The effect of defoliation on growth and yield of sorghum (Sorghum bicolor (L) Moench) variety- segaolane

Gabatshele M. Legwaila*, Thembinkosi Mathowa¹ and Ephraim Jotia¹

¹Department of Crop Science and Production, Botswana College of Agriculture, Private Bag 0027, Gaborone, Botswana
Email: lgabatshele@yahoo.com/tmathowa@yahoo.com
Tel. +267 3650253/ +267 71370573

ABSTRACT

Field experiment was carried out to evaluate the effect of leaf defoliation at different stages on plant growth and yield of Sorghum bicolor as it may be caused by animals, pests or diseases at Botswana College of Agriculture, Botswana during the cropping season from November 2011 to April 2012. The experiment was laid out in a randomized complete block design (RCBD) with three leaf defoliation treatments and the control each replicated four times. The four treatments were as follows; harvesting 3 leaves when the plant had 5 fully expanded leaves - growth stage 2 (Def at 20 DAE), harvesting 3 leaves when the flag leaf was visible in the whorl - growth stage 4 (Def at 40 DAE), harvesting 3 leaves at half bloom - growth stage 6 (Def at 60 DAE) and the control (no defoliation). Defoliating three leaves 20 DAE and no defoliation treatments on sorghum plant significantly (p<0.01) increased the vegetative dry matter, leaf area and seed weight. The results also revealed a non-significant (p>0.05) effect on the stem diameter and plant height across the treatments. Based on the findings farmers are urged to guard against late defoliation on the development of the sorghum plant since this will impact negatively on the yields and to some extent compromise the plant growth with regard to leaf area and vegetative dry matter.

Keywords: Defoliation, vegetative dry matter, stem diameter, leaf area, grain weight

INTRODUCTION

Sorghum is a cereal crop native to Africa belonging to the family of Poaceae. It is widely spread throughout inter-tropical zones and temperate regions (Doggett, 1965). In many areas or countries where sorghum is grown, it is truly a dual purpose crop. It is grown for grain in developing countries and stover is highly valued in developed countries (Rooney et al., 1986). Likewise, sorghum is a predominant crop than most other field crops in Botswana as a grain food crop. Studies in north eastern district of Botswana revealed that the majority of the farmers (96%) grew it for consumption (RIIC, 1992). The report by IITA (1997) also indicated that 52% of people in northern Botswana consume sorghum-based food daily and this confirms that sorghum is indeed a staple food of Botswana.

Most of the resource challenged farmers in Africa, in particular to Botswana have their fields unsecured against grazing animals. The animals eventually destroy crops by defoliating them. The final yield is therefore reduced through this damage by the grazing animals. A much earlier study by Stickler and Pauli (1961) compared varying defoliation intensity applied at different growth stages. Muro et al. (2001) reported the effects of simulated defoliation of sunflower (Heliathus annuus L.) at four different growth stages of the crop on yield and achene weight. The effect of premature defoliation of cotton on yield of lint was also studied (Siebert et al., 2005). All these studies concluded that the yield response depended on growth stage at which the defoliation occurred and the extent of the damage. The negative results of non-fencing of the fields or just weak fences experienced by rural farmers who are resource challenged. The land tenure system allows for grazing land and crop production land not to be separated. This makes the crops to be susceptible to livestock and wildlife damage all the time. The problem of crop defoliation can be reduced by separation of grazing land from crop production land or strong fences built around crop fields. Much of the studies on defoliation of crops were particular about situation in North America and some European countries (Rahman et al., 2008).
There is little or no information on sorghum defoliation in Botswana where sorghum is a staple crop. It is therefore important to understand and quantify the impact of these clippings by animals on growth and yield of sorghum hence the objective of the study which was to evaluate the effect of defoliation at different stages on yield of sorghum as it may be caused by animals, pests or diseases. Quantifying the yield reduction may play an important role in predicting yields after any defoliation (Rahman et al., 2008).

MATERIALS AND METHODS

Field experiment was conducted at Botswana College of Agriculture (BCA), Gaborone, Botswana during the cropping season from November 2011 to April 2012. BCA is located at Sebele (latitude 24°34′ S and longitude 25°57′ E with an altitude of 994 above sea level. The experiment was laid out in a randomized complete block design (RCBD) with three leaf defoliation (Def) treatments and the control, each replicated four times. The four treatments were as follows; harvesting 3 leaves when the plant had 5 fully expanded leaves - growth stage 2 (Def at 20 DAE), harvesting 3 leaves when the flag leaf was visible in the whorl - growth stage 4 (Def at 40 DAE), harvesting 3 leaves at half bloom - growth stage 6 (Def at 60 DAE) and the control (no defoliation).

Establishment and management; the field was ploughed and then harrowed to a fine tilth. Sixteen (16) plots, each measuring 3 m by 3 m were prepared and sorghum (Sorghum bicolor) seeds were sown at 25 cm by 75 cm i-row spacing respectively. Three seeds were sown per station at a depth of 3 cm and the seedlings were thinned out to one, ten days after emergence. The crops were kept moist by using an overhead sprinkler system. Weeding was done using a hand hoe four weeks after crop establishment. The first and last treatments were done 20 and 60 days after emergence respectively.

Field sampling and data collection; data collection commenced 20 days after the last treatment, this was done to allow the treatment to take effect. The middle two rows out of the four rows in each plot were used for data collection and outer two rows were used as guard rows. Ten seedlings were tagged and were used over the entire period of the experiment. The following parameters were determined during the experiment; plant height, vegetative dry matter, stem diameter, leaf area and 1000 seed weight. Measurements for plant height were recorded after every week for a period of 6 weeks using a meter ruler whereas other parameters were taken once at the termination of the experiment. The experiment was terminated 120 days after emergence. Ten fully expanded leaves were randomly sampled from the tagged plants and the area was measured by tracing the leaf on A1 graph pad with grid squares, each measuring 1 cm by 1 cm. Calibrated digital caliper (0-150 mm) was used to measure the outer stem diameter. This was measured about 2 cm from the base of the plant and all the ten plants were used.

Threshing and cleaning of the grains was done manually. Grains were air dried to constant weight and the weight of 1000 grains drawn from the grain yield was recorded. For vegetative dry matter, plant samples were harvested; stems and leaves separated and oven dried at 80°C for 48 hours. The dry weights were recorded using an electronic weighing balance (PGW 4502e), max: 4500 g and readability: 0.01 g. Grain weight was used to determine grain yield whereas plant height, stem diameter, leaf area and vegetative dry matter were used to determine plant growth.

Data analysis: The data collected was subjected to analysis of variance (ANOVA) using STATISTIX-8 program. Where F-test was observed and means comparison test carried out using Least Significant Difference (LSD) at p≤0.05 to separate treatment means.

RESULTS AND DISCUSSION

Vegetative dry matter: Harvesting the three leaves 20 DAE (growth stage 2) and no defoliation treatments showed similar results producing highest vegetative dry matter. Both treatments were highly significant (p<0.01) in the production of dry matter compared to harvesting three leaves at 40 DAE (growth stage 4) and 60 DAE (growth stage 6) (Table 1). Pearson and Fletcher (2008) reported the same results in the defoliation of leaves study done at the early stages of maize growth. They found that cutting leaves during early stages of growth allows for leaf regrowth within the next three days. In sweet sorghum studies, maximum dry weight was recorded at no defoliation and 30 days after sowing (Harish, 2007). Because of the recovery and regeneration of the photosynthetic surface, higher interception of light and net photosynthetic canopy results in increased
Dry matter production and yield (Harish, 2007; Baleseng, 2010). From the same study, the leaf area of the plant had maximized in these two treatments. In another study on orchard grass, Berlesky and Fedders (1994) showed a decrease in dry matter of up to 35% of total annual yield when the canopy was defoliated at a later stage of growth. In agreement, the growth stages 4 and 6 (Table 1) recorded lower dry matter in this study and these could be attributed to delayed defoliation which resulted in partial recovery of the plant.

Leaf area and weight (1000 seeds): Defoliation at 40 DAE (growth stage 4) and 60 DAE (growth stage 6) significantly (p<0.01) reduced the plant leaf area as compared to no defoliation and defoliation at 20 DAE (Table 1). The same trend was observed for seed weight except for defoliation at 20 DAE (growth stage 2) which had the second highest seed weight but non-significant statistically with defoliation at 40 and 60 DAE (Table 1). The yield of plants is intimately associated with the photosynthetic rate of the leaf and the active leaf area which plays an important role in carbon fixation. Consequently, formation of new leaves and stalks and increased leaf area are of critical importance in determining the final performance of the plant (Gifford and Evans, 1981). Yield reductions occur when leaf area is below optimum levels (Pereira, 1978). Leaf area may be adversely affected by a variety of factors including defoliation. In this study, defoliation affected the performance of sorghum in growth stages 4 and 6 which could not sufficiently compensate for the loss of the leaf area hence reduced leaf area (Table 1). Defoliation affects the dry matter accumulation and seed yield particularly by reducing the leaf area available for light interception and photosynthesis (Polat et al., 2011). Other studies suggested that there was a strong association between light interception percentage and CO₂ fixation with the leaf area index (Boote et al., 1985; Higley, 1985). The impact of the loss is closely related to development stages and defoliation levels. Optimum leaf area should be produced to achieve maximum yield potential in crops.

The no defoliation significantly (p<0.05) increased the 1000 grain weight (Table 1). This treatment has repeated the findings of this study on vegetative dry matter (Table 1). Reductions of grain yield appear to be experienced at later stages of defoliation than defoliation at early stages. Defoliation, in optimum conditions had been shown to reduce crop yield and reduction was greatest when leaf removal coincides with pollination stage (Rajewiski and Francis, 1991; Board, 2004; Yang and Midmore, 2004). Other studies had also reported that partial defoliation about 25% to 33% did not change grain weight in any developmental stages of the seed (Lal and Sing, Shneiter et al., 19871997). However, in this study partial defoliation (3 leaves) at growth stages 4 and 6 revealed a reduction in the 1000 seed weight. Our findings are also supported by Egharevba et al. (1976) who reported that damage to maize leaves at 50% silking stage to over 20 days after silking, reduced yield by reducing the 1000 seed weight. Hassen and Chauhan (2003) emphasized that the grain yield of maize is significantly affected by rate of defoliation.

Stem diameter and plant height: There was no significant (p>0.05) effect on the stem diameter and plant height across the treatments (Table 1 and Figure 1). The results agree with the findings by Krans and Beard (1985) who showed from their experiment with Kentucky bluegrass that lateral formation of the stem was not determined or affected by plant clippings. The probable unchanging stem diameter (Table 1) of sorghum plant after defoliation treatments could be that it is pre-determined as this form earlier than other plant parts. Moreover, Moriondo et al. (2005) and Barimavandi et al. (2010) found that defoliation had no significant effect on stem diameter of sunflower and stem height in maize plant respectively. In this study the defoliation was partial and it had not reached the threshold of having an effect on stem diameter and plant height especially at the early stage of development of the plant. The effect of defoliation on stem depends on the stage of growth, intensity of defoliation and the position of the leaves in maize. There is no upset of stem/leaf ratio which would otherwise affect the stem height when intense defoliation occurred at grain filling. The effect of such defoliation cause weakening of stem rather than the height which may cause lodging (Barimavandi et al., 2010). Furthermore, a study with radio-active carbon showed that assimilates retransferring from stem to grain is done during grain filling period when there are fewer or no leaves at all (Hashemi et al., 1995). Enyi (1973) also found that the removal of leaves of field grown sorghum (cv Serena) decreased plant height, dry weight of leaf sheaths, stems, ear and grain when leaf removal was performed at flag leaf than at anthesis. Other studies had shown that the intensity (over 50% defoliation) had affected the stem dry
weight and grain dry weight yield in corn and sunflower (Abdi et al., 2007; Nezami et al., 2008; Barimavandi et al., 2010).

CONCLUSION

Harvesting three leaves 20 DAE (growth stage 2) and no defoliation treatments on sorghum plant recorded the highest values for vegetative dry matter, leaf area and seed weight. Defoliation treatments had no effect on plant height and stem diameter of the sorghum plant. Therefore, based on the findings farmers are urged to guard against late defoliation on the development of the sorghum plant since this will impact negatively on the yields and to some extent compromise the plant growth with regard to leaf area and vegetative dry matter.

Table 1 Effect of leaf defoliation on seed weight, vegetative dry matter, leaf area and stem diameter.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Weight of 1000 seeds (g)</th>
<th>Vegetative dry matter (g)</th>
<th>Leaf area (cm²)</th>
<th>Stem diameter (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Def at 20 DAE</td>
<td>15.9&lt;sup&gt;a&lt;/sup&gt;</td>
<td>161.9&lt;sup&gt;a&lt;/sup&gt;</td>
<td>395.6&lt;sup&gt;a&lt;/sup&gt;</td>
<td>6.4</td>
</tr>
<tr>
<td>Def at 40 DAE</td>
<td>15.4&lt;sup&gt;b&lt;/sup&gt;</td>
<td>123.1&lt;sup&gt;b&lt;/sup&gt;</td>
<td>356.0&lt;sup&gt;b&lt;/sup&gt;</td>
<td>5.7</td>
</tr>
<tr>
<td>Def at 60 DAE</td>
<td>14.3&lt;sup&gt;b&lt;/sup&gt;</td>
<td>114.0&lt;sup&gt;b&lt;/sup&gt;</td>
<td>352.6&lt;sup&gt;b&lt;/sup&gt;</td>
<td>6.0</td>
</tr>
<tr>
<td>No Defoliation</td>
<td>18.2&lt;sup&gt;b&lt;/sup&gt;</td>
<td>172.7&lt;sup&gt;a&lt;/sup&gt;</td>
<td>424.6&lt;sup&gt;a&lt;/sup&gt;</td>
<td>6.5</td>
</tr>
<tr>
<td>Significance</td>
<td>*</td>
<td>**</td>
<td>**</td>
<td>ns</td>
</tr>
<tr>
<td>LSD 0.05</td>
<td>2.33</td>
<td>20.09</td>
<td>32.16</td>
<td>ns</td>
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<tr>
<td>CV (%)</td>
<td>9.15</td>
<td>8.79</td>
<td>3.26</td>
<td>10.24</td>
</tr>
</tbody>
</table>

* significant at p<0.05, ** highly significant at p<0.01, ns non-significant at p>0.05. Means separated by Least Significance Difference (LSD) Test at p≤0.05, means within columns followed by the same letters are not significantly different.

Fig. 1. Effect of leaf defoliation on sorghum plant height over the period of the study.
Bars are the standard deviation (SD) values. Overlapping SD bars are non-significant at p>0.05.

REFERENCES

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