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Effect of seed rate and row spacing on grain yield of maize (*Zea mays* L.) cultivar 'Sargodha 2002'

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Abstract

The effect of seed rate 20, 25, 30, 35 and 40kg/ha and row spacing 30, 45, and 60cm on agronomic characteristics of plants including plants/m², plant height, stem diameter, number of cobs/m², cob/plant, number of grains/cob, 1000 grain weight and grain yield was conducted using the cultivar "Sargodha 2002" for two years from 2015-16 to 2016-2017. Seed rates and row spacing had significant effect on number of cobs/m², number of cobs /plant number of grain/cob and grain yield/ha. Row spacing had non-significant effect on plant height, stem diameter, plants/m² and seed rate had non-significant effect on 1000grain weight. During the two years study row spacing (45cm) with seeding (35kg/ha) produced the highest grain yield. Significant effect of seed rate and row spacing on different parameters was recorded. Row spacing at 45cm produced the highest number of cobs/m², number of cobs/plant and 1000 grain weight. In each row spacing increase in seed rate resulted in increase in plant height. Increase in the seed rate and row spacing resulted in decreased stem diameter. Maximum yield was recorded with 45cm spacing and 35kg/ha seed rate. Row spacing 30 and 60cm and seed rates 20, 25, 30 & 40kg/ha resulted in lower yields.

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Introduction

Maize (*Zea mays* L.) is one of the most important crop cultivated throughout the world (FAO, 2009) contributing to global food security significantly (Bekele *et al*., 2011). Maize cultivation may be dated back to some 6000 to 10000 years back in Mexico by the indigenous people (Doebley, 2004). Adoption of maize crop took place to as to its current status as agricultural crop, from its wild ancestors, during the 15th to 16th century (Abdolreza *et al*., 2006). Maize crop is primarily cultivated for direct consumption by humans as well as forage for livestock animals. Maize consumption has increased worldwide during the last decade constituting 40% of the world's major cereals with 70% use as animal feeds in the developed world (Bekele *et al*., 2011). It is being adopted as raw material to produce biofuel replacing the fossil fuel (Persson *et al*., 2009).

Having the highest yield among cereal crops it carries significant importance for countries like Pakistan, where rapidly increasing population has exposed the available food supplies. Maize occupies third cereal crop status in Pakistan after wheat and rice account for 4.8% of the total cropped area with 3.5% of the agricultural output value. Maize crop production stood at record high of 6.130 million tonnes during 2016 showing a major increase of 16.3 percent over the last year's production of 5.271 million tonnes. (Pakistan Economic Survey, 2017). In establishing production technology of any crop, seed rate and row spacing, contributing to the plant population or optimum planting density, play vital role for obtaining maximum yield to enhance the net return from different crops. A dense plant population causes shading of lower leaves, poor light penetration and reduced rate of photosynthesis developing weaker plants that are prone to lodging resulting in reduced yield (Lemerle *et al*., 2004; Lemerle *et al*., 2006). However, it is believed that providing proper nutrition and water supply to the crop having increased plant population, due to decreased row spacing geometry in maize, may enhance the per unit area yield (Owino *et al.,* 2009). Therefore, row spacing and seeding rate needs to be adjusted under different agro-ecological zones or environmental conditions.

The row spacing affects the crop yield potential (Staggenborg, 1999; Bryant *et al*, 1986). Reducing the distance between rows, improves weed control (Walker & Buchanan, 1982) by intercepting the light to weed population on soil (Andrade *et al*, 2002). Higher grain yields have been reported through narrow row spacing in soybean (De Bruin & Pederson, 2008) and other crops (Stickler & Laude, 1960). This effect has been explained due to light interception (Steiner, 1986) and decreased plant to plant competition among the crop plants (De Bruin & Pederson, 2008). Johnson, *et al.* (2005) reported a reduction in total weed density under 30cm apart rows of peanut (*Arachis hypogea*) as compared to the weed density at greater spacing. Maize crop for the grain is normally cultivated in rows, 75 to 90cm apart, but with the development of new production technology and introduction of new herbicides has provided new horizons to explore narrower row spacing for grain production of maize.

There is a need to establish the optimum seed rate and row spacing for maize crop under the changing scenario to maximize grain and fodder yield. The aim of this research is to study the effect of seed rate, row spacing and their impact on different attributes of maize crop.

Material and methods

Experiment layout

The study was conducted for two years from 2015 to 2016 on maize variety "Sargodha 2002" in split plot design having row spacing, 30, 45 & 60cm apart, in main blocks and seeding rate, 20, 25, 30, 35, & 40kg/ha, in sub-plots measuring 3.6m x 6m having three replications.

Procedure

The experiments were performed at Fodder Research Institute (FRI), Sargodha (Pakistan). Sowing was done by hand drill maintaining the row spacing and seed rates following the above-mentioned treatments. All agronomic practices such as fertilizer, irrigation, weed control and plant protection measures were applied uniformly across all treatments of the experiment.

Agronomic data of different parameter i.e. plant-height, stem diameter, number of plants/m², number of cobs/m², number of cobs/plant and grain yield/ha were recorded at maturity.

Data Analysis

Individual cobs under a treatment were harvested, threshed separately and data regarding numbers of grains per cob were recorded. Each plot was threshed separately and the data on 1000 grain weight and yield per plot were recorded. Pooled data of two years were analyzed statistically and the significance was tested using M. Stat. C.

Results and discussion

Row spacing differed significantly for its effect on number of cobs per square meter, number of cobs per plant, 1000 grain weight, number of grains per cob and grain yield per hectare in the two year study (see Table). The seed rates differed significantly for their effect of all the agronomic parameters except 1000 grain weight. The combined effect of row spacing seed rates on 1000 grain weight and grain yield was also significant.

Plant Height

The effect of seed rate on plant height was significant with a general trend of increase in the plant height due to increase in the seed rate. The highest plant height (247.33cm) was recorded in 40kg/ha seed rate against the lowest (225.67) in 20kg/ha. Snider *et al.*, (2012) have reported similar effect of seeding rate on the plant height.

Table. Effect of seeding rate (SR) and row spacing (RS) on yield determining traits and grain yield in maize cultivar '*Sargodha 2002*'.

Treatment/Level	Plant Height (cm)	Stem Diameter (cm)	Number of Plants/m²	No. of Cobs/m²	1000 Grains Weight (gm)	No. of Grains/Cob	Grain Yield (kg/ha)
SR_1 (20kg/ha)	225.67c	2.1444a	6.333e	7.222e	352.66	198.78c	4926.8d
SR_2 (25 kg/ha)	229.22bc	2.0556ab	7.556d	9.444d	353.33	213.56b	5550.9c
SR_3 (30 kg/ha)	229.56bc	1.9111abc	9.111c	11.778c	350.66	224.78a	6113.8b
SR_4 (35 kg/ha)	234.44b	1.8444bc	10.889b	14.667b	352.66	228.78a	7507.1a
SR_5 (40 kg/ha)	247.33a	1.7889c	12.111a	16.444a	349.66	228.56a	7431.6a
LSD	*6.8647*	*0.2449*	*0.7031*	*1.0974*	*Ns*	*10.093*	*365.15*
RS_1 (30 cm)	232.40	1.999	9.3999	11.133b	344.27b	206.53b	6158.5b
RS_2 (45 cm)	233	1.959	9.3333	13.400a	356.20a	227.80a	6759.5a
RS_3 (60 cm)	234.33	1.887	8.7999	11.200b	354.93a	222.33a	6000.1b
LSD	*Ns*	*Ns*	*Ns*	*0.4406*	*3.2273*	*7.4193*	*233.34*
RS_1SR_1	226.66	2.1	7.00	7.00	339.00g	191.66	4446.0i
RS_1SR_2	231	2.13	8.3333	8.6666	342.67efg	204.00	5244.7gh
RS_1SR_3	224	1.9333	9.00	10.0000	341.33fg	204.66	5870.3efg
RS_1SR_4	226	1.9	1.6666	13.6666	351.00bcde	217.00	7805.3ab
RS_1SR_5	254.33	1.9333	12.6666	16.3333	347.33defg	215.33	7426.3bc
RS_2SR_1	223.33	2.27	6.3333	8.0000	360.33a	208.00	5269.3gh
RS_2SR_2	227	2.03	7.3333	10.3333	360.00a	225.00	5796.3fg
RS_2SR_3	232	1.9333	9.6666	14.3333	355.67abc	236.33	6545.7d
RS_2SR_4	238.66	1.83	11.3333	17.0000	352.33abcd	234.33	8307.7a
RS_2SR_5	244	1.7333	12.00	17.3333	352.67abcd	235.33	7878.3ab
RS_3SR_1	227	2.07	5.6666	6.6666	358.67ab	196.66	5065.0h
RS_3SR_2	229.67	2.0	7.00	9.3333	357.33abc	211.66	5611.7fgh
RS_3SR_3	232.66	1.8666	8.6666	11.0000	355.00abcd	233.33	5925.3ef
RS_3SR_4	238.66	1.80	10.6666	13.3333	354.67abcd	235.00	6397.6de
RS_3SR_5	243.66	1.70	11.6666	15.6666	349.00cdef	235.00	6990.0cd
LSD	Ns	Ns	Ns	Ns	8.3440	Ns	609.25

Row spacing and the interaction of the row spacing with seed rate had no significant effect on plant height (see table) due to internode elongation (Schmitt & Wulff, 1993). Similar results of row spacing on plant height have been reported by others (Srivastava *et al*., 1980; and Rana & Ahuja 1986.

Stem Diameter

The effect of seed rate on stem diameter was significant with a general trend of decrease in the stem diameter due to increase in the seed rate. Maximum stem diameter (2.14cm) was recorded from 20kg/ha seed rate closely followed by statistically similar (2.06cm) stem thickness at 25kg/ha seed rate. A higher seed rate, or plant density, resulted in decreased stem diameter due to higher plant competition (Schmitt & Wulff, 1993; Van Der Werf *et al*; 1995) that is prone to lodging (Kashiwagi *et al*, 2008; Venuto & Kindiger, 2008). Row spacing and the interaction of row spacing with the seed rate showed no significant effect on the stem diameter.

Number of Plants/Square Meter

Seed rate had a significant effect on number of plants per square meter. Number of plants per square meter, or plant density, increased with the increase in the seed rate in maize cultivar "Sargodha 2002". All the seed rates differed significantly from each other. Maximum number of plants (12.11) per square meter were recorded at 40kg/ha seed rate while lowest (6.33) at 20kg/ha. Increase in the number of plants or plant population has been reported by other workers (De Bruin & Pederson 2008; Geleta *et al*., 2002; Habyarimana *et al*., 2004; Wortmam *et al*., 2010).

Number of Cobs/Square Meter

As for the number of plants per square meter, seed rate significantly affected the number of cobs per square meter and the number of cobs per square meter was proportionally related with the seed rate. The highest number of cobs/square meter (16.44) was recorded at 40kg/ha seed rate while the lowest (7.22) at 20kg/ha seed. All the seed rates differed significantly from each other for number of cobs/square meter. Results of the study conform to the findings of Tianu *et al*. (1983), Sharma & Adamu (1984), and Tyagi *et al*. (1998) who have reported increase in the number of ears per meter square due to increase in plant population density.

1000-Grain Weight

According to the results, row spacing showed significant differences on 1000-grrain weight. Row spacing of 45cm resulted in significantly higher 1000-grain weight (356.20g) than at the 1000-grain weight obtained at 30cm (344.27g) and 60cm (354.93g) spacing. Considering the interaction of both the factors, it was observed that 45cm row spacing with seed rate of 20, 25, 30, 35 and 40kg seed/ha resulted in better 1000-grain weight followed by statistically similar interaction of row spacing of 60cm up to the seed rate of 35kg/ha. However, Akcin *et al*. (1993) have reported increase in 1000-grain weight with decrease in plant population density in maize.

Number of Grains/Cob

Number of grains/ cob was significantly affected by the increase in the seed rate. Increase in the seed rate resulted in increased number of grains/cob. However, seed rate of 30, 35 and 40kg/ha proved did not differ significantly for the number of grains per cob. Similarly, row spacing also had a significant effect on number of grains per cob. Row spacing of 45cm and 60cm had significantly greater number of grains per cob, 227.80 and 222.33 respectively, than the number of grains (206.53) produced by the treatment having 30cm apart rows. Interaction of the two factors, seed rate and row spacing, had no significant effect on number of grains. Fernandez *et al*., 2012 have attributed such increase in the number of grains per head due low plant population or more plant to plant distance in sorghum crop (Fernandez *et al*., 2012).

Grain Yield

Significant differences were recorded in the effect of seed rate on the grain yield. Grain yield increased generally with increase in the seed rate and significantly higher yield was recorded at 35 and 40kg/ha seed rate, yielding 7507.1 and 7431.6kg/ha respectively, as compared to the other seed rates. A positive effect of higher seed rates have been reported to increase the dry matter production (Habyarimana *et al*, 2004; Wortmann *et al*, 2010) in other crops.

In some studies higher seed rate has been associated with lower yields as well (Snider *et al.*, 2012). Row spacing had significant effect on the yield. Row spacing of 45 m gave the highest yield as compared to the other row spacing.

Interaction of the two factors also showed significant results for grain yield. The maximum grain yield was recorded with 45cm row spacing & 35kg/ha seed treatment yielding 8307.7 kg/ha grain yield, followed by statistically similar yield by the interactions of 45cm row spacing & 40kg seed rate (7878.3kg/ha) and the interaction between 30cm row spacing & 65kg/ha seed rate (7805.3kg/ha). Similar response to row spacing has been reported in previous studies (J.M. FULTON, 1970) reported that higher plant population produced higher yield than lower plant population and row spaced at 50cm produced higher yield than row spaced at 100cm apart in maize. Our study is in accordance with their studies except the slight variation that the current study was conducted with 45cm apart rows instead of 50cm. Higher biomass production of sorghum crop with a narrower row spacing has been mentioned by other workers (Snider *et al.* 2012) and attributing the phenomenon due to decreased inter-row competition between plants (De Bruin & Pederson, 2008).

Conclusions

Row spacing primarily influences the number of plants/m² and the grain yield is considered to be more dependent on plant to plant space, row to row distance or the or the planting geometry. The present study indicates that the plant characters such as stem diameter and plant height are affected by the plant population due to varying seed rate or the plant spacing. Increase in the seed rate was reflected in the form of increased plant height and decreased stem diameter. Stem diameter was inversely related with the plant height among the recorded traits. Both the parameters, in common observation, are affected oppositely as plant height or tiller height increases the stem diameter decreases. Higher seed rate or wider row spacing, within a given seed rate giving more number of plants per row, produces thinner plants that are more vulnerable to lodging.

The results indicated that row spacing and seed rate also control growth behavior of maize plant. Data also revealed that plant height increased with increasing seed rate that probably due to plant competition for light.

A positive effect of higher seed rates have been reported on the dry matter production (Habyarimana *et al*, 2004; Wortmann *et al*, 2010) in other crops. In some studies higher seed rate has been associated with lower yields as well (Snider *et al.*, 2012). Considering all the agronomic and yield contributing parameters of maize crop it may be suggested that the use of 35kg seed/ha planted with a row spacing 45cm apart, giving maximum yield with the least inputs, is considered the most optimum for grain production of maize crop using the cultivar “Sargodha 2002”.

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