Impact of planting techniques on the growth and quality performance of maize hybrids in the spring season

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ABSTRACT
A field trial was conducted at Yamunanagar, Haryana, India during the spring season to study the performance of maize hybrids under different planting techniques. The 5 maize hybrids viz; HM-4, HM-9, HM-10, HM-11, and HQPM-5 were tested under three planting techniques: ridge, flat, and furrow methods. The growth parameters like plant-stand per hectare, plant height (cm), and dry matter accumulation (g/plant) were recorded higher under ridge method of planting followed by flat and furrow but had no significant effect on the quality parameters such as tryptophan, lysine, protein, zinc, iron and nitrogen content in maize grains. The periodic growth parameters such as plant stand per hectare, plant height, and dry matter accumulation were significantly higher with hybrid HM-10 followed by the rest of maize hybrids whereas, zinc and iron content was not significantly affected in any of the maize hybrids. Tryptophan and lysine content was significantly higher in HQPM-5 hybrid but nitrogen and protein content were more in HM-4 hybrid. In conclusion, the planting method had significant effects on the yield parameters yet quality parameters are less affected by the planting. The varietal genotype has more influence on the performance, productivity, and quality, under different planting techniques.

Keywords: Planting methods, hybrids, dry matter, nitrogen, growth and quality parameters

INTRODUCTION
Maize (Zea mays L.) is one of the important cereal crops next to wheat and rice in the world. Globally, maize is referred to as ‘Miracle crop’ or ‘Queen of the Cereals’ due to its high productivity potential compared to other Gramineae family members. Maize serves as a basic raw ingredient to thousands of industrially manufactured products viz; alcoholic beverages, pharmaceutical, food sweeteners, cosmetic, textile, gum, and paper industries (Kumar et al., 2012). In India, nearly about 28% of maize produced is used for food purposes, 11% used in livestock feed, 12% in the wet milling industry, 48% as poultry feed, and 1% as seed (Anonymous, 2013). Maize cultivation is gaining popularity in the spring season because Spring maize usually gives more production as compared to kharif crop and it is relatively safe from insect pest attack and it can easily be grown in the areas where adequate irrigation facilities are available but the yield recovery of maize at farmer’s field is very low as compared to other maize producing countries such as Italy, U.S.A., Canada, and Egypt, etc., therefore, to boost up the maize production, proper management techniques are essential (Kumar et al., 2018).

The major techniques are high-yielding hybrids and proper methods of planting. Maize can be planted in different ways viz. ridge planting, furrow planting, flat planting, and broadcasting. Inputs such as water and nutrients are economically utilized if the plants are planted with appropriate planting
techniques (Ali et al., 1998). Agronomical practices and crop varieties possibly affecting the yield, evapotranspiration, and energy balance status (Hussain et al., 2019). The response of maize hybrids to various agro-management practices especially; fertilizers, planting methods, etc. is different. This variable response is mainly due to differences in plant morphology, intraspecific competition in maize plants crop growth rate, crowding stress tolerance of different maize varieties. The total biomass production of maize depends upon the water use and different planting techniques affect the water use efficiency (WUE) of crop and field application efficiency (Hamilton et al., 2015).

The mature maize kernel consists of a small embryo, much large endosperm, pericarp, and tip cap. The endosperm contains the main carbohydrates. In normal maize, essential amino acids like lysine, tryptophan, and threonine are found in reduced quantities. In contrast, QPM (Quality Protein Maize) has a great potential in human nutrition and it is also a good source of protein requirement and it has nearly twice the amount of lysine and tryptophan, which make the protein of QPM equivalent to 90% of milk protein. HQPM hybrids are found to be the best hybrids for the cultivation of high-quality protein therefore comparative study of promising maize hybrids was also essential to screen the most promising hybrids for spring planting. Keeping the above facts in view, the present investigation was undertaken.

MATERIALS AND METHODS

A field investigation was carried out at the village Talakaur, district Yamunanagar under KVK, Damla of Chaudhary Charan Singh Haryana Agricultural University (CSSHAU), Hisar, Haryana during spring season of 2015. The experimental site was situated in a semi-arid, sub-tropical region at an elevation of 255m above mean sea level (msl) having 30°07’ North latitude and 77°17’ East longitude. The weather data is presented in Fig. 1 showed that the maximum rainfall was received during 9th standard week and a total of 259 mm rain was received during the crop growing season whereas, the maximum and minimum temperature ranged from 21.1°C to 41.7°C and 9.1°C to 27.4°C respectively. The mean weekly value of relative humidity during morning and evening time ranged from 47.3% to 95.9% and 30.8% to 83%, respectively, during the crop period. In general, weather conditions were favorable for plant growth, and no severe pests and diseases were noticed during the entire period.

To measure the soil physico-chemical properties, samples were drawn randomly from 0-15 cm depth from the five randomly selected spots in the experimental field, and after that a representative sample was prepared by mixing all samples. This composite sample was analyzed to determine the physical and chemical properties of the soil (table 1).

The treatments comprised of 3 different planting techniques viz., ridge, flat, and furrow and 5 maize hybrids viz., HM-4, HM-9, HM-10, HM-11, and HQPM-5. The research trial was performed in a split-plot design (SPD). The methods of planting were kept in the main plot and maize varieties were placed in a subplot with 3 replications. The layout of the field is presented in Fig. 2.

The seedbed in the field was prepared by practicing 4 harrowing’s followed by twice cultivator and then planking. The pre-sowing irrigation was given to the desired area of the field to facilitate preparatory tillage and seed germination. Depending upon the treatments, the furrow and ridges were
Table 1. Physico-chemical properties of the experimental soil

<table>
<thead>
<tr>
<th>Soil properties</th>
<th>Value/characteristic</th>
<th>Method used</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil texture</td>
<td>Sandy-loam</td>
<td>Hydrometer method (Piper, 1966)</td>
</tr>
<tr>
<td>Sand (%)</td>
<td>53</td>
<td>International pipette method (Piper, 1966)</td>
</tr>
<tr>
<td>Silt (%)</td>
<td>35</td>
<td></td>
</tr>
<tr>
<td>Clay (%)</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Soil pH (1:2 soil: water)</td>
<td>8.5</td>
<td>Glass electrode pH meter (Jackson, 1973)</td>
</tr>
<tr>
<td>Electrical conductivity(dSm⁻¹)</td>
<td>0.56</td>
<td>Conductivity bridge meter 1:2 soil-water suspension (Richards, 1954)</td>
</tr>
<tr>
<td>Available nitrogen (kg ha⁻¹)</td>
<td>116</td>
<td>Alkaline Permanganate method (Subbaiah and Asija, 1956)</td>
</tr>
<tr>
<td>Available phosphorus (P₂O₅ kg ha⁻¹)</td>
<td>14.0</td>
<td>Olsen’s method (Olsen et al., 1954)</td>
</tr>
<tr>
<td>Available potassium (K₂O kg ha⁻¹)</td>
<td>365.0</td>
<td>Flame photometer method (Richards, 1954)</td>
</tr>
</tbody>
</table>

Figure 2. Layout of the experiment. P1 = Flat planting, P2 = Ridge planting, P3 = Furrow planting; H1 =HM-4, H2 =HM-9, H3 =HM-10, H4 =HM-11, H5 =HQPM-5.

made with the assistance of a tractor-drawn ridger for manually dibbling of seed. The maize crop was raised with the help of a recommended package of practices. The growth parameters viz., plant stand ha⁻¹, dry matter accumulation, plant height, phenological stages were recorded from the penultimate rows of each plot. The number of plants per hectare was noted by counting plant numbers per meter (m) row length in each plot and converted to net plot size and finally to thousand plants ha⁻¹. The plant height was measured at different growth stages from the base of the plant to the top leaf (fully opened) (Malik et al., 2019) but after tasselling, plant height was taken from the plant base to the collar of the flag leaf. For dry matter accumulation measurement, 5 plants were selected randomly in each plot and carefully uprooted which were oven-dried at 65±5°C to attained constant weight and further weighed. The phenological readings of maize (50% tasselling and 50% silking) were noted by counting the non-tassel and non-silk bearing and tassel and silk bearing plants whereas, the number of days to maturity was measured by counting the numbers of days (from sowing to maturity) when...
mostly cobs husk turns yellow colour followed drying. The nitrogen content in the grain was measured by adopting the Nessler reagent method. Oven-dried grain sample (0.2 g) was digested in di-acid mixture of $\text{H}_2\text{SO}_4$: $\text{HClO}_4$ (9:1) and after digestion, a known volume of sample was made with the distilled water and filtered through Whatman No. 42 filter paper and used for further analysis. The nitrogen (N) content in the grain was measured by reading the intensity of color on a spectrophotometer at 440 nm wavelength. The protein, lysine, and tryptophan content in maize grains were estimated by Near-Infrared Spectrophotometer (NIRS) NIR analyzer (Infratec™ 1241 grain analyzer) whereas, zinc (Zn) and iron (Fe) content were measured by Atomic Absorption Spectrophotometer (AAS) instrument. In this method, oven-dried sample (0.2 g) of grain was digested in diacid mixture of $\text{HNO}_3$: $\text{HClO}_4$ (4:1) and used for further analysis.

RESULTS AND DISCUSSION

Growth parameters

Different planting methods of maize crop influenced the plant height (cm) at all the growth stages at 30 days intervals and found that the plant height significantly increased from 30 days after planting to maturity which is depicted in Fig. 3A. The results showed that the maximum plant height of maize was achieved in the ridge planting method followed by the flat and furrow method of planting. This was due to the presence of loose fertile soil having more aeration and moisture availability, along with better uptake of nutrients which might provide a better environment to maize crop resulting in improved plant height. These results conformed with Singh et al. (2011).

The plant height (cm) of maize hybrids was measured at 30 days interval. The hybrid (HM-11) attained more plant height at all stages which was superior to the rest of the maize hybrids presented in Fig. 3B. This could be due to varietal variation of crop and also environmental conditions that prevailed during stem elongation and growth of plants (Gaile, 2012 and Azadbakhat et al., 2012). The plant stand per hectare was recorded highest under the ridge method followed by flat and furrow methods of planting (Table 2). The higher number of plant population in ridge planting techniques may be attributed to the fine-tilth and better aeration on ridges which helped in deeper root penetration (Singh et al., 2011; Painyuli et al., 2013; Kumar et al., 2014) Nevertheless, the plant population was not influenced significantly in relation to maize hybrids but numerically maximum plant stand (79824) were recorded with hybrid HM-10 followed by HM-11, HQPM-5, HM-4 and HM-9 (Khan et al., 2012).

The study results also revealed that the phenological stages of maize crop were also significantly affected by different treatments. The number of days taken to attain the phenological stages namely 50 % tasseling, 50 % silking and the maturity were less on ridge planting techniques than flat and furrow methods of planting. It was because of more nutrients uptake on ridges and further

![Figure 3](image-url)
Table 2. Growth parameters of maize as affected by different planting methods and hybrid.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Plant Stand ha⁻¹ (15 DAP)</th>
<th>Days to 50% Tasseling</th>
<th>Days to 50% Silking</th>
<th>Days to Maturity</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Planting Techniques</strong></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Ridge</td>
<td>82810</td>
<td>58</td>
<td>61</td>
<td>108</td>
</tr>
<tr>
<td>Flat</td>
<td>76754</td>
<td>61</td>
<td>63</td>
<td>113</td>
</tr>
<tr>
<td>Furrow</td>
<td>74143</td>
<td>62</td>
<td>65</td>
<td>114</td>
</tr>
<tr>
<td>SEm±</td>
<td>846</td>
<td>0.5</td>
<td>0.5</td>
<td>1.3</td>
</tr>
<tr>
<td>CD (P=0.05)</td>
<td>3306</td>
<td>2</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td><strong>Hybrids</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HM-4</td>
<td>76811</td>
<td>57</td>
<td>60</td>
<td>107</td>
</tr>
<tr>
<td>HM-9</td>
<td>76484</td>
<td>59</td>
<td>61</td>
<td>109</td>
</tr>
<tr>
<td>HM-10</td>
<td>79824</td>
<td>62</td>
<td>64</td>
<td>115</td>
</tr>
<tr>
<td>HM-11</td>
<td>78748</td>
<td>63</td>
<td>65</td>
<td>115</td>
</tr>
<tr>
<td>HQPM-5</td>
<td>77644</td>
<td>61</td>
<td>63</td>
<td>113</td>
</tr>
<tr>
<td>SEm±</td>
<td>1272</td>
<td>1</td>
<td>1</td>
<td>1.4</td>
</tr>
<tr>
<td>CD (P=0.05)</td>
<td>NS</td>
<td>3</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

facilitate better root growth which known to stimulate more flowering in maize (Rasheed et al., 2003; Mehta et al., 2011) however, among hybrids of maize, HM-4 and HM-9 hybrids took lower number of days to attain 50% tasseling, 50% silking and maturity stage while HQPM-5, HM-10 and HM-11 hybrids required more days to reach different phonological stages because of their different maturity timing (Kagasago, 2006; Tsimba et al., 2013).

The accumulation of dry matter is a good index, to express the photosynthetic efficiency of the plants, noticeably higher total dry matter including leaves, cob and stem was recorded with ridge planting method which could be due to higher plant height and functional leaves under ridge planting techniques. These results are also in agreement with Husain et al. (2010) and Gul et al. (2015). The HM-10 hybrid significantly differed with respect to dry matter accumulation (g plant⁻¹) at different growth stages and at harvest stage also (Dawadi and Sah, 2012).

Quality parameters

The lysine, tryptophan, protein, nitrogen, zinc, and iron content in maize seeds are the important quality factors that are to be considered while assessing the effect of different treatments and competitive ability of the crop with nutrients. The effect of planting techniques on different quality parameters was found to be non-significant in the present study. However, the ridge method of planting had maximum values of quality parameters as compared to flat and furrow methods. These

Figure 4. Dry matter accumulations (g plant⁻¹) of maize crop affected by different treatments viz.: (A) Planting methods, (B) Maize Hybrids
differences were due to the vigorous growth, bolder size of grains, and higher nutrient uptake by the maize crop. Similar results were also obtained by Rehman et al. (2011). Amongst different hybrids, HQPM-5 hybrid contained significantly higher lysine and tryptophan content while protein and nitrogen content were found to be more in HM-4 hybrid. Zinc and iron content was almost same in all the hybrids. These differences in maize hybrids with respect to tryptophan, lysine, protein and nitrogen content were ascribed to variation in their genetic makeup (Nagy, 2009).

**CONCLUSION**

Overall, the study revealed that in spring season, ridge planted maize crop has significantly higher growth and better growth parameters. However, quality parameters of maize grain do not get influenced by planting methods. Among the compared hybrids, the HM-10 hybrid had significantly higher growth parameters, but the lysine and tryptophan content were considerably higher in hybrid HQPM-5, and protein and nitrogen content were higher in hybrid HM-4.

**REFERENCES**


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