YIELD AND YIELD COMPONENTS OF MAIZE (ZEA MAIS L.): PHYSIOLOGICAL ANALYSIS ON SEASONAL VARIATIONS

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SUMMARY

To understand the physiological reasons for variation in grain yield of maize in two different seasons i.e., monsoon and winter, which differ strikingly for rain fall and temperature regimes, an experiment was conducted with six cultivars grown during monsoon (June-Sept.) and winter (Nov.-Apr.) seasons. Yield components like number and weight of grain/cob, harvest index (HI), grain filling period (GFP) and grain yield and physiological parameters like LAI, LAD, TDM and plant nitrogen content were higher in winter grown maize than in the monsoon crop, whereas unexploited spikelets/cob, grain yield/ha/day, CGR, RGR, NAR and leaf NR activity (NRA) were more during monsoon. The grain weight/cob and grain yield/ha were positively correlated with physiological parameters like LAI, LAD, CGR, TDM, NRA and plant nitrogen content. From the data it appears that the genotypes with high LAI (broad leaves) will be suitable for monsoon crop and genotypes with high photosynthetic rate, RGR and longer GFP for winter crop.

Key words: Growth analysis, maize, seasonal variations, yield.

INTRODUCTION

Earlier workers have concluded from long term weather data that higher mean seasonal temperature was negatively correlated with grain yield and final grain yield was dependent on the number of grains as well as the rate and duration of grain growth and drymatter accumulation (Thompson, 1986). Increase in temperature decreased spikelet fertility, and the grain number was found to be dependent on temperature and radiation regimes during the period from ear initiation to silking (Badu Apraku et al., 1983). The grain yield of maize was negatively correlated with air temperature and positively with relative humidity at flowering and pollination (Baktash, 1985). High temperatures reduced grain size by decreasing the duration of filling (Jones et al., 1981).

Physiological parameters like NAR and RGR are dependent on temperature to some extent (Grzesiak et al., 1981). The RGR of maize plant increased with increase in temperature regimes up to 33/28°C (Muldoon et al., 1984) and optimum temperature for NAR lay between 30-36°C for maize and it decreased at low or very high temperatures (Wilson, 1966). However, the relationship of physiological parameters with the yield components in two contrasting seasons, i.e., monsoon and winter has not been worked out in detail. The present investigation was aimed to understand the influence of seasons i.e., monsoon and winter on various yield components of maize in terms of physiological parameters and their relationship in both seasons.

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MATERIALS AND METHODS

An experiment was conducted with maize (Zea mays L.) genotypes namely Ganga-11, Deccan-103, Hi-starch (all hybrids), Arun, Manjari and Vijay (all composites), sown in RBD with a plot size of 5 x 5 m, having an inter and intra row spacing of 65 and 22.5 cm, respectively with four replications during monsoon (June-Sept.) and winter (Nov.-Apr.) seasons for four years (1988-1992). Crop was grown under assured irrigation with a fertilizer dose of 120, 60, 60 kg/ha of N, P and K respectively. Forty plants/plot were tagged in the middle four lines in a series to provide the data on various yield components.

The data on physiological parameters was taken on five plants from each plot at seven growth stages of maize i.e., at 4th, 8th, 12th leaf, tassel emergence, grain formation, rapid grain filling and black layer formation stages. The grain yield was taken at 14% grain moisture level. The relative growth rate of grain (RGRG) was estimated during the grain filling period (GFP) by collecting the grain samples at every four days interval from silking to black layer formation (BLF) stages. Growth analyses, nitrate reductase activity assay in the first fully matured leaf (Nicholos et al., 1976) and nitrogen content (modified micro Kjeldhal method) in plant was estimated at seven growth stages. Meterological data was collected daily at the experimental site during the crop growth period. The data were pooled and statistically analyzed following general linear model and the critical differences were used to compare the means at $P = 0.05$.

RESULTS AND DISCUSSION

Significant variations were observed for various yield components between the seasons (Table I). In general, mean values of number of grain/cob, number of spikelets/cob, grain weight of cob, harvest index, GFP and grain yield/ha were significantly higher for winter than monsoon grown plants. But, monsoon grown plants have significantly higher number of unexploited spikelets/cob and grain weight/ha/day. However, the number of grain rows/cob, 100 grain weight, shelling percentage and number of cobs/ha were less affected by the change in environment. The higher weight of grain/cob during winter was attributed to increased number of grain/cob rather than the weight of individual grain. The similar 100 grain weight in both seasons suggests that the potential grain weight had been realized in both seasons and was not influenced by the length of the GFP in contrast to the findings of Peacock and Heinrich (1984) in sorghum. These findings are in agreement with those of Zink and Michael (1985). A distinct relation between temperature during the ear initiation to silking and grain number was also observed in the study. The day/night temperature regimes during winter were 20-27°/15-18°C, when more number of grain/cob were observed as against lesser number obtained during monsoon with higher temperature.

<table>
<thead>
<tr>
<th>Character</th>
<th>Monsoon</th>
<th>Winter</th>
<th>CD at P.05</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cob length with out husk (cm)</td>
<td>13.2</td>
<td>17.2</td>
<td>0.6</td>
</tr>
<tr>
<td>Cob bearing leaf from top (no.)</td>
<td>6.4</td>
<td>6.5</td>
<td>NS</td>
</tr>
<tr>
<td>Number of grain/cob</td>
<td>306.2</td>
<td>517.5</td>
<td>23.1</td>
</tr>
<tr>
<td>Number of spikelets/cob</td>
<td>496.0</td>
<td>603.0</td>
<td>27.0</td>
</tr>
<tr>
<td>Number of unexploited spikelets/cob</td>
<td>135.0</td>
<td>86.0</td>
<td>23.8</td>
</tr>
<tr>
<td>Weight of cob (g)</td>
<td>136.6</td>
<td>168.5</td>
<td>6.7</td>
</tr>
<tr>
<td>Weight of grain/cob (g)</td>
<td>104.0</td>
<td>130.0</td>
<td>4.9</td>
</tr>
<tr>
<td>100 grain weight (g)</td>
<td>27.9</td>
<td>27.5</td>
<td>NS</td>
</tr>
<tr>
<td>Shelling percentage</td>
<td>76.4</td>
<td>77.7</td>
<td>NS</td>
</tr>
<tr>
<td>Harvest Index</td>
<td>41.7</td>
<td>43.5</td>
<td>0.9</td>
</tr>
<tr>
<td>Days to silk</td>
<td>55.6</td>
<td>96.8</td>
<td>0.7</td>
</tr>
<tr>
<td>Days to physiological maturity</td>
<td>27.5</td>
<td>130.5</td>
<td>0.8</td>
</tr>
<tr>
<td>Grain filling period (days)</td>
<td>31.8</td>
<td>39.8</td>
<td>0.5</td>
</tr>
<tr>
<td>Number of cobs/ha (1000's)</td>
<td>60.5</td>
<td>68.0</td>
<td>NS</td>
</tr>
<tr>
<td>Weight of cobs/ha (g)</td>
<td>61.1</td>
<td>83.0</td>
<td>2.3</td>
</tr>
<tr>
<td>Grain yield/ha (g)</td>
<td>45.5</td>
<td>62.4</td>
<td>2.5</td>
</tr>
<tr>
<td>Grain weight/ha/day (kg)</td>
<td>52.0</td>
<td>47.8</td>
<td>3.2</td>
</tr>
</tbody>
</table>

NS : Not-significant
regimes (30-35°/25-28°C) during the corresponding phase.

The data on physiological parameters indicate that LAI, LAD, TDM and total nitrogen content were significantly higher during winter whereas CGR, RGR, NAR and leaf NRA were more during monsoon under high day/night temperature regimes. Higher temperatures seem to enhance NAR directly and thus RGR (Tollenaar, 1989). The total nitrogen uptake by plant was higher during winter as were the crop growth duration, LAI and LAD thus felicitating the production of higher TDM and grain yields.

The higher number of grain/cob during winter was correlated with higher source capacity as LAD and LAI during winter (Table II) which was associated with the prevailing low day/night temperature regimes and high cumulative sun shine duration. These factors might have contributed towards higher grain weight/cob and better harvest index and grain yield during winter. During the monsoon season fewer spikelets were formed and many failed to develop into grain because of shortened GFP due to high day/night temperature regimes, reduced total radiation receipt, low LAI and LAD which limited the supply of photo-assimilates for growth and development of plant in general and grain in particular. During the monsoon RGRG was low during the final stages of grain filling as compared to that in winter which might have hastened the black layer formation at the tip of the grain thus cutting off the phloem link with the plant and resulting in stoppage of grain filling as evident from the higher number of unfilled spikelets/cob during monsoon. The reduced GFP does not appear to be compensated by the increased grain growth rate resulting in lower yields during monsoon. Earlier workers also reported that higher mean temperature correlated with lower yields (Peacock and Heinrich, 1984, Baktash, 1985, Thompson, 1986). Further the present study revealed that the longer GFP increased yields even when grain growth rate was low in winter. Badu Apraku et al., (1983) also found that the yield is dependent on number of grain/cob and duration and rate of grain growth.

### TABLE II: Mean seasonal values of physiological and growth analysis parameters of monsoon and winter grown maize (mean of four years).

<table>
<thead>
<tr>
<th>Character</th>
<th>Monsoon</th>
<th>Winter</th>
<th>P 05</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leaf Area Index (LAI)</td>
<td>1.77</td>
<td>2.04</td>
<td>0.060</td>
</tr>
<tr>
<td>Leaf Area Duration (LAD) (m²/day)</td>
<td>4.08</td>
<td>5.90</td>
<td>0.010</td>
</tr>
<tr>
<td>Crop Growth Rate (CGR) (g/m²/day)</td>
<td>16.90</td>
<td>16.06</td>
<td>0.030</td>
</tr>
<tr>
<td>Relative Growth Rate (RGR) (g/g/day)</td>
<td>0.07</td>
<td>0.05</td>
<td>0.003</td>
</tr>
<tr>
<td>RGR Grain (RGRG) during Grain filling Period</td>
<td>0.15</td>
<td>0.12</td>
<td>0.008</td>
</tr>
<tr>
<td>at grain formation stage</td>
<td>0.18</td>
<td>0.14</td>
<td>0.006</td>
</tr>
<tr>
<td>at rapid grain filling stage</td>
<td>0.18</td>
<td>0.13</td>
<td>0.007</td>
</tr>
<tr>
<td>at black layer formation stage</td>
<td>0.08</td>
<td>0.09</td>
<td>0.003</td>
</tr>
<tr>
<td>Net Assimilation Rate (NAR) (g/m²/day)</td>
<td>14.22</td>
<td>8.91</td>
<td>1.380</td>
</tr>
<tr>
<td>Total Dry matter (TDM) (g)</td>
<td>252.00</td>
<td>302.20</td>
<td>12.380</td>
</tr>
<tr>
<td>Plant nitrogen content (mg/g dry weight)</td>
<td>8.01</td>
<td>7.73</td>
<td>0.160</td>
</tr>
<tr>
<td>Leaf NR activity* (µmol NO₃·released/g fresh leaf tissue/h)</td>
<td>3.19</td>
<td>1.17</td>
<td>0.030</td>
</tr>
</tbody>
</table>

The correlation coefficient between various physiological parameters and grain yield/plant and grain yield/ha (Table III) showed that grain yield was positively correlated with LAI, LAD, CGR, TDM, total N and grain N. The NAR was negatively correlated with the grain yield during monsoon and positively during winter. However, RGR, RGRG and HI were negatively correlated with grain yield during both seasons. NR activity was positively correlated with grain yield during winter but the correlation was non-significant during monsoon. The yield components like grain weight/cob, 100 grain weight, and GFP : pre-silking period ratio was positively correlated with grain yield. Interestingly the grain number/cob and grain yield/ha/day were positively correlated with grain yield during winter and negatively during monsoon. The low yields during monsoon can be attributed to the
YIELD VARIATION IN MAIZE

TABLE III: Correlation coefficient values between grain yield and various physiological parameters and yield components.

<table>
<thead>
<tr>
<th>Character</th>
<th>Grain yield/plant</th>
<th>Grain yield/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Monsoon</td>
<td>Winter</td>
</tr>
<tr>
<td>LAI</td>
<td>0.834</td>
<td>0.978</td>
</tr>
<tr>
<td>LAD</td>
<td>0.789</td>
<td>0.970</td>
</tr>
<tr>
<td>CGR</td>
<td>0.801</td>
<td>0.975</td>
</tr>
<tr>
<td>NAR</td>
<td>-0.889</td>
<td>0.324</td>
</tr>
<tr>
<td>RGR</td>
<td>-0.444</td>
<td>0.511</td>
</tr>
<tr>
<td>RGRG</td>
<td>-0.813</td>
<td>0.831</td>
</tr>
<tr>
<td>Total dry matter (TDM)</td>
<td>0.829</td>
<td>0.989</td>
</tr>
<tr>
<td>NR activity</td>
<td>0.171</td>
<td>0.907</td>
</tr>
<tr>
<td>Nitrogen content in plant</td>
<td>0.950</td>
<td>0.941</td>
</tr>
<tr>
<td>Nitrogen content in grain</td>
<td>0.844</td>
<td>0.774</td>
</tr>
</tbody>
</table>

Yield components

<table>
<thead>
<tr>
<th></th>
<th>Grain no./cob</th>
<th>Grain yield/cob</th>
<th>100 grain weight</th>
<th>Grain yield/ha/day</th>
<th>Harvest Index</th>
<th>GFP/pre-silking period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monsoon</td>
<td>-0.590</td>
<td>0.870</td>
<td>-0.601</td>
<td>0.931</td>
<td>-0.420</td>
<td>0.872</td>
</tr>
<tr>
<td>Winter</td>
<td>-0.690</td>
<td>0.900</td>
<td>-0.630</td>
<td>0.951</td>
<td>-0.494</td>
<td>0.692</td>
</tr>
</tbody>
</table>

limitation of source capacity as LAI and LAD were low, even though the NAR was higher. From the results it appears that to develop a cultivar suitable for monsoon, selection of genotypes with higher LAI (broad leaves) and LAD will be desirable. Whereas, for winter, genotypes having higher photosynthetic rate, RGRG and GFP will be suitable for inclusion in the breeding programmes in order to increase productivity.

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REFERENCES


