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SYSTEM PRODUCTIVITY OF TROPICAL SUGARBEET INTERCROPPED WITH SUGARCANE

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ABSTRACT

An experiment was conducted at experimental farm of Panchagarh sugar mills, Panchagarh under Old Himalayan Piedmont Plain Soils (AEZ 1) at northern region of Bangladesh during cropping season 2014-2015 to evaluate the effect of inter-cropping of sugarbeet with sugarcane with respect to attributes of yield, quality and economic benefits of both the crops. Four tropical sugarbeet genotypes, namely Shubra, PAC 6008, Aranka and SZ 35 were used along with the variety of Sugarcane (Isd 39). Results implied that maximum germination percentage (89.37), beet length (20.46 cm), beet diameter (8.05 cm), average beet weight (1.30 kg), beet yield (90.50 t ha^{-1}) and brix (19.28 %) were found in Shubra genotype while the highest tiller population (221.25× 10^3 ha^{-1})), millable cane (102.86×10^3 ha^{-1}), stalk height (3.36 cm), stalk diameter (2.28 cm) and cane yield (96.48 t ha^{-1}) were found from sole sugarcane. However, inter-node, average cane weight and brix percentage of cane provided no significant variations. Maximum income was recorded in single row sugarcane with sugarbeet Shubra (268381.30 Tk.ha^{-1}) and the highest benefit cost ratio 3.00 was found from same treatment combination. The maximum profit was found in sugarcane-sugarbeet inter-cropping system than sole sugarcane and also sole sugarbeet. Considering the total cost and economic return, different factors associated with production of sugarbeet intercrop with sugarcane might be a profitable package in Northern region of Bangladesh.

Keywords: *S*ugarcane, sugarbeet, intercrop, yield, brix%, benefit cost ratio

Introduction

Sugarcane *Saccharum officinarum* L. is a vegetative propagated perennial crop. It is a high value cash crop and thus, plays a vital role in improvement of socio economic condition of farming community, industry and trade situation. It is the raw material of sugar industry and the main source of white sugar and jaggary (locally called gur). By-products of sugar milling such as bagasse, molasses, alcohol, dextrin, and diacetyl (Reilly 1998) have several uses. It is cultivated in many countries of the world with Brazil as a major producer followed by India, China, Thailand, Pakistan, Mexico, Indonesia and the Philippines (FAOSTAT 2014). It is mainly grown in high and medium high land under rain fed condition mostly in the north-west and south-west regions of Bangladesh.

Sugarcane is a long duration crop, takes about 12-14 months from planting to harvesting which decreases economic return of the farmers compared to other crops. To get higher economic return from sugarcane field, appropriate inter-cropping practices with short duration crops might be the alternative way to increase total yield, interim and higher monetary return. Inter-cropping is the practice of cultivating two or more crops simultaneously on the same piece of land per year (Guleria and Kumar 2016) and have many advantages over sole cropping such as enhancement of efficient use of environmental factors (e.g., light, nutrient and soil moisture) and labors, reduces the adverse effect of various biotic and abiotic stress, provides the diversity of food, generates more income, offers insurance against crop failure, higher return and total productivity per unit area (Farhad *et al*. 2014).

The growth rate of sugarcane during its initial stages (first 90-120 days) is rather slow, with the leaf canopy providing sufficient uncovered area for growing of other

crops (Shahana *et al.* 2019). In early stage of growth, some short duration winter crops viz., vegetables, pulses, oil seeds and spices can be grown as intercrop in the vacant spaces between two rows of sugarcane (Alam *et al.* 2008).

Sugarbeet is a herbaceous dicotyledonous plant species under the Chenopodiaceae family, whose roots contain a high concentration of sucrose, and which is grown commercially for sugar production. It is one of the important comercial crops that supplies approximately 35 % of the worlds sugar (Wu *et al.* 2016). Its by-products e.g., beet molasses and beet pulp are used as animal feed. It is also increasingly grown for bio-fuel production (Panella 2010, Singh *et al.* 2013). Ethanol is produced from impure sugary pulp (molasses) and it also fermented to beers. Although sugarbeet is a temperate crop, tropical sugarbeet verities have been developed for growing under tropical climatic condition. It is grown in 57 countries in the world (FAOSTAT 2018). Production of sugarbeet has got many benefits compared to sugarcane production.It is short duration crop which matures within 5 to 6 while sugarcane requires 12-14 months. On the other hand sugar recovery rate from the sugarbeet is 12-14 percent while the rate from sugarcane is 8-10 percent (Paul *et al*. 2019).

Increasing sugarcane crises urge that sugarcane–sugarbeet inter-cropping system to be strenghtened to provied raw material ans prolong crushing season of sugar mills (Rehman *et al.* 2014). Inter-cropping results in an increased farm income and better utilization of resources. The farming community can get inspiration and higher net returns from this system (Akhtar *et al*. 2010). Agronomic interventions offer the opptunities of intercrops in sugarcane based system to improve the crop pructivity, profitabitly and sustainability (Shukla *et al.* 2017). The information on varietal performance regarding growth, yield and quality of sugarbeet under inter-cropping with sugarcane is limited. Considering the fact, an experiment was undertaken to evaluate the performance of sugarbeet genotypes intercropped with sugarcane in the northern region of Bangladesh.

Materials and Methods

The experiment was conducted at experimental farm of Panchagarh sugar mills, Panchagarh, Bangladesh during 2014-2015 cropping season under irrigated condition. The site represents the Old Himalayan Piedmont Plain Soil (Agro Ecological Zone 1) at northern region of Bangladesh with medium high land of typical sandy loam soil having pH 5.5. Three selected sugarbeet genotypes Shubra, PAC 6008 and Aranka were grown as intercrop with sugarcane in single row planting system where sugarcane variety was Isd 39. The experiment was laid out in a Randomized Complete Block Design with four replications. The unit plot size was 6 m × 6 m with the following treatment combinations.

T_1: Sole single row cane (SRC)
T_2:SRC + Sugarbeet (Shubra)
T_3:SRC + Sugarbeet (PAC 6008)
T_4: SRC + Sugarbeet (Aranka)
T_5: SRC + Sugarbeet (SZ 35)
T_6 : Sole sugarbeet (Shubra)
T_7: Solesugarbeet (PAC 6008)
T_8: Solesugarbeet (Aranka)
T_9: Sole sugarbeet (SZ 35)

Plantation was done with two budded setts end to end placement in mid November 2014 maintaining 100 cm spacing in single row planting system. The intercrop sugarbeet was sown in the same date of sugarcane plantation. Fertilizers were applied according to the recommended dose for both the crops. Sugarbeet seeds were sown maintaining seed to seed distance of 20 cm at 3-4 cm depth with a distance between two ridges 50 cm. Intercultural operations for sugarcane like irrigation, gap filling, weeding, mulching, earthing-up, tying and cross tying were done in time. Cultural operations for intercrops were also done when required. Germination of sugarbeet was counted at 30 days after sowing. Others data on yield and various yield contributing parameters (beet length, beet diameter, beet brix%, avarge beet weight and beet yield) of sugarbeet were collected at harvest i.e. after five months of seed sowing. Tiller population of sugarcane was recorded at 150 days after plantation. Stalk height, stalk diameter, millable cane, inter-node per stalk, average cane yield, cane yield and brix (%) were recorded at harvest. Equivalent cane yield and adjusted cane yield of intercrop was calculated by adding the cane value. Fisher's analysis of variance (ANOVA) was used for statistical analysis of collected data and for comparison of differences among treatment means. Least significant difference (LSD) test was done at 5% level of probability (Steel *et al*. 1996). Statistix 10 (Tallahassee FL 32317) was used for the determination of statistical differences.

Benefit cost ratio was calculated with the recommended formula suggested by (CIMMYT 1988)

BCR = Gross return = Value of cane

Cost of production = The sum of the cost of the resources.

Results and Discussion

The performances of the tested different sugarbeet genotypes such as germination (%), beet length, beet diameter and brix (%) of beet are represented in Table 1.

Germination percent is the most critical factor which determines the varietal potential to exploit the available resources and ultimately effects on cane stand. In the study highest germination (89.37 %) was observed in T_2 which was at par with the treatment T_6, T_8 and T_4. The lowest germination (70.34 %) was observed inT_7 followed by the treatment T_3 and T_9, respectively. Similar results were reported by Islam *et al*. (2016) where, beet germination percentage was significantly different among tested genotype with sugarcane inter-cropping.

Beet length

The highest beet length was observed from the treatment T_2 (20.46 cm) which was statistically similar with T_5, T_4, T_3 and T_9, respectively. The lowest beet length (18.75) was obtained from the treatment T_8 which was statistically similar with all other treatments except T_1 .The results corroborated with that demonstrated by Islam *et al*. (2015).They observed the highest beet length (20.56 cm) from sugarbeet genotype Shubra and the lowest beet length (18.10) from sugarbeet genotype Cuvery among the 17 sugarbeet genotypes.

The highest beet diameter was recorded from the treatment T_2 (8.05 cm) which was statistically similar with all other treatments except T_9 and T_7. The lowest beet diameter (18.75) was recorded from the treatment T_7 which was statistically similar with all other treatments except T_1.The results are similar with that of Islam *et al*. (2015). They observed the highest beet length (8.00 cm) of sugarbeet in the genotype Shubra and the lowest beet length (6.36) from HI 0044 among the 17 sugarbeet genotypes.

The highest brix percentage was obtained from the treatment T_6 (19.28) which was statistically similar with all other treatments except T_5 and T_3. The lowest brix percentage (16.5) was obtained from the treatment T_3 which was statistically similar with T_5, T_4 and T_7. The results are almost similar as demonstrated by Islam *et al*. (2016) where they found the variation in brix percentage among different genotypes with sugarcane inter-cropping. The highest brix percentage (19.80) was found from sugarbeet genotype Cauvery with sugarcane inter-cropping system and the lowest brix percentage (18.73) was found from sugarbeet genotype CS 0328.

Results from our study further indicated that inter-cropping exerted significant influence on the yield and its component viz, tiller, millable cane, stalk height, stalk diameter and number of inter-node per stalk and brix (%) those presented in Table 2.

Tillering potentiality of sugarcane ultimately affects on cane yield positively. The maximum tiller population 221.25 × 10^3 ha^{-1} was found from the treatment T_1 (sole SRC). The minimum population tiller 163.67 × 10^3 ha^{-1}

Table 1. Performance of sugarbeetat germination, beet length, beet diameter and brix as intercropped with sugarcane

Treatments	Germination (%)	Beet length (cm)	Beet diameter (cm)	Brix (%)
T_1:SRC sole	-	-	-	-
T_2:SRC + Sugarbeet (Shubra)	89.37a	20.46a	8.05a	18.43ab
T_3:SRC + Sugarbeet (PAC 6008)	75.10de	19.51abc	7.66ab	16.51c
T_4: SRC + Sugarbeet (Aranka)	83.14abc	19.59abc	7.70ab	17.70abc
T_5: SRC + Sugarbeet (SZ 35)	79.18bcd	20.11ab	7.80ab	17.22bc
T_6 : Sugarbeet (Shubra)	87.35a	19.10bc	7.53ab	19.28a
T_7: Sugarbeet (PAC 6008)	70.34e	18.88bc	7.25b	17.88abc
T_8: Sugarbeet (Aranka)	85.27ab	18.75c	7.48ab	18.16ab
T_9: Sugarbeet (SZ 35)	76.36cde	19.20abc	7.31b	18.28ab
Lsd (0.05)	7.06	1.35	0.65	1.34

In a column similar letters are not significantly different by LSD at < 0.05

Table 2. Effect of sugarbeet Inter-cropping on tiller, millable cane, stalk height, stalk diameter and brix (%)of sugarcane

Treatments	Tiller ($\times 10^3$ ha^{-1})	Millable cane ($\times 10^3$ ha^{-1})	Stalk height (m)	Stalk diameter (cm)	Inter-node (stalk^{-1})	Brix (%)
T_1:SRC sole	221.25a	102.86a	3.36a	2.28a	25.25	20.21
T_2:SRC + Sugarbeet (Shubra)	163.67c	86.73b	3.17c	2.13c	23.37	19.23
T_3:SRC + Sugarbeet (PAC 6008)	185.22b	95.12 ab	3.31ab	2.24ab	24.36	20.14
T_4: SRC + Sugarbeet (Aranka)	168.52bc	88.57 b	3.20c	2.16bc	25.13	19.03
T_5: SRC + Sugarbeet (SZ 35)	177.17bc	92.43ab	3.26bc	2.20abc	23.88	20.08
T_6 : Sugarbeet (Shubra)	-	-	-	-	-	-
T_7: Sugarbeet (PAC 6008)	-	-	-	-	-	-
T_8: Sugarbeet (Aranka)	-	-	-	-	-	-
T_9: Sugarbeet (SZ 35)	-	-	-	-	-	-
LSD (0.05)	18.00	13.22	1.00	0.11	NS	NS

In a column followed by NS are not significantly (NS) different by LSD at < 0.05

was observed in treatment T_2 (SRC + sugarbeet Shubra) which was statistically similar with T_4 (SRC + sugarbeet Aranka) and T_5 (SRC + sugarbeet SZ 35). The similar result was found by Islam *et al*. (2017) that sole sugarcane produced higher tiller than inter-cropping system. The highest tiller population (201.66 $\times 10^3$ ha^{-1}) was found from sole sugarcane and the lowest tiller population (155.20 $\times 10^3$ ha^{-1}) was found from single row sugarcane with 2 lines sugarbeet inter-cropping system.

The number of millable cane directly influences cane yield. The highest number of millable cane (102.86 $\times$ 10^3 ha^{-1}) was observed in T_1 (sole SRC) that was statistically similar with T_3 (SRC + sugarbeet PAC 6008) and T_5 (SRC + sugarbeet genotype SZ 35). The lowest number of millable cane (86.73 $\times$ 10^3 ha^{-1}) was observed in T_2 (SRC + sugarbeet Shubra) which was statistically similar to all other treatments except T_1 (Sole SRC). A similar finding was observed by Islam *et al*. (2017). They observed that sole sugarcane produced higher millable cane (88.16 $\times$ 10^3 ha^{-1}) than millable cane (77.25 $\times$ 10^3 ha^{-1}) paired row sugarcane with 3 lines sugarbeet inter-cropping system.

Stalk height of cane contributes materially towards final cane yield Panhwar *et al.* (2006). Among different treatments the highest stalk height (3.36 m) was found from T_1 which statistically similar with the findings from the plot treated with T_3 treatment (3.31 m) while the lowest stalk height (3.17 m) was found from the treatment T_2 that was statistically similar with T_4 and T_5, respectively. Similar findings were revealed by Soomro (2008) who reported that sugarcane as sole crop resulted maximum height while the cane height minimum sugarcane-onion inter-cropping system.

Cane diameter (cm) is an important parameter for obtaining the optimum yield of sugarcane crop. The highest stalk diameter (2.28 cm) was found from the plots treated with T_1 treatment, and that was at par with T_3 (2.24 cm) and T_5 (2.20 cm) while the lowest cane diameter (2.13 cm) was found from the treatment T_2 which was identical with the treatment T_4 and T_5. Similar finding was shown by Yang *et al*. (2015). They showed that the stalk diameter was significantly affected by sugar cane-soybean inter-cropping.

Internode from all the treatments were not affected significantly but it was numerically different. Inter-node number range from 25.25 to 23.37. The highest number of internode (25.25) recorded in T_1 (Sole SRC). The lowest number of inter-node (23.37) was recorded in the treatment T_2 (SRC + sugarbeet Shubra). A similar result was reported by Alam *et al.* (2015), who reported that number of inter-node of sugarcane was not affected by the soyabean-mungbean sequential inter-cropping with sugarcane.

Brix readings obtained from all the treatments were not affected significantly but it were numerically different. The brix % reading was (20.21 to 19.03). The maximum

brix % (20.21) was recorded in T_1. The minimum brix % (19.03) was recorded in the treatment T_4.

The highest average beet weight of 1.30 kg was found from the treatment T_2. The lowest average beet weight was found from the treatment T_7 which was significantly similar with the treatments T_9, T_8, T_6 and T_3, respectively. The findings of the present experiment were in agreement with Paul *et al.* (2018) where they found variation in unit beet weight among different genotypes in sole and inter-cropping condition. They found that average beet weight ranged from 0.98 to 0.22 kg among different genotypes.

The highest beet yield of 90.50 t ha^{-1} was obtained from the treatment T_6 (Sole sugarbeet Shubra) which was statistically similar with the treatment of T_8 (Sole sugarbeet Aranka) (86.59 t ha^{-1}) and T_9 (Sole sugarbeet SZ 35) (80.74 t ha^{-1}), respectively. The lowest beet yield (42.31 t ha^{-1}) was obtained from the treatment T_3 (SRC + sugarbeet PAC 6008) which was statistically similar with T_5 (SRC + sugarbeet SZ 35) (47.32 t ha^{-1}). The findings of this study were found in line with the findings of Khan (2017) where, sole sugarbeet (75.87 t ha^{-1}) attained higher yield compared to those cultivated in inter-cropping of sugarbeet yield (13.22 t ha^{-1}) with sugarcane sole sugarbeet.

Average cane weight obtained from all the treatments were not affected significantly but it was numerically different. Average cane weight rage was 0.94 to 0.91 kg. The maximum average cane weight (0.94 kg) was recorded in T_1. The minimum average (0.91 kg) was recorded in the treatment T_4. The similar result was found by Alam *et al.* (2015). They found that average cane weight of sugarcane was not affected by the soyabean-mungbean sequential inter-cropping with sugarcane where range of average cane weight was 0.72 -0.86 kg.

The highest cane yield of 96.48 t ha^{-1} was obtained in T_1 (Sole SRC) which was similar with the treatment T_3 (SRC + sugarbeet PAC 6008) 88.52 t ha^{-1}). The lowest cane yield (80.68 t ha^{-1}) was obtained from T_4 (Sugarcane + sugarbeet Aranka) which was statistically similar with all other treatments except T_1 (Sole SRC). Similar result was found by Islam *et al*. (2017) that sole sugarcane was given higher cane yield (96.48 t ha^{-1}) than inter-cropping system sugarcane yield (68.28 t ha^{-1}).

The maximum equivalent cane yield of intercrop (99.82 t ha^{-1}) was calculated in T_6 (sole sugarbeet Shubra) treatment and the minimum equivalent cane yield of 46.18 t ha^{-1} was calculated in T_3 (SRC+ sugarbeet PAC 6008). The findings were in agreement with that of Islam *et al.* (2016). The maximum total adjusted cane yield of 149.77 t ha^{-1} was calculated in T_2 (SRC+sugarbeet Shubra) and

Table 3. Effect of sugarbeet inter-cropping with sugarcane on yield of sugarbeet and sugarcane

Treatments	Average Beet weight (kg)	Beet yield (tha^{-1})	Average cane weight (kg)	Cane yield (t ha^{-1})	Eq. cane yield of intercrop (t ha^{-1})	Adj. cane yield of intercrop (t ha^{-1})
T_1:SRC sole	-	-	0.94	96.48a		96.49
T_2:SRC + Sugarbeet (Shubra)	1.30a	62.60c	0.93	80.73b	69.09	149.77
T_3:SRC + Sugarbeet (PAC 6008)	1.00bcd	41.87e	0.93	88.52ab	46.18	134.70
T_4: SRC + Sugarbeet (Aranka)	1.13b	54.12cd	0.91	80.68b	59.67	140.35
T_5: SRC + Sugarbeet (SZ 35)	1.03bc	47.85de	0.92	84.72b	52.78	137.50
T_6 : Sugarbeet (Shubra)	1.00bcd	90.50a	-	-	99.82	99.82
T_7: Sugarbeet (PAC 6008)	0.87d	76.50b	-	-	84.38	84.38
T_8: Sugarbeet (Aranka)	0.93cd	86.59a	-	-	95.50	95.50
T_9: Sugarbeet (SZ 35)	0.90cd	80.74ab	-	-	89.05	89.05
Lsd (0.05)	0.15	9.76	NS	10.48	-	-

In a column followed by NS are not significantly (NS) different by LSD at < 0.05. Price of crops: Sugarcane: 2720 Tk. t^{-1}, Sugarbeet assume: 3000 Tk. t^{-1}

Table 4. Total cost of production, grows return, net return and benefit cost ratio as affected by Inter-cropping of sugarbeetwith sugarcane

Treatments	Cost of production (Tk.ha^{-1})	Gross return (Tk.ha^{-1})	Net return (Tk.ha^{-1})	BCR
T_1:SRC sole	1,13,500.00	259558.10	146058.10	2.28
T_2:SRC + Sugarbeet (Shubra)	1,34,500.00	402881.30	268381.30	3.00
T_3:SRC + Sugarbeet (PAC 6008)	1,34,500.00	362343.00	227843.00	2.69
T_4: SRC + Sugarbeet (Aranka)	1,34,500.00	377541.50	243041.50	2.81
T_5: SRC + Sugarbeet (SZ 35)	1,34,500.00	369875.00	235375.00	2.75
T_6 : Sugarbeet (Shubra)	1,26,000.00	271510.00	145510.40	2.15
T_7: Sugarbeet (PAC 6008)	1,26,000.00	229513.60	103513.60	1.82
T_8: Sugarbeet (Aranka)	1,26,000.00	259760.00	133760.00	2.06
T_9: Sugarbeet (SZ 35)	1,26,000.00	242216.00	116216.00	1.92

Price of crops: Sugarcane: 2720 Tk. t^{-1}, Sugarbeet assume: 3000 Tk. t^{-1}

the minimum total adjusted cane yield 84.38 t ha^{-1} was calculated in T_7 (sole sugarbeet PAC 6008). The result was observed by Islam *et al.* (2017) that the highest adjusted cane yield (149.81 t ha^{-1}) of sugarcane with sugarbeet inter-cropping system than adjusted cane yield (101.12 t ha^{-1}) sole sugarbeet and (97.63 t ha^{-1}) sole sugarcane.

The economic analysis of the experiment under different treatment combinations is presented in Table 3. Among the different treatments, the plots received T_2 (SRC + sugarbeet Shubra) treatment gave the maximum profit 268381.30 Tk. ha^{-1} with BCR (3.00) that was followed by the plots with T_3 (SRC + sugarbeet PAC 6008) treatment resulted profit (243041.50 Tk. ha^{-1}) and BCR(3.81). The lowest profit (103513.60 Tk. ha^{-1}) and BCR (1.82) was achieved from the plot treated with T_7 (Sole sugarbeet SZ 35). The similar findings were found by Munir *et al*. (2008). They found a maximum profit of 156538.5 Rs ha^{-1} in sugarcane-sugarbeet inter-cropping system where sole sugarcane was 104588.5 Rs ha^{-1} and sole sugarbeet was 99141.5 Rs ha^{-1}.

Conclusion

The overall result of this experiment showed the effect of planting system on yield and quality, and economic benefits of both the crops. The maximum profit was found in sugarcane-sugarbeet inter-cropping system than sole single row sugarcane and also sole sugarbeet. Among them the highest yield, brix % and maximum BCR were achieved from single row sugarcane with sugarbeet (Shubra). It can be concluded that growing sugarbeet intercrop with sugarcane might be a profitable practice in northern region of Bangladesh.

References

Akhtar M, Yaqub M, Iqbal Z, Ashraf MY, Akhter J and Hussain F. 2010.Improvement in yield and nutrient uptake by co-cropping of wheat and chickpea. Pakistan Journal of Botany, *42*: 4043-4049.

Alam MJ, Hossain MS, Islam AK, MR, Rahman MK and Kabir ML. 2008. Performance of jute varieties for seed production as first and mungbean as second intercrop under transplanted cane in paired row. Bangladesh Journal of Sugarcane, *30*: 116-121.

Alam MJ, Rahaman MM, Sohel MAT, Razzak MA, Roy HP, Islam S, Khaiyam MO and Rahman, MS. 2000. Poductivity of soybean-mungbean sequential inter-cropping with paired rows transplanted sugarcane. Bangldesh Journal of Sugarcane, *36:* 59-68.

CIMMYT. 1988. From Agronomic Data to Farmers Recommendations: An Economics Training Manual. Mexico. Pp. 31-45.

FAOSTAT. 2014. Food and Agriculture Organization of the United Nations: Economic and Social Department, The Statistical division FAOSTAT, http://faostat3. fao.org/home/index.html# Download

FAOSTAT. 2018. Food and Agriculture Organization of the United Nations: Economic and Social Department, The Statistical division FAOSTAT, http://faostat3. fao.org/home/index.html# Download.

Farhad ISM, Chowdhury MMU, Bhowal SK, Choudhury AK and Khan ASMMR. 2014. Chilli-garlic inter-cropping system in coastal saline area. Applied Science Report, *6*: 47-50.

Guleria G and Kumar N. 2016. Sowing methods and varying seed rates of cowpea on production potential of sorghum, sudan grass hybrid and cowpea: a review. Agricultural Reviews, *37*: 290-299.

Islam AKMR, Razzak MA, Sohel MAT, Roy HP and Islam N. 2016. Inter-cropping tropical sugarbeet varieties with sugarcane in different planting geometry. Bangladesh Journal of Sugarcane, *37*: 1-9.

Islam MJ, Begum MK, Arefin MS, Ghose AK, Islam S, Razzak MA and Reza ME. 2015. Yield and quality attributes of tropical sugarbeet genotyes. Bangladesh Journal of Sugarcane, *36*: 29-36.

Islam MS, Hossain MS, Alam MJ, Rashid MM and Habib MA. 2017. Productivity of tropical sugarbeet as intercrop with sugarcane in old Himalayan piedmont plain soil. Bangladesh Journal of Sugarcane, *38*: 109-118.

Kashem MN, Hossain GMA, Kanner MA, Basher MK and Alam KS. 2007. Performance of selected winter vegetables as first and sunhemp as second intercrop with paired row sugarcane. Bangladesh Journal of Sugarcane, *29*: 68-73.

Khan DI. 2017. Studies on inter-cropping of sugarbeet (*Beta vulgaris* L.) with sugarcane (*Saccharum officinarum* L.) by different management practices. PhD thesis submitted to the Department of Agronomy, Gomal University, Pakistan. Pp. *42-129.*

Munir MA, Sarwar MA, Iqbal J, Hussain F and Chattha AA. 2008. Effect of spacing on yield and quality of autumn sown sugarcane intercropped with sugarbeet. Pakistan Sugar Journal, *23*: 19-24.

Panella L. 2010. Sugarbeet as an energy crop. Sugar Technology,*12*: 288-293.

Panhwar RN, Panhwar DB, Memon MA, Unar GS, Chohan M, Kaloi GM and Mari AH. 2006. Comparative growth and quality assessment of diverse sugarcane clones in 3rd cycle under ThattaAgro-ecological conditions. Pakistan Sugarcane Journal, *23*: 2-8.

Paul SK, Jonil RA, Sarkar MAR, Hossain MS and Paul SC. 2019. Performance of tropical sugarbeet (*Beta vulgaris* L.) as influenced by date of harvesting. *Archives of* Agriculture and Environmental Science, *4*: 19-26.

Paul SK, Paul SC, Sarkar AB and Hossain MS. 2018. Influence of integrated nutrient management on the growth, yield and sugar content of tropical sugarbeet (*Beta vulgaris* L.). Pakistan Sugar Journal, *33*: 11-22.

Rehman A, Qamar R and Qamar J. 2014. Economic assessment of sugarcane through inter-cropping. Journal of Agricultural Chemistry and Environment, *3*: 24-28.

Reilly G. 1998. The south African sugar industry. International Sugar Journal, *100:* 266-268.

Shahana F, Bharati Y and Joseph B. 2019. Identification of profitable intercrops in summer sugarcane in NTZ. Journal of Pharmacognosy and Phytochemistry, *8*: 1602-1604.

Shukla SK, Sharma L, Awasthi SK and Pathak AD. 2017. Sugarcane in India: package of practices for different agro-climatic zones. ICAR-Indian Institute of Sugarcane Research. Pp. 1-64.

Singh RK, Sharma AK, Singh RK and Prakash B. 2013. Problems and prospects of sugarbeet cultivation as fodder crop in subtropical India. Indian Institute of Sugarcane Research (ICAR) and Association of Sugarcane Technologists of India. Pp. 53-54.

Soomro SA. 2008. Economic impact of inter-cropping different minor crops with sugarcane. MSc Thesis. Department of Agronomy, Sindh Agricultural University, Tandojam, Pakistan. P. 63.

Steel RGD, Torrie JH and Dicky DA. 1996. Principles and Procedures of Statistics, A Biometrical Approach. McGraw Hill, Inc. Book Co., New York, NY, USA.

Wu GQ, Feng RJ and Shui QZ. 2016. Effect of osmotic stress on growth and osmolytes accumulation in sugarbeet (*Beta vulgaris* L.) plants. Plant, Soil and Environment, *62*: 189-194.

Yang JB, Peng DH, Qin LD, Xing YX, Li YR and Yang LT. 2015. Effect of sugar cane-soybean inter-cropping on cane yield, quality and economic benefit under low nitrogen condition. Chinese Journal of Applied Ecology, *26*: 1426-1432.