J Bangladesh Agril Univ 16(1): 23–26, 2018 doi: 10.3329/jbau.v16i1.36476

ISSN 1810-3030 (Print) 2408-8684 (Online)

Journal of Bangladesh Agricultural University

Journal home page: http://baures.bau.edu.bd/jbau, www.banglajol.info/index.php/JBAU

Productivity and economics of maize–squash intercropping at different planting systems

S. Mahmud[1], M. M. Alam[2], M.M. Rahman[2], M. Amin[2] and M.M. Hassan[3]

[1]Agronomy Division, Bangladesh Agricultural Research Institution, Joydebpur, Gazipur
[2]Regional Agricultural Research Station, Hathazari, Chittagong
[3]Department of Agricultural Extension (DAE)

ARTICLE INFO

Article history:
Received: 17 January 2018
Accepted: 07 April 2018

Keywords:
Maize–squash intercropping, Paired row, Maize equivalent yield, Land equivalent ratio

Correspondence:
S. Mahmud
(sujanmahmudantor@gmail.com)

Abstract

The competitive behaviors of maize–squash intercropping at different planting systems were studied at Regional Agricultural Research Station, Hathazari, Chittagong, Bangladesh during the *Rabi* season of 2016–17 to find out the suitable planting arrangement of maize–squash intercropping for maximum productivity and economic return. There were seven treatments *i.e.* T_1= sole maize, T_2= 1 row maize (100%) + 1 row squash (6 plants/row), T_3= maize paired row (100%) + 1 row squash (5 plants/row), T_4= maize paired row (100%) + 1 row squash (4 plants/row), T_5= maize paired row (100%) + 2 row squash (5 plants/row), T_6= maize paired row (100%) + 2 row squash (4 plants/row) and T_7= sole squash. Results revealed that the Maize Equivalent Yield (MEY) was highest (18.39 t/ha) in T_5treatment, where Maize paired row (100%) + 2 row squash (5 plants/row) was consummated. The highest Land Equivalent Ratio (LER) 1.62 was found in T_5 treatment. Benefit Cost Ratio (BCR) was also the highest (3.29) in T_5 treatment. Maize paired row (100%) and two rows of squash (5 plants /row) was the suitable row arrangement of the intercrops for judicious use of land consisting optimum populations of the component crops to produce more yield and economic profit.

Introduction

Maize (*Zea mays*) is a versatile photo insensitive crop which can give high yield relatively in a shorter period of time due to its unique photosynthetic mechanism as C_4 plant (Hatch and Slack, 1998). At present maize is the third important cereal crop in Bangladesh (BBS, 2015). It can be consumed as food, feed or fodder for human, poultry or livestock, respectively. Maize can be grown in both *Rabi* and *Kharif–1* season of Bangladesh. Maize is a wide spaced crop and farmers can accommodate intercrops (mostly vegetables of *Rabi* and *Kharif–1* season) within the available interspaces of maize. Squash (*Curcubita moschata*) is a relatively new vegetable cultivated in *Rabi* season of Bangladesh. Squash mainly grows in tropical highlands of America and Africa. Hernandez *et al.* (2005) found in a survey that 50% farmers of Mexico intercropped two cultivated squash species (*Cucurbita argyrosperma* ssp. *Argyrosperma* and *Curcubita moschata*) with maize. Mixed or intercropping can increase total productivity of land through maximum utilization of natural resources (Thayamini *et. al.*, 2010). The important determinants of an intercropping system are the sensible choices of compatible crops with minimum inter–specific competition, optimum populations of the component crops as well as row arrangement of the intercrops (Lewis *et al*., 2003). In maize–squash intercropping, maize being tall statured C_4 crop has higher competitive ability for light than underneath squash (C_3 crop). Competition for light may be minimized by changing the planting pattern of without affecting the yield (Waghmare and Singh, 1982). Bavec and Bavec (2001) tested four maize cultivars plant spacing variability in double row (0.55m+0.15m) and single row spacing (0.70m) in seven plant population densities (from 4.5 to 13.0 plants/m^2). There were significant effect of planting systems and plant populations on leaf area index, net assimilation rate and double row spacing resulted in statistically higher yield than single row spacing. Akbar *et al.* (2016) showed that, narrow spacing (75 cm × 25 cm) and double row spatial arrangements increased radiation interception of maize plants by 16 to 24% and maize grain yields increased by 15 to 26% compared to wide (90 cm × 30 cm) and single row spatial arrangement. Serita (2015) worked on maize (*Zea mays*)–squash (C*ucurbita moschata*) intercropping at different plant population (squash density of 30%, 40% and 50% of total maize population) and showed that LER values decreased as squash population density increased. However in respect of Bangladesh appropriate planting system for maize–squash intercropping is inadequate. Therefore this experiment was undertaken to find out the suitable planting arrangement of squash intercropped with maize to increase the productivity and earn more profits from maize–squash cultivation.

Materials and Methods

The experiment was conducted at Regional Agricultural Research Station, Hathazari, Chittagong, Bangladesh during *Rabi* season of 2016–17. The experiment site was located in between 22°50´N latitude and 91°79´E longitude. It was situated in the Chittagong coastal plain *i.e.* agro ecological zone no. of 23. Soil texture of the experiment field was Clay loam to sandy loam and soil P^H was 6.3. The maximum temperature range was 23–25^{o}C and the minimum temperature range was 10–15^{o}C. No major rainfall occurred during the experiment period. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The unit plot size was 5m × 4m. Seven treatment combinations were used in this experiment viz. T_1= sole maize, T_2= 1 row maize (100%) + 1 row squash (6 plants/row), T_3= maize paired row (100%) + 1 row squash (5 plants/row), T_4= maize paired row (100%) + 1 row squash (4 plants/row), T_5= maize paired row (100%) + 2 row squash (5 plants/row), T_6= maize paired row (100%) + 2 row squash (4 plants/row), T_7= sole squash. The spacing of Sole maize and maize normal plating was (75 cm × 25 cm) whereas in maize paired row planting, spacing was row to row distance 37.5 cm and plant to plant distance was 25 cm (BARI, 2014). Among the treatments there was no difference in total plant populations/area of maize. Sole squash spacing was 100 cm × 80 cm. Squash var. Hybrid Bulam House and maize var. BARI Hybrid maize–9 were used in the experiment. On15th November, 2016 maize seeds were sown and 15 days old squash seedlings were transplanted according to the treatments. Fertilizers were applied @ $N_{100}P_{40}K_{80}S_{10}Zn_5B_{1.2}$ kg/ha; @ $N_{260}P_{72}K_{148}S_{48}Zn_4B_2$ kg/ha and @ $N_{300}P_{73}K_{150}S_{50}$ Zn_6B_2 kg/ha for sole squash, sole hybrid maize and intercropping respectively (BARC, 2015). The sources of N, P, K, S, Zn and B were urea, triple super phosphate (TSP), muriate of potash (MoP), gypsum, zinc sulphate and boric acid, respectively. All fertilizers except N were applied at the time of final land preparation. Nitrogen was side dressed in three equal splits at 10, 30 and 50 days after planting followed by light irrigation. Fungicide (Dithane M 45) @ 1ml/liter water was sprayed at every 10–day interval beginning from 25 days after planting to 70 days after planting for preventing fungal disease. Pheromone traps (Cue lure) were used to control cucurbit fruit fly in the squash field @ 10 traps/ha from 30days after planting up to harvesting of squash (Cork *et al.,* 2003). Squash was harvested upon maturity from the last week of January to 2ndweek of February, 2017 and maize was harvested at3rdweek of April, 2017 upon maturity. Data on yield contributing parameters of maize such as plant height (cm), no. of cobs/plant, cob length (cm), weight of 1000 grain (g) and seed yield/plot (kg) were recorded. Data on yield contributing parameters of squash such as no. of fruits/plant, average fruit weight (g), weight of fruits/plant (kg), and fruit yield/plot (kg) were also recorded. All the data were statistically analyzed using R–package. Plot yields were converted to crops yield in t/ha. Component crop (squash) yields were converted to maize equivalent yield using the following formula: MEY = Ym+ {(Ys× Ps) /Pm}.

Here, MEY = maize equivalent yield, Ym= yield of maize; Ys= yield of squash; Ps= selling price of squash; Pm= selling price of maize (Thayamini *et. al.,* 2010 and Uddin *et. al.,* 2009).

The land equivalent ratio (LER) was calculated using the following formula: LER = $(Y_iC_1/YsC_1) + (YiC_2 / YsC_2)$

Here, Y_iC_1=intercropping yield of crop1; YsC_1=sole cropping yield of crop1;

YiC_2=intercropping yield of crop2; YsC_2=sole cropping yield of crop2 (Begum *et al.,* 2016, Uddin *et. al.,* 2009 and Metwally *et. al.,* 2015).

When LER value is higher than 1 it means there is an advantage of intercropping in terms of the use of resources for the plant growth compared to sole cropping. When LER value is lower than 1 it means that sole cropping use the resources more efficiently in comparison with intercropping (Sullivan, 1998). Cost of production, gross returns and net returns were calculated. Benefit cost ratio (BCR) was calculated by the formula of, BCR = Gross Return/ Cost of production (Esmat *et al.,* 2011).

Results and Discussion

Yields obtained in the sole maize (10.98 t/ha) and sole squash (35.00 t/ha) were significantly higher than yields achieved in the maize–squash intercropping (Table 1 and Table 2). The results were in an agreement with Islam (2002) in hybrid maize + bush bean intercropping. According to Islam (2002) plants having more space, light and nutrients grow luxuriously to produce higher yield than respective intercropping treatments. The reduction of maize and squash yields in different variants of intercropping in relation to sole crops was also established in previous studies (Silwana and Lucas 2002). Results showed that maize plant height (cm) was not statistically significant among the treatments (Table 1). The highest no. of cobs/plant (2.98), cob length (19.92 cm), 1000 seed weight (358.66 g) and seed yield/plot (21.96 kg) were produced by the treatment T_1 (sole maize) followed by T_4(Maize paired row (100%) + 1 row squash (4 plants/row)). Yield of maize decreased in treatment T_5 (maize paired row (100%) + 2 row squash (5 plants/row)) and T_6 (maize paired row (100%) + 2 row squash (4 plants/row)) due to the increase of number of squash plants. According to Mashingaidze (2004), in case of intercropping squash plants competes with other component crops for light, water and nutrients. So due to increase of number of squash plants maize yield decreased. Differences between treatments in no. of fruits/plants of squash were not statistically significant (Table 2). The highest average fruit weight (1090 g) and weight of fruits/plant (4.36 kg) were obtained in the T_7 (sole squash). The lowest average fruit weight (590 g) and weight of fruits/plant (2.12 kg) were in the T_2 treatment and was statistically similar with T_6.

The highest squash yield (35.00 t/ha) was obtained from treatment T_7 and the lowest squash yield (19.05t/ha) was observed in T_2 where Maize paired row (100%) + 1 row squash (6 plants/row) was practiced. This might be due to intercrop competition for growth resources like light, nutrients, moisture and space. This corroborates with the findings of Hernendez *et al*. (1997) and Thayamini *et al.* (2010). Here results also revealed that T_5 *i.e* maize paired row (100%) + 2 row squash (5 plants/row) had the highest LER (1.62) and MEY (18.39 t/ha) where yields of the component crops were also highest among the intercropping treatments (Table 3). Productivity increased with optimum ratio of number of component crops because it enhance greater penetration of radiation to the companion crop and increase dry matter accumulation (Begum *et al.*, 2016). In case of economic analysis from Table 3 it was clearly evident that all the intercropping treatments gave higher gross returns, net returns and BCR than sole cropping for both component crops. This was supported by the findings of Esmat *et al.* (2011). The highest gross return (275850 Tk/ha), net return (191850 Tk/ha) and BCR (3.29) were found from treatment T_5 where maize paired row + 1 row squash (5 plants/row) was practiced (Table 3).

Table 1. Yield and yield contributing characters of maize under varying planting system of maize–squash intercropping

Treatment	Plant height (cm)	Cobs/plant (no.)	Cob length (cm)	Weight of 1000-grain (g)	Seed yield/plot (kg)	Yield (t/ha)
T_1	202	2.98	19.92	358.66	21.96	10.98
T_2	198	2.48	17.54	323.67	18.58	9.29
T_3	197	2.51	17.61	331.40	19.00	9.50
T_4	195	2.57	18.29	352.87	20.18	10.09
T_5	199	1.98	16.21	323.14	16.48	8.24
T_6	195	2.09	16.51	315.00	16.96	8.48
T_7	–	–	–	–	–	–
CV (%)	8.90	4.61	3.85	6.34	5.04	6.14
LSD	12.04	0.54	1.08	19.67	3.09	1.34
Lev of sig	NS	*	*	*	**	**

In a column, ‘CV’= Coefficient of variation, ‘LSD’=least significant differences ‘*’= Significant at 5% level, **= Significant at 1% level, ‘NS’=Non significant, T_1= Sole maize, T_2= 1 row maize (100%) + 1 row squash (6 plants/row), T_3= Maize paired row(100%) + 1 row squash (5 plants/row), T_4= Maize paired row(100%) + 1 row squash (4 plants/row), T_5=Maize paired row(100%) + 2 row squash (5 plants/row), T_6=Maize paired row(100%) + 2 row squash (4 plants/row), T_7= Sole squash

Table 2. Yield and yield contributing characters of squash under varying planting system of maize–squash intercropping

Treatment	Fruits/plant (no.)	Average fruit weight (g)	Weight of fruits/plant (kg)	Fruit yield/plot (kg)	Yield (t/ha)
T_1	–		–		–
T_2	3.60	590	2.12	38.10	19.05
T_3	3.30	990	3.27	40.26	20.13
T_4	3.95	580	2.29	45.00	22.50
T_5	3.80	1050	3.99	60.90	30.45
T_6	3.89	590	2.28	49.44	24.72
T_7	4.00	1090	4.36	70.00	35.00
CV (%)	7.09	12.40	10.25	5.08	6.97
LSD	3.06	99.10	0.503	12.89	3.87
Lev of sig	NS	**	*	**	**

In a column, ‘CV’= Coefficient of variation, ‘LSD’=least significant differences ‘*’= Significant at 5% level, **= Significant at 1% level, ‘NS’=Non significant, T_1= Sole maize, T_2= 1 row maize (100%) + 1 row squash (6 plants/row), T_3= Maize paired row(100%) + 1 row squash (5 plants/row), T_4= Maize paired row(100%) + 1 row squash (4 plants/row), T_5=Maize paired row(100%) + 2 row squash (5 plants/row), T_6=Maize paired row(100%) + 2 row squash (4 plants/row), T_7= Sole squash

Table 3. Economic analysis of maize–squash intercropping under varying planting system

Treatment	Maize yield (t/ha)	Squash yield (t/ha)	Maize equivalent yield (t/ha)	LER	Gross return (Tk/ha)	Total variable cost (Tk/ha)	Net return (Tk/ha)	BCR
T_1	10.98	–	10.98	1.00	164700	60000	104700	2.75
T_2	9.29	19.05	15.64	1.39	234600	84000	150600	2.79
T_3	9.50	20.13	17.69	1.44	265350	84500	180850	3.14
T_4	10.09	22.50	17.59	1.56	263850	86000	177850	3.07
T_5	8.24	30.45	18.39	1.62	275850	84000	191850	3.29
T_6	8.48	24.72	16.72	1.48	250800	85500	165300	2.93
T_7	–	35.00	11.67	1.00	175050	70000	105050	2.50

T_1= Sole maize, T_2= 1 row maize (100%) + 1 row squash (6 plants/row), T_3= Maize paired row(100%) + 1 row squash (5 plants/row), T_4= Maize paired row(100%) + 1 row squash (4 plants/row), T_5=Maize paired row(100%) + 2 row squash (5 plants/row), T_6= Maize paired row(100%) + 2 row squash (4 plants/row), T_7= Sole squash, Selling price of Maize 15 Tk/kg and Squash 5Tk/kg, Wage rate (man–day 8 hours) = 500 Tk/day/labour, seed =50 Tk/Kg Urea=16 Tk/kg, TSP=22 Tk/kg, MOP=15Tk/kg, Cue lure=600 Tk/ha, Dithane (M 45)=500 Tk/L, Irrigation =1000 Tk/day

Conclusion

From this study, it is inferred that maize paired row (100%) + 2 row squash (5 plants/row) would give higher crop production, better land use efficiency and increase income than sole cultivation of each crop species.

References

Akbar, M.A., Siddique,M. A., Marma, M.S., Rahman, M.M., Molla, M.R.I., Rahman, M.M., Ullah, M.J., Hossain, M.A. and Hamid, A. 2016. Planting Arrangement, Population Density and Fertilizer Application Rate for White Maize (*Zea mays* L.) Production in Bandarban Valley. J. Agril. Forestry and Fisheries.5 (6):215–224.

BARC. 2015. Fertilizer Recommendation Guide, Bangladesh Agricultural Research Council, New Airport Road, Farmgate, Dhaka Bangladesh. pp. 73–100.

BARI. 2014. Krishi Projukti Hatboi (in Bengali), Bangladesh Agricultural Research Institute, Gazipur 1701, Bangladesh. 6th edition. pp. 65–75.

Bavec, F. and Bavec,M. 2001. Effect of maize plant double row spacing on nutrient uptake, leaf area index and yield. J. Rost. Vyroba. 47(3): 135–140.

BBS (Bangladesh bureau of statistics). 2015. Statistical Pocket Book of Bangladesh. Statistics and Informatics Division, Ministry of Planning, Government of the People's Republic of Bangladesh. pp. 91–93.

Begum, A.A., Bhuiya, M.S.U., Hossain, S.M.A., Khatun, A. and Das, S.K. 2016. Effect of planting system of potato and plant density of maize on productivity of potato– hybrid maize intercropping system. Bangladesh J. Agril. Res. 41(3): 397–409.

Cork, A., Kamal, Q.N., Alam, S.N., Choudhury, S.C.J. and Talekar,N.S. 2003. Pheromones and their application to insect pest control–A Review. Bangladesh J. Entomol., 13: 1–13.

Esmat, B. A., Islam, M.N, Alam. Q.M and Hossain,S.M.B. 2011. Profitability of some BARI released crop varieties in some locations of Bangladesh. Bangladesh J. Agril. Res., 36(1): 111–122.

Hatch, M.D. and Slack,C.R. 1998. C_4 photosynthesis: discovery, resolution, recognition and significance. Discoveries in Plant Biology, World Scientific Publishing, Singapore.1:175–196.

Hernandez, C.S.L., Pino, M. and Delos, A. 1997. Different crop association systems with pumpkin (*Cucurbita moschata* Duch. cv. *mariucha*.). Report on Cucurbit genetics cooperative. (20):53.

Hernandez, S.M., Merrick, L.C. and Luis E. 2005. Maintenance of Squash (*Cucurbitaspp*.) landrace diversity by farmers' activities in México. J. Gen. Res. Crop Evol. 52(6): 697–707.

Islam, M.N.2002.Competitive interference and productivity in maize–bush bean intercropping system, PhD Thesis, Dept. Agron., Bangabandhu Sheikh Mujibur Rahman Agril. Univ., Gazipur, Bangladesh.

Lewis, W., Jett, Chasm, J.S. and Conley, S.P. 2003. Intercropping systems for tomato within a high tunnel, Report submitted to Dept. of Horticulture, Missouri Univ. Colombia, pp.118.

Mashingaidze, A.B. 2004. Improving weed management and crop productivity in maize systems in Zimbabwe. PhD Dissertation, Wageningen University, Wageningen.

Metwally, A.A., Safina, S.A. and Noaman, A.H. 2015. Yield and land equivalent ratio of intercropping maize with Egyptian cotton. J. Agri–Food & Appl. Sci., 3(4):85–93.

Serita, M. 2015. Effects of intercropping maize (*Zea mays*) with butternuts (*Cucurbita moschata*) at varying butternut population levels on maize growth yield and weed suppression. MS thesis. Dept. of Horticulture, Midlands state Univ. USA, pp.3–4.

Silwana, T. and Lucas, E.O. 2002. The effect of planting combinations and weeding on the growth and yield of component crops of maize/bean and maize/pumpkin intercrops. J. Agril. Sci. 138: 193–200.

Sullivan, P. 1998. Intercropping Principles and Production Practices. Appropriate Technology Transfer for Rural Areas (ATTRA), Fayetteville Publications, Arizona, pp.230.

Thayamini, H., Seran and Brintha, I. 2010. Review on Maize Based Intercropping. J. Agron. 9(3):135–145.

Uddin, M.J., Quayyum, M.A. and Salahuddin, K.M. 2009. Intercropping of hybrid maize with short duration vegetables at hill valleys of Bandarban. Bangladesh J. Agril. Res. 34(1): 1–57.

Waghmare, A.B. and Singh, S.P. 1982. Total Productivity and Net Returns of Different Sorghum–Legume Intercropping Systems under Varying N Levels. Indian J. Agron. 27: 423-428.