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EFFECT OF ROW ORIENTATION ON PRODUCTIVITY OF SUGARCANE WITH POTATO AS INTERCROP

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Abstract

An experiment was carried out at the Regional Sugarcrop Research Station (RSRS) farm, Thakurgaon under the agro-ecological zone of Old Himalayan Piedmont Plain (AEZ-1) of Bangladesh, during 2016-2017 to 2017-2018 cropping seasons to evaluate the impact of row orientation on the productivity of sugarcane with potato as intercrop. Under the study eight treatments *viz* T_1: Single row cane (SRC) only in north-south direction, T_2: SRC + potato in North-South direction, T_3: SRC only in east-west direction, T_4: SRC + potato in east-west direction,T_5: Paired row cane (PRC) only in North-South direction, T_6: PRC + potato in north-south direction, T_7: PRC only in east-west direction and T_8: PRC + potato in east-west direction were tested following Randomized Complete Block Design with three replications Significant differences were found among the observed parameters except germination (%) of setts, number of internodes per stalk and unit stalk weight of sugarcane. The highest number of tiller and millable cane population, cane yield and brix reading were achieved from the treatment SRC + potato in the North-South direction. The highest intercrop yield, equivalent cane yield of intercrop, total adjusted yield and gross return were obtained from the treatment PRC + potato in north-south direction, but the highest net return and benefit cost ratio were obtained from the treatment SRC + potato in the North-South direction. Having the highest cane yield, net return and benefit cost ratio with less variable cost, sugarcane planting in a single row system with potato as intercrop in a North-South row direction could be considered the best package practice for successful sugarcane farming.

Introduction

Sugarcane (*Saccharum officinarum* L.) is a profitable cash crop grown mainly for sugar production. It is cultivated in more than 103 countries of the world with Brazil as a major producer followed by Brazil (829.74 million tons), India (446.89 million tons), Thailand (144.41 million tons), China (121.21 million tons), Pakistan (77.72 million tons) and Mexico (65.40 million tons) (FAOSTAT, 2019). In Bangladesh sugarcane was grown under many diverse agro-ecological conditions with an average production of about 3203 thousand tons (BB, 2019). It is the main source of sugar (80%) globally and holds a prominent position as a cash crop. The sugarcane juice is used for making white sugar, brown sugar, and jaggery (gur). The main byproducts of the sugarcane industry are bagasse and molasses. Bagasse is mainly used as fuel. It is also used for the production of compressed fibre board paper, plastic and others. Molasses is used in distilleries for the manufacturing of ethyl alcohol, butyl alcohol, citric acid etc. Rum is the best potable spirit made from molasses. Molasses is also used as an additive to feed for livestock. Press mud can be used as soil amendment in saline and alkali soils. Green tops of cane are a good source of fodder for cattle (Shukla *et al.*, 2017). It is a long duration crop that takes about 12-14 months from planting to harvesting which decreases economic return of the farmers compared to other crops. To get the higher economic returns 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 (Islam *et al.*, 2016). Intercropping is the practice of cultivating two or more crops simultaneously on the same piece of land per year (Guleria and Kumar, 2016). 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 the 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). Similarly, the interaction between plant population and row orientation influences solar radiation interception by the plant canopy and soil moisture and nutrient uptake by the crops (Tsubo *et al.*, 2003). Orientation of the rows also affects photosynthetic efficiency and canopy temperature as it affects interception of solar radiation by the crop canopy (Drews *et al.*, 2009). Reducing space between rows or orientating rows to right angles (north-south) to sunlight direction increases weeds shading, water use efficiency and crop yields (Fedelibus, 2005). North-South row had the potential for yield advantage and may be slightly preferable over East-West (Dhillon *et al.*, 1982). More radiation penetration and interception in north-south rows increased the crop profile temperature and decreased humidity within the canopy and made the crop micro-environment unfavorable for pests and diseases. So, the crops grown in north-south direction were found the most efficient in terms of producing more leaf area index, biomass and yield (Das, 2014). Improper row direction and seeding density is the most critical factors that reduce sugarcane yield in the country (Mahmood *et al.*, 2007). North to South direction gives the most sun exposure and allows for ample air circulation. When crops are planted east to west, the rows tend to shade each other. But information in this respect for sugarcane which remains in the field round the year is either lacking or scanty, and limited research has so far been done. Given the above circumstances, the study was undertaken to determine the appropriate row orientation for sugarcane production with intercrop under the agro-ecological zone of the Old Himalayan Piedmont Plain of Bangladesh.

Materials and Methods

The experiment was conducted at Regional Sugarcane Research Station (RSRS) farm, Thakurgaon in Bangladesh during 2016-2017 to 2017-2018 cropping seasons under irrigated conditions. The site represents the Old Himalayan Piedmont Plain (AEZ-1) with medium high land of typical sandy loam soil having pH 5.5. Sugarcane (cv. Isd 37) was planted in a single and paired row planting system, where potato (cv. Cardinal) was planted as intercrop in between two rows/paired rows of sugarcane in the same land. The experiment was laid out in a randomized complete block design (RCBD) with three replications. The unit plot size was 8m × 6m and the treatments were as follows-

T_1: Single row cane (SRC) only in north-south direction
T_2: SRC + potato in North-South direction
T_3: SRC only in East-West direction
T_4: SRC + potato in East-West direction
T_5: Paired row cane (PRC) only in north-south direction
T_6: PRC + potato in North-South direction
T_7: PRC only in East-West direction
T_8: PRC + potato in east-west direction.

Two budded sugarcane setts were planted following end to end placement in trenches in mid-November of 2016 and 2017 for the two cropping seasons. In single row planting system, row to row distance was 100 cm where in paired row planting system, distance between two rows was 60 cm and two paired rows was 140 cm. The intercrop potato was planted in the vacant spaces between two rows/paired rows on the next day of the sugarcane plantation. Fertilizers were applied following the recommended rate (BARC, 2012). Urea, TSP, MoP, Gypsum and Zn sulphate for sugarcane @ 358, 275, 240, 194 and 7 Kg ha^{-1}, respectively and 210, 120, 180, 75 and 6 Kg ha^{-1}, respectively for potato as intercrop, respectively. Pest and disease management and necessary intercultural operations like weeding, mulching, gap filling, irrigation, earthing-up, tying etc. were done accordingly in proper time. Intercrop potato was harvested in mid-February of the following years and data were recorded properly. Germination (%) of setts was counted at 30 days after planting (DAP) and tiller population on 150 DAP. Stalk height, stalk diameter, unit stalk weight, number of internodes per stalk, number of millable cane, cane yield and brix (%) of cane juice were recorded at harvest. Sugarcane was harvested after

twelve months from plantation at maturity stage for every season. Calculation of tiller mortality (%), equivalent cane yield of intercrop, total adjusted cane yield and economic return were done accordingly on the basis of present market price. Fisher's analysis of variance (ANOVA) was used for statistical analysis of collected data and 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.

$$\text{Tiller mortality (\%)} = \frac{\text{Number of tiller - Number of millable cane}}{\text{Number of tiller}} \times 100$$

The benefit cost ratio (BCR) indicated whether the cultivation was profitable or not, which was calculated as follows (CIMMYT, 1988):

$$\text{Benefit cost ratio} = \frac{\text{Gross return (Tk.ha}^{-1})}{\text{Cost of production (Tk.ha}^{-1})}$$

Gross return = Value of cane and intercrop
Cost of production = Sum of costs for the resources.

Results and Discussion

Response of row orientation of sugarcane and its effect on germination (%) of setts, stalk height, stalk diameter, number of internodes per stalk and unit stalk weight were represented in Table 1.

Table 1. Effect of row orientation on germination (%) of sett, stalk diameter, no. of internode stalk^{-1} and unit stalk weight of sugarcane (pooled data, 2016-2017 to 2017-2018)

Treatments	Germination (%)	Stalk diameter (cm)	Internodes stalk^{-1}	Unit stalk weight (Kg)
T_1: SRC only in north-south direction	78.14	2.29 ab	26	0.88
T_2: SRC + potato in north-south direction	79.42	2.33 a	27	0.89
T_3: SRC only in east-west direction	76.84	2.13 bc	26	0.82
T_4: SRC + potato in east-west direction	79.24	2.20 abc	25	0.84
T_5: PRC only in north-south direction	76.67	2.15 bc	27	0.85
T_6: PRC + potato in north-south direction	77.64	2.24 abc	25	0.86
T_7: PRC only in east-west direction	76.50	2.10 c	27	0.87
T_8: PRC + potato in east-west direction	77.57	2.17 abc	26	0.88
$LSD_{(0.05)}$	NS	NS	NS	NS

In a column, figures with similar letters do not differ significantly at 5% level

Germination percentage

Germination percentage is the most critical factor that determines the varietal potential to exploit the available resources and ultimately affects on cane stand. In the study, germination percentage is not affected significantly by row orientation of sugarcane but the highest germination percentage of 79.42 was observed in T_2 (SRC + potato in north-south direction) and the lowest germination percentage of 76.50 was observed in T_7 (PRC only in east-west direction).

Stalk height

Environmental factors and genetic characteristics of plants play an important role in determining the plant height and other physical characteristics. Among different treatment combinations stalk height as obtained was significantly affected by row orientation of sugarcane and intercropping (Fig. 1.). The highest stalk height of 3.20 m was observed in T_2: SRC + potato in north-south direction. The lowest stalk height of 2.84 m was recorded in T_7: PRC sole in east-west directions. Ruk *et al*. (2014) and Karanja1 *et al.* (2014) mentioned the same result in their report. Ruk *et al.* (2014) reported that height of cane 241.33 cm in North-South row direction than East-West row orientation (232.50 cm). Karanja *et al.* (2014) also reported that sorghum plant height of 0.95 m oriented in North-South compared to 0.87 m in East-West row orientation.

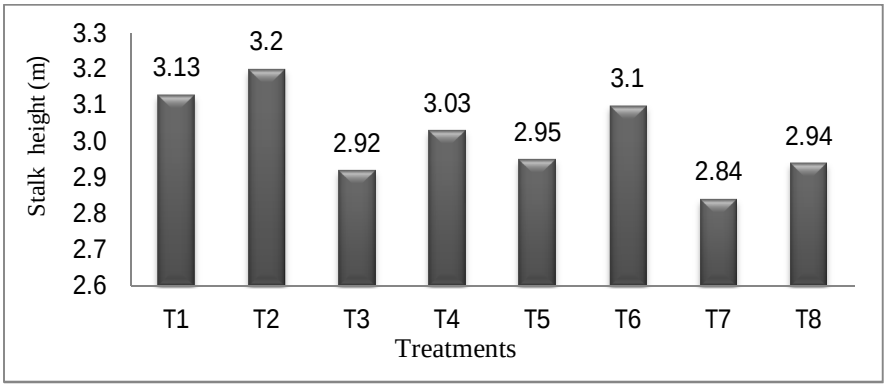

Fig. 1. Effect of row direction on stalk height of sugarcane.

Stalk diameter

The significant difference was observed in stalk diameter due to plantation with varied row orientation. The highest stalk diameter (2.33 cm) was found from the treatment T_2 (SRC + potato in north-south direction) followed by T_1 which was statistically similar and the lowest of 2.10cm was found from the treatment T_7 (PRC only in east-west direction). From the result, it was observed that a higher stalk diameter was found from the canes planted in the North-South direction and intercropping had no adverse effect on stalk diameter. Similar result was reported by Ruk *et al.* (2014). They reported that sugarcane planted in rows of North-South direction produced the higher cane diameter of 3.18 cm than the East-West row direction (3.06 cm).

Number of internodes

The number of internodes per stalk was not differ significantly among the treatment combinations ranges from 25 to 27. This result was agreement with Ruk *et al.* (2014). They showed that number of internode range (18-18.73) among the North-South and East-West row direction.

Unit stalk weight

No significant difference was observed in unit stalk weight and ranged from 0.82 to 0.89 Kg per stalk. The highest unit stalk weight of 0.89 kg was found from T_2: SRC + potato in north-south direction and the lowest weight of 0.82 Kg was found from T_3: SRC only in an East-West direction. Similar result was also observed by Ruk *et al.* (2014) who observed that canes weight (1.5 Kg cane^{-1}) in the North-South direction and the lowest cane weight (1.4 Kg) in the East-West row direction.

Results from this study further indicated that all the treatments exerted significant influence on yield and other yield attributes viz, tiller population, millable cane, cane yield and brix (%) of cane as presented in Table 2.

Table 2. Effect of row direction on number of tiller and millable cane production, cane yield and brix (%) of sugarcane (pooled data, 2016-2017 to 2017-2018)

Treatments	Tiller (10^3 ha^{-1})	Millable cane (10^3 ha^{-1})	Cane yield (t ha^{-1})	Brix (%)
T_1: SRC only in north-south direction	162.28 ab	91.87 a	78.36 abc	21.00
T_2: SRC + potato in north-south direction	174.24 a	96.50 a	86.23 a	21.10
T_3: SRC only in east-west direction	148.69 abc	88.54 ab	77.93 abc	20.00
T_4: SRC + potato in east-west direction	152.13 abc	89.72 ab	85.89 ab	20.10
T_5: PRC only in north-south direction	152.52 abc	90.93 ab	72.03 c	20.33
T_6: PRC + potato in north-south direction	153.05 abc	91.76 ab	79.91 abc	20.00
T_7: PRC only in east-west direction	132.68 c	79.04 b	71.60 c	19.86
T_8: PRC + potato in east-west direction	139.88 bc	81.35 b	76.29 bc	19.70
$LSD_{(0.05)}$	27.79	9.85	12.01	NS

In a column, figures with similar letters do not differ significantly at 5% level

Tiller population

The tillering potentiality of sugarcane ultimately affects cane yield positively. A significant difference in the tiller population was found among the treatment combinations. The highest number of tiller 174.24×10^3 ha^{-1} was recorded in the treatment T_2: SRC + potato in north-south direction and the lowest tiller of 132.68×10^3ha^{-1} was recorded in the T_7: PRC only in the East-West direction. Similar observation was reported by Ruk *et al.* (2014); Singh and Sharma, (2019). They show that North-South row direction resulted in higher tiller than of 144.35 than other direction.

Millable cane

The number of millable cane directly influences cane yield. The highest number of millable cane of 96.50×10^3 ha^{-1} was found from the treatment T_2: SRC + potato in north-south direction which was statistically similar to other treatments except T_7 and T_8. The lowest millable cane of 79.04×10^3 ha^{-1} was found from the T_7: PRC only in east-west direction treatment. Similar report was reported by Ruk *et al.* (2014) who reported that effect of North-South row direction resulted in a higher millable cane of 144.35 ×10^3 ha^{-1} than the East-West row orientation (142.00 ×10^3 ha^{-1}).

Tiller mortality (%)

The highest tiller mortality (46.51%) was recorded in the treatment T_8: PRC + potato in east-west direction while the lowest mortality of 40.04% was obtained in the treatment T_6: PRC + potato north-south direction. It was observed that among the treatments, higher tiller mortality was calculated with treatments that produced higher numbers of tillers but finally more millable canes were obtained with those treatments (Fig. 2).

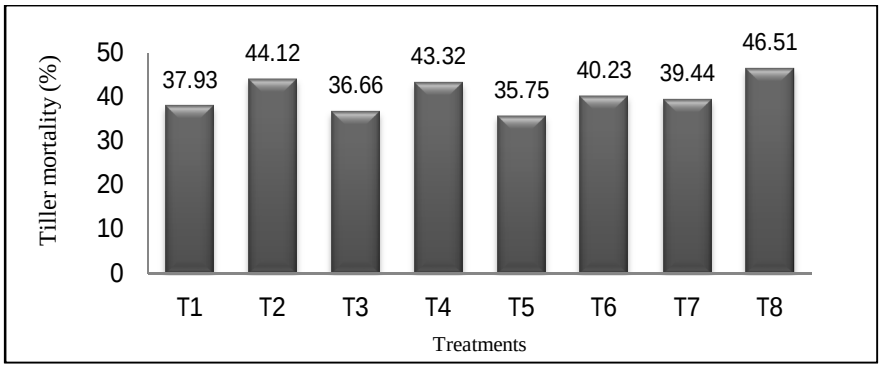

Fig. 2. Effect of row direction on tiller mortality of sugarcane.

Cane yield

The highest cane yield of 86.23 t ha^{-1} was obtained from the treatment T_2 (SRC + potato in north-south direction) which was statistically similar with 91.87 t ha^{-1} obtained in T_1 (SRC only in north-south direction) and partially similar to the treatments T_3, T_4, T_5 and T_6. The lowest cane yield of 71.60 t ha^{-1} was obtained from the treatment T_7 (PRC only in east-west direction). Similar report was reported by Ruk *et al*. (2014) and Karanja1 *et al.* (2014). Ruk *et al.* (2014) reported that the crop planted in rows of North-South direction produced the maximum cane yield of 91.96 t ha^{-1} and the lowest cane yield of 88.267 t ha^{-1} in East-West row direction. Karanja *et al.* (2014) also reported that North-South row orientation however, produced higher sorghum grain yields of 2.50 tons ha^{-1} than East-West 2.30 tons ha^{-1}. Results from the study further indicated that all the treatments exerted significant influence by the intercropping on cane yield, equivalent cane yield of intercrop and total adjusted cane yield presented in Table 3.

Table 3. Intercrop yield, equivalent cane yield of intercrop and total adjusted cane yield as affected by row direction of intercropping with sugarcane cropping system (pooled data, 2016-2017 to 2017-2018)

Treatments	Cane yield (t ha^{-1})	Intercrop (potato) yield (t ha^{-1})	Equivalent cane yield of intercrop (t ha^{-1})	Total Adjusted. cane yield (t ha^{-1})
T_1: SRC only in north-south direction	78.36	-	-	78.36
T_2: SRC + potato in north-south direction	86.23	14.77	59.08	145.31
T_3: SRC only in east-west direction	77.93	-	-	77.93
T_4: SRC + potato in east-west direction	85.89	13.86	55.44	141.33
T_5: PRC only in north-south direction	72.03	-	-	72.03
T_6: PRC + potato in north-south direction	79.91	16.80	67.20	147.11
T_7: PRC only in east-west direction	71.60	-	-	71.60
T_8: PRC + potato in east-west direction	76.29	14.34	57.36	133.65

Price of crops: Sugarcane: 2,500 Tk t^{-1} and Potato: 10,000 Tk t^{-1}

Brix percentage

Brix readings of sugarcane juice were significantly affected by row orientation and intercropping. The highest brix % of 21.66 was obtained from T_2 (SRC + potato in north-south direction) which was statistically similar but numerically different with the other treatments except T_7 (PRC only in east-west direction) when the lowest brix % of 19.16 was obtained. Similar result was in agreement with Ruk *et al.* (2014). They found that the crop planted in rows of North-South direction resulted in maximum brix content of 22.76% and the lowest brix (22.75%) resulted in crops planted in East-West row direction.

Intercrop yield

The overall yield performance of the intercrop potato was found satisfactory (Table 3.) The highest potato yield of 16.80 t ha^{-1} as intercrop was obtained from T_6 (PRC + potato in north-south direction) followed by T_2 (SRC + potato in north-south direction). The lowest potato yield as intercrop of 13.86 t ha^{-1}was obtained from T_4 (SRC + potato in east-west direction).

Adjusted cane yield

Adjusted cane yield is an important parameter for determining the total yield potentials of intercropped plot over the sole sugarcane plot (Alam *et al.*, 2000). The highest total adjusted cane yield of 147.11 t ha^{-1} was achieved from the treatment T_6 (PRC + potato in north-south direction) followed by 145.31 t ha^{-1} from T_2 (SRC + potato in north-south direction) and the lowest total adjusted cane yield of 71.60 tha^{-1} was recorded from the treatment T_7 (SRC only in east-west direction) (Table 3).

Economic analysis

The cost and returns of the experimentation under different treatments are presented in Table 4.

Table 4. Production cost, grows return, net return and benefit cost ratio (BCR) of sugarcane with potato cultivation as affected by row direction and planting method (pooled data, 2016-2017 to 2017-2018 cropping seasons)

Treatments	Total production cost	Total Adjusted.	Gross return (Tk ha^{-1})	Net return (Tk ha^{-1})	Benefit cost ratio

	(Tk ha^{-1})	cane yield (t ha^{-1})			
T_1: SRC only in north-south direction	95,000	78.36	1,95,975	1,00,975	2.06
T_2: SRC + potato in north-south direction	1,70,000	145.31	3,63,275	1,93,275	2.14
T_3: SRC only in east-west direction	95,000	77.93	1,94,825	99,825	2.05
T_4: SRC + potato in east-west direction	1,70,000	141.33	3,53,325	1,83,325	2.08
T_5: PRC only in north-south direction	1,05,000	72.03	1,80,075	75,075	1.72
T_6: PRC + potato in north-south direction	1,80,000	147.11	3,67,775	1,87,775	2.04
T_7: PRC only in east-west direction	1,05,000	71.60	1,79,000	74,000	1.70
T_8: PRC + potato in east-west direction	1,80,000	133.65	3,34,125	1,54,125	1.85

Price of crops: Sugarcane: 2,500 Tk t^{-1} and Potato: 10,000 Tk t^{-1}

The highest gross return, net return and BCR of 3,63,275 Tk ha^{-1}, 1,93,275 Tk ha^{-1} and 2.14, respectively are calculated in the treatment T_2: SRC + potato in north-south direction and the lowest of these are from the treatment T_7: PRC only in east-west direction. From the calculation, it was observed that higher returns were obtained from the plots when the cane was planted in north-south direction irrespective of single or paired row planting system. It was also observed that a higher amount of earnings were obtained from the intercropped plots than the sole sugarcane plots. Similar results confirmed with Singh and Sharma (2019) who depicted that North-South row orientation of wheat crops gave maximum BCR (1.58) as compared to East-West (1.55).

Conclusion

The overall results of the experiment revealed that cane and intercrop yield and different yield contributing parameters of sugarcane were significantly affected by row orientation both in single or paired row planting systems. The highest cane yield, gross return, net return and BCR of 86.23 t ha^{-1}, 3,63,275 Tk ha^{-1}, 1,93,275 Tk ha^{-1} and 2.14, respectively were achieved from the plot when the cane was planted in North-South direction following single row system with potato as intercrop. It was observed that higher returns were obtained from the plots, when cane was planted in North-South direction irrespective of planting systems. It was also observed that higher yields were harvested in single row planting system irrespective of row directions and intercropped plots earned more than the sole sugarcane plots. It can be noted that sugarcane cultivation in North-South row direction following a single row planting system with potato as an intercrop is the best and may be recommended for farmers' practice.

References

Alam, M.J., M.S. Hossain, A.K.M.R. Islam, M.K. Rahman and M.L. Kabir. 2008. Performance of jute varieties for seed production as first and mungbean as second intercrop under transplanted cane in paired row. Bangladesh J. Sugarcane. 30: 116-121.

Alam, M.J., M.A. Islam, M.M. Rahaman and A.K.M.M. Zaman. 2000. Impact of paired row sugarcane with double intercrops. Bangladesh J. Sugarcane. 22: 1-9.

Bangladesh Bank. 2019. Bangladesh production: Sugarcane data remains active status in CECIC. Global data bases Bangladesh.

BARC (Bangladesh Agricultural Research Council). 2012. Fertilizer Recommendation Guide. BARC, Farmgate, Dhaka, Bangladesh. pp. 191.

CIMMYT. 1988. From agronomic data to farmers recommendations: An economics training manual. Completely revised edition. Mexico. pp. 31-45.

Das, D.K. 2014. Micrometeorological studies of crop row direction on growth and biotic stress in oilseed *Brassica.* MS thesis. Agricultural Research Institute. New Delhi, India.

Dhillon, G.S., S. Surjut, M.S. Dhillon and A.S. Atwal. 1982. Developing agri-silvicultural practices: studies on the shading effect of *Eucalyptus* on the yield of adjoining crops. Indian J Ecol. 9(2): 228-236.

Drews, S., D. Neuhoff and U, Kopke. 2009. Weed suppression ability of three winter wheat varieties at different row spacing under organic farming conditions. Weed Res. 49: 526-533.

Fedelibus, M. 2005. Grapevine row orientation offers light environment, growth and development of black night shade (*solanum nigram* L.). Weed sci. 53: 802-812.

FAOSTAT. 2019. Food and Agriculture Organization of the United Nations: Economic and Social Department.The Statistical division FAOSTAT. https://www.fao.org/faostat/en/#rankings/countries_by_commodity.

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

Islam, M.S., M.J. Alam, M.S. Hossain, M.M. Rashid and M.K. Rahman. 2016. Productivity and profitability of flower- mungbean sequential intercropping with sugarcane. Bangladesh J. Sugarcane. 37: 83-92.

Karanja, S.M., A.M. Kibe1, P.N. Karogo and M. Mwangi. 2014. Effects of intercrop population density and row orientation on growth and yields of sorghum- cowpea cropping systems in semi-arid rongai, Kenya. J. of Agri. Sci. 6: 34-43.

Mahmood, A., M. Ishfaq, J. Iqbal and M. S. Nazir. 2007. Agronomic performance and juice quality of autumn planted sugarcane (*Saccharum officinarum* L.) as affected by flat, ditch and pit planting under different spatial arrangements. Int. J. Agri. Biol. 9: 167-169.

Ruk, A. S., M. N. Kandhro, S. K. Baloch, S. U. Baloch and A. B. Baloch. 2014. Impact of sett placement methods and row directions on growth and yield of sugarcane variety LRK-2001. Persian Gulf Crop Pro. 3(2): 53-69.

Shahana, F., Y. Bharati and B. Joseph. 2019. Identification of profitable intercrops in summer sugarcane in NTZ. J. Pharmacogn. Phytochem. 8(5): 1602-1604.

Shukla, S.K., L. Sharma, S.K. Awasthi and A.D. Pathak. 2017. Sugarcane in India: package of practices for different agro-climatic zones. ICAR-Indian Institute of Sugarcane Research. pp. 1-64.

Singh, K. and R. Sharma. 2019. Effect of different methods of sowing and row orientation on growth, yield and quality of wheat (*Triticum aestivum* L.). Agric. Sci. Digest., 39(1): 51-54.

Steel, R.G.D., J.H. Torrie and D.A. Dicky. 1996. Principles and procedures of statistics, a biometrical approach. 3rd Edn. McGraw Hill, New York.

Tsubo, M., E. Mukhala, H.O. Ogindo and S. Walker. (2003). Productivity of maize-bean intercropping in a semi-arid region of South Africa. Water SA. 29(4): 381-388.