ISSN 0258-7122 (Print), 2408-8293 (Online)
Bangladesh J. Agril. Res. 50(4): 443-452, December 2025

YIELD ADVANTAGE AND LAND USE EFFICIENCY OF BUSH BEAN - SORGHUM INTERCROPPING SYSTEMS

M. Z. ALI[1], A. A. BEGUM[2], J. A. CHOWDHURY[3], S. AKHTER[4] AND M. A. H. KHAN[5]

Abstract

The experiment was conducted at the Agronomy Research Field of Bangladesh Agricultural Research Institute (BARI), Gazipur during *rabi* seasons of 2021-22 and 2022-23 to find out the suitable crop combination of bush bean with sorghum for increasing total productivity, economic return, maximizing land utilization through intercropping system. Six treatments *viz.,* T_1= Sorghum normal row 100% (60 cm line to line × 20 cm plant to plant) + 1 row bush bean (30 cm line to line × 5 cm plant to plant; 43.75%) in between two rows of sorghum, T_2= Sorghum normal row 100% (60 cm × 20 cm) + 2 row bush bean (30 cm × 5 cm; 87.75%) in between two rows of sorghum T_3= Sorghum paired row 100% (30 cm-120 cm-30 cm × 20 cm) + 2 row bush bean (30 cm × 5 cm; 37.50%) in between two paired rows of sorghum , T_4= Sorghum paired row 100% (30 cm-120 cm-30 cm X 20 cm) + 3 row bush bean (30 cm × 5 cm; 56.25%) in between two paired rows of sorghum , T_5= Sole sorghum (60 cm × 20 cm) and T_6= Sole bush bean (30 cm × 5 cm) were used. Light availability on bush bean decreased with the increase of shade produced by sorghum canopy over the time up to 65 Days After Sowing (DAS) (). The lowest light availability on bush bean was in T_2 treatment which was sorghum normal row 100% (60 cm × 20 cm) + 2 row bush bean (30 cm × 5 cm; 87.75%) in between two rows of sorghum. The maximum grain yield of sorghum was observed in sole crop 4.58 t ha^{-1} and it was decreased by 2.84-20.74% among the intercrop combination. The highest sorghum equivalent yield (SEY) of 9.00 t ha^{-1}, gross return (Tk. 1,79,900 ha^{-1}), gross margin (Tk. 1,33,900 ha^{-1}) and benefit cost ratio (BCR) of 3.91 were obtained from T_2 treatment. The highest land equivalent ratio (LER) of 1.70 was also found in the same treatment. The results revealed that sorghum normal row 100% (60 cm × 20 cm) + 2 row bush bean (30 cm × 5 cm; 87.50%) could be agronomically feasible and economically profitable intercropping.

Keywords: Sorghum, bush bean, intercropping, land equivalent ratio, light interception, yield.

Introduction

Intercropping is a traditional practice in Bangladesh. It increases total productivity per unit area through maximum utilization of land, labour and growth resources

[1-5]Agronomy Division, Bangladesh Agricultural Research Institute (BARI), Gazipur-1701, Bangladesh.

(Ahmed *et al*., 2013; Islam *et al*., 2006; Mahfuza *et al*., 2012). By judicious choice of compatible crops and adopting appropriate planting geometry, inter/intra specific competition may be minimized resulting higher total productivity (Alom *et al.,* 2013). Canopy architecture of tall stature crop regulates the availability of light under storied crop (Faruque *et al.,* 2006). Sorghum (*Sorghum bicolor* L. Moench) is an unbranched and erect cereal crop grown with wider spacing. Several short duration and short stature vegetable like bush bean may be grown in association with sorghum. Sorghum grain is as nutritious as other cereal grains; contains about 11% water, 340 k cal^{-1} of energy, 11.6% protein, 73% carbohydrate and 3% fat by weight (Thimmaiah, 2002; Taylor *et al*., 2006; Yan *et al*., 2012). Sorghum is used as food, feed, fodder and fuel. On a field basis, sorghum yields have exceeded 11 t ha^{-1} with above average yields ranging 7-9 t ha^{-1}, where moisture is not a limiting factor (Mohamed, 2011).

Bush bean (*Phaseolus vulgaris*. L) is an important high yielding legume crop. It can be used as vegetable, soup and in other form. Bush bean contains vitamin A (23%), vitamin C (27%), vitamin K (12%) carbohydrates (5.5%), and protein (3%) (Davis *et al.,* 2001). Generally, legumes in association with non-legumes not only helps in utilization of the nitrogen being fixed in the current growing season, but also helps in residual nutrients buildup of the soil (Islam *et al.,* 2006). Farmers often demand for quick return from their crops, and they can get quick return by growing short duration vegetable crops with sorghum. But literature is meager regarding sorghum + bush bean intercropping under different planting systems in Bangladesh condition. By adopting appropriate planting geometry in the intercropping system, the total productivity of the crops can be enhanced (Umrani *et al.,* 1984). This experiment was, therefore, conducted to find out suitable planting system of sorghum and bush bean (short duration crop) intercropping for higher productivity and economic return.

Materials and Methods

The experiment was conducted at the research field of Agronomy Division BARI, Gazipur during *rabi* season of 2020-21 and 2022-23. The soil of the research area belongs to AEZ-28. The soil was clay loam with pH 6.3. Treatments included in the experiment were T_1= Sorghum normal row 100% (60 cm line to line × 20 cm plant to plant) + 1 row bush bean (30 cm line to line × 5 cm plant to plant; 43.75%) in between two rows of sorghum, T_2= Sorghum normal row 100% (60 cm × 20 cm) + 2 row bush bean (30 cm × 5 cm; 87.75%) in between two rows of sorghum T_3= Sorghum paired row 100% (30 cm-120 cm-30 cm × 20 cm) + 2 row bush bean

(30 cm × 5 cm; 37.50%) in between two paired rows of sorghum , T_4= Sorghum paired row 100% (30 cm-120 cm-30 cm X 20 cm) + 3 row bush bean (30 cm × 5 cm; 56.25%) in between two paired rows of sorghum , T_5= Sole sorghum (60 cm × 20 cm) and T_6= Sole bush bean (30 cm × 5 cm) The experiment was laid out in a randomized complete block design with three replications and the unit plot size was 4.8 m × 5 m. Sorghum (Var. BARI Sorghum-1) and Bush bean (Var. BARI Jharsheem-2) were used in the experiment. Sorghum and bush bean seeds were sown on 22 November 2021 and 27 November 2022, respectively. The seeds of both crops were treated with provex @ 3g kg^1 of seed. Fertilizers were applied at the rate of 120-48-75-30-3-1 kg ha^{-1} of N-P-K-S-Zn-B (FRG, 2018) as urea, triple super phosphate (TSP), muriate of potash (MoP), gypsum, zinc sulphate and boric acid for sole sorghum 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 25 and 45 days after sowing (DAS) of sorghum. In intercrop, extra N (40 kg ha^{-1}) was applied in 2 splits at 25 and 45 DAS of bush bean. Sole bush bean was fertilized at the rate of 88- 35-53-11-2.2-1.5 kg ha^{-1} of N-P-K-S and Zn (FRG, 2018). 1/3 N and all other fertilizers were applied as basal at the time of final land preparation. Remaining N was applied as side dress at 20 and 35 DAS under moist soil condition and mixed thoroughly with the soil as soon as possible for better utilization. Light availability or Photosynthetically active radiation (PAR) was measured by PAR Ceptometer (Model – LP-80, Accu PAR, Decagon, USA). The PAR was measured at 5-day intervals from 25 to 65 days after sowing (DAS) at around 11:30 am to 13:00 pm. Four readings each of PARinc and PARt were recorded at different spots of each plot. The proportion of intercepted PAR (PARint) was calculated using the following equation and expressed in percentage (Ahmed *et al*., 2013):

$$\text{Light availability } \{\text{PARint } (\%)\} = \frac{\text{PARt}}{\text{PARinc}} \times 100$$

whrer, PARinc= Incident PAR, PARt= Transmitted PAR, PARint= Intercepted PAR.

Data on yield contributing characters of sorghum were taken from randomly selected 10 plants from each plot. Yields of both the crops were taken from whole plot area. Sorghum was harvested on 04 April, 2022 and 09 April 2023 and bush bean was harvested 2 times on 02 and 10 February, 2022 and 06 and 12 February 2023, respectively. Sorghum equivalent yield (SEY) was calculated by converting yield of intercrops on the basis of prevailing market price of individual crop following the formula (Islam *et al*., 2012) as given below:

$$SEY = Yis + \frac{Yibn \times Pbn}{Ps}$$

Where, Yis = Yield of intercropped sorghum, Yibn = Yield of intercropped bush bean,

Pbn = Market price of bush bean and Ps = Market price of sorghum.

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

$$LER = \frac{S_{IY}}{S_{SY}} + \frac{B_{IY}}{B_{SY}}$$

Where,

S_{IY} = Yield of intercrop sorghum

S_{SY} = Yield of sole sorghum

B_{IY}= Yield of intercrop (Component crop)

B_{SY} = Yield of sole crop (Component crop)

Collected data of both the crops were analyzed statistically and pooled data were also analyzed statistically and mean separations were done by LSD test at 5% level of significance. Economic analysis was also done considering local market price of harvested crops. Mean separations were done by Least Significant Difference (LSD) test at 5% level of significance.

Results and Discussion

Light availability

Availability of light on sorghum and bush bean was not markedly affected with each other because bush bean was harvested at 67-74 DAS. At that time sorghum canopy could not produce much shade which might affect bush bean. Irrespective of treatments, availability of light on bush bean canopy was almost 100% at earlier growth stage, 30 DAS of bush bean, and it decreased with the increase of shade produced by sorghum canopy over the time up to 74 DAS or up to harvest of bush bean. However, among the intercropping treatments the higher light availability on bush bean was observed in T_3 treatment (SPR 100% (30 cm/ 120 cm/ 30 cm × 20cm) + 2 row bush bean 37.50% (30 cm × 5 cm) followed by T_4 treatment (SPR 100% (30 cm/ 120 cm/ 30 cm × 20cm) + 3 rows bush bean 56.25% (30 cm× 5 cm) throughout the growing period. The lowest light availability on bush bean was observed in T_2 treatment (SNR 100% + 2 rows bush bean 87.50%) followed by T_1 treatment (SNR + 2 rows bush bean 43.75%) at 65 DAS of bush bean. Among all treatments, the highest light availability was observed in sole bush bean, T_5 treatment (Fig.1).

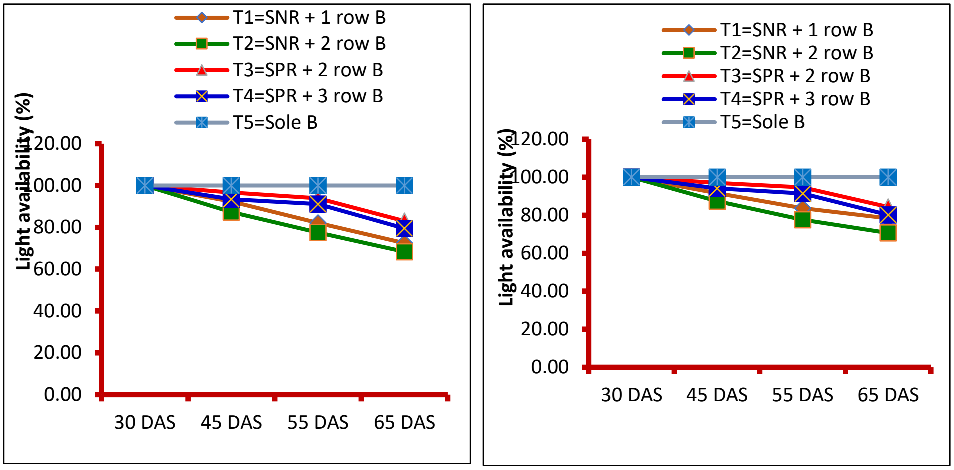

Fig. 1. Light availability on bush bean canopy in sorghum + bush bean intercropping system during *rabi* season 2021-22 and 2022-23 at Gazipur.

Grain yield and yield contributing characters of sorghum

Panicle length (cm), number of grains panicle^{-1}, 1000 -grain weight (g), and grain yield (t ha^{-1}) of sorghum was significantly varied due to intercropping of sorghum with bush bean and sole crop of sorghum, except plant height which was insignificant (Table 1). Higher panicle length (18.94 cm) was obtained from sole planting of sorghum and it was statistically identical with T_1 (17.88 cm) and T_2 (17.40 cm) treatment. The lowest panicle length (16.40 cm) was recorded in T_4 treatment and it was statistically identical with and T_3 (16.88 cm). Similar trend was found in case of number of grains panicle^{-1} and 1000-grain weight. The highest number of grains panicle^{-1} (1841) and 1000-grain weight (36.49 g) was recorded in sole sorghum (T_5 treatment). Among the intercropping situation, the maximum number of grains panicle^{-1} (1662) and 1000-grain weight (33.64 g) was obtained from T_1 treatment and it was statistically identical with T_2 (1630 and 32.71 g) and T_3 (1550 and 31.26 g) treatments and the lowest number of grains panicle^{-1} (1457) and 1000-grain weight (31.07 g) was in T_4 treatment. The maximum grain yield 4.58 t ha^{-1} was obtained in sole sorghum (T_5) followed by T_5, which was probably due to less intercrop competition for growth resources like light, nutrient, moisture and space. It was apparent that all the yield contributing characters and yields in the intercrops increased gradually with the decreased of bush bean population. This was possibly due to competition between sorghum and bush bean crop for growth resources like moisture, light, nutrient. Bandyophadhyay *et al.* (1984) also reported that significant difference was not found in yield and yield attributes of sorghum due to intercropping with bush bean i. e. growing of the intercrops in interspaces between sorghum rows did not affect the base crop. Under intercropping, the maximum grain yield 4.45 t ha^{-1} was recorded in T_1 treatment which was statistically identical with T_3 (3.84 t ha^{-1}) treatment. The lowest grain yield 3.63 t ha^{-1} was recorded in T_4 treatment. However, grain yield of sorghum in different treatments were attributed by the cumulative effect of yield components. Islam *et al.* (2012) also reported similar result when bush bean was intercropped with maize.

Table 1. Grain yield and yield attributes of sorghum under sole and intercropping system

Treatment	Plant height (cm)	Panicle length (cm)	Grains panicle^{-1} (no.)	1000- grain wt. (g)	Grain yield (t ha^{-1})
T_1	184.60	17.88	1662	33.64	4.45
T_2	179.17	17.40	1630	32.71	3.66
T_3	181.73	16.88	1550	31.26	3.84
T_4	178.57	16.40	1457	31.07	3.63
T_5	191.18	18.94	1841	36.49	4.58
LSD $_{(0.05)}$	NS	1.45	245	2.11	0.64
CV (%)	3.63	4.41	8.02	3.39	8.38

Note: T_1= Sorghum normal row 100% (60 cm line to line × 20 cm plant to plant) + 1 row bush bean (30 cm line to line × 5 cm plant to plant; 43.75%) in between two rows of sorghum, T_2= Sorghum normal row 100% (60 cm × 20 cm) + 2 row bush bean (30 cm × 5 cm; 87.75%) in between two rows of sorghum T_3= Sorghum paired row 100% (30 cm-120 cm-30 cm X 20 cm) + 2 row bush bean (30 cm × 5 cm; 37.50%) in between two paired rows of sorghum , T_4= Sorghum paired row 100% (30 cm-120 cm-30 cm × 20 cm) + 3 row bush bean (30 cm × 5 cm; 56.25%) in between two paired rows of sorghum , T_5= Sole sorghum (60 cm × 20 cm) and T_6= Sole bush bean (30 cm × 5 cm).

Green pod yield and yield contributing characters of bush bean

Plants m^{-2}, plant height, number of pods plant^{-1}, pod length (cm), 10-green pod weight (g) and green pod yield (t ha^{-1}) of bush bean were markedly differed by intercrop combinations (Table 2). The maximum number of plants m^{-2} of bush bean (59) was obtained from T_6 treatment (Sole bush bean). Among the intercropping situation, the maximum number of plants m^{-2} of bush bean (46) was obtained from T_2 treatment and the minimum number of plants m^{-2} of (24) in T_3 treatment and it was statistically identical with T_1 (27 m^{-2}) and T_4 (31 m^{-2}) treatments, which were probably due to variation of planting system. The maximum plant height (46.63 cm), number of pods plant^{-1} (7.54), pod length (11.67 cm) and 10-green pod weight (56.40 g) was recorded in T_6 treatment (sole bush bean). Among the intercropping situation the highest plant height (46.37 cm) was obtained from T_3 treatment which was statistically identical with T_1 (44.33 cm). The lowest plant height (40.08 cm) was obtained from T_2 treatment. Similar trend was found in case of pods plant^{-1}, pod length and 10-green pod weight. The maximum number of pods plant^{-1} (7.07), pod length (10.92 cm), and 10-green pod weight (53.19 g) was obtained from T_3 treatment which was statistically identical with T_1 treatment. The minimum number of pods plant^{-1} (5.84), pod length (8.78 cm) and 10-green pod weight (47.04 g) was recorded in T_2 treatment. The highest green pod yield of bush bean 11.86 t ha^{-1} was obtained from T_6 treatment (Sole bush bean) followed by T_2 treatment due to higher plant population per unit area. There was no intercrop competition for growth resource in sole bush bean. Among the intercropping situation, the highest green pod yield of bush bean 10.67 t ha^{-1} was obtained from T_2 treatment, whereas the lowest green pod yield of bush bean 4.31 t ha^{-1} was obtained from T_3 treatment followed by T_1 due to the lowest number of plant population per unit area. The higher green pod yield in bush bean was attributed to maximum number of plant m^{-2}. Faruque *et al.* (2006) also reported similar result in maize/spinach-red amaranth intercropping system.

Table 2. Green pod yield and yield attributes of bush bean under sole and intercropping system

Treatment	Plant m^{-2} (no.)	Plant height (cm.)	Pods plant^{-1} (no.)	Pod length (cm)	10-green pod (g)	Green pod yield (t ha^{-1})
T_1	27	44.33	7.06	10.08	51.36	5.15
T_2	46	40.08	5.84	8.78	47.04	10.67
T_3	24	46.37	7.07	10.92	53.19	4.31
T_4	31	41.03	6.18	9.91	47.47	6.79
T_6	59	46.63	7.54	11.67	56.40	11.86
LSD $_{(0.05)}$	4.64	4.21	0.96	1.02	4.99	0.95
CV (%)	6.60	5.12	7.54	5.28	5.19	6.47

Note: T_1= Sorghum normal row 100% (60 cm line to line × 20 cm plant to plant) + 1 row bush bean (30 cm line to line × 5 cm plant to plant; 43.75%) in between two rows of sorghum, T_2= Sorghum normal row 100% (60 cm × 20 cm) + 2 row bush bean (30 cm × 5 cm; 87.75%) in between two rows of sorghum T_3= Sorghum paired row 100% (30 cm-120 cm-30 cm X 20 cm) + 2 row bush bean (30 cm × 5 cm; 37.50%) in between two paired rows of sorghum , T_4= Sorghum paired row 100% (30 cm-120 cm-30 cm × 20 cm) + 3 row bush bean (30 cm × 5 cm; 56.25%) in between two paired rows of sorghum , T_5= Sole sorghum (60 cm × 20 cm) and T_6= Sole bush bean (30 cm × 5 cm).

Sorghum equivalent yield

Sorghum and bush bean intercrop productivity was evaluated on the basis of sorghum equivalent yield (SEY) and land equivalent ratio (Bandyophadhyay,1984). Sorghum equivalent yield (SEY) and land equivalent ratio are presented in Table 3. Sorghum equivalent yield expressed the total productivity of the intercropping system. Sorghum equivalent yield was higher in all the intercrops (6.00 to 9.00 t ha^{-1}) than the sole crop of sorghum 4.58 t ha^{-1} (Table 3). In intercrop combination, the highest sorghum equivalent yield 9.00 t ha^{-1} was recorded in T_2 treatment followed by T_1 (7.03 t ha^{-1}) and T_4 treatments. The lowest sorghum equivalent yield (6.00 t ha^{-1}) was obtained from T_3 treatment over the sole sorghum. Total productivity also increased by 96.40%, 53.38% and 30.90% in T_2, T_1, T_4 and T_3 treatments, respectively. Ahmed *et al.* (2013) also reported that intercrop combination of leafy vegetables with okra increases the equivalent yield.

Land equivalent ratio

The highest land equivalent ratio (1.70) was recorded in T_2 treatment (Table 3) and the lowest (1.20) was recorded in T_3 treatment. LER of different crop combinations ranged from 1.20 to 1.70 which indicating that land utilization was increased to 20 to 70% by intercropping. The mean value of LER (more than one) in all intercropping treatments indicated that land was more efficiently utilized under intercropping than sole cropping of sorghum and bush bean.

Table 3. Sorghum equivalent yield (SEY), land equivalent ratio (LER) and % increase of SEY over sole sorghum in sorghum + bush bean intercropping system.

Treatment	SEY (t/ha)	% increase of SEY over sole sorghum	LER
T_1 (SNR + 1 row bush bean)	7.03	53.38	1.41
T_2 (SNR + 2 rows bush bean)	9.00	96.40	1.70
T_3 (SPR + 2 rows bush bean)	6.00	30.90	1.20
T_4 (SPR + 3 rows bush bean)	7.03	53.38	1.37
T_5 (Sole sorghum)	4.58	-	1.00
T_6 (Sole bush bean)	5.93		1.00

Note: SEY= Sorghum equivalent yield (t/ha), LER= Land equivalent ratio.

Cost benefit analysis

Cost and return analysis, an important tool to evaluate the economic feasibility of intercropping system and monetary advantage, was evaluated according to Shah *et al.* (1991). Cost and return analysis of bush bean with sorghum intercropping system is presented in Table 4. Gross return and BCR depends on equivalent yield. Intercropping combination of bush bean with sorghum showed higher monetary return than sole crop of sorghum and bush bean (Table 4). The highest gross return (Tk. 1,79,900 ha^{-1}) was recorded from T_2 treatment. This intercropping combination also gave the highest gross margin (Tk. 1,33,900 ha^{-1}) and benefit cost ratio (BCR) 3.91 followed by T_1 treatment owing to gross return (Tk. 1,40,500 ha^{-1}), gross margin (Tk. 96,500 ha^{-1}) and benefit cost ratio (3.19). The lowest gross return (Tk. 91,600/ha), gross margin (Tk. 49,600/ha) and BCR (2.18) was obtained from sole sorghum (T_5) treatment. The results of increased productivity and returns were consistent with the earlier reports of yield advantage of crop mixture compared to monoculture (Ahmed *et al*., 2013 and Islam *et al*., 2012).

Table 4. Cost and return analysis of sole sorghum and sorghum + bush bean intercropping system.

Treatment	Gross return (Tk. ha^{-1})	Cost of cultivation (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})	Benefit cost ratio (BCR)
T_1	1,40,500	44,000	96,500	3.19
T_2	1,79,900	46,000	1,33,900	3.91
T_3	1,19,900	45,000	74,900	2.66
T_4	1,40,500	48,000	92,500	2.93
T_5	91,600	42,000	49,600	2.18
T_6	1,18,600	43,000	75,600	2.76

Price: Sorghum: Tk. 20/Kg and Bush bean: Tk. 10/Kg according the prevailing market price.

Conclusion

All intercropping combinations were more productive and profitable than growing sole sorghum and bush bean. Among the tested several sorghums - bush bean intercropping systems, sorghum normal row 100% (60 cm × 20 cm) + 2 row bush bean (30 cm × 5 cm; 87.50%) was found agronomically feasible and economically profitable with respect to SEY (Sorghum equivalent yield) and BCR (benefit cost ratio).

References

Ahmed, F., M. N. Islam, M. S. Alom, M. A. I. Sarker and M. A. Mannaf. 2013. Study on intercropping leafy vegetables with okra (*Abelmoschus esculentus* l.). *Bangladesh J. Agril. Res*. **38** (1): 137-143.

Ahmed, F., M.N. Islam, M.T. Rahman, M.A. Jahan and M.S.A. Khan. 2010. Leaf area index, radiation interception, dry matter production and grain yield of hybrid maize as influenced by plant spacing. *Bangladesh Agron. J*. **13** (1 & 2): 51-58.

Alom, M. S., B. L. Nag, M. N. Islam, F. Ahmed and S. Akter. 2013. Performance of different crop species with pointed gourd (*Trichosanthes dioica Roxb*.). *Bangladesh J. Agril. Res.* 38 (3): 523-529.

Bandyophadhyay., S. N. 1984. Nitrogen and water relations in grain sorghum- legume intercropping system. Ph. D. Dissertation, *Indian Agricultural Research Institute*, New Delhi.

Davis, J. H. C., M. Santalla, A. P. Rodino, P. A. Casquero and A. M. De Ron. 2001. Interactions of bush bean intercropped with field and sweet maize. *Eueopean J. of Agron*. **15**(3): 185-198.

Faruque, A., M. A. Rahaman, M. A. H. S. Jahan, M. Ahmed and M. A. Khayer. 2006. Effect of different planting systems in maize/spinach-red amaranth intercropping. *Bangladesh J. Agric. And Environ.* **2**(2**)**: 69-76.

FRG. 2018. Fertilizer Recommendation Guide, Bangladesh Agricultural Research Council (BARC), Farm gate, Dhaka 1215. 223p.

Islam M. R., M. A. K. Mian and M. T. Rahman. 2012. Suitability of intercropping sesame with mukhikachu. *Bangladesh J. Agril. Res.* **37(**4): 625-634.

Islam, M. N., M.M. Haquue and A. Hamid. 2006. Planting arrangement and population density effect on the physiological attributes and productivity of maize-bush bean intercropping systems. *Bangladesh J. Agril. Res*. **3**(3): 353-364.

Mahfuza, S. N., M. N. Islam, A. Hannan, M. Akhteruzzaman and S. Begum. 2012. Intercropping different vegetables and spices with pointed gourd. *J. Expt. Biosci*. **3**(1): 77-82.

Mohamed, S. S. 2011. Genetic Diversity among some Sudanese Sorghum Accessions using Molecular Markers and Phenotype Pic characterization. Thesis of MSc – Sudan Academy of Sciences.

Shah, N. H., P. K. Koul, B. A. Khanday and D. Kachrov. 1991. Production potential and monetary advantage index of maize intercropped with different grain legumes. *Indian J. Agron.* **36**(1): 23-28.

Taylor, J., T. J. Schober and S. R. Bean. 2006. Novel food and work at Sabine and Merse Mengesha /Arch. Agr. *Environ. Sci*. **3**(2): 180-186.

Thimmaiah, S. K. 2002. Effect of salinity on biochemical composition of sorghum (*Sorghum bicolor* L.) seeds. *Indian J. of Agri. and Biochemistry* **15**(1-2): 13-15.

Umrani, N. K., Shinde, H. S. and Dhonde, P. M. 1984. Studies on intercropping of pulses in Kharif sorghum. *Indian J. Agron.* **29**(1): 27-30.

Willey, R.W. 1979: Intercropping: its performance and research needs. Part I. Competition and yield advantages. Field Crops Abs. 321-10.

Yan, K., P. Chen, H. Shao, S. Zhao, L. Zhang, G. Xu and J. Sun 2012. Responses of photosynthesis and photosystem ii to higher temperature and salt stress in sorghum. *J. of Agron. and Crop Sci.* **198**(3): 218 -225.