GROWTH AND YIELD OF MAIZE UNDER INTRA-ROW AND PLANT SPACING IN RAIN-FED CONDITIONS

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ABSTRACT
The field study was conducted at Faculty of Agriculture, Rawalakot, Azad Jammu and Kashmir, Pakistan, to determine the optimum intra-row plant spacing for maize. The design used was a Randomized Complete Block with three replications. 15, 20, 25 and 30 cm intra-row plant spaces were managed in 60 cm inter rows in a net plot size of 3 x 4m. Maize plants react differently to various plant densities and intra-row spacing. The effects of intra-row plant spaces on number of grains row⁻¹, cob length, grains cob⁻¹, 1000-grain weight, grain wt. cob⁻¹, grain yield, stover yield and biological yield varied significantly, whereas, number of days taken to 50% tassel, number of days taken to 50% silk, number of cobs plant⁻¹, number of grain rows cobs⁻¹, grain shelling and harvest index showed no response to intra-row plant spacing. It was concluded that maize crop is much responsive at 15-20 cm plant spacing where most of the crop parameters recorded satisfactory values.

Keywords: Maize, Row, Plant, Spacing, Cobs, stover, grain, silk, tasseling, harvest index

INTRODUCTION
Maize (Zea mays L.) is an important food and fodder crop possessing a remarkable nutritive value for human beings and animals. Due to high yield potential and short maturity period against the other cereals, it is gaining popularity among farmers all over the world. Maize grain is used for the extraction of oil used for various purposes. Maize cobs after boiling in water and seeds after roasting are eaten by human. The corn dry stalks are used for making paper, wallboard and as fuel and feed for animals. Despite higher yield potential, the average corn yield in Pakistan is lower as compared to other advanced countries. One of the various major factors responsible for low yield per unit area of maize is improper planting density as well as geometry.

Proper adjustment of plants for space not only helps in maintaining optimum plant population but also enables the plants to utilize land, light and other input resources uniformly and efficiently. Plant population beyond a certain limit causes more competition, makes weak, severe lodging, accelerates leaf senescence, reduces net assimilation rate of individual leaves and results in less grain formation. In order to overcome this bottleneck, maize production technology must comprise proper and uniform plant population unit⁻¹ area. Akram et al. (1992) reported significant increase in number of grains cob⁻¹, grains weight cob⁻¹, cob length and 1000-grain weight with the increase in plant spacing in maize among intra-row plant spaces of 20, 25 and 30 cm. whereas, grain yield increased significantly with decrease in plant spacing and the number of cobs plant⁻¹ showed no response to intra-row plant spacing. Hassan (2000) noted less number of grains row⁻¹ and 1000-grain weight in plant density of 3000 as compared to 2000 plants feddan⁻¹ in maize whereas there was no effect on number of grain rows ear⁻¹. Bavec and Bavec (2002) reported significant decrease in 1000-kernel weight with increase in plant density and significant increase in kernel yield with increase in plant population.
Hussain, et al. (2007). Growth and yield of maize

Rasheed et al. (2004) reported no effect of plant spacing on number of days taken to 50% silk among 20, 25 and 30 cm spaced sown plants. Sener et al. (2004) reported no effect on number of days taken to 50% tassel among all maize plant spacing of 10, 12.5, 15, 17.5 and 20 cm. So it is imperative to develop such a planting pattern which can help to avoid excessive crowding and thereby enabling the plants to utilize the resources more effectively and efficiently for increased crop yield. Therefore, this study was conducted to determine the effect of various intra-row and plant spacing on the yield and yield components of maize under rain-fed conditions of Rawalakot, Azad Jammu and Kashmir, Pakistan.

MATERIALS AND METHODS
An investigation to ascertain the effect of plant and row spacing on the growth, yield components and yield with fixed inter-row spacing of 60 cm and intra-row plant spacing of 15, 20, 25 and 30 cm was conducted on the maize variety "Babar" at Agronomic Research Area, Faculty of Agriculture, Rawalakot, Azad Jammu and Kashmir, Pakistan. The experiment was laid out in Randomized Complete Block Design having three replications. The net plot size was measured 3 x 4m² consisting of five rows per treatment. Nitrogen and phosphorus @ 120 and 60 kg ha⁻¹ as urea and single supper phosphate respectively were incorporated in finely prepared seedbed before sowing of the experiment. The crop was sown manually with the help of single row hand drill using the seed rate of 30 kg ha⁻¹.

In order to maintain the required intra-row plant spacing, the first thinning was done at 10 cm plant height and the final at 20 cm plant height stage. All the treatments had the normal and uniform cultural practices. Weeds were removed manually throughout the experimental period of the crop. Total rainfall received during the experimental period was 1272.7 mm. The crop was harvested manually, cobs were removed from the stalks, unsheathed and grain yield was recorded after shelling the cobs at about 14% moisture level. Cob removed plants were dried in field in sun, tied into bundles and weighed. Biological yield was calculated by adding the grain weight and dried stover weight.

The data on plant density, number of days taken to 50% tassel, number of days taken to 50% silk, number of cobs plant⁻¹, number of grain rows cob⁻¹, number of grains row⁻¹, number of grains cob⁻¹, grain weight cob⁻¹, grain shelling and 1000-grain weight were collected from the randomly selected ten plants per entry. Harvest index was calculated by following the formula of Donald (1962). The data collected were tabulated and statistically analyzed using the computer statistical program MSTAT-C (Freed and Eisensmith, 1986).

RESULTS AND DISCUSSION

Plant population
Optimum plant population plays significant role in the ultimate yield of a crop by using the growth factors efficiently. The data regarding plant population varied significantly among all the treatments. It decreased progressively due to its maintenance through thinning according to the experimental requirement. The plant count m⁻² ranged from the highest (11.27) in 15 cm plant spacing to the lowest (5.58) in 30 cm spaced sown entry.

Number of days taken to 50% tassel
The number of days taken to 50% tassel for all the planting spacing did not vary significantly among themselves. The number of days taken to 50% tassel was minimum (63.5) in 30 cm and maximum (65.09) in 25 cm apart maintained plants. These results match with those of Sener et al. (2004) who also reported non-significant effect of intra-row plant spacing on number of days taken to 50% tassel in maize.

Number of days taken to 50% silk
The number of days taken to 50% silk had non-significant differences among all the plant spacing and the ranged from 66.79 to 67.55 in 30 cm and 20 cm spaced plants, respectively. These results are consistent with those of Rasheed et al. (2004) who also reported the similar results for intra-row spaces in maize.

Number of cobs plant⁻¹
The number of cobs plant⁻¹ was not affected significantly by intra-row plant spacing. Number of cobs plant⁻¹ varied from 1.04 to 1.05 among various planting spacing. These results are in conformity with those of Akram et al., (1992) who reported no response of plant spacing for number of cobs plant⁻¹.
Cob length (cm)
The cob length resulted significant variations among all intra-row plant spacing. It was the highest (21.66 cm) in plants spaced at 30 cm and the lowest in 15 cm spaced sown plants. This may be due to efficient use of growth factors by the plants. These results contradict with those of Akram et al. (1992) who recorded significant variation among the plants for cob length spaced at 20, 25 and 30 cm in maize.

Number of grain rows cob\(^{-1}\)
Plant spacing showed non-significant response to number of grain rows cob\(^{-1}\). Grain rows cob\(^{-1}\) were highest (14.71) in 30 cm plant spacing while the minimum number of grain rows (14.14) cob\(^{-1}\) was found in the plants sown at 15 cm spacing. These results are in harmony with those of Hassan (2000) who also reported similar results for number of grain rows cob\(^{-1}\) among various plant spacing in maize.

Number of grains row \(^{-1}\)
The number of grains row \(^{-1}\) had the significant variations among the plant spacing. The maximum number of grains row \(^{-1}\) (33.6) was recorded in 30 cm apart sown plants, which differed significantly from 15 cm and 20 cm intra-row plants with the number of grain row \(^{-1}\) 27.44 and 30.83, respectively. This may be due to the variations in cob length. These results are conformity with those of Hassan (2000) who also found similar results in number of grains row \(^{-1}\) in intra-row plant spacing of maize.

Number of grains cob\(^{-1}\)
The number of grains cob\(^{-1}\) was affected significantly by plant spacing among all the treatments resulting in the highest number of grains (459.9) cob\(^{-1}\) in planting geometry of 60 cm by 30 cm in contrast to the planting geometry of 60 cm by 15 cm producing the least number of grains (396.76) cob\(^{-1}\). This may be due to more efficient use of growth factors by optimum number of plants as compared with more plant density unit\(^{-1}\) area and the cob length. These results are in consonance with those of Akram et al. (1992) who also reported significant variation for plant spacing in maize.

1000 grain weight (g)
The 1000 seed weight among all the plant spacings varied significantly. The relationship between intra-row spacing and 1000 seed-weight was negatively correlated. The maximum seed index (279.01 g) was recorded in the greatest plant spacing while the minimum seed index (266.05 g) was noted in the lowest plant spacing, which may be the result of efficiency of the plants to use the growth factors. These results plain those of Akram et al. (1992), Hassan (2000) and Bavec and Bavec (2002) who also reported significant decrease in 1000 seed weight with the decrease in the intra-row plant spacing in maize.

Grain shelling (%)
The grain shelling resulted the non-significant variation among all the intra-row plant spacing being maximum (71.88 %) in the plots having the maximum plant spacing and the minimum (68.68 %) in minimum plant spacing. This may probably be due to approximately equal sink efficiency of grains and growth of shanks in all the treatments.

Grain weight cob\(^{-1}\)
The grain weight cob\(^{-1}\) indicated the significant differences among all the plant spacing. It increased from 105.5 g in 15 cm intra-row plants to 128.3 g in 30 cm intra-row spaced plants. This may be the result of effect of seed index, grains cob\(^{-1}\) and grain rows\(^{-1}\). These results are in conformity with those of Akram et al. (1992) who reported significant variation among plant spacing for grain weight cob\(^{-1}\) in maize.

Grain yield (t ha\(^{-1}\))
Data regarding the grain yield had the negative association between the plants spacing and the grain yield. There were significant variations among all the treatments being the highest grain yield (9.75 t ha\(^{-1}\)) with the planting geometry of 60 cm x 15 cm and the lowest grain yield (6.44 t ha\(^{-1}\)) with the planting geometry of 60 cm x 30 cm. This may be attributed to the differences among the plant densities. These results comply with those of Akram et al. (1992) and Bavec and Bavec (2002) who also reported significantly more grain yield of maize with less plant spacing as compared to more plant spacing in maize.

Stover yield (t ha\(^{-1}\))
The stover yield of various plant densities had significant differences among all the treatments. The stover yield increased significantly with the decrease in intra-row plant spacing. The maximum stover yield (13.34 t ha \(^{-1}\)) was obtained in less intra-row plant spacing and the minimum (8.84 t ha \(^{-1}\)) in the maximum intra-row plant distance. This may be the result of variation in number of plants unit\(^{-1}\) area.
**Biological yield (t ha\(^{-1}\))**

All the plant spacing resulted statistically significant variation for biological yield showing that the total dry matter yield was negatively correlated to the intra-row plant spacing. It decreased from 23.11 t ha\(^{-1}\) in 15 cm plant spacing to 15.28 t ha\(^{-1}\) in 30 cm apart plant spacing. It may be attributed to the number of plants unit\(^{-1}\) area.

**Harvest index (%)**

The harvest index did not differ significantly among all the plant spacing. It was maximum (42.32 %) for 25 cm spaced plants and the minimum (42.03 %) for 20 cm intra-row treatment. It may probably be due to approximately equal proportional increase in grain as well as in the stover yield in all the treatments.

**Table-1:** Growth and yield of maize as affected by different intra-row plant spacing to grain yield components and grain yield in maize.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Intra-row plant spacing (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>15</td>
</tr>
<tr>
<td>Plant density (m(^{-2}))</td>
<td>11.27 a</td>
</tr>
<tr>
<td>Number of days taken to 50% tassel</td>
<td>64.47ns</td>
</tr>
<tr>
<td>Number of days taken to 50% silk</td>
<td>66.98ns</td>
</tr>
<tr>
<td>Number of cobs plant(^{-1})</td>
<td>1.04ns</td>
</tr>
<tr>
<td>Number of grain rows cob(^{-1})</td>
<td>14.14ns</td>
</tr>
<tr>
<td>Number of grains row(^{-1})</td>
<td>27.44c</td>
</tr>
<tr>
<td>Grain shelling (%)</td>
<td>68.68ns</td>
</tr>
<tr>
<td>Cob length (cm)</td>
<td>16.4d</td>
</tr>
<tr>
<td>Number of grains cob(^{-1})</td>
<td>396.76d</td>
</tr>
<tr>
<td>1000-grain weight (g)</td>
<td>266.05c</td>
</tr>
<tr>
<td>Grain weight cob(^{-1}) (g)</td>
<td>105.5d</td>
</tr>
<tr>
<td>Grain yield (t ha(^{-1}))</td>
<td>9.75a</td>
</tr>
<tr>
<td>Stover yield (t ha(^{-1}))</td>
<td>13.34a</td>
</tr>
<tr>
<td>Biological yield (t ha(^{-1}))</td>
<td>23.11a</td>
</tr>
<tr>
<td>Harvest index (%)</td>
<td>42.18ns</td>
</tr>
</tbody>
</table>

Means followed by different letters in a row differ significantly at 0.05. 
ns= non-significant
REFERENCES


