Progressive Agriculture 28 (2): 92-99, 2017 ISSN: 1017 - 8139

Progressive Agriculture
Journal homepage:http://www.banglajol.info/index.php/PA

Performance of ash gourd (*benincasa hispida*) in intercrop with different leafy vegetables

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Abstract

Due to depletion of per capita land, consistent stress on improving factor productivity has warranted many alternative cropping strategies. The intercropping effect of red amaranth (*Amaranthus gangeticus* Linn, var. BARI Lalshak-1), jute leaf (*Corchorus capsularis*, var. Local) and stem amaranth (*Amaranthus tricolor* var. BARI Data-1) on the yield performance and thereby economic return of ash gourd as main crop was tested in low nitrogen and medium phosphorus and potassium under Netrakona district of Bangladesh. The experiment consisted of four crop combinations viz., sole ash gourd, ash gourd + red amaranth, ash gourd + jute leaf and ash gourd+ stem amaranth.Companion vegetables did not influence on the yield and yield parameters of ash gourd. Although, the highest yield was obtained from sole ash gourd (34.11 t ha^{-1})which was close to ash gourd + jute leaf (30.65 t ha^{-1}) followed by ash gourd + red amaranth (29.34 t ha^{-1}) intercrop combination. By intercropping of ash gourd with different vegetables, total productivity increased up to 6-16% over sole ash gourd due to the contribution of companion crops. The highest ash gourd equivalent yield (39.61 t ha^{-1}) was recorded from ash gourd + stem amaranth combination. Ash gourd + stem amaranth combination gave the highest monetary returns in respect of gross return (Tk. 296880 ha^{-1}) and gross margin (Tk. 174433 ha^{-1}). The LER and ATER value for all the treatments were above one and this indicated that intercropping in ash gourd is biologically efficient. Considering the experimental findings, ash gourd + stem amaranth might be suitable combination for higher productivity and economic return.

Key words: Intercropping, yield advantages, equivalent yield, LER, ATER, companion crop

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Introduction

Ash gourd (*Benincasa hispida* Thumb.) is a favorite palatable cucurbitaceous vegetable crop grown extensively throughout the tropical and sub-tropical countries. It is a popular summer as well rainy season vegetables fulfill the demanded need of lag period consumption of nutrient from vegetable sin Bangladesh. It is moisture enriched vegetable contained nearly 96% water and a great source of vitamin B1, B3 and vitamin C and also possesses carbohydrates and various minerals such as calcium, sodium, zinc, iron, phosphorus. Ash gourd is a major contributor to the total vegetable production in Bangladesh in an account2.63%grown over an area of 24 thousand acres with a total production of 72 thousand metric tons (BBS, 2015) and plays an important role in the economy of Bangladesh farmers. In addition to provision of food value and of the place of vegetables in the nation food requirement ash gourd

production has increased in recent years which in an account 29.48 ton in 1994-95 and it increased to 32.69 ton in 1996-97 (BBS, 1998). Generally, ash gourds are grown as mono cultured crop by keeping wider spacing about 2m × 2m in between two rows. This space remained vacant until the whole canopy development providing ample chance of weed to grow which uptake huge nutrient and moisture from soil. Moreover, ash gourd is slow growth in early stage and has taken a long duration to cover the whole trellis. In this context, growing high value leafy vegetables as intercrop at early growth stage in between the wider spacing of ash gourd might be of great interest in vegetable production. Noteworthy, the rapidly increasing population in Bangladesh is continuously adding to the demand for food, feed, fodder and fuel as well as other plant products. This increasing demand has to be met by utilizing the natural resources which is getting decreased due to increasing urbanization. Shortage of vegetables is another problem which demands a simultaneous increase in the production of ash gourd and leafy vegetables to meet the problem. Hence, it is necessary to augment for vegetable production through intensifying the cultivation by combination of different vegetable crops utilizing the available resources more efficiently and by adopting an efficient cropping system.

Intercropping is an important tool for multiple cropping systems has been practiced by farmers for many years in various ways and has played a very important role in modern agriculture as well. It is a type of mixed cropping of cultivating two or more crops in the same space at the same land (Andrew and Kassam, 1976) to increase productivity per unit land area (Singh *et al*., 1992; Islam *et al*., 2010;Woolley and Devis, 1991; Francis, 1989)by utilizing all environmental resources. Besides this, intercropping offered several advantages from the view point of economy of space, saving tillage, complete utilization of the surplus nutrients, minimize crop risk, better utilization of soil moisture and increased returns from land unit area. The biggest complementary effect as thus biggest yield advantages in intercropping system is achieved by selecting the component crop growing periods, height, root system, nutrient requirements so that the crops can utilize the resources efficiently (Reddy and Willey, 1981). Choosing of appropriate crop combination (Santalla *et al*., 2001), population density and planting geometry of component crops (Myaka, 1995) is a good marker for achieving higher yield potential in intercropping system. Greater productivity of intercropping system is possible by minimizing inter-specific competition and thereby maximizing the use of growth resources (Islam, 2002).Most intercropping researches have focused on field crops (Kubota *et al*., 2015; Ghosh *et al*., 2006; Tsubo *et al*., 2005). Indeed, a little research indicated that intercropped vegetables would be a suitable choice to improve vegetable production per unit area (Varghese, 1999; Varghese, 2013; Rodge and Yadlod, 2009). However, a few studies evident have received on the effects of intercropping on ash gourd than mono cultured ash gourd. Although, Joseph and Balan (2008) reported that additional production could be realized by intercropping of short duration vegetables with ash gourd by utilizing the wider space in the higher pre-bearing period. Consequently, the present investigation was carried out to evaluate the performance of ash gourd in intercropping with leafy vegetables and to find out a suitable companion crop for higher yield and economic return.

Materials and Methods

***Experimental site*:** The experiment was conducted at the farmers' field of Shamgonj under Netrakona district of Bangladesh. The experimental site was located at about 24˚53′ 0″ North and 90˚43́ 0″ E longitudes. The soil of experimental site was silt loam to silty clay loam having pH 6.4 and 1.07% organic carbon of medium highland under the Agro-Ecological Zone-9 (AEZ-9). Soils at 0-15 cm depth are low in N (0.056%), medium in P (16.8 µg ml^{-1}), K (0.19 meq $100ml^{-1}$) and B (0.34 µg ml^{-1}), optimum in S (25.6 µg ml^{-1}) and Zn in high (1.82µg ml^{-1}).

***Experimental and crop culture*:** The crop varieties were used in this intercropping system as for ash gourd, BARI Ash gourd-1, red amaranth, BARI Red amaranth-1, stem amaranth, BARI Stem amaranth-1 and jute leaf as of local. The following crop combinations were treated as treatment Sole ash gourd, Ash gourd + red amaranth, Ash gourd + jute leaf and Ash gourd + stem amaranth. For ash gourd, row to row spacing was maintained 20 cm and plant to plant as of 20 cm in a plot of 4m × 2.5m. Thirty days old seedling of ash gourd was planted on March 01, 2015, the same day seeds of red amaranth, jute leaf and stem amaranth were broadcasted on in the field. The treatments were laid out in a randomized complete block design (RCBD) with four replications. The plots were fertilized with 75-30-60-29-2-1 kg N-P-K-S-Zn-B ha^{-1} in the form of urea, triple super phosphate, muriate of potash, gypsum, zinc sulphate and boric acid. A blanket dose of 5 t cow dung ha^{-1} was applied during final land preparation. The entire amount of gypsum, zinc sulphate, boric acid, one fourth of cow dung, half of TSP and one third of MoP were applied as basal during final land preparation. Rest cow dung and TSP were fertilized in pit 7-10 days prior to transplanting of seedling. Remaining MoP was applied in two equal installments at 7-10 days before planting and 10-15 days after planting the seedling, respectively in the pit. All urea was top dressed in four equal installments at 10-15, 30-35, 50-55 and 70-75 DAP in pit.

***Production efficiency*:** Now a day, farmers are concerned mostly in total profit and marginal benefit: cost ratio from investment in labor and inputs (Ghosh, 2004). The yield and economic performance of intercropping was assessed to determine whether the ash gourd yield and additional red amaranth or jute or stem amaranth yield were sufficient to convince farmers for practicing intercropping system. For comparing, the economic values of systems, the yields were converted into gross return. The yields of sole and intercrop of ash gourd was converted into red amaranth or jute leaf or stem amaranth equivalent yield on financial basis, following the formula of Prasad and Srivastava (1991) and expressed as AEY=Yield of ash gourd +Yield of intercrop × unit price of intercrop /unit price of ash gourd. However, the AEY does not indicate the net gain obtained from the cropping system and also does not explain the land use pattern on the cropping system. As yield is a function of duration and land use utilization, Hiebsch (1978) suggested that area time equivalent ratio (ATER) is a better index for assessing yield advantage in intercropping system. In the present study, the companion crops were of different maturity periods, thus, ATER was calculated as

$$ATER = [(Y_a/S_a) \times T_a + (Y_b/S_b) \times T_b]/T$$

Where Y_a= Yield of 'a' in intercropping, S_a= Yield of 'a' in sole cropping, Y_b= Yield of 'b' in intercropping, S_b= Yield of 'b' in sole cropping, T_a= duration of 'a', T_b= duration of 'b', T= Total duration of intercropping system. The ATER value is greater than unity indicates more efficient use of area and time.

On the other hand, land equivalent ratio (LER) was used as the criteria for measuring the efficiency of intercropping advantages using the resources of environment compared to monoculture (Mead and Willey, 1980) and it was calculated by the following formula

$$LER = Y_{ab}/Y_{aa} + Y_{ba}/Y_{bb}$$

Where, Y_{aa} and Y_{bb}= Sole yields of crop 'a' and 'b' respectively, Y_{ab} and Y_{ba}= Mixture yield of crops 'a' and 'b' respectively (Willey, 1979).

The LER value is greater than unity, the intercrops favors the growth and yield of the species. When the LER value is lower than one, the intercropping negatively effects on growth and yield of crops grown in mixtures (Caballero *et al*., 1995).

***Data collection and analysis*:** After attaining maturation red amaranth, jute and stem amaranth were harvested on 35, 30 and 45 days after sowing respectively, harvest of ash gourd was started on May 05 and it continued up to July 02, 2015. Benefit cost analysis was done with the prevailing price of ash

gourd, red amaranth, jute leaf and stem amaranth in the local market. Five ash gourds from each plant were selected randomly to collect data on yield components. Then all data were computed and analyzed statistically using statistical software MSTAT-C (Gomez and Gomez, 1984) and means were separated by Duncan's Multiple Range Test (DMRT) at 5% level of significance.

Results and Discussion

***Yield and yield attributes of ash gourd*:** The yield attributing parameters and yield of ash gourd were found to be affected by different intercropping systems. Although, the fruit circumference and average fruit weight per plant does not differed significantly due to intercropping combinations (Table 1). The number of fruits per plant showed significant difference due to different treatment combinations. The sole ash gourd produced the highest number of fruits per plant (12.13) while it was lowest in ash gourd + stem amaranth treatment (10.35) at finally harvested stage. Significantly the highest fruit length (24.13 cm) was observed in sole ash gourd followed by ash gourd + red amaranth (20.61cm) and it was lowest in ash gourd + stem amaranth. It might be due to fact that sole ash gourd up take maximum nutrient and got greater inter-space for growth than intercrop. Sole ash gourd significantly produced the highest fruit weight (1.29 kg) followed by ash gourd + jute leaf (1.07 kg). This might associated with the longer length of fruit. Both of the fruit length and individual weight of fruit might contributed to be the highest fruit weight per plant (16.86 kg) which was very close to ash gourd + red amaranth. Sole ash gourd significantly produced the highest fruit yield (34.11 t ha^{-1}) which was followed by ash gourd + jute leaf (30.65 t ha^{-1}) combination (Figure 1). Better yield of sole ash gourd and ash gourd + jute leaf treatment compared to red amaranth and stem amaranth might associated with the highest number of fruits per plant, their length and highest weight per fruit as well as average fruit weight per plant. This implies that more utilization of natural farm resources by combined cultivation of red or stem amaranth than sole or jute leaf. On the other hand, the yield of ash gourd in sole was highest due to getting non inter-specific competition, growth and nutrient uptake. The lowest yield (25.57 t ha^{-1}) of ash gourd was in ash gourd intercropped with stem amaranth which was significantly similar to ash gourd +jute leaf and ash gourd + red amaranth combination might be due to shoot growth of jute leaf or red amaranth or stem amaranth hampered the vegetative or reproductive growth of ash gourd. The findings of higher yield of monoculture as compared to intercropped are agreement with those Akhtar *et al*. (2015) and Rodge & Yadlod (2009).

Table 1. Yield attributes of ash gourd as sole and intercrop as influenced by different intercropping system

Crop combinations	Fruit plant^{-1} (no)	Fruit length (cm)	Fruit circumference (cm)	Individual fruit wt (kg)	Average fruit wt plant^{-1} (kg)
Sole ash gourd	12.13	24.13	11.56	1.29	16.86
Ash gourd +red amaranth	11.03	20.92	10.61	1.01	14.37
Ash gourd +jute leaf	11.38	22.58	11.09	1.07	14.23
Ash gourd+ stem amaranth	10.35	19.99	9.76	0.98	12.40
LSD ($_{0.05}$)	0.98	3.08	NS	0.72	NS
CV (%)	5.45	8.79	11.38	5.82	10.23

NS=Not significant

***Yield of companion crop*:** The yield of intercrop in intercropping system varied in different type of vegetables due to combined cultivation with ash gourd (Figure 1). The yield of red amaranth, jute leaf and stem amaranth were recorded as 8.3, 7.3 and 19.7t ha^{-1}respectively, in ash gourd + red amaranth, ash gourd + jute leaf and ash gourd + stem amaranth combinations (Figure 1). The intercrop stem amaranth yielded the highest (19.7 t ha^{-1}) in ash gourd + stem amaranth combination followed by red amaranth and jute leaf in ash gourd plus red amaranth and jute leaf treatment. This might be due to the fact that the physiological structure of ash gourd and thereby up taking enoughnutrient from soil and ample space to grow at vegetative stage.

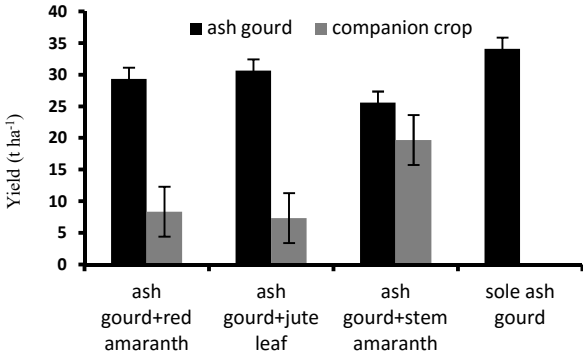

Figure 1. Fruit yield of ash gourd as sole and yield of companion crops as influenced by different intercropping system. The error bars are the standard deviation of the means (n=4)

By intercropping of ash gourd with different vegetables, the yield of ash gourd significantly reduced up to 10 to 25 % (Figure 2). This might be due to the fact that the inter-specific competition for space, solar radiation, nutrient uptake or water absorption. Ash gourd + stem amaranth combination reduced 25% ash gourd yield followed by ash gourd + red amaranth (14%) while the minimum yield loss was observed in ash gourd + jute leaf (10%) intercrop system. The negative impact of yield in main crop in intercropping system was reported by Varghese (2013) in cabbage of cabbage plus radish intercropping system. The yield loss due to intercropping was also reported by Begum *et al*. (2015), Ahmed *et al*. (2013) and Muoneke and Ndukwe (2008).

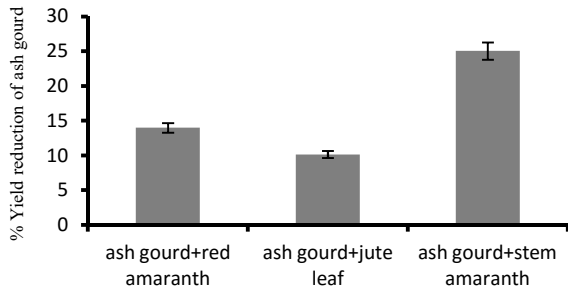

Figure 2. Per cent yield reduction of ash gourd in intercropped over sole ash gourd as influenced by different intercropping system. The error bars are the standard deviation of the means (n=4)

Yield advantage: The advantageous effect of ash gourd in intercropping system was expressed by ash gourd equivalent yield and that was influenced by different intercropping systems (Figure 3). The ash gourd equivalent yield was greater in ash gourd + stem amaranth intercropping system than in sole cropping of ash gourd. Among the treatment, all intercrop combinations produced higher AEY over sole ash gourd. The greater AEY was found in ash gourd + stem amaranth (39.61 t ha^{-1}) followed by ash gourd + jute leaf (36.93 t ha^{-1}) and lowest one was recorded from ash gourd + red amaranth (36.48 t ha^{-1}) combination might be due to market price and yield of companion crop. Over the study, 7-16% yield advantage was observed in different intercropping combinations over sole ash gourd (Table 2). Of them 16% yield advantage was observed in ash gourd + stem amaranth treatment over sole ash gourd.

Land equivalent ratio is the index of yield advantage of intercropping system over sole cropping. The maximum LER was found in ash gourd + red amaranth (1.69) followed by ash gourd + stem amaranth (1.64) and the lowest was observed in ash gourd + jute leaf

intercropping (Table 2). In this study, all three combinations showed more than unit of LER which indicated an advantage in intercropping over sole in terms of the use of environmental resources for plant growth. The results of the present study indicated that 51 to 69% more area would be required by a sole cropping system to recover the yield of intercropping system. Higher LER values (32-46%) of cotton based intercrop with cowpea and sorghum have also been reported by (Aasim *et al*., 2008). Area time equivalent ratio provides yield advantage of intercropping over sole cropping in terms of variation in time taken by component crops of different intercropping system. The ATER values showed an advantage of 6 to 7 % in all planting system than sole cropping with maximum (1.07) advantage from ash gourd + jute leaf or ash gourd + stem amaranth (Table 2). The lowest ATER (1.06) was recorded in ash gourd + red amaranth intercropping system.

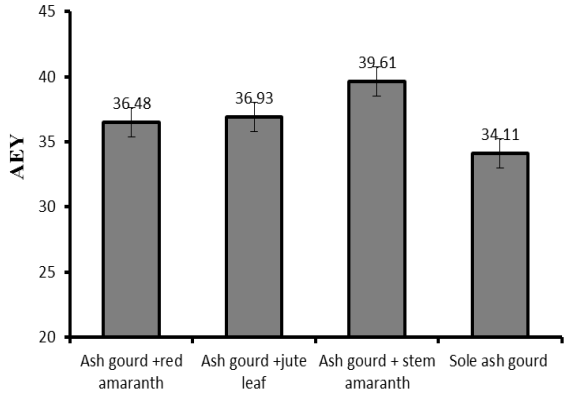

Figure 3. Ash gourd equivalent yield (AEY) in different intercrop based cropping system over sole ash gourd

Table 2. Per cent yield increase, land equivalent ratio and area time equivalent ration of ash gourd intercropping with red amaranth, jute leaf and stem amaranth

Crop combination	Yield increased over sole ash gourd (%)	LER			ATER	
		Ash gourd	Intercrop	Total	Intercrops	Total
Sole ash gourd	-	1.00	-	1.00	-	1.00
Ash gourd + red amaranth	6.95	0.86	0.83	1.69	0.20	1.06
Ash gourd + jute leaf	8.28	0.90	0.61	1.51	0.17	1.07
Ash gourd + stem amaranth	16.13	0.75	0.89	1.64	0.32	1.07

***Cost and return analysis of ash gourd based intercropping system*:** The monetary advantage values were positive which showed a definite yield advantage in all intercropping system compared to sole cropping. The highest gross return (296880 Tk ha^{-1}) as well as gross margin (174433 Tk ha^{1}) were obtained from ash gourd + stem amaranth combination. Whereas, the minimum gross return (238770 Tk ha^{-1}) and gross margin (119923 Tk ha^{-1}) were recorded from sole ash gourd cropping system (Table 3). The variations in gross returns from different intercropping system were mainly due to difference in yield and market prices. Considering the economics of intercropping, ash gourd + stem amaranth combination was found to be the best with highest economic return, LER and other competition indices.

Table 3. Cost and return analysis of different ash gourd based intercropping system

Treatments	Gross return (Tk ha^{-1})	Variable cos (Tk ha^{-1})	Gross margin (Tk ha^{-1})
Sole ash gourd	238770	118847	119923
Ash gourd + red amaranth	255360	122472	132888
Ash gourd + jute leaf	251200	128147	123053
Ash gourd + stem amaranth	296880	122447	174433

Price of input and output (Tk kg^{-1}): Urea: 16, TSP: 20, MOP: 16, Gypsum: 10, Zinc sulphate: 150, Boric acid: 300, Ash gourd seed: 600 (Tk kg^{-1}),red amaranth seed: 250 (Tk kg^{-1}), jute seed: 900 (Tk kg^{-1}), stem amaranth: 200 (Tk kg^{-1}), Selling price (Tk kg^{-1}): Ash gourd: 7, Red amaranth: 6, Jute leaf: 6, Stem amaranth: 5

Conclusion

The practice of intercropped in vegetable culture is still not a popular practice in Bangladesh. Any attempt to improve total vegetable production under a given agro-climatic condition would therefore open a new frontier for better use of available resources. The findings of present study have provided sound basis that ash gourd intercropped with other vegetables like red amaranth, jute leaf or stem amaranth would be highly remunerative compared to sole crop of ash gourd. Considering the study result leads to the conclusion that there is effective utilization of space when intercrops are raised along with ash gourd and stem amaranth in higher pre-bearing period. The value of competition functions clearly reveals the bio suitability of ash gourd based intercropping system. It is also found that ash gourd intercropped with stem amaranth is more profitable than sole crop ash gourd.

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