. Presently, intercropping is gaining acceptance among small holder farmers as it provides a yield advantage compared to sole cropping through yield stability and helps achieve diversified domestic needs (Bhatti et al., 2013). Multiple cropping facilitates the farmers to cultivate two or three crops in a year especially in those areas where growing season is shrinking for sequential farming due to climate change (Jabbar et al., 2010). Inter cropping systems are more stable than sole cropping. It increases total productivity per unit area through maximum utilization of land labour and growth resources.

It is believed that, poverty cannot be reduced to a desired level without increasing productivity of agriculture sector and at the same time it has to be assured that farmers get fair price of the crops. Natural calamities like draught, flood, cyclone, tornado etc. are a very regular phenomenon which hinders the production of agriculture to a great extent. Cultivable land is being decreased due to the pressure of massive population. As a result, food security is being threatened. So, intercropping is an excellent technique to increase total productivity, monetary return and utilizes the available growth resources more efficiently and sustainably as well as to fulfill the diversified need of farmers (Akhteruzzaman et al., 2008). Moreover, it provides several major advantages namely; diversification reduces risk associated with crop failure, offers greater yield stability.

In Bangladesh small and marginal farmers constitute 79.4% of our farming community and their cultivated lands are decreasing day by day (MoA, 2022). Besides, multiple cropping may ensure proper utilization of resources towards increased production per unit area and time on a sustainable basis (Ahmad et al., 2013). Banana is an important fruit crop in Bangladesh. Potato, cabbage and cauliflower are also important vegetable crops in Bangladesh. Banana growers are used to grow vegetables as intercropping in some pocket areas of Bangladesh. For getting higher productivity and economic return, it is in need to find out the optimum combination of banana-vegetable intercropping system. However, various studies have been conducted in the past about vegetables intercropping system but results on banana-vegetable intercropping are very scanty. Therefore, this experiment was undertaken to optimize the productivity and economic return of banana-vegetable based intercropping system.

Materials and Methods

The field experiment was conducted at the farmers' field of Madhupur MLT site, under On-Farm Research Division, Bangladesh Agricultural Research Institute (BARI), Tangail in irrigated condition during two consecutive years of 2020-21 and 2021-22 to find out a suitable intercrop combination of vegetables with banana for higher productivity and profitability. The experimental site located at approximately $24^0 64^/$N latitude and $90^0 09^/$E longitude with the altitude of 19 m above sea level. The

land was medium high and the soil of the study area was clay loam to clay in texture with well drainage system and almost acidic in reaction having pH range of 4.3 to 6.5. Mean annual precipitation was 2212 mm, most of which (90%) was received during May to September due to monsoon. The highest temperature (33.9^{o}C) in August and the lowest in December (10.1^{o}C). The relative humidity was the highest (84.5%) in August and the lowest (75.2 %) in 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 experiment consisted of four treatments viz. T_1= Sole banana, T_2= Banana + Potato, T_3=Banana +Cabbage +Potato and T_4=Banana + Cauliflower + Potato. The variety of banana (Amrit Sagar), cabbage (Parel), cauliflower (Thirty-three) and potato (Granola) were used as test materials.

The experiment was laid out in a randomized complete block design with six dispersed replications. The unit plot size was 400 m^2. Banana was the main crop, cabbage; cauliflower and potato were the intercrops in the study. Banana, cabbage, cauliflower and potato were transplanted in 1m×1.5m, 60cm×45cm and 45cm×15cm plant to plant and row to row distance, respectively. The recommended fertilizer doses at the rate of 230-80-300-36-2 kg NPKSZn ha^{-1} along with cowdung 5 t ha^{-1}, 180-45-60-24 kg NPKS ha^{-1} and 125-30-136-15kg NPKS respectively were applied in banana, cabbage, cauliflower and potato. In banana, all of cowdung, P, S and Zn were applied as basal during final land preparation 3 to 4 days prior to planting. The N and K were applied in four equal splits as side dressing first one at sucker establishment next two sides dressing at two months' interval and last one at after emergence of inflorescence and mixed thoroughly with the soil followed by irrigation. For cabbage and cauliflower all P and S fertilizer were applied as basal. N and K applied in three equal splits at 10-15, 30 and 45 days after transplanting as ring method. For potato all of P, S and half of N and K applied a basal and remaining half of N and K applied as side dressing at 30-35 days after planting during earthing up operation. Thirty to forty days old suckers of banana were transplanted on 15- 20 September 2020 and 17-21 September 2021.Cabbage and cauliflower were sown at five days after planting of banana. Forty to forty-five days old seedlings of cabbage and cauliflower were transplanted on 20-24 September 2020 and 22-26 April 2021 and potato were planted on 09-12 November 2020 and 06-11November 2021, respectively. First weeding was done at 15 days after cabbage and cauliflower transplanting while the banana was 20 days old after planting. Second weeding was done at 40 DAT especially prior to head and card stage. Potato tubers were planted after harvest of cabbage and cauliflower as intercrop with banana. Weeding followed by earthing up was done at 35 days after planting of potato. Irrigation was done for banana 10 days (cabbage and cauliflower at 5 DAT) and 25 days (cabbage and cauliflower at 20 DAT) after sucker planting. The 3rd irrigation for cabbage and cauliflower was done at 40 DAT (before head initiation) while the banana plant was 45 days old. Potato was irrigated at 25, 50 and 65 days after planting (age of banana

plant was 81, 106 and 121 DAT, respectively). Plant protection measures were done properly for normal growth and development of crops. Cabbage and cauliflower were harvested on 10-14 November 2020 and 11-15 November 2021. Potato was harvested on 12-16 January 2021 and 10-15 January 2022 in two consecutive years. Banana was also harvested on 15-20 October 2021 and 15-19 October 2022 in successive years. The yield contributing characters of banana was recorded from 10 randomly selected plants in both the years.

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

Banana equivalent yield (BEY)=

$$\text{Yield of inter crop banana} + \frac{\text{Yip} \times \text{Pp}}{\text{Pb}} + \frac{\text{Yic} \times \text{Pc}}{\text{Pb}} + \frac{\text{Yica} \times \text{Pca}}{\text{Pb}}$$

Where, Yi= Yield of intercrop potato, Pp= Price of potato, Yic= Yield of intercrop cabbage, Pc= Price of cabbage and Yica= Yield of intercrop cauliflower, Pca= Price of cauliflower and Pb= price of banana.

Production efficiency: Production efficiency value in terms of kg $ha^{-1}day^{-1}$ was calculated by total main product divided by total duration of crops. (Tomar and Tiwari, 1990).

Production Efficiency (kg $ha^{-1}day^{-1}$) = $\frac{\sum Yi}{\sum di}$ Where, Yi= Yield (kg) of ith crop, di= Duration (day) of ith crop of the intercrop and i= 1, 2&3

Land utilization index (LUI): It was worked-out by taking total duration of crops in an individual intercropping system divided by 365 days (Rahman *et al.* 1989). It was calculated by the following formula:

$$\text{Land Utilization Index (\%)} = \frac{d_1 + d_2 + d_3}{365} \times 100$$

Where d_1, d_2 and d_3 the duration of 1st, 2nd and 3rd crop.

Pooled analysis was done as there was no significant difference in yield and yield contributing characters between two years. The collected data on different parameters were statistically analyzed using analysis of variance technique 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).

The gross economic return was calculated 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 attributes of banana

Yield attributes of banana are presented in Table 1. The result indicated that yield contributing characters of banana were not varied significantly among the treatments in two consecutive years. It was noticed that there was no significant adverse effect of the intercrops on the performances of banana regarding yield and yield contributing characters. This is probably due to the advantages came from root and canopy structures of the main crop banana and all intercrops grown at early stages of planting. These results are in agreement with the findings of (Hasan et al*.,* 2017).

Table 1. Yield attributes of banana as influenced by different vegetables intercropping systems at Madhupur,Tangail during 2020-21 and 2021-22 (Pooled data).

Treatments	Length of hand (cm)	No. of hands/bunch	No. of Finger /Hand	Wt. of hands (kg)	Wt. of bunch (kg)
T_1	91.80	11.00	17.00	2.77	24.41
T_2	90. 41	10.00	16.00	2.54	22.91
T_3	89. 37	10.00	16.00	2.58	22. 38
T_4	89. 94	10.00	16.00	2.57	22.50
$LSD_{(0.05)}$	ns	ns	ns	ns	ns
CV (%)	4.68	5.79	4. 82	5.87	7. 21

T_1= Sole banana, T_2= Banana +Potato, T_3=Banana+ cabbage +Potato and T_4= Banana +Cauliflower +Potato

Yield of banana and component crops

The sole banana cultivation produces slightly higher yield of banana as compared to intercrop situation. Banana grown in association with intercrops like cabbage, cauliflower and potato contributed to slightly lower yield (8-12%). This might be due to the competition by the intercrops for the same resources i.e. space, nutrition, water etc. grown in association with banana. However, banana yield ranged from 53.45 to 60.49 tha^{-1}. Cabbage and cauliflower yield was recorded as 35.19 and 34.82 tha^{-1}. Potato yield was recorded 13.97 to 15.64 tha^{-1}in different treatments which were far below the potential yield of potato but it contributed to the higher system productivity with the same management practices. Similar reflection was noticed by (Rahman et al., 2006) and (Hasan et al., 2017). It was observed that potato grown after cabbage and cauliflower produced lower tuber yield than that of potato and banana grown only. The reason might be that, the preceding intercrops cabbage and cauliflower delayed the optimum sowing time for potato cultivation. Therefore, growing potato after cabbage and cauliflower as intercrop with banana might be

involved in comparatively lower tuber yield as well as acted as a risk factor for exposing diseases to the next crop potato. When two crops (Banana + Potato) grown as intercrop showed 8% yield reduction while three crops (Banana+ Cabbage or Cauliflower +Potato) grown as intercrop resulted in 10.10-11.64% yield reduction than sole banana.

Table 2. Yield of banana and component crops as influenced by different intercropping systems at Madhupur, Tangail during 2020-21 and 2021-22 (pooled data).

Treatments	Banana yield (t ha^{-1})	Cabbage yield (t ha^{-1})	Cauliflower yield (t ha^{-1})	Tuber yield (t ha^{-1})	*Crop index (%)
T_1	60.49	-	-	-	-
T_2	55.94	-	-	15.64	92.48
T_3	54.38	35.19	-	13.97	89.90
T_4	53.45	-	34.82	14.82	88.36
$LSD_{(0.05)}$	5. 38	-	-	1. 29	-
CV(%)	7.83	-	-	8.23	-

T_1= Sole banana, T_2= Banana +Potato, T_3=Banana+ cabbage +Potato and T_4= Banana +Cauliflower +Potato and *Crop index (%) means percent reduction or increase of yield as compared to sole crop in intercrop situation.

System productivity

System productivity was measured in terms of banana equivalent yield from different treatment combinations (Table 3). The yield of banana was not varied curiously but component crops yield played a significant role for increasing banana equivalent yield. Yield of intercrops i.e. cabbage, cauliflower as well as potato donated to higher system productivity over the sole banana cultivation. All the intercropping treatments showed better performance than sole banana cultivation. The highest equivalent yield (101.89 tha^{-1}) was obtained from Banana + Cauliflower + Potato (T_4) treatment which was statistically similar with Banana + Cabbage + Potato (T3) treatment but differed from other treatments. The lowest yield (60.49 tha^{-1}) was obtained from sole banana cultivation. Higher productivity from the intercrop combinations indicated the consequences of higher production from the component crops under intensified land use systems. (Musa et al., 2013) reported that higher system productivity obtained from the intercrop-based systems over the sole crop. (Nazrul et al., 2007) also showed higher system productivity in intercrop vegetables combinations with banana than sole banana. Banana + vegetables intercropping system increased total productivity by 18.33-68.44% over sole banana (Table 3). Among the treatments, BEY in banana + cauliflower + potato combination was

68.44% higher over the sole banana and lowest in banana + potato intercropping system. Similar results were reported by (Hasan et al., 2017).

Production efficiency

Mean maximum production efficiency was measured for the treatments and presented in the Table 3. Production efficiency was found always higher from intercrop combinations than that of sole banana cultivation. The intercrops-based results supported the findings of (Rahman et al*.,* 2006) and (Bantie, 2015). The maximum production efficiency (202 $kgha^{-1}$ day^{-1} was recorded from Banana + Cauliflower + Potato (T_4) followed by Banana+cabbage+Potato (T_3) and the minimum (154 $kgha^{-1}day^{-1}$) from sole banana. Higher production efficiency from the intercropping systems indicated the suitability, productivity as well as profitability of the systems over the sole banana farming.

Land utilization index (LUI)

Land use efficiency is the effective use of land in a cropping year which mostly depends on crop duration. The average land utilization index indicated that intercropping system used the land for 126-140 % period of the year whereas sole crop banana used the land for 108% period of the year (Table 3). Land utilization index was about 17-30 % higher in intercropping system than sole cropping due to intercropping system occupied the land for longer period than sole crop.

Table 3. Banana equivalent yield (BEY), production efficiency and land equivalent ratio of different intercropping systems of banana with vegetables at Madhupur, Tangail (Pooled 2020-21 and 2021-22)

Treatment	Banana equivalent yield (t ha^{-1})	% Increase BEY over sole banana	Production efficiency ($kg^{-1}ha^{-1}day^{-1}$)	Land equivalent ratio (LER)
T_1	60.49	-	154	108
T_2	71.58	18.33	156	126
T_3	97.68	69.52	203	140
T_4	101.89	70.42	200	140
$LSD_{(0.05)}$	8.12	-	-	-
CV (%)	9.15	-	-	-

T_1= Sole banana, T_2= Banana +Potato, T_3=Banana+ cabbage +Potato and T_4= Banana +Cauliflower +Potato

Economic advantage

The cost and return analysis were done on the basis of prevailing market price during the crop season are shown in Table 4. On the basis of two years' average result, all

intercrop combinations gave monetary advantages over sole crops. It was noticed that all the intercrop combinations resulted in higher gross return and gross margin over sole banana. Similar statement regarding higher yield from intercropping system was given by (Hasan et al*.,* 2017). The higher gross margin (Tk. 6,66,898 ha^{-1}) was found in intercropping of banana with cauliflower + potato followed by cabbage +potato (Tk. 6,36,060 ha^{-1}) which gave an additional income of (Tk. 3,10,488 and 2,79,650 ha^{-1}) over sole banana. Total cultivation cost was lower in sole crop than intercropping treatments due to inclusion of component crops. Intercropping of cabbage, cauliflower and potato brought about an increase in return per unit investment. It was evident that intercropping was beneficial and recorded higher benefit cost ratio (BCR) than monoculture of banana. Among the intercropping systems the highest BCR (3.79) was obtained from Banana + cauliflower + Potato intercropping systemwhich further indicated the superiority of this treatment over other treatments (Table 4). These results are in agreement with the findings of Khan *et al*. (2023).

Table 4. Cost and return analysis of different intercropping systems of banana with vegetables at Madhupur, Tangail (average of 2020-21 and 2021-22)

Treatment	Gross return ($Tkha^{-1}$)	Total cost ($Tk\ ha^{-1}$)	Gross margin ($Tk\ ha^{-1}$)	BCR
T_1	4,79,960	1,33,550	3,56,410	3.59
T_2	5,69,120	1,66,252	4,02,868	3.42
T_3	8,65,320	2,29,260	6,36,060	3.77
T_4	9,06,160	2,39,262	6,66,898	3.79

Price of output: ($Tkkg^{-1}$): Banana=12.00, Cabbage=10.00, Potato= 12.00 and Cauliflower= 12.00 Input cost ($Tkkg^{-1}$): Urea= 16.00, TSP=22.00, MoP=15.00, Gypsum=12.00, Zinc sulphate=220, Boric acid=450.00

Conclusion

Two years average result indicated that intercropping banana with cauliflower/cabbage and potato gave higher productivity as well as monetary advantage than monoculture of banana. Thus, it could be concluded that a planting pattern comprising on banana + cabbage/cauliflower + potato in banana intercropping system should be adopted for better productivity and to get maximum profit. So, the farmers of Madhupur Tracts (AEZ-28) and similar areas of Bangladesh could be suggested to cultivated cauliflower, cabbage and potato as intercrop with banana as an alternative of sole banana.

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