Management of Source-Sink Balance for Maintaining Seed Vigor and Storability of Maize

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Introduction

Source capacity was determined by photosynthetic activity which related to availability of carbohydrate reserves (Uhart and Andrade, 1991). During effective grain filling period, the interaction between source capacity and sink strength (i.e., the source/sink ratio) would result in variation of final grain weight (Borrás and Otegui, 2001). Middle leaves of the stem had greater important role than the other leaves because of greater surface for light absorbing in the photosynthesis. Completely defoliation was led to minimum seeds yield because of decrease in seed weight and filled grain percent (Gifford et al., 1984). Distance of leaves and ear which participant in photosynthetic efficiency were important in a slight defoliation. Top leaves of the ear transferred about 23 to 91 percent of photosynthates to the cob and the greatest number of transferred materials belonged to the nearest leaf on top of the ear (Collantes et al., 1997). Defoliation treatments imposed when the numbers of grains had been established to reduce the source/sink ratio then results in a sharp decreasing of soluble carbohydrates in stems (Uhart and Andrade, 1995).

According to (Borrás et al., 2004), the imbalance of source/sink ratio during post-flowering could dramatically reduce final kernel weight. Restricting the source capacity during the effective grain-filling period affected Kernel Water Content (KWC) and the differently dynamics of dry matter deposition. Shortage of assimilate availability per grain (post-flowering source/sink ratio) in case that promoted by low irradiance values or defoliation might be reflected on both kernel weight and kernel composition (Borrás et al., 2002). The analysis source/sink ratio during post-flowering stage which effect on kernel weight determination would improve the understanding of the magnitude and source limitations during grain filling of maize (Borrás et al., 2009). The short period of maize leaf defoliation up to 50% did not had an adverse effect on...
maize grain and yield components (van den Boogaard et al., 2001). Remove of leaves in the pollination phase decreased dry matter and grain yield of maize significantly (Borrás et al., 2004).

Seed development was the period between fertilization, maximum fresh weight accumulation and seed maturation; it began at the end of seed development and continues till harvested (Mehta et al., 1993). Optimum harvesting period at seed matured helps to obtain better seed quality and harvesting stage influenced the quality of seed which related to germination, vigor, viability and storability. Storability of seeds was a major genetically character and is influenced by pre-storage history of seed, seed maturation and environmental actors during pre/post-harvest stages (Shaheb et al., 2015). Early harvested seeds would be low seed quality caused by immature and poorly developed and poor storage compared to seed harvest at physiological maturity (Khatun et al., 2009). Storability of seeds was influenced by pre-storage history of the seeds, seed maturation and environmental factors during pre-harvest and post-harvest (Tuite and Foster, 1979).

Materials and Methods

The experiment was supported by Syngenta seed (Thailand) Co. Ltd. in research place and plant material, two experiments were conducted at the experimental field where located at U-Thong district, Suphan Buri province, Thailand. During the 2018 and 2019 growing seasons.

Plant Sampling Management and Experimental Design

In 2018, F1 maize hybrids were planted 10 December the experiment was arranged into Split-plot in Randomized Complete Block Design with four replications.

Main-plot: The pattern of leave cutting with 5 levels were D1 = control, (without defoliation), D2 = complete defoliation, D3 = defoliating leaves below the ear, D4 = remain 2 top leaves, D5 = remain ear leaf.

Sub-plot: Leaf cutting date with 4 levels were C1 = 7 days after silking, C2 = 10 days after silking, C3 = 13 days after silking and C4 = 16 days after silking.

In 2019, hybrids were planted 9 May in plots, again into Split-plot in Randomized Complete Block Design with four replications.

Plant materials and seed samples were F1 hybrid maize seeds collected from parental hybrids lines for production. Plants were grown by 20x40 cm. of crop spacing. Compound fertilizer (15-15-15) at 60 kg h⁻¹, 40 kg h⁻¹ after 3-5 days of germination, 20 kg h⁻¹ after 40 days of emergence was applied for topping fertilizer single fertilizer (46-0-0) was applied as basal fertilizer amount 50 to 30 kg h⁻¹ divided at 20 days after emergence and 15 kg after h⁻¹ 40 days after emergence. Droplet irrigation was applied once a week. Weeds were controlled herbicides by spraying (2.4-D, glufosinate1.0 L h⁻¹ + fluroxypyr 0.3 L h⁻¹).

Plants were harvested when at 110 day after emergence. After each harvest, samples containing 10 ears were placed in paper bags and then taken to a hot air oven for drying at 40°C. The drying was performed until the seeds reached approximately 12% of moisture content. Seeds were stored in plastic sealed bag in 25°C. Then, seeds were sampling for seed qualities and vigor was tested at 6th month.

For the sampling, five plants were used as represent from each sampling block then separated each plant part and dried. Data collection was consisting of seed yield (gram), row number per cob, seed number per row and ear weight and 100-seed weight with remarkably that seed samples were bulk in each sampling block before the measurement.

Seed Parameters

Seeds of maternal plants were stored for 6th month then used for the seed parameters measurement, the effect of maternal environment was studied by testing seed germination traits. Seed qualities were tested following.

Determination of Germination Percentage

Germinations were carried out according to (ISTA, 2020). For each treatment, 100 seeds were germinated by using between paper techniques with four replications. The rolled papers were cultivated at room temperature (25±2°C). After the first count and final count 4 and 7 days after germination, normal, abnormal and diseased seeds were counted. Seed germination was calculated by the following formula:

\[
\text{Seed germination (\%)} = \frac{\text{No. of seeds germinated}}{\text{Total seeds}} \times 100
\]

Measurement of Root and Shoot Length

Final count, five seedlings were randomly selected as a represent for study, taking from each replicate of each treatment. The seedlings were cut into root and shoot parts and their lengths were measured as centimeter (cm).

Determination of Seed Vigor

Seedling vigor parameters were testing followed up protocols which were determined by ISTA: The Accelerated Aging test (AA) (ISTA, 2020), speed of germination (ISTA, 2020) and seedling growth rate (ISTA, 2020). These tests would predict storage and field planting potential. High humidity and high temperature stress were imposed on the seed, which was incubated for a period under these conditions, then transferred to a growth chamber to assess germination potential. Seed lots that withstand these conditions, while maintaining a
germination rate of 90% or above, are considered high vigor (ISTA, 2020).

**Speed of Germination**

This parameter was calculated by the following formula given by ISTA, (2020):

\[
\text{Speed of germination} = \frac{n1}{d1} + \frac{n2}{d2} + \frac{n3}{d3}
\]

Where:

\[n = \text{Number of germinated seeds}
\]
\[d = \text{Number of days}
\]

**Seedling Growth Rate Test**

This test was closely related to the standard germination test and is useful to figure out field planting potential under optimal or near ideal conditions. Seeds were planted under optimal condition and promoted to grow for an extended period, usually several days past the typical germination period. The seedlings are evaluated by their growth characteristics, such as stem length, leaf development or root branching (ISTA, 2020).

The data were submitted to the Analysis Of Variance (ANOVA). Using a Split plot in Randomized Complete Block Design with 4 replications, mean comparisons were accomplished using a Least Significant Difference (LSD) test at the 5% level. Simple correlation analysis between the results obtained from each test method was conducted.

**Results and Discussion**

**Ear Weight**

Completely defoliation severely reduced ear weight in both years 2018 and 2019 (Table 1 and 4). Defoliating leaves under of the ear had greater ear weight than removing top leaves of the ear. Maybe it was due to that ear leaf acted as a parasitic sink for ear growth at grain filling period because it was in middle part of maize stem then easily shade on it. Reduction of leaf area reduced resources for grain filling (Koptur et al., 1996). According to leaf cutting date, leaves cut at defoliation in 13 days after silking (C3) showed the highest ear weight (Table 4). A decreasing of source in the post-flowering source/sink ratio could reduce final kernel weight dramatically (Borrás et al., 2004). Ear weight was decreased significantly by early defoliation treatment (13 days after silking in both years had greater ear weight than 7 and 10 days after silking). Ear weight had shown to vary with environmental conditions that directly affect to plant growth and assimilate supply per kernel during the period when plants are setting their kernels (i.e., flowering) (Gambín et al., 2006). Differences in ear weight among hybrids and years were mostly affected by differences in the rate of kernel growth, as there were no differences in the duration of grain filling (Table 1 and 4).

**Row Number Per Ear and Seed Number Per Row**

Completely defoliation severely decreased row number per ear and seed number per row in both years 2018 and 2019 (Table 1 and 4). Reduction of supply assimilation by defoliations had significantly reduced row number per ear and seed number per row. Heidari (2012) reported, the row number per ear was harmful by complete defoliation. Minor effect of defoliation on seed number per row and row number per ear was due to that stem reserves can compensate insufficient photosynthesis from leaves. Defoliating top leaves of the ear produced lower seed number per row than defoliating leaves below ear. Upper leaves could be available to receive greater light than lower leaves, so defoliation of upper leaves had more adverse effect on seed number per row than lower leaves. Interaction between defoliation and leaf cutting date did significantly alter seed number per row concentration in 2018 year (Table 2). Interaction of D3 and C3 showed the highest row number per ear which was statistically significant (Table 5).

**100-Seed Weight**

The result of both years 2018 and 2019 showed, Removing all leaves severely reduced seed yield (Table 1 and 4). Defoliating leaves below the ear had greater amount of seed yield than defoliating leaves at the top of ear (D4, D5). It was probably due to that ear leaf in central part of maize stem and upper leaves can shade on it, so it becomes consumer and competes with ear for photosynthates. Lower seed yield of complete defoliation treatment was due to lower seed number per row and lower row number per ear. Defoliation treatments had significantly affected on 100-seed weight (Table 1 and 4) as same as the observed that defoliation decreased seed weight. It seems that seed weight is more dependent on genetic factors than environmental factors (Heidari, 2012).

**Seed Germination Percentage**

D1 and D4 had higher seed germination percentage than D2, D3 and D5 in both years 2018 and 2019 (Table 3 and 6). It might be due to that defoliation as an environmental stress can reduce seed germination percentage as described by (Heidari, 2012). Defoliation of leaves top ear (D4 and D5) had no effect as great as a defoliation of leaves under ear (D3). The reason was bottom leaves was currently senescent and available to receive low light so removal of them does have great effect on plant growth. According to leaf cutting date, leaves cut at defoliation in 13 days after silking (C3) showed the highest seed germination percentage (Table 6).
Table 1: Effect of defoliation patterns and leaf cutting date on total maize yield and yield components during 2018 (year 1)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Ear weight, g/plant b</th>
<th>Row number per ear</th>
<th>Seed number per row</th>
<th>100 - Seed weight</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Defoliation</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D1</td>
<td>48.50a</td>
<td>12.58a</td>
<td>14.47a</td>
<td>26.84a</td>
</tr>
<tr>
<td>D2</td>
<td>27.75b</td>
<td>9.96b</td>
<td>14.77b</td>
<td>10.99c</td>
</tr>
<tr>
<td>D3</td>
<td>48.00a</td>
<td>12.21a</td>
<td>14.34a</td>
<td>28.84a</td>
</tr>
<tr>
<td>D4</td>
<td>40.75a</td>
<td>12.03a</td>
<td>13.96a</td>
<td>23.27b</td>
</tr>
<tr>
<td>D5</td>
<td>40.00a</td>
<td>11.53a</td>
<td>12.70a</td>
<td>23.05b</td>
</tr>
<tr>
<td>LSDD0.05</td>
<td>4.37</td>
<td>0.56</td>
<td>13.02</td>
<td>0.98</td>
</tr>
<tr>
<td>CV. (%)</td>
<td>9.51</td>
<td>1.22</td>
<td>28.36</td>
<td>19.60</td>
</tr>
<tr>
<td><strong>Cutting date</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C1</td>
<td>36.15b</td>
<td>11.15b</td>
<td>122.96a</td>
<td>23.20a</td>
</tr>
<tr>
<td>C2</td>
<td>39.80ab</td>
<td>11.55ab</td>
<td>107.95a</td>
<td>23.21a</td>
</tr>
<tr>
<td>C3</td>
<td>45.90a</td>
<td>11.65ab</td>
<td>122.83a</td>
<td>24.43a</td>
</tr>
<tr>
<td>C4</td>
<td>42.15ab</td>
<td>12.28a</td>
<td>114.74a</td>
<td>23.54a</td>
</tr>
<tr>
<td>LSDD0.05</td>
<td>3.93</td>
<td>0.47</td>
<td>0.91</td>
<td>2.90</td>
</tr>
<tr>
<td>CV. (%)</td>
<td>7.92</td>
<td>0.96</td>
<td>22.32</td>
<td>6.19</td>
</tr>
</tbody>
</table>

a and b compared with LSD (P<0.05)
1/ D1 = control, (without leaf removal), D2 = defoliating all leaves, D3 = defoliating leaves under the ear, D4 = remain 2 top leaves, D5 = remain ear leaf
2/ C1 = 7 days after silking, C2 = 10 days after silking, C3 = 13 days after silking and C4 = 16 days after silking

Table 2: The interaction of the defoliation patterns and leaves cutting date on seed number per row during 2018 (year 1)

<table>
<thead>
<tr>
<th>Defoliation</th>
<th>C1</th>
<th>C2</th>
<th>C3</th>
<th>C4</th>
</tr>
</thead>
<tbody>
<tr>
<td>D1</td>
<td>14.98ab</td>
<td>15.43a</td>
<td>15.30a</td>
<td>12.16abcd</td>
</tr>
<tr>
<td>D2</td>
<td>6.25e</td>
<td>8.38de</td>
<td>9.83ede</td>
<td>14.61ab</td>
</tr>
<tr>
<td>D3</td>
<td>13.08abc</td>
<td>16.38a</td>
<td>14.00abc</td>
<td>13.56abc</td>
</tr>
<tr>
<td>D4</td>
<td>13.56abc</td>
<td>15.53a</td>
<td>12.25abcd</td>
<td>4.65f</td>
</tr>
<tr>
<td>D5</td>
<td>16.45a</td>
<td>13.35abc</td>
<td>10.50bcde</td>
<td></td>
</tr>
<tr>
<td>LSDD0.05</td>
<td>2.04</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CV. (%)</td>
<td>4.12</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a, b, c, d, e and f compared with LSD (P<0.05)
1/ D1 = control, (without leaf removal), D2 = defoliating all leaves, D3 = defoliating leaves under the ear, D4 = remain 2 top leaves, D5 = remain ear leaf
2/ C1 = 7 days after silking, C2 = 10 days after silking, C3 = 13 days after silking and C4 = 16 days after silking

Table 3: Effect of defoliation patterns and leaf cutting date on maize seed germination traits during 2018 (year 1)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Germination, %</th>
<th>Shoot length, cm</th>
<th>Root length, cm</th>
<th>Seedling growth rate</th>
<th>Speed of germination</th>
<th>AA - test germination at 6th month</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Defoliation</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D1</td>
<td>90.78a</td>
<td>10.42ab</td>
<td>6.72b</td>
<td>2.15ab</td>
<td>22.50a</td>
<td>87.50ab</td>
</tr>
<tr>
<td>D2</td>
<td>58.25c</td>
<td>6.79e</td>
<td>8.60a</td>
<td>1.98c</td>
<td>17.51c</td>
<td>59.75d</td>
</tr>
<tr>
<td>D3</td>
<td>92.25a</td>
<td>11.22a</td>
<td>6.72b</td>
<td>2.21a</td>
<td>22.90a</td>
<td>90.14a</td>
</tr>
<tr>
<td>D4</td>
<td>80.53b</td>
<td>7.91cd</td>
<td>7.99ab</td>
<td>2.06bc</td>
<td>20.78b</td>
<td>80.38bc</td>
</tr>
<tr>
<td>D5</td>
<td>74.25b</td>
<td>8.75bc</td>
<td>7.69ab</td>
<td>2.14ab</td>
<td>20.91b</td>
<td>76.75e</td>
</tr>
<tr>
<td>LSDD0.05</td>
<td>5.56</td>
<td>0.88</td>
<td>0.69</td>
<td>0.06</td>
<td>0.63</td>
<td>5.86</td>
</tr>
<tr>
<td>CV. (%)</td>
<td>24.10</td>
<td>1.92</td>
<td>1.52</td>
<td>0.13</td>
<td>1.36</td>
<td>12.17</td>
</tr>
<tr>
<td><strong>Cutting date</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C1</td>
<td>81.00a</td>
<td>8.25a</td>
<td>7.69a</td>
<td>2.03a</td>
<td>20.89a</td>
<td>73.20a</td>
</tr>
<tr>
<td>C2</td>
<td>86.00a</td>
<td>9.07a</td>
<td>7.93a</td>
<td>2.21a</td>
<td>20.63a</td>
<td>71.80a</td>
</tr>
<tr>
<td>C3</td>
<td>64.00b</td>
<td>9.03a</td>
<td>7.25a</td>
<td>2.06a</td>
<td>21.63a</td>
<td>83.80a</td>
</tr>
<tr>
<td>C4</td>
<td>78.20ab</td>
<td>9.72a</td>
<td>7.45a</td>
<td>2.14a</td>
<td>20.92a</td>
<td>66.40a</td>
</tr>
<tr>
<td>LSDD0.05</td>
<td>9.29</td>
<td>0.73</td>
<td>0.54</td>
<td>0.09</td>
<td>0.59</td>
<td>6.42</td>
</tr>
<tr>
<td>CV. (%)</td>
<td>19.80</td>
<td>1.48</td>
<td>1.10</td>
<td>0.19</td>
<td>1.19</td>
<td>10.15</td>
</tr>
</tbody>
</table>

a, b, c and d compared with LSD (P<0.05)
1/ D1 = control, (without leaf removal), D2 = defoliating all leaves, D3 = defoliating leaves under the ear, D4 = remain 2 top leaves, D5 = remain ear leaf
2/ C1 = 7 days after silking, C2 = 10 days after silking, C3 = 13 days after silking and C4 = 16 days after silking
Table 4: Effect of defoliation patterns and leaf cutting date on maize yield and yield components during 2019 (year 2)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Ear weight, g/plant b</th>
<th>Row number per ear</th>
<th>Seed number per row</th>
<th>100 - Seed weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Defoliation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D1</td>
<td>62.01a</td>
<td>11.61ab</td>
<td>13.18ab</td>
<td>26.04a</td>
</tr>
<tr>
<td>D2</td>
<td>29.80b</td>
<td>9.98d</td>
<td>9.99c</td>
<td>17.28d</td>
</tr>
<tr>
<td>D3</td>
<td>61.71a</td>
<td>12.21a</td>
<td>13.80a</td>
<td>26.20a</td>
</tr>
<tr>
<td>D4</td>
<td>30.80b</td>
<td>10.57cd</td>
<td>11.57bc</td>
<td>23.62b</td>
</tr>
<tr>
<td>D5</td>
<td>38.75b</td>
<td>11.26bc</td>
<td>12.78ab</td>
<td>22.71c</td>
</tr>
<tr>
<td>LSD0.05</td>
<td>7.15</td>
<td>0.38</td>
<td>0.79</td>
<td>0.40</td>
</tr>
<tr>
<td>CV. (%)</td>
<td>15.58</td>
<td>0.84</td>
<td>1.74</td>
<td>0.88</td>
</tr>
</tbody>
</table>

Cutting date

| C1        | 38.11b                | 11.10a             | 12.54ab             | 22.85a           |
| C2        | 43.50ab               | 10.85a             | 12.28ab             | 23.18a           |
| C3        | 53.36a                | 11.66a             | 13.33a              | 23.19a           |
| C4        | 43.49ab               | 10.88a             | 10.91b              | 23.46a           |
| LSD0.05   | 4.98                  | 0.50               | 1.08                | 0.49             |
| CV. (%)   | 10.04                 | 1.00               | 2.17                | 0.99             |

a and b compared with LSD (P<0.05)

1'D' = control, (without leaf removal), D2 = defoliating all leaves, D3 = defoliating leaves under the ear, D4 = remain 2 top leaves, D5 = remain ear leaf.

1'1' = 7 days after silking, C2 = 10 days after silking, C3 = 13 days after silking and C4 = 16 days after silking

Table 5: The interaction of the defoliation patterns and leaves cutting date on row number per ear during 2019 (year 2)

<table>
<thead>
<tr>
<th>Defoliation</th>
<th>C1</th>
<th>C2</th>
<th>C3</th>
<th>C4</th>
</tr>
</thead>
<tbody>
<tr>
<td>D1</td>
<td>12.06abc</td>
<td>11.05abcd</td>
<td>12.02abc</td>
<td>11.30abcd</td>
</tr>
<tr>
<td>D2</td>
<td>10.33cd</td>
<td>10.03cde</td>
<td>9.24de</td>
<td>10.33cd</td>
</tr>
<tr>
<td>D3</td>
<td>11.73abc</td>
<td>12.65ab</td>
<td>13.00a</td>
<td>11.45abc</td>
</tr>
<tr>
<td>D4</td>
<td>10.78bcd</td>
<td>7.95e</td>
<td>12.46ab</td>
<td>11.09abcd</td>
</tr>
<tr>
<td>D5</td>
<td>10.60bcd</td>
<td>12.558ab</td>
<td>11.60abc</td>
<td>10.25cd</td>
</tr>
<tr>
<td>LSD 0.05</td>
<td>1.12</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CV. (%)</td>
<td>2.26</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a, b, c, d and e compared with LSD (P<0.05)

1'D' = control, (without leaf removal), D2 = defoliating all leaves, D3 = defoliating leaves under the ear, D4 = remain 2 top leaves, D5 = remain ear leaf.

1'1' = 7 days after silking, C2 = 10 days after silking, C3 = 13 days after silking and C4 = 16 days after silking

Table 6: Effect of defoliation patterns and leaf cutting date on maize seed germination traits during 2019 (year 2)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Germination, %</th>
<th>Shoot length, cm</th>
<th>Root length, cm</th>
<th>Seedling growth rate</th>
<th>Speed of germination</th>
<th>AA - test germination at 6th month</th>
</tr>
</thead>
<tbody>
<tr>
<td>Defoliation</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>D1</td>
<td>89.19a</td>
<td>9.65ab</td>
<td>6.75bc</td>
<td>1.47a</td>
<td>21.90a</td>
<td>83.19a</td>
</tr>
<tr>
<td>D2</td>
<td>70.31c</td>
<td>6.22c</td>
<td>8.58a</td>
<td>1.23c</td>
<td>17.75c</td>
<td>64.31c</td>
</tr>
<tr>
<td>D3</td>
<td>91.31a</td>
<td>10.41a</td>
<td>6.52c</td>
<td>1.50a</td>
<td>22.59a</td>
<td>85.31a</td>
</tr>
<tr>
<td>D4</td>
<td>70.88c</td>
<td>7.23c</td>
<td>7.86abc</td>
<td>1.32bc</td>
<td>17.42c</td>
<td>64.88c</td>
</tr>
<tr>
<td>D5</td>
<td>76.69b</td>
<td>7.94bc</td>
<td>7.98ab</td>
<td>1.41ab</td>
<td>18.90b</td>
<td>70.69b</td>
</tr>
<tr>
<td>LSD0.05</td>
<td>1.19</td>
<td>0.94</td>
<td>0.65</td>
<td>0.05</td>
<td>0.50</td>
<td>1.16</td>
</tr>
<tr>
<td>CV. (%)</td>
<td>2.60</td>
<td>2.05</td>
<td>1.41</td>
<td>0.12</td>
<td>1.10</td>
<td>2.60</td>
</tr>
</tbody>
</table>

Cutting date

| C1        | 78.35c         | 7.53b             | 7.70a            | 1.29b               | 19.24b               | 72.35c                           |
| C2        | 79.45bc        | 8.44ab            | 7.78a            | 1.51a               | 19.61b               | 73.45bc                          |
| C3        | 80.95a         | 8.09ab            | 7.36a            | 1.33ab              | 20.36a               | 74.95a                           |
| C4        | 79.95ab        | 9.10a             | 7.30a            | 1.42ab              | 19.65b               | 73.95ab                          |
| LSD0.05   | 0.72           | 0.78              | 0.53             | 0.09                | 0.32                 | 0.51                             |
| CV. (%)   | 1.45           | 1.54              | 1.08             | 0.19                | 0.65                 | 1.05                             |

a, b, c and d compared with LSD (P<0.05)

1'D' = control, (without leaf removal), D2 = defoliating all leaves, D3 = defoliating leaves under the ear, D4 = remain 2 top leaves, D5 = remain ear leaf.

1'1' = 7 days after silking, C2 = 10 days after silking, C3 = 13 days after silking and C4 = 16 days after silking
Shoot Length and Root Length

Defoliation treatments had significantly impact on seedling shoot length and root length in both years 2018 and 2019 (Table 3 and 6). There had a negative correlation between root length reduced while shoot length, seedling growth rate and germination percent increased (Heidari, 2012).

Seed Vigor

The significantly effect of defoliation treatments on seedling weight and vigor was shown in both years 2018 and 2019 (Table 3 and 6). D3 the best increased high seedling growth rate, speed of germination and AA test germination percentage after 6th month of storage it’s not significantly different from D1. While the D2, D1 and D5 still show low seedling growth rate, speed of germination and AA test germination percentage after at 6th month of storage when compared with control which was no leaf removal (Table 3 and 6).

Defoliation leaves under ear severely (D2) increased 100 - seeds weight, seed germination percentage, speed of germination and seed vigor. This might be due to those defoliating leaves under ear acting as a parasitic or metabolic sink that competed for ear and kernel development during the grain filling period. Those leaves at below part of the maize stem and upper leaves could provided shade for the leaves in the central position (Heidari, 2012). A senescent leaf undoubtedly reduces the supply of photosynthate available for distribution to the grain developing as indicated by the decline in stem weight and carbohydrate concentration (Jones and Simmons, 1983). If the defoliation leaves under ear severely, the quantity of retransferred assimilation from stem to grain would be increased. Defoliating leaves below the ear did not significantly decrease corn yield and seed quality (Koptur, et al., 1996).

Complete defoliation (D2) caused the decreasing in yield and yield components. As same as study on grain maize showed, complete defoliation caused to diminish of the yield about 95% (Melchiori and Caviglia, 2008). Defoliation leaves on top of the ear (D2 and D3) caused more impact which decreased in the rate of grain filling because of only remained leaves were unavailable to supply enough to requirement of assimilate for plant. The effective period of grain filling had greater effected increasing by defoliation than the rate of grain filling. The results suggest that the top leaves should be prevent for defoliate, because this treatment showed the negative effect on yield (Heidari, 2012). As reported by (Borrás et al., 2004), a decreasing of the post-flowering source/sink ratio could reduce final kernel weight dramatically. Matthews, (1973) reported large seed size could promoted the higher germination percentage (48%) while small seed size gave a lower germination percentage (46.0%) as same as the observing that germination was higher (89.6%) in large sized seeds and lower (85.2%) in small sized seeds.

Storability of seeds was a major genetic characteristic and was influenced by pre-storage history of seeds, seed maturation and environmental factors during both of pre-harvest and post-harvest (Tuite and Foster, 1979).

Conclusion and Suggestions

The results of this study showed defoliating leaves under ear (D3) could maintain seed storability with high seed germination percentage and seed vigor. The result in maize seeds had the potential to grow to normal seedlings in the field condition, compared to removing the top of the ear (D4 and D5). Therefore, improving the seed quality in maize, hybrids and agronomic practices should focus to promote the post-flowering source/sink ratio. The recommendation is to study the effect of other environmental factors such as light by removing leaves under and at the top of ear on seed qualities and storability is remarkably interesting. Finally, leaf defoliation at upper of ear was more impact to all investigated characteristics as well as the results that suggested the upper leaves should not defoliate, because this treatment has negative effect on the yield.

Acknowledgment

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References


