Research Article

Behaviour of different pre and post-tasseling irrigation schedules in bed planted winter maize (Zea mays L.)

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Summary

The study on behaviour of different pre and post-tasseling irrigation schedules in bed planted winter maize (Zea mays L.) was conducted at Punjab Agricultural University, Ludhiana on loamy sand soil. The experiment was laid out in twelve treatment combinations of different irrigation schedules with four pre-tasseling (55, 70, 85 and 100) and three post-tasseling (60, 80 and 100) treatments replicated four times in randomized block design (RBD) showed that high frequency of 60 mm CPE in post-tasseling phase coincides with high evaporative demand resulted well established crop plants with better root system and anchorage of plants reduces the chances of lodging and breakage maintained their superiority in growth, source size, sink capacity and strength resulted more grain yield 74.8 q/ha and the grain yield was declined to 46.0 q/ha with widening a gap in irrigation intervals while shifting CPE from 60 to 80 mm and 100 mm. So, I70/60 was observed to be best irrigation schedule for winter maize under Punjab conditions which resulted in 74.2 q/ha grain yield.

During the reproductive phase the canopy temperature showed a negative and significant relationship with dry matter (DM), cob girth and cob length, number of grains per cob, 1000-grain weight and grain yield which explained 53 to 77 per cent variation in different characters.

Key words: Pre and post-tasseling, CPE, Irrigation schedules, Dry matter, Significant


Introduction

Maize (Zea mays L.) is one of the most important cereal crop which contains about 70.7 per cent carbohydrates, 10 per cent proteins, 4 per cent oil, 13.5 per cent moisture, 1.4 per cent ash and 0.4 per cent other substances. In India, out of total production, 35 per cent is being used for human consumption, 25 per cent each in poultry feed and cattle feed and 15 per cent in food processing and other industries mainly starch, dextrose, corn syrup, corn oil etc. All the vital physiological processes of a plant like cell division, cell elongation, cell wall synthesis, NO3-reductase activity, protein synthesis, photosynthesis, and translocation of assimilates are very sensitive to water stress. This shows that plant water status plays a key role for attaining potential yield by enabling a genetic variable to exploit fully its physical environment. So one of the biggest problem in crop production over the globe is “how to maintain optimum plant/soil moisture status during crop growing season” which signifies the scope of irrigation scheduling as a single limiting factor in crop production. Viswanatha et al. (2002) observed the highest green cob yield (20.1 t/ha) under normal planting at (0.8 Epan) level of irrigation, which was significantly higher than paired planting (14.0 t/ha) and was at par with drip 0.8 Epan level of irrigation. Maize ranks third (Punjab) with respect to acreage and production after wheat and rice, occupying 165 thousand hectares, with a production of 449 thousand tonnes (Anonymous, 2013). Maize is known to be highly sensitive to moisture requirement at different stages of the growth and development. It is quite likely that irrigation schedules and water use of winter maize with respect to time/soil depth be at variance from summer and rainy season crops; primarily because of basic differences in the shoot and root growth pattern, evaporativity of two seasons and the duration of the two crops. The growing period of winter maize during later phase (March-May) coincides with a period of hot and dry conditions which resulted in as
high as 40 per cent of the total annual evaporation during such a short span. The water table in Punjab on an average is declining @ 23 cm/year (Taneja, 2002). So, winter maize by virtue of its high yield potential, low incidence of insect-pest and diseases, lodging tolerance coupled with its wider adaptability at aerial environment especially to low temperature conditions as compared to main season crop, is a viable choice in diversification (Lal et al., 2001).

The crop season of winter maize especially during reproductive phase coincides with a period of clear sky conditions having high evaporative demand. So, it is but natural that any evaporative demand based on irrigation schedule will have a direct bearing on the performance of winter maize crop in terms of its growth and yield and among the different evaporative demand based irrigation schedules. Any schedule with a higher irrigation frequency will keep the plant water status at optimum level during the reproductive phase of winter maize and thus, it will keep an edge in terms of growth and yield over other irrigation schedules which fail to maintain proper plant water status by keeping pace with high evaporative demand during the reproductive period of winter maize crop which is very critical period as far as water stress is concerned.

So, from the above, it may be concluded that the impact of irrigation scheduling was positive on the growth, yield and yield attributes of maize as frequency was increased. Thus, there is a great need to try various irrigation schedules (pre and post tasseling) in order to reduce its water requirement without reduction in yield. Keeping these considerations in view, the present study has been planned with the following objective. To find out an appropriate pre and post-tasseling irrigation schedule in winter maize and to study the effect of different pre and post-tasseling irrigation schedules on growth, yield and yield attributes of winter maize.

Resource and Research Methods

The study on behaviour of different pre and post-tasseling irrigation schedules in bed planted winter maize (Zea mays L.) was conducted at Students’ Research Farm, Department of Agronomy, Punjab Agricultural University, Ludhiana on loamy sand soil. The experiment was laid out in twelve treatment combinations of different irrigation schedules with four pre-tasseling and three post-tasseling schedules and these were replicated four times in Randomized Block Design (RBD). The treatment combinations comprised of irrigation applied at CPE of 55 mm before tasseling followed by CPE of 60 mm (I_{5560}), irrigation applied at CPE of 55 mm before tasseling followed by CPE of 80 mm (I_{5580}), irrigation applied at CPE of 55 mm before tasseling followed by CPE of 100 mm (I_{55100}), irrigation applied at CPE of 70 mm before tasseling followed by CPE of 60 mm (I_{7060}), irrigation applied at CPE of 70 mm before tasseling followed by CPE of 80 mm (I_{7080}), irrigation applied at CPE of 70 mm before tasseling followed by CPE of 100 mm (I_{70100}), irrigation applied at CPE of 85 mm before tasseling followed by CPE of 60 mm (I_{8560}), irrigation applied at CPE of 85 mm before tasseling followed by CPE of 80 mm (I_{8580}), irrigation applied at CPE of 85 mm before tasseling followed by CPE of 100 mm (I_{85100}), irrigation applied at CPE of 100 mm before tasseling followed by CPE of 60 mm (I_{10060}), irrigation applied at CPE of 100 mm before tasseling followed by CPE of 80 mm (I_{10080}) and irrigation applied at CPE of 100 mm before tasseling followed by CPE of 100 mm (I_{100100}). A common basal dose of 60 kg P_{2}O_{5}/ha through single super phosphate (16% P_{2}O_{5}) and 30 kg K_{2}O/ha through muriate of potash (60% K_{2}O) was applied at the time of sowing. The crop was fertilized with recommended dose @ 175 kg N/ha which applied through urea (46% N). One-third N was applied at the time of sowing; one-third was top dressed in mid January and the remaining one third at pre-tasseling stage. The winter maize cv. Sheetal was sown in first fortnight of November. The sowing was done with dibbling method by putting 3 seeds per hill.

Research Findings and Discussion

The results of the present study as well as relevant discussions have been presented under following sub heads:

Plant Height:

The data pertaining to final plant height under different irrigation schedules are presented in Table 1. The similar trend in plant height was observed during the crop growth season under various irrigation schedules viz., pre-tasseling irrigation schedule basis on CPE 55 mm, 70, 85 and 100 mm and post-tasseling 60, 80 and 100 mm. During initial phase of crop growth, a very slow pace of growth rate in terms of plant height was observed from emergence to 100 days after sowing (DAS) under all the irrigation schedules which is well depicted through a very small increment on an average of 4.4 to 12.1 cm. Thereafter, a sharp increase in plant height was observed from 100 to 130 DAS which was 36.5 cm. It was also observed that more plant height under bed and ridge plantings might be due to better physical conditions for root development. Later on, a linear increase in plant height was observed upto 160 DAS under all the irrigation schedules where the increment in plant height was 94.7 cm. During later phase 160-190 DAS the plants under different irrigation schedules showed a progressive increase in plant height which was to the tune of 134.6 to 162.6 cm. The tallest plant (169.2 cm) was observed under I_{5560} irrigation schedule which was found to be at par with I_{7060}, I_{8560} and I_{10060} irrigation schedules, but remained significantly taller than those observed under rest of the irrigation schedules. The irrigation schedule I_{10060} was found to be at par with I_{7060}, I_{8560} and I_{10060} irrigation schedules. Similarly, a non-significant difference was observed in plant
height under treatments $I_{55/60}$, $I_{85/60}$, $I_{55/100}$, $I_{100/60}$ and $I_{100/100}$, respectively. The time trend of growth of winter maize in terms of plant height very well matching to the evaporative demand of the aerial environment which further depends on the air temperature, relative humidity, hours of bright sunshine/clear sky conditions, wind velocity etc. During early phase of growth November to Mid-February, the plants under different irrigation schedules followed a similar slow pace of growth which may be due to very poor evaporative demand of atmosphere due to low temperature coupled with shorter days with lesser hours of bright sunshine and high relative humidity. All these conditions are responsible for generating a very poor transpiration pull which resulted in poor uptake of nutrients by mass flow. Moreover sub-optimal air temperature resulted in poor source size which contributed a little towards plant height. While during later phase of growth the reproductive period of winter maize coincided well with high evaporative demand which generated a strong transpiration pull to cause more uptake of nutrients through mass flow. So, during this phase, the irrigation schedules with frequent irrigations i.e. at 60 mm CPE resulted in taller plants over those schedules where irrigation applied at 80 and 100 mm CPE during the reproductive phase. The data on plant height at harvest clearly indicates that under each of the pre-tasseling levels (55, 70, 85 and 100 mm), the tallest plants were observed where post-tasseling irrigation schedules (60 mm) i.e. the frequency of irrigation was highest followed by 80 and 100 mm, respectively.

**Leaf area index:**

The time trend of leaf area index (LAI) during the life span of winter maize revealed a continuous increase in LAI up to 160 DAS and later on a sharp decline up to 190 DAS was observed under all the pre and post-tasseling irrigation schedules. It was observed that under all the irrigation schedules, a very slow pace of growth during early phase from 40 to 100 DAS which was indicated through on an average increment of 0.53 in LAI and thereafter up to 160 DAS a sharp and linear increase in LAI was observed which was linear from 130 to 160 DAS and the increment in LAI was 2.15. Reaching a peak at 160 DAS the LAI showed a sharp decline which was 2.20. The data pertaining to the peak LAI under different irrigation schedules are presented in Table 1. A significant difference was observed in peak LAI under all the irrigation schedules. The maximum LAI (4.38) was observed under $I_{55/60}$ irrigation schedule, which was at par with $I_{70/60}$, $I_{85/60}$ and $I_{100/60}$ irrigation schedules. The leaf area index under these irrigation schedules was significantly higher than rest of irrigation schedules except for $I_{100/60}$ irrigation schedule where it was at par with that of $I_{70/60}$ and $I_{85/60}$ irrigation schedules. A non-significant difference was observed in maximum LAI under $I_{55/80}$, $I_{85/100}$, $I_{100/80}$ and $I_{100/100}$ irrigation schedules.

**Dry matter accumulation:**

The dry matter accumulation (g/plant) monitored at monthly interval under different irrigation schedules is indicated that during the initial phase of crop growth due to low temperature in the month of December-January, there was a non-significant increase in dry matter accumulation by the crop under different irrigation schedules of pre and post-tasseling treatments of irrigation. The early phase of crop growth i.e. 40-100 DAS a very slow pace in growth in dry matter accumulation per plant on an average (11.8 g) at 40 and 100 DAS (12.0 g). Then a sharp increase in dry matter accumulation up to 190 DAS and the growth was linear from

<p>| Table 1: Effect of different irrigation schedules on plant height at harvest, LAI at 160 DAS, dry matter accumulation at harvest, stover and grain yield of bed planted winter maize |</p>
<table>
<thead>
<tr>
<th>Treatment</th>
<th>Plant height (cm)</th>
<th>LAI</th>
<th>DM accumulation (g/plant)</th>
<th>Stover yield (q/ha)</th>
<th>Grain yield (q/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$I_{55/60}$</td>
<td>169.2</td>
<td>4.38</td>
<td>184.0</td>
<td>123.2</td>
<td>74.8</td>
</tr>
<tr>
<td>$I_{55/80}$</td>
<td>159.8</td>
<td>4.00</td>
<td>159.7</td>
<td>105.5</td>
<td>61.0</td>
</tr>
<tr>
<td>$I_{55/100}$</td>
<td>156.1</td>
<td>3.84</td>
<td>147.0</td>
<td>78.6</td>
<td>54.5</td>
</tr>
<tr>
<td>$I_{70/60}$</td>
<td>166.8</td>
<td>4.32</td>
<td>180.1</td>
<td>121.9</td>
<td>74.2</td>
</tr>
<tr>
<td>$I_{70/80}$</td>
<td>160.5</td>
<td>4.04</td>
<td>160.1</td>
<td>91.3</td>
<td>62.1</td>
</tr>
<tr>
<td>$I_{70/100}$</td>
<td>155.0</td>
<td>3.90</td>
<td>150.7</td>
<td>80.2</td>
<td>55.5</td>
</tr>
<tr>
<td>$I_{85/60}$</td>
<td>165.1</td>
<td>4.24</td>
<td>172.8</td>
<td>108.0</td>
<td>69.0</td>
</tr>
<tr>
<td>$I_{85/80}$</td>
<td>152.0</td>
<td>3.80</td>
<td>142.5</td>
<td>79.2</td>
<td>53.5</td>
</tr>
<tr>
<td>$I_{85/100}$</td>
<td>149.1</td>
<td>3.66</td>
<td>132.2</td>
<td>69.8</td>
<td>49.2</td>
</tr>
<tr>
<td>$I_{100/60}$</td>
<td>162.8</td>
<td>4.10</td>
<td>167.4</td>
<td>103.5</td>
<td>66.7</td>
</tr>
<tr>
<td>$I_{100/80}$</td>
<td>152.5</td>
<td>3.76</td>
<td>141.7</td>
<td>74.1</td>
<td>53.3</td>
</tr>
<tr>
<td>$I_{100/100}$</td>
<td>147.6</td>
<td>3.60</td>
<td>124.4</td>
<td>66.2</td>
<td>46.0</td>
</tr>
<tr>
<td>C.D. (0.05)</td>
<td>11.6</td>
<td>0.41</td>
<td>19.75</td>
<td>8.1</td>
<td>4.0</td>
</tr>
</tbody>
</table>
130-190 DAS. The data pertaining to dry matter at harvest under various irrigation schedules are presented in Table 1. A significant difference in dry matter accumulation was observed under different irrigation schedules. Maximum dry matter was observed under I\(_{55/60}\) irrigation schedule to the tune of (184.0 g) which was found to be at par with I\(_{70/60}\), I\(_{85/60}\) and I\(_{90/60}\) irrigation schedules. The dry matter under I\(_{70/60}\), I\(_{85/60}\) and I\(_{100/60}\) irrigation schedules remained significantly higher than rest of the irrigation schedules except for I\(_{100/60}\) irrigation schedule which was found to be at par with I\(_{55/60}\) and I\(_{70/60}\) irrigation schedules.

Yield and yield attributes:

The data pertaining to three vital yield contributing characters viz., number of cobs per plant, cob length, cob girth, numbers of grains per cob and 1000-grain weight under different irrigation schedules are presented in Table 2.

Number of cobs per plant:

The maximum number of cobs per plant (1.4) was observed under I\(_{55/60}\) irrigation schedule which was at par with I\(_{70/60}\) and I\(_{85/60}\) irrigation schedules, but it remained significantly higher than that observed under rest of the irrigation schedules. The number of cobs per plant under I\(_{70/60}\), I\(_{85/60}\) and I\(_{100/60}\) irrigation schedules were also at par and significantly superior to the rest of the irrigation scheduling. Similar number of cobs per plant (0.85) were observed under I\(_{55/100}\) and I\(_{70/100}\) irrigation. The data showed that as the irrigation frequency decreased, there was a significant difference in number of cobs per plant.

Cob length:

The maximum cob length (15.4 cm) was observed under I\(_{55/60}\) irrigation schedule which was significantly higher than rest of the irrigation schedules except I\(_{70/60}\) and I\(_{85/60}\) irrigation schedules. The irrigation schedule I\(_{55/60}\) was found at par with I\(_{55/60}\), I\(_{70/60}\) irrigation schedules. The irrigation schedule I\(_{55/100}\) was found to be at par with I\(_{70/100}\), I\(_{85/60}\) and I\(_{100/60}\) but it remained significantly higher than I\(_{55/100}\) and I\(_{100/100}\) irrigation schedules. The data revealed that as the frequency of irrigation was reduced which significantly reduced the cob length.

Cob girth:

The maximum cob girth was attained under I\(_{55/60}\) irrigation schedule (13.3 cm) which remained at par with I\(_{70/60}\) irrigation schedule, but produced significantly higher cob girth than rest of the irrigation schedules. The irrigation schedules I\(_{55/60}\) and I\(_{100/60}\) produced similar cob girth, but produced significantly higher cob girth than rest of the irrigation schedules. The irrigation schedule I\(_{55/100}\) remained at par with I\(_{70/60}\) and I\(_{85/60}\) irrigation schedules and it was significantly superior than rest of the irrigation schedules. The minimum cob girth (10.0 cm) was recorded under I\(_{100/100}\) irrigation schedule, which remained significantly lower than all the irrigation schedules.

Number of grains per cob:

The maximum number of grains per cob (434) was recorded under I\(_{55/60}\) irrigation schedule which remained at par with I\(_{70/60}\) and I\(_{85/60}\) irrigation schedules but significantly superior than rest of the irrigation schedules. The irrigation schedule I\(_{100/60}\) produced (388.9) number of grains per cob which were at par with I\(_{55/60}\), I\(_{55/100}\) and I\(_{70/60}\) irrigation schedules but produced significantly higher number of grains per cob than irrigation schedules viz., I\(_{70/100}\), I\(_{85/60}\), I\(_{85/100}\), I\(_{100/60}\) and I\(_{100/100}\).

1000 grain weight:

A significant difference in 1000 grain weight was...
observed under all the irrigation schedules. The maximum 1000 grain weight was observed under irrigation schedule I<sub>55/60</sub> (268.4 g) which remained at par with irrigation schedules I<sub>55/80</sub>, I<sub>70/80</sub>, I<sub>85/100</sub> and I<sub>100/100</sub>. Irrigation schedules but produced significantly higher 1000 grain weight than irrigation schedules I<sub>55/100</sub>, I<sub>70/100</sub>, I<sub>85/100</sub>, I<sub>100/80</sub> and I<sub>100/100</sub> irrigation schedules. The irrigation schedule I<sub>55/80</sub> which was found to be at par with irrigation schedules I<sub>55/100</sub>, I<sub>70/100</sub>, I<sub>85/100</sub> and I<sub>100/80</sub> irrigation schedule but significantly gave higher 1000 grain weight than irrigation schedule I<sub>100/100</sub>. The data showed that as the frequency of irrigation was reduced then significant reduction in 1000 grain weight was observed. This may be due to less availability of moisture during the reproductive phase, which ultimately affects the physiological processes like cell division and cell elongation NO<sub>3</sub> - reductase activities, photosynthesis and then translocation of assimilates.

**Grain yield**

The data pertaining to grain yield and stover yield under all the irrigation schedules are presented in Table 1 and 2. The grain yield under irrigation schedules I<sub>55/60</sub> and I<sub>70/60</sub> was observed to be of 74.8 and 74.2 q/ha which was found to be at par with each other but it remained significantly higher than the grain yield observed under rest of the irrigation schedules. The grain yield was found to be at par under irrigation schedules I<sub>55/80</sub> and I<sub>100/60</sub> (69.0 and 66.7 q/ha) but these remained significantly higher than rest of the irrigation schedules except irrigation schedule I<sub>55/60</sub> and irrigation schedule I<sub>70/80</sub> and I<sub>100/80</sub>. The irrigation schedule I<sub>100/60</sub> was found to be at par with irrigation schedule I<sub>55/80</sub>. The irrigation schedule I<sub>55/100</sub>, which was found to be at par with irrigation schedules I<sub>70/100</sub> and I<sub>100/80</sub>, produced significantly higher grain yield than irrigation schedules I<sub>55/100</sub>, I<sub>85/100</sub> and I<sub>100/100</sub>. The lowest grain yield (46.0 q/ha) was observed under irrigation schedule I<sub>70/100</sub> which remained at par with irrigation schedules I<sub>55/60</sub> and I<sub>55/100</sub>. Irrigation schedules but these irrigation schedule produced significantly less grain yield than the remaining irrigation schedules. The increase in grain yield under more frequent irrigation schedules was primarily due to higher leaf area index, dry matter accumulation (Table 1) and other yield attributing characters in (Table 2) viz., number of cobs per plants, number of grains per cob and 1000 grain weight which had a direct bearing on grain yield. The data on grain yield showed that as the frequency of irrigation decreased from CPE 60 mm to 100 mm, the availability of water in the root zone was reduced, which ultimately effects the reproductive phases (tasseling, silking dough). Kalaghatai <i>et al.</i> (1990) reported that frequent irrigations scheduled at 0.8 IW/CPE ratio resulted in higher (53.5 q/ha) grain yield of maize as compared to shallow irrigation treatments of 0.4 and 0.6 IW/CPE ratios. Similarly, Varughese and Iruthayaraj (1996) observed that increased yield and yield attributes of maize with shift in CPE of irrigation schedule 100 to 65 mm resulted in significant increase in yield attributes like cob girth 4.8 per cent and cob length 5.6 per cent with increase in grain yield 13.3 per cent of winter maize. A study was conducted to determine the water requirement of winter maize under shallow water-table condition on a sandy loam soil by Bandyopadhyay and Mallick (1996). Three irrigation schedules viz., 1.2, 0.9 and 0.6 based on IW/CPE ratio were followed. They observed significantly higher yield (2.22 Mg/ha) with five irrigations applied at IW/CPE ratio of 1.2 than IW/CPE ratios of 0.9 (1.85 Mg/ha) and 0.6 (1.77 Mg/ha) respectively.

**Stover yield**

The data presented in Table 1 revealed maximum stover yield was observed to the tune of 123.2 q/ha under irrigation schedule I<sub>55/60</sub>, which was found to be at par with irrigation schedule I<sub>100/80</sub>, but it produced significantly higher stover yield than rest of the irrigation schedules. The lowest stover yield was found under irrigation schedule I<sub>100/100</sub> irrigation schedule to the tune of 66.2 q/ha which was found to be at par with irrigation schedule I<sub>55/100</sub>. The irrigation schedule produced significantly less stover yield than the remaining irrigation schedules.

**Conclusion**

The grain yield under irrigation schedules I<sub>55/60</sub> and I<sub>100/80</sub> was observed to be of 74.8 and 74.2 q/ha which was found to be at par with each other but it remained significantly higher than the grain yield observed under rest of the irrigation schedules.

**Literature Cited**


