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Response of maize varieties under variable planting geometry in Kandahar semi-arid situation

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Abstract
A field experiment was conducted during spring season, 2015 at Tarnak Research Farm of Afghanistan National Agricultural Sciences and Technology University (ANASTU), Kandahar, Afghanistan with semi-arid climate to found out the response of yield, economics and energy relation of maize varieties under varying planting geometry. The experiment was conducted in FRBD and replicated thrice. The treatment details include: two maize hybrids - CS-200 and AB-01 and four planting geometry [P1 (75 × 33.3cm) with plant population of 40,000 plantsha^{-1}, P2 (75 × 22.2cm) with plant population of 60,000 plantsha^{-1}, P3 (75 × 16.7cm) with plant population of 80,000 plantsha^{-1} and P4 (75 × 13.3cm) with plant population of 100,000 plantsha^{-1}]. Results showed that maize hybrid CS-200 performed significantly superior in terms of grain yield (6.41 t ha-^{1}) and harvest index (37.6%) compared to AB-01 (5.81 tha^{-1} and 33.4%, respectively). Both of maize hybrids (CS-200 and AB-01) did not differ significantly with respect to gross return, net return. B: C ratio, energy output and energy use efficiency due to their significant variation in producing grain and stover yields. Among the varying planting geometry, the wider planting geometry recorded significantly better performance for all yields attributes. Planting geometry P2 recorded significantly greater performance in terms of yields attributes. Therefore, hybrid CS-200 and planting geometry P2 is recommended for obtaining higher yield of maize, which can assure a net income of 221,371Afnha^{-1} to the farmers of Kandahar semi-arid situation.

Keywords: Maize varieties, optimum planting geometry, yield, economics and energy relations

Introduction

Maize (*Zea mays* L.) enjoys an important position in the existing cropping systems of Afghanistan; it ranks third after wheat and rice in the country for its grain production. Maize is grown in almost all the provinces of the country. It is not only consumed by human beings in the form of food grain but it is also used as feed for livestock and poultry besides being a good forage crop. In Afghanistan, it is grown on 0.142 million hectare in all of the provinces in irrigated and rain fed areas. The total production of maize in the country is 0.312Mt. with the average productivity of (2.2 th^{-1}): (MAIL, 2014). The average grain yield of maize is not only substantially lower compared with other important maize growing countries but also less than the production potential of existing genotypes. Maize is grown twice a year in Afghanistan (spring, autumn). Although the soil and climatic conditions of Afghanistan are favorable for maize production but it's per hectare yield is very low as compared to other maize growing countries of the world. Maize crop bears high yield potential and responds to various agro-management practices. Low yield of maize is due to many constraints but among them, cultivation of local genotypes, imbalanced use of fertilizers, traditional sowing methods, lack of optimal crop stand and optimum planting geometry are the factors of prime importance. Successful maize production requires an understanding of various management practices as well as environmental conditions that affect crop performance (Eckert, 1995) [11]. Selection of appropriate genotypes, plant population and planting geometry are cultural practices that have been shown to affect maize yield potential and stability (Norwood, 2001) [15]. Moreover, there are numbers of biotic and a biotic factors that affect maize yield considerably, however, maize grain yield is more affected by variations in plant population density than other members of the grass family due to its low tillering ability, its monoecious floral organization and the presence of a brief flowering period. (Vega *et al*, 2001) [21].

In Afghanistan situation very less work has been done to evaluate the different maize varieties in order to find out the appropriate varieties and optimal planting geometry of maize genotype to discover the yield potential at higher level under agro-climatic situations. Hence, the study was undertaken to assess the response of maize varieties under variable planting geometry in Kandahar semi-arid situations of Afghanistan.

Materials and methods

The experiment was carried out under irrigation condition during the period from April to August 2015. The site of experiment was located in south region of country with distance of 35 km from Kandahar city. (31° 20′50”) N latitude and (65° 20′30”) E longitude, altitude of the location was 985 msl.

The minimum and maximum temperature, relative humidity and total rainfall during crop growth period were recorded ranged between (12.5 to 44.5 ^{0}C), (11.8 to 26.6 %) and (1.00 to 403mm) respectively.

The experiment design was a factorial arranged in a FRCBD with three replications. The two factors included of two hybrid varieties (CS-200 × AB-01) and four planting geometries for each verities with four plant populations (40,000 plantsha^{-1}; 60,000 plantsha^{-1}; 80,000 plants ha^{-1} and 100,000 plantsha^{-1}), each replication involved with eight treatments and in all there were 24 treatments. Plant population was replicated three times for either genotype. Net plot size was (3 m × 4 m =12 m^2) involved four rows of 75cm inter-row and with variable intra-row spacing.

Data collections of the field experiment were noted on the basis of grain yields economics and energy relation as followed.

The dried cobs of each harvested row from either plot were threshed by hand then obtained grains were cleaned, dried and weighted separately by using sensitive electronic balance. Grain yield of each harvested row of each plot was recorded as (kg ha^{-1}) individually and converted to (tha^{-1}) basis.

The harvest index (HI) was computed by dividing grain yield with total biological yield.

The benefit cost ratio for each treatment of interaction was calculated on the basis of the price of harvested crop, cost of each treatment and the cost of cultivation.

Energy input and output for the purposes of the analysis undertaken in this study, the energy values for inputs (e.g. machinery, seeds, fertilizer, water, and labour requirements) and outputs (e.g. grain and stover) were estimated using energy equivalents were entered into excel spreadsheets and automatically calculated as recommended by Behera *et al*, (2015) [9] and Shahan *et al*. (2008) [19]. Are given in the (Table 1).

The energy use efficiency was calculated by equation followed: Shahan *et al*. (2008) [19]. Table 1. Energy equivalents of inputs and outputs in agricultural production for the maize varieties under varying planting geometries during spring, 2105 under Kandahar situation.

Particulars	Unit	Energy equivalent (MJ/unit)
A. Inputs		
1. Human labor (man)	hr	1.96
2. Machinery (tractor)	hr	62.7
3. Diesel fuel	liter	56.31
4. Chemical fertilizers		
(a) Nitrogen (N)	kg	66.1
(b) Phosphate (P_2O_5)	kg	12.4
(c) Potassium (K_2O)	kg	11.2
(d) Zinc (Zn)	kg	8.4
7. Water for irrigation	m^3	1.02
8. Seed (maize)	kg	14.7
B. Outputs		
1. Grain maize	kg	14.7
2. Stover	kg	12.5

The data were analyzed using standard procedure of data analysis (Gomez and Gomez, 1984).

Results and discussion

Yields and yields attributes

Yields and yields features of maize varieties under various planting geometry are existing in (Table 2). The number of cobs/plant, cob length, cob girth, number of grains/cob and 1,000-grain weight are the fundamental yield contributing parameters. The genetic potential of particular genotype can be judged by these attributes to enable regulate yield of maize plant. Results revealed that, response of both the hybrids was not significantly different in terms of evaluated parameters. These results are in agreement with the findings of (Azam *et al.*, 2007) [6]; (Saqib *et al,* 2012) [17] and (Karki *et al.*, 2015) [14]. Maize hybrid CS-200 gave higher grain yield (6.41 t ha^{-1}) than hybrid AB-01, (5.81tha^{-1}). It might be attributed to differences in genetic characteristics of the specific variety. These findings are in line with those stated by (Alias *et al*., 2008) [4]; (Azam *et al.*, 2007) [6], and (Saqib *et al.*, 2012) [17]. Hybrids AB-01 revealed significantly greater stover yield (12.2 t ha^{-1}), while hybrid CS-200 showed least stover yield (10.5 t ha^{-1}). These results showed that hybrid AB-01 was not more effective in transporting photosynthates from leaves, stem to grains (source to sink). Hybrid CS-200 indicated high harvest index than as hybrid AB-01. These findings showed that hybrid CS-200 was more efficient to convert photosynthates into economical yield. Azam *et al.*, 2007 [6] and Saqib *et al.*, 2012 [17]. Among the varying planting geometries, P1 recorded significantly greater number of cobs/plant (1.65) than others while, the minimum number of cobs/plant was recorded under P4 (0.98). These results are in agreement with the reported of Abuzar *et al.* (2011) [1]. Similarly, wider planting geometry P1 observed significantly longer cobs (20.2 cm) than others but, it was statistically at par with planting geometry P2. This could be due to the effect of interplant competition for light, soil water and nutrients. Sarjamei *et al.* (2014) [18]. Cob girth of the maize varieties was non-significant among the various planting geometry. Viorelion *et al*., (2014). Again treatment of P1 showed greater performance (34.4 and 515.1) than others with respect to number of grains/row and number of grains/cob which was statistically at par with planting geometry P2 respectively. Singh *et al*., (1997) [20] and Bhatt *et al*., (2012) [10]. Weight of 1,000 grains of maize was not affected significantly by different planting geometry. Babu and Mitra., (1989) [7]., Arif *et al*., (2010) [5]. Under P2 highest grain yield (7.71 t ha^{-1}) was noted than others while, minimum grain yield was observed under P4 (4.96 t ha^{-1}). (Abuzar *et al*., 2011) [1]; (Ramu and Reddy 2007) [16]; (Arif *et al*., 2010) [5] and (Fanadzo *et al*., 2010) [12], (Ali *et al*., 2003) [3]. Narrow planting geometry P4 had significantly greater stover yield (13.6 t ha^{-1}) as matched to wider planting geometry of P1 (9.00 t ha^{-1}). Difference clearly indicated that stover yield increased with decrease in planting geometry. Its might be due to higher population and more numbers plants in particular unit area. Verma and Singh (1976) [22]. Planting geometry P2 showed significantly greater performance in term of harvest index (41.6%) compared to others. These results are in agreement (Arif *et al*., 2010) [5] and (Bahadori *et al*., 2015) [8].

The significant interaction effects among the varieties and planting geometry for the yield characteristics and yields revealed that, both of hybrids showed significantly superior grain yield under planting geometry P2. Hybrid AB-01 had greater act of the stover with planting geometry of P4. The interaction effect of harvest index and planting geometry specified that hybrid CS-200 gave significantly higher harvest index under planting geometry P2. These results showed that planting geometry P2 indicated significantly better harvest index for the hybrid CS-200.

Economics

Economics of maize varieties under different planting geometry are presented in (Table 3). Results showed that maize hybrid AB-01 recorded higher cost of production (55,825 Afn ha^{-1}) compared to hybrid CS-200 (55,755Afn h^{-1}). This modification might be due to higher test weight of the grains of the particular hybrid variety. Both of varieties did not varied significantly with reverence to, gross returns, net returns and B: C ratio. These results are due to their significant dissimilarity in producing grain and stover yields. Regularly, hybrid CS-200 produces higher grain yield while hybrid AB-01 produced higher stover yield, and as both yields were taken into account for working out the economics, the net differences among the two hybrid varieties become non-significant. Among the planting geometry cost of production increased linearly as the planting geometry decreased. Treatment of P4 noted higher cost of production (57,350 Afn. ha^{-1}) followed by P3, P2 and P1. These results may be due to higher amount of sown seed. Planting geometry P2 showed significantly superior and best performance in terms of gross returns, net returns and B: C ratio (255,629 $Afnha^{-1}$, 200,359Afn ha^{-1} and 3.63) related to other planting geometry. The performance of planting geometry followed the trend of P2 > P3 > P4 > P1 for the concerned parameters. These findings clearly indicated that the sustainable productivity of maize could be achieved through maintenance of optimum planting geometry P2. In this context, the present review would show the way to improve the productivity of maize in order to get more net returns. These results are supported with results reported by (Bhatt, 2012) [10].

The significant interaction effects among the varieties and planting geometry for the economics showed that, hybrid CS-200 recorded significantly greater gross return, net return and B: C ratio with planting geometry P2. These finding evaluated that hybrid CS-200 performed significantly greater gross return, net return and B: C ratio under planting geometry P2. Saqib *et al*., (2012) [17].

Energy relations

Energy relations of maize varieties under various planting geometry are given in (Table 3). Results showed that maize hybrid AB-01 had significantly higher input energy (20,529 $MJha^{-1}$) compared to hybrid CS-200 (20,483 $MJha^{-1}$). This difference might be due to higher test weight of the grains of the particular hybrid variety. Both of varieties significantly were not differed in terms of energy output and energy use efficiency. These differences of the results might be due to their significant variation in grain yield, stover yields. Treatment of P4 recorded greater input energy (20,835 MJ ha^{-1}) followed by P3, P2 and P1. These results may be resolved that the input energy increased linearly as the planting geometry decreased due to its higher amount of seed. Planting geometry P2 showed significantly best performance (247,726 $MJha^{-1}$) regarding to output energy. The results clearly showed that it could be due to higher grain yield production from the mentioned planting geometry. While the planting geometry P4 recorded significantly greater energy use efficiency (14.4) than P1 (10.7) which were statistically at par with planting geometry of P2 and P3. These findings indicated that the energy use efficiency increased linearly as the planting geometry decreased.

The interaction effects among the hybrid varieties and different planting geometry were significant for the energy output. Maize hybrid AB-01 indicated significantly higher energy output under planting geometry P4.These findings may be due to high biomass production of the particular variety with concern planting geometry.

Conclusion

It may be concluded that maize hybrid CS- 200 showed significantly superiority in terms of grain yield and harvest index compared to AB-01. Both of the hybrids did not differed significantly with respect to gross returns, net returns and B: C ratio, energy output and energy use efficiency. Invariably, hybrid CS-200 produces higher grain yield while hybrid AB-01 produced higher stover yield. Among the varying planting geometries, planting geometry P2 resulted significantly greater performance in terms of grain yield, harvest index, gross return, net return, B: C ratio and output energy. Overall, hybrid CS-200 and plant population of 60,000 plants ha^{-1} keeping plant to plant geometry of P2 (75×22.2 cm) recorded batter performance for higher yield of maize, which can assure a net income of 221,371Afn ha^{-1} to the farmers of Kandahar semi-arid region.

Table 2: Response of maize varieties under variable planting geometry on yields and yields attributes during spring 2015 in Kandahar semi-arid situation.

Hybrid varieties	No of cobs/plant	Cob length (cm)	Cob girth (cm)	No of grains/cob	1,000- grain weight (g)	Grain yield (t/ha)	Stover yield (t/ha)	Harvest index (%)
Hybrid CS-200	1.28	18.5	13.6	430.3	275.1	6.41	10.5	37.6
Hybrid AB-01	1.20	18.8	13.6	402.3	268.1	5.81	12.2	33.4
SEm±	0.052	0.359	0.271	18.0	4.72	0.123	0.262	0.344
CD (P=0.05)	NS	NS	NS	NS	NS	0.372	0.794	1.043
Planting geometry								
P1 (75×33.33cm)	1.65	20.15	14.2	515.1	281.3	5.71	9.00	39.0
P2 (75×22.22cm)	1.29	19.93	13.9	446.1	273.9	7.71	10.8	41.6
P3 (75×16.67cm)	1.04	17.57	13.4	386.5	265.4	6.08	11.9	34.2
P4 (75×13.33cm)	0.98	16.88	12.8	317.4	265.8	4.95	13.6	27.2
SEm±	0.074	0.508	0.383	25.4	6.67	0.174	0.370	0.486
CD (P=0.05)	0.223	1.54	NS	77.1	NS	0.526	1.12	1.48

Table 3: Response of maize varieties under variable planting geometry on economics and energy relations during spring 2015 in Kandahar semi-arid situation.

Hybrid varieties	Cost of production (AFN/HA)	Gross returns (AFN/HA)	Net returns (AFN/HA)	BCR	Input energy (MJ/HA)	Output energy (MJ/HA)	Energy use efficiency
Hybrid CS-200	55,755	224,886	169,131	3.04	20,483	225,221	12.7
Hybrid AB-01	55,825	225,261	169,174	3.01	20,529	237,610	14.1
SEm±	-	4,298	4298.9	0.077	_	4,590	0.529
CD (P=0.05)	-	NS	NS	NS	_	NS	NS
Planting geometry							
P1 (75×33.3 cm)	54,230	197,598	142,843	2.61	20,182	196,447	10.7
P2 (75×22.2 cm)	55,270	255,629	200,359	3.63	20,395	247,726	14.3
P3 (75×16.7 cm)	56,310	229,032	172,722	3.07	20,611	238,337	14.1
P4 (75×13.3 cm)	57,350	218,037	160,687	2.80	20,835	243,153	14.4
SEm±	-	6,079	6,079	0.109	_	6,492	0.748
CD (P=0.05)	-	18,439	18,439	0.329	_	19,690	2.29

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