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INTERCROPPING OF DWARF YARD LONG BEAN WITH MAIZE UNDER DIFFERENT PLANTING SYSTEM

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Abstract

The field experiment was conducted at Agronomy Research Field, BARI, Gazipur during *kharif-1* season of 2020 and 2021 to find out suitable combination of maize and dwarf yard long bean intercropping for higher productivity and monetary advantage. Treatments included in the experiment were: T_1= Maize normal row (MNR) +1 row dwarf yard long bean (DYLB), T_2= Maize paired row (MPR) + 2 rows DYLB, T_3= MPR +3 rows DYLB, T_4= MPR + 4 rows DYLB, T_5= Sole maize (60 cm x 20 cm) and T_6= Sole DYLB (40 cm x 25 cm). Light availability on DYLB decreased with the increase of shade produced by maize canopy over the time up to 105 DAS. The lowest light availability on DYLB was observed in T_1 treatment and the highest light availability in sole DYLB (T_6). The maximum grain yield of maize was observed in sole maize decreased by 1-4 % among the intercrop treatments. The highest maize equivalent yield (13.75 t ha^{-1}), gross return (Tk. 247500 ha^{-1}), gross margin (Tk. 139000 ha^{-1}) and benefit cost ratio (2.28) were observed inT_3 followed by T_1. The highest land equivalent ratio (1.56) was also found in the same treatment. The results revealed that maize paired row + 3 rows dwarf yard long bean and hybrid maize normal row (60cm x 20cm) + 1 row dwarf yard long bean might be agronomically feasible and economically profitable for maize and dwarf yard long bean intercropping system at Joydebpur.

Introduction

Agriculture is facing great challenges to ensure food security, enhance resource use efficiency, and mitigate climate change, which cannot be addressed in isolation (Chen *et al.*, 2014). Intercropping, as an ancient and traditional cropping system, has a vast potential for realizing sustainable agriculture (Knörzer *et al.*, 2009) and it plays important roles in ensuring food and nutrient supply and raising farm income (Yin *et al.*, 2017). Numerous studies have reported multiple benefits of intercropping systems, such as diversifying crops for market supply (Chai *et al.*, 2014), increasing farm income (Yang *et al.*, 2018), maximizing land use (Dhima *et al.*, 2007), increasing crop yield (Li *et al.*, 2001), improving soil quality (Cong *et al.*, 2015), and controlling pests and weeds (Blaser *et al.*, 2007). Some studies have indicated that intercropping system with legume crops could simultaneously reduce N fertilizer and irrigation input and also decrease CO_2 emissions (Yang *et al.*, 2018). Intercropping is an important tool for getting higher productivity per unit area of land (Mahfuza *et al.*, 2012). Intercropping also helps to reduce weed populations, insect pests infestation and risk of complete crop failure (Ahmed, 2001; Islam *et al.*, 2013). Higher productivity from intercropping depends on judicious choice of component crops, suitable planting system or proportion of component crops (Begum et al., (2020). Research and development work on multiple cropping should be emphasized for sustainable agriculture. Maize based intercropping is found profitable and suitable in many countries as well as in Bangladesh. Maize is C_4 plant which has higher yield potential (Ahmed, 2001) and greater land use efficiency (Bhuiyan, 2001). The newly released hybrids have potential to give yields of 10-12 t ha^{-1} (Rahman *et al.,* 2011). Maize is an unbranched and erect cereal crop grown with wide spacing. Several short duration and short stature vegetable like dwarf yard long bean (DYLB) may be grown in association with hybrid maize. Maize is an important cereal crop and DYLB is a very popular legume vegetable especially to the urban people with rich in calcium and protein. Generally legumes in association with non-legumes helps in not only utilization of the nitrogen being fixed in the current growing season, but also helps in residual nutrients buildup of the soil (Kakraliya *et al.,* 2018). Farmers often demand for quick return from their crops, so they can get it by growing short duration vegetable crops with long duration crop like maize. Moreover, there is no need any trellis or sticks as supporting for dwarf yard long bean plant. It could minimize the production cost of maize + DYLB intercropping. Therefore, this experiment was conducted to find out suitable planting system of hybrid maize and DYLB intercropping for higher productivity, monetary advantage and ensuring food and nutritional security.

Materials and Methods

The field experiment was conducted at Agronomy Research Field, BARI, Gazipur, during *kharif-1* season of 2020 and 2021, respectively. Treatments included in the experiment were: T_1= Maize normal row (MNR) +1 row DYLB), T_2= Maize paired row (MPR) + 2 rows DYLB, T_3= MPR +3 rows DYLB, T_4= MPR +4 rows DYLB, T_5= Sole maize (60 cm x 20 cm) and T_6= Sole DYLB (40 cm x 25 cm). The experiment was laid out in a randomized complete block design with three replications and the unit plot size was 4.8 m x 5 m. Hybrid maize (var. BARI Hybrid maize-9) and DYLB (BARI Barboti-2) were used in both years. Seeds of maize and yard long bean were sown on 10 March, 2020 and 15 March, 2021, respectively, after treated with provex @ 3 g kg^{-1} seed. Fertilizers were applied at the rate of 225-60-120-45-4-1.6 $kgha^{-1}$ of NPKSZnB (FRG, 2018) as urea, triple super phosphate (TSP), muriate of potash (MoP), gypsum, zinc sulphate and boric acid for sole maize and intercrop. One third of N, whole amount of TSP, MoP, gypsum, zinc sulphate and boric acid were applied as basal. Remaining 2/3 N was top dressed at 20 and 40 days after sowing (DAS) of maize. In intercrop, extra N (20 kg ha^{-1}) was applied in two equal splits at 20 and 40 DAS as side dress to DYLB (FRG, 2018). Sole DYLB was fertilized at the rate of 21- 27-33-9-1.2-1.2 kg ha^{-1} of NPKSZnB. Two third of N and all other fertilizers were applied as basal. Rest N was applied at 20 and 40 DAS. Light availability or Photo synthetically active radiation (PAR) was measured by PAR Ceptometer (Model – LP-80, Accu PAR, Decagon, USA). The PAR was measured at 15-day intervals from 30 to 105 DAS at around 11:30 am to 13:00 pm in both years. Four readings each of PARinc and PARt were recorded at different spots of each plot. PARt indicated the light availability above underneath crop (DYLB). The proportion of transmitted PAR (PARt) was expressed in percentage (Ahmed *et al.*, 2010):

$$\text{Light availability, PARt (\%)} = \frac{\text{PAR t}}{\text{PAR inc}} \times 100$$

where, PAR inc= Incident PAR, and PAR t = Transmitted PAR

Data on yield contributing characters of maize were taken from randomly selected 5 plants from each plot. Yields of both crops were taken from whole plot area. Maize was harvested on 25 June 2020 and 30 June 2021. DYLB was harvested five times on 20 April, 30 April, 10 May, 18 May and 24 May 2020 and on 25 April, 05 May, 14 May, 22 May and 01 June 2021. Maize equivalent yield was computed by converting yield of intercrops on the basis of prevailing market price of individual crop following the formula of Bandyopadhyay (1984) as given below:

Maize equivalent yield = Yim + (Yib × Pb)/ Pm

Where, Yim = Yield of intercropped maize, Yib = Yield of intercropped DYLB, Pm = Market price of maize and Pb = Market price of DYLB.

Land equivalent ratio (LER) was obtained according to Willey (1979) as follows:

$$\text{LER} = \frac{\text{Yield of maize as intercrop}}{\text{Yield of maize as sole crop}} + \frac{\text{Yield of DYLB as intercrop}}{\text{Yield of DYLB as sole crop}}$$

Collected data of both years of both crops were pooled analyzed statistically and the means were adjudged by using LSD at 5% level of significance. Cost benefit analysis was also done considering local market price of harvested crops. Monetary advantage was evaluated according to Shah *et al.* (1991) as follows:

$$\text{BCR} = \frac{\text{Gross return}}{\text{Total Cost of production}}$$

Results and Discussion

Light availability

Irrespective of treatments, availability of light on DYLB canopy was almost 100% at earlier growth stage (30 DAS) and it decreased with the increased of shade produced by maize canopy over the time up to 105 DAS and then increased up to harvest due to leaf senescence of maize. The flower initiation of DYLB started from 30 DAS. So, flowering was slightly affected with the increased of shade produced by maize canopy over the time up to 105 DAS in both years. The lowest light availability (50%) on DYLB was observed at 105 DAS in hybrid maize normal row (MNR) + 1 row DYLB treatment and the highest was observed in sole DYLB treatment and light availability on DYLB was more or less similar in MPR + 2 rows DYLB, MPR + 3 rows DYLB and MPR + 4 rows DYLB. Among the treatments, light availability on DYLB canopy was more in the paired row than normal row of maize throughout the growing period (Fig.1).

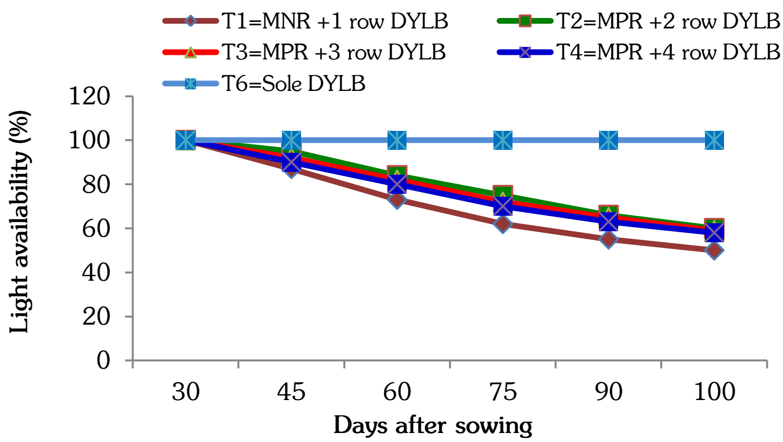

Fig.1. Light availability on DYLB canopy in hybrid maize + DYLB intercropping

Effect of intercropping on maize

Yield contributing characters and grain yield of maize influenced by intercropping have been presented in Table 1. Plant height, yield contributing characters (cob length, cob diameter, number of grains cob^{-1}, 1000 - grain weight) and grain yield of maize were not significantly differed. Although the highest grain yield ($8.07 tha^{-1}$) was recorded in sole maize due to no intercrop competition for growth resources like light, nutrients, moisture and space in sole cropping. This result corroborates with the findings of Begum *et al.* (2020) in maize + garden pea intercropping. The lowest grain yield (7.75 t ha^{-1} was recorded in MPR + 4 rows of DYLB. Grain yield in different treatments were attributed to the cumulative effect of yield components.

Table 1. Plant height, yield components and yield of maize in maize +DYLB intercropping under different planting system during two *kharif* -1 seasons (pooled analysis of 2020 and 2021)

Treatments	Plant height (cm)	Cob length (cm)	Cob diameter (cm)	Grains /cob (no.)	1000-grain wt.(g)	Grain yield (t/ha)	Yield decreased over sole maize (%)
T_1	219	16.5	4.45	511	300	7.99	1.0
T_2	219	16.7	4.38	506	290	7.85	2.7
T_3	220	16.8	4.36	503	288	7.80	3.3
T_4	220	16.8	4.35	500	285	7.75	4.0
T_5	214	16.0	4.60	516	305	8.07	-
T_6	-	-	-	-	-	-	-
$LSD_{(0.05)}$	NS	NS	NS	NS	NS	NS	-
CV (%)	6.80	4.35	4.07	8.29	5.54	7.53	-

T_1= MNR + 1 row DYLB, T_2= MPR + 2 rows DYLB, T_3= MPR + 3 rows DYLB, T_4= MPR + 4 rows DYLB, T_5= Sole maize and T_6=Sole DYL

Effect of intercropping on yield of DYLB

Yield of DYLB (pooled of *kharif-1* 2020 and 2021) in maize + DYLB intercropping has been presented in (Table 2). Yield of DYLB was significantly influenced by different planting systems. The highest vegetable /pod yield ($6.03 tha^{-1}$) was found in sole DYLB due to no intercrop competition for growth resources and higher number of plants m^{-2}. But in intercropping treatments, light availability for photosynthesis to DYLB was depended on degree of shading produced by maize canopy. Because, flowering of DYLB was slightly affected by insufficient transmitted light (light availability) through the maize canopy in intercrop situation. However, among the intercrop treatments, the highest vegetable yield (3.57 tha^{-1}) was observed in T_3 (MPR + 3 rows DYLB) treatment followed by T_1 (MNR + 1 row DYLB) treatment. The lowest vegetable yield was observed in T_2 (MPR + 2 row DYLB) due to lowest number of $plantsm^{-2}$. On the other hand, treatment T_4 (MNR + 4 rows DYLB) having the highest number of plants m^{-2} failed to produce the highest vegetable/pod yield due to more number of plants m^{-2} of DYLB which was over crowded in T_4 treatment. It might be due to T_4 had the highest number of plants m^{-2} (8.89 m^{-2}).

Table 2. Plant population, vegetable yield of DYLB, MEY and LER as influenced by maize + DYLB intercropping under different planting system (pooled analysis of *kharif-1* season 2020 and 2021)

Treatments	Plants m^{-2} (no.)	Vegetable/pod yield (t ha^{-1})	MEY (t ha^{-1})	Increased of MEY over sole maize (%)	LER
T_1	5.56	2.51	12.17	50.81	1.41
T_2	4.44	2.04	11.25	39.41	1.31
T_3	6.67	3.57	13.75	70.38	1.56
T_4	8.89	2.30	11.58	43.49	1.34
T_5	-	-	8.07	-	1.00
T_6	10.00	6.03	-	-	1.00
$LSD_{(0.05)}$	1.81	0.78	-	-	-
CV (%)	9.26	8.64	-	-	-

T_1= MNR + 1 row DYLB, T_2= MPR + 2 rows DYLB, T_3= MPR + 3 rows DYLB, T_4= MPR + 4 rows DYLB, T_5= Sole maize and T_6=Sole DYLB

Intercrop productivity

Land equivalent ratio and MEY in maize + DYLB intercropping have been presented in Table 2. The LER values were more than unity in all the intercropping systems indicated that land was more efficiently utilized under intercropping than sole cropping of maize and DYLB. The LER values in the intercrops ranged from 1.31 to 1.56 which indicated 31 to 56 % land utilization increased by intercrop cultivation. The highest LER (1.56) was observed in T_3 (MPR + 3 rows DYLB) treatment followed by T_1 treatment. Maize/pea (*Pisum sativum* L.) intercropping systems can also increase LER compared with sole cropping systems in northwest China (Yang *et al.*, 2018). On the other hand, MEY of all the intercropping systems was higher than sole maize indicating higher productivity of intercropping than sole maize. Among the intercropping, the highest MEY (13.75 t ha^{-1}) was observed in T_3 treatment (MPR + 3 rows DYLB) which was 70% higher over sole maize followed by T_1treatment. The lowest was observed in T_2 (MPR + 2 rows DYLB).

Economic return

Cost and return analysis of maize + DYLB intercropping systems have been presented in Table 3. The highest gross return (Tk. 247500 ha^{-1}) was observed in T_3 treatment (MPR + 3 rows DYLB) and it was close to T_1 due to higher MEY. The gross margin followed the similar trend of gross return. Maize /pea (*Pisum sativum* L.) intercropping systems can also increase net income, compared with sole cropping systems in northwest China (Yang *et al.*, 2018). The highest cost of production (Tk.112500 ha^{-1}) was recorded in T_4 treatment which was close to T_3 due to involvement of different costs. The highest benefit cost ratio (2.28) was obtained from T_3 (MPR + 3 rows DYLB) followed by T_1 treatment. This result has been supported by the findings of Islam *et al.* (2013) and Begum *et al.* (2020).

Table 3. Cost- benefit analysis of hybrid maize- DYLB intercropping (pooled of *kharif-1* 2020 and 2021)

Treatments	Gross return (Tk.ha^{-1})	Cost of cultivation (Tk.ha^{-1})	Gross margin (Tk.ha^{-1})	BCR
T_1	219120	105500	113620	2.08
T_2	202500	104500	98000	1.94
T_3	247500	108500	139000	2.28
T_4	208500	112500	96000	1.85
T_5	145260	96000	49260	1.51
T_6	180900	95000	85900	1.90

T_1= MNR + 1 row DYLB, T_2= MPR + 2 rows DYLB, T_3= MPR + 3 rows DYLB, T_4= MPR + 4 rows DYLB, T_5= Sole maize and T_6=Sole DYLB

Market price (Tk.kg^{-1}): Maize= 18, DYLB= 30

Conclusion

Two years result revealed that all the intercropping systems showed better productivity than sole maize. Hybrid maize paired row (30cm/120cm/30cm x 20cm) + 3 rows dwarf yard long bean and hybrid maize normal row (60cm x 20cm) + 1 row dwarf yard long bean intercropping might be agronomically feasible and economically profitable in Joydebpur.

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