International Journal of Advances in Engineering and Management (IJAEM)
Volume 2, Issue 3, pp: 09-18 www.ijaem.net ISSN: 2395-5252

Effect of Percent and Stage of Leaf Defoliation on the Biomass Yield of Sugarcane, at Arjo - Dedessa Sugar Factory, in Western Ethiopia

Kasahun Tariku[1]*, Hirpa Legesse[2], Tadesse Negi[3]
[1,2]Department of Plant Science, College of Agriculture and Natural Science, Wollega University, Ethiopia
[3]Wonji Research and Development Center, Ethiopia
*Corresponding Author: Kasahun Tariku

Date of Submission: 15-07-2020 Date of Acceptance: 31-07-2020

ABSTRACT: The experiment was conducted at Arjo-Didessa Sugar Factory which is located in East Wollega Zone of Oromia Regional State with the objective of determining the effect of leaf defoliation at different stages of sugarcane (Saccharum officinarum) on thebiomass yield. Sugarcane (Saccharum spp.) is unusual among field crops in that it is not the seed that have economic values, but rather the stalk. Sucrose is extracted from the large stalks that are produced by sugarcane plants. The effect of percent and stage of defoliation on biomass yield and agronomic parameters of sugar cane is still unknown. Effect of leaf defoliation at three different stages on sugarcane biomass yield was studied under field conditions. The methodology used include seven percent of leaf defoliation comprises of 10%, 20%, 30%, 40%, 50%, 60% and 0% (control) and three growth stages of defoliation at 9, 10 & 11 month of sugarcane was arranged in Randomized Complete Block Design. The result shows that, significant variations among leaf removal and cane age were noted for agronomic parameters like biomass yield. Thus significantly higher biomass yield(8.5kg) at 20% of leaf removal and (8.0kg) at 50% of leaf removal was recorded from 10 and 9 month age of NCO-334 sugarcane varieties respectively,however,lower biomass yield of (2.5kg) at 10 month age was obtained from 0 % of leaf removal. In general this results indicated that sugar cane plants could be partially defoliated with changing biomass production and the retention of defoliated leave in the field providing advantage to the sugar factory, that should be used as fodder, increase nutrient conservation, reduce weed growth, and conserve soil moisture on substantial losses of C and N due to sugarcane leaf burning at harvesting stage. However, further future research is required to strengthen the investigation and repeating similar research on different location are necessary to recommend to all Ethiopian sugar factories.

Key word: sugarcane, defoliation, stage and biomass yield.

I. INTRODUCTION

This research was initiated with the objective of to evaluate the effect of defoliation at different stages on yield, quality, and response of sugarcane crop to defoliation and its advantage to increase sugar recovery at Arjo-Didessa Sugar Factory which is located in East Wollega Zone of Oromia Regional State.Sugarcane is one of the most important crops in the world (Dagar et al., 2002). Sugarcane belongs to the genus (Saccharum L.,) of the grass family (Poaceae) and originated in Papua New Guinea, as original habitat and from where it spread to south East Asia and India in the course of few thousand years (Bull, 2000).

The Office of Agricultural Economy, (2008) reported that the sugarcane burned in the field had many disadvantages such as weight reduction, microorganism destroyed easily, rapid decrease of sweetness, high production cost of plant, that organic material and structure in soil were destroyed and decreased sugar production.Sugarcane harvesting is a critical step that must be managed to maintain good quality and quantity of sugarcane production. Farmers harvesting sugarcane have a leaves-removing or leave defoliating step and cut the stem closing to the soil, then cut the top of sugarcane stem. Leaves and leaf sheaths of sugarcane caused delay of harvesting. Moreover, the sugarcane crop that has not been fully leaves-removed (leave defoliations) could carry some soil, sand and mud, thus damaging the downstream sugarcane process machine and reduced sugar yield (Yangyeun and Wongpicheth, 2008).

The contamination will be increased more when using the car to grip sugarcane to the truck. Sugarcane leaf-defoliating tools could help to speed up sugarcane harvest and reduce contamination. However, researchers in the past had focused on tools or equipments used to help harvest sugarcane crop; for example, sugarcane harvester, knife used for sugarcane crop on performance to sugarcane harvester. However, leaf-removal machinery can solve the problems of sugarcane burning and reduce contaminants. Retention of unburned residues can increase nutrient conservation, reduce weed growth, and conserve soil moisture on the other hand substantial losses of C and N due to sugarcane residue burning have been reported (Viator et al., 2006).

In general physiological and morphological responses of individual plants to defoliation was evaluated in chronological sequence beginning with plant function during "steady state" growth prior to defoliation, followed by the short-term effects of defoliation, and concluding with long-term processes contributing to the reestablishment of "steady-state" growth (Steingraeber et al., 1993). Particularly according to Gutierrez et al (2004), mechanical defoliation of sugar cane plants (Saccharum spp.) will provide leaves that can be used as fodder but the effect of partial mechanical defoliation on sucrose content, enzyme activities and agronomic parameters of sugar cane is still unknown and also the concentration of sucrose in the stems of partial defoliated plants was significantly different from that found in intact plants. Similarly, Dendooven et al (2004) indicated that some agronomic parameters and enzyme activities were different in defoliated plants compared with intact plants except for the moisture content which was higher in defoliated plants than in intact ones. These makes sugar cane plants could be partially defoliated changing sucrose production and agronomic parameters while providing leaves that could be used as fodder.

The Ethiopian Government is building modern sugar factories and expanding the existing ones with the aim of maximizing the production volume to alleviate the scarcity of sugar in the country (EIA, 2008). This work was conducted in view of the limited information on the effect of leaf defoliation at different stages of sugarcane on biomass yield and quality but the hypotheses tested in these studies, the effect of leaf defoliation at different stages of sugarcane on biomass yield and quality were superior in defoliated than undefoliated sugarcane.

II. MATERIALS AND METHODS

2.1. Description of the Study Area

The experiment was conducted at Arjo-Didessa Sugar Factory located in East Wollega Zone of Oromia Regional State. Arjo Dedessa Sugar Factory is located at 9^0 N latitude and 39^0 E longitudes, with an altitude of 1300-1600 masl. The area receives high rain fall from June to September with average of 1477 mm annually. The mean average temprature of the study area is 22^0C, the soil types of the experimental site are dominated by Vertisols and few red Latosols.

2.2 Experimental Materials and Design

NCO -334 sugarcane varieties was used as an experimental material. Treatments comprising six levels of defoliation percent of 10 %, 20 %, 40 %, 50 %, 60 % and one control of 0 % of percent of defoliation at three different stages of sugarcane, that is, at 9 month growth stage (S_1), 10 month growth stage (S_2) and at 11 month growth stage (S_3) and each of which replicated three times. The percent of defoliation was made after counting total number of leaf from three randomly sampled and the leaf was defoliated according to percent of defoliation treatment. The two factors were combined factorially and arranged in randomized complete block design (RCBD). The actual experimental area was designed with PL = number of treatment x plot length + spacing between plot x number of block – 1i.e (7 X 5m + 2m x 3 -1= 40m) and PW = number of block x plot width + spacing between block + number of spacing (3 x 7.25m + 2m x2 =25.75m). The total area used was 40m x 25.75m (1030m^2). Plot width = 1.45 x 5 and plot length= 5m, the distance between block used were 2m, between plot were 1m and the sugarcane was spaced at 1.45m between rows.

2.3. Data Collection and Sampling

The data were collected on eight parameters (Internodes number, Internodes length, Stem diameter, Internodes weight, sugarcane height, Leaf area index, biomass yield and number of leaf). The middle two rows out of the four rows in each plot were used for data collection, the number of plants per row was 1260 and the distance between rows were 1.45m. The agronomic parameter measurement were determined by using different procedure & apparatus i.e. stem diameter was measured by calibrated digital caliper of standing plant in the field. Biomass yield was determined from three randomly sampled sugarcane plants per plot. Internodes length and stalk height were measured by using meter. Internodes number and number new leaf after defoliations were measured by counting number of internodes & leave across the stalk. Internodes weight was measured by taking total weight of the three stalks and then dividing by average number of internodes across the stalk. Leaf area was measured by using meter and Leaf area index was calculated by using LA = L x W x 0.867 and GCA (ground cover area) = 5m x 1.45m (distance b/n furrow & plant spacing) and then the LAI was determined by dividing LA to the ground cover area.

2.5. Data Analysis

The data collected were subjected to analysis of variance (ANOVA) using SAS software (SAS, 2004). Treatment means that exhibited significant differences were separated using the least significant difference at 5% level of significance (SAS, 2004).

III. RESULT AND DISCUSSION

The of analysis of variance result for different characters are presented in Table 1 design. The analysis of variance table for percent of defoliation showed a highly significance difference for all parameters while stage of defoliation showed significantly ($P< 0.05$) affect all the parameters except for stem diameter, internodes weight, stalk height, internodes number and internodes length.However, their interaction effect showed that a significance difference for all characters (Table 1).

3.1 Effect of Defoliation on Internodes' Number

As indicated in table 1, the analysis of variance for number of internodes showed a highly significant difference for percent of defoliation and their interaction effect. However, the stages of defoliation have no significant on internodes number. On average the treatment gave 18.99 mean values of numbers of internodes per stalk (Table 2). The highest internodes number was recorded from 60 % of leaf defoliation at 10 months of growth stage of defoliation (Table 2).

The value recorded from 50 % and 60 % of leaf defoliation at 9 month growth stage and 40 % and 50 % of leaf defoliation at 10 month growth stage was equivalent with 50 % and 60 % of leaf defoliation at 11 month growth stage were not significantly different, however, at 0 % (control) of leaf defoliation with 9 month growth stage age relatively lower number of internodes was recorded (Table 2).

From this result it was observed that defoliation increases the number of internodes which have an advantage to get longer stalk which will resulted in high biomass yield and sugar recovery. This result obtained was in line with Alados et al., (1997) who reported an enlargement of the stem increase in leaf and internodes number, greater vegetative growth and inflorescence length in albaida (Anthylis cylisoides L.) after 10% - 50% leaf removal by clipping.

In white clover (Trifolium repens L.), defoliation of 1, 2, and 4 leaves for 36 days increased stolon elongation rate, leaf area, root mass, leaf number, and stolon number, but total nonstructural carbohydrate decreased with the lower supply of phosphorus (P). However, various mechanisms have been proposed for compensatory growth, such as higher photosynthetic rate, stomata conductance and delayed senescence (Striker et al., 2008).

3.2 Effect of Defoliation on Internodes Length

The analysis of variance showed that the effect due to percent of defoliation and interaction effect on internodes length were highly significance; however the stage of defoliation has no significant effect on the length of internodes (Table 1).

There were differences in internodes length at nine, ten and eleven month age after defoliation (Table 2). On average the mean length of internodes recorded was 15.04cm long after defoliation (Table 2). The longest internodes length (22.3 cm) was recorded after 60 % of defoliation at 9 month growth stage and the longer internodes length 17.6 cm were recorded after 50 % of defoliation at 9 month growth stage, however, the shorter internodes length 14.0 cm was recorded after 60 % of defoliation at 10 month growth stage (Table 2).

When defoliation was applied on 10 %, 20 % and 40 % at 9 month growth stage as well as 30 % and 40 % of defoliation at 10 month growth stage have equivalent effect on internodes length (Table 2). Additionally interactions of 30 % of defoliation with 9 month age and 10 % of defoliation with 11 month growth stage have equivalent effect on internodes length (Table 2).

All defoliations treatment except control among the stage additional internodes length was added to the stalk and that the size of internodes increased. From this result obtained, the advantage was increasing the whole stalk length leads to higher biomass yield and sugar recovery. In sugarcane, the stalks are the harvested part and stalk size has a major influence on yield.

3.3 Effect of Defoliation on Stem diameter and Internodes Weight

Analysis variance for stem diameter was indicated in (Table 1). Analysis of variance for stem diameter showed a highly significance difference for percent of defoliation and their interaction effect, however, stage of defoliation has no significant effect on stem diameter. On average the treatments gave 33.12mm stem diameter of mean value (Table 2).

The maximum stem diameter (40.90mm) was recorded after 60% of the leaf defoliation at ten month growth stage and followed by 60 % of leaf defoliation at 9 month growth stage of 40.01mm stem diameter (Table 2).

On the other hand the thinner stem diameter (22.66mm) was recorded from 0 % of leaf defoliation at 9 month growth stage and followed by (23.83mm) stem diameter from 20 % of leaf defoliation at 10 month growth stage (Table 2). From the result recorded defoliation significantly increases the stem diameter especially after higher percent of treatment which is related to the increment of total weight of sugarcane (biomass) that results in the advantage of having the thicker stalk of sugarcane increasing sugar recovery due to defoliation. This is because of the reserve stored in the remaining leaf reallocated to stem of the stalk that leads to increase the total weight of sugarcane.

The results agree with the findings by Moriondo et al., (2005) and Barimavandi et al. (2010) found that defoliation had significant effect on stem diameter of sunflower and stem weight in maize plant, respectively.

As indicated in table 1, the analysis of variance for internodes weight showed a highly significance difference for percent of defoliation and the interaction effect, however, the sage of defoliation have no significance effect on internodes weight. On average the mean of internodes weight recorded were 408.9gm (Table 2). On the other hand relatively the internodes weight increasing from nine to eleven month growth stage when defoliation was applied at 20 %, 50 % and 60 % 0f leaf defoliation (Table 2).

Results obtained from 60 % of leaf defoliation at eleven month growth stage was recorded as highest internodes weight followed by 50 % of leaf defoliation at 11 month growth stage (Table 2). Similar result was recorded from 40 % and 50 % of leaf defoliation at 10 month growth stage. The lowest internodes weight was recorded from 20 % of leaf defoliation at all growth stage equivalent to the control as compared to the other defilation percentages and growth stages (Table 2). This is due to low number of leaf were defoliated. As indicated in table 2, internodes weight increases as the percentage of defoliation increases from 9 to 10 month growth stage of defoliation because of more leaf was removed from randomly sampled sugarcane plant.

Therefore the increase in diameter of sugarcane resulting in increasing the total dry weight of sugarcane, similarly studies had shown that the intensity (over 60% 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). These findings are also supported by Egharevba et al., (1976) who reported that damage to maize leaves above 50% silking stage to over 20 days after silking, increases biomass by increasing the 1000 seed weight. Hassen and Chauhan (2003) emphasized that the grain yield of maize is significantly affected by rate of defoliation.

3.4 Effect of Defoliation on Leaf area Index

The analysis of variance for leaf area index showed a highly significance difference for percent of defoliation, stage of defoliation and their interactions effect (Table 1).On average, the different defoliation percentage and growth stage was gave leaf area index of 2.45m^2 (Table 3).

The highest leaf area index was recorded from 20 % of leaf defoliation at 9 and 11 month growth stages (Table 3). However, defoliation above 30 %, with all months of growth stage gave the lowest leaf area index (Table 3). Defoliation significantly increases leaf area index in all growth stages as the percentage defoliation decreases in this study indicating defoliation from lower percent of treatment had a positive effect of renewing, refreshing and good standing of leaf area development of sugarcane.

LAI is an important adjustment factor in most sugarcane growth and yield models (Doorembos and Kassan 1979; O'Leary 2000). Researchers have evaluated the relationship of LAI with sugarcane yield. For example, Hodges and Kanemasu (1977) found that photosynthesis, respiration, and dry matter accumulation could be expressed as a function of LAI.

Other studies suggested that there was a strong association between light interception percentage and CO_2 fixation with the leaf area index (Boote et al., 1985; Higley, 1992). 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). Additionally, solar radiation intercepted by the leaves and transformation into chemical energy during photosynthesis is directly related to determination of sugarcane yield (Teruel et al., 1997).

3.5 Effect of Defoliation on Leave Number

Analysis of variance for number of leaf showed that a highly significance difference for percent of defoliation and significantly difference for stage of defoliation and their interaction effect (Table 1). On average, the mean value of the new leaf emerged after defoliation recorded was 0.69 (Table 3). Hence after defoliation was conducted the re-growth of approximately two new leaves was observed from 10 % and 20% of defoliation at 9 month growth stage, and from 60 % of defoliation at 11 month growth stage (Table 3).

On the other hand after defoliation was applied the re-growth of approximately one new leaf was recorded from 0 % of defoliation at 9 and 11 month growth stage, from 10 %, 20 %, 50 % and 60 % of defoliation at 11 month growth stage and 50 % and 60 % at 10 month growth stage (Table 3). Additionally, from 0 %, 10 % and 40 % of defoliation at 10 month growth stage and from 30 % and 50 % of defoliation at 9 month growth stage after defoliation the emergency of new leaf recorded was one (Table 3). As a result, formations of new leave increases number of leaf are the critical importance in determining the final performance of the sugarcane plant.

The result was agreed with the findings Following defoliation root growth is reduced, while leaf re growth is maintained by the increase in the allocation of reserves from root to shoot (Ourry et al., 1988). Studies on ryegrass (Lolium perenne L.) showed defoliation-induced reduction in root growth, diversion of assimilates and remobilization of N compounds from root and stubble to leaf (Millard et al., 1990). Overcoming a threshold value results in the emergence of new leaves with modified assimilatory capacity and stimulates relative growth rate (Zhao et al., 2008).

Similarly other studies reported that after defoliation the number of leaf added significantly enhanced photosynthesis and growth in the remaining leaves (Khan et al. (2002a). Additionally compensating for tissue removal, especially after intense defoliation, requires large amounts of energy investment (Reichman and Smith 1991), which is derived from reallocating energy stored in the remaining leaves, shoots, and roots of the damaged plants (Liu et al., 2007). Quentin et al., (2011) have reported that removal of 45% of leaf area of blue gum (Eucalyptus globules Labill.) was compensated by the increased photosynthetic rate, improved water relations and increased utilization of carbon assimilates. The source and sink restriction due to defoliation (removal of both leaf and flower at full flowering stage) is compensated for by enhanced flowering in soybean (Glycine max. L.) (Saitoh et al., 2001). Defoliation of 50% lower leaves on plant axis at pre flowering, i.e., 40 d after sowing (DAS), in B. juncea resulted in enhanced photosynthesis and growth in the remaining leaves (Khan et al., 2002a).

Defoliation up to 40–50% in T. repens increased the emergence and the development of youngleaves at maturity (Marriott and Haystead 1990). The responses of plants to shortage of C brought about by defoliation (moderate or heavy) generally increases allocation of resources to shoot growth than root growth (Yang and Midmore 2004). Priority allocation of C and N resources to active shoots sink is the main adaptive response of plants to frequent defoliation, which results in re growth after defoliation (Khan et al., 2007).

3.6 Effect of Defoliation on Stalk Height

As indicated in table 1, stalk height was a highly significance difference for the percent of defoliation and their interaction effect, however, the stage of defoliation have no significant effect on stalk height. Defoliation of 10 % of leaf removal at 10 month growth stage gave significantly higher stalk as compared to 20 % of leaf removal at 10 month of growth stage (Table 3). However, when defoliation was applied at 50 % of leaf removal at 10 and 11 month growth stage and 20 % of leaf removal at 11 month growth stages were significantly equivalent with 50 % of leaf removal at nine month growth stage (Table 3).

The mean value of stalk height recorded was 1.81m through all growth stage and percent of defoliation (Table 3). In general the result from undefoliated 0 % of leaf removal at all stage recorded indicates shorter height of sugarcane than other defoliation treatment and growth stage (Table 3). Therefore, this shows that the effect of defoliation was more beneficial than undefoliated effect to increase the biomass yield and the quality of sugar recovery.

This result has an advantage of longer stalk height this is due to well aeration after defoliation, the reserve in the root reallocated shoot and leaf that agreed with Similar results were reported by Moriondo et al., 2005 and Barimavandi et al., 2010 who found that defoliation had significant effect on stalk height of sugarcane and stem diameter in maize plant because of reallocation of reserves in the root to upper part of

International Journal of Advances in Engineering and Management (IJAEM)
Volume 2, Issue 3, pp: 09-18 www.ijaem.net ISSN: 2395-5252

the plant. In this study the defoliation was not almost harming the crop and it had not reached the threshold of having a greater effect on stem diameter and stalk height especially at the steady stage of development of the sugarcane plant. The effect of defoliation on stem depends on the stage of growth, intensity of defoliation and the position of the leaves in sugarcane. There is no upset of stem/leaf ratio which would otherwise affect the stem height when severity defoliation occurred at sucrose accumulation across Culm (stalk height). The effect of such defoliation cause weakening of stem rather than the height which may cause lodging (Barimavandi et al., 2010). Other studies had shown that the intensity (over 60% 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).

3.7 Effect of Defoliation on Biomass Yield

As it had been recorded in table 1, the biomass yield was a highly significance difference for both main factor (stage of defoliation and percent of defoliation) and significantly different for its interaction effect.

Defoliation at different stages significantly affects biomass yield of sugarcane. The highest biomass yield was recorded from 20 % of leaf defoliation at ten month growth stage followed by 50 % of leaf defoliation at 9 month growth stage as compared to the control and other treatment at all stage (Figure 1). However, the lowest biomass yield was recorded from 0 % of leaf removal at all growth stage (Figure 1). The biomass yield recorded from10 % of leaf removal at nine month growth stage, 10 % of leaf removal at ten growth stages, 10 % of leaf removal at eleven month growth stage was not significantly different from each other (Table 3). Due to less number of leaf removal non-significant effect was observed on biomass yield. On average the different factor combinations gave 5.66kg biomass yield (Table 3).

Almost in all the three growth stages biomass yield increases as the percent defoliation increases from 10 % - 50 % of leaf removal (Figure 1), Hence defoliation of sugarcane after 9 months of growth stage enhances biomass yield which could later increases the amount of sucrose harvested. This supported by the study of increasing in pearl millet yield (hybrid GHB-30 and MH-179) as a function of the level of defoliation was seen by Josshi et al., (2003). These results are partially the same as those obtained by Fonseca et al. (2014); upon studying levels of artificial defoliation in millet, they concluded that only defoliation of 100% in the ED1 (third visible sheet) phase was less than the other levels of defoliation. The results may be related to a compensatory effect of the remaining leaves; however, the quantity of the photo assimilates is limited, especially in all the reproductive phases and at the defoliation levels of 66 and 99%.
Biomass yield of the plant is correlated to the production of photo assimilates during photosynthesis. Therefore, photosynthetic efficiency in transformation of solar radiation intercepted and transformed into dry biomass (Casaroli et al., 2007) is highly dependent on leaf area (Alcântara Neto et al., 2011). Thus, harsh damages brought about in leaves impede photosynthetic activity (Mondo et al., 2009).

IV. CONCLUSION

In light of the results obtained, the different levels and stages of defoliation have a significant effect on all the parameters studied .Partial defoliation in sugarcane (i.e. removal of half leaves) has been shown to not have a long-term negative effect on the biomass yield. Generally the results obtained in this study are based on data of three month experiment and, hence do not warrant the formulation of a clear-cut recommendation.However suggestive enough to draw the following recommendations:

- When defoliation was applied on 20 % of leaf removal at 10 month growth stage in relative to other percent of defoliation and stage higher biomass yield was recorded. On the other hand trash or leave without defoliating that is delivered with the stalks to the factory could also reduce the quality of sugarcane juice. However, further study is required to support some leaves defoliated in the field should be utilized as a soil fertilizer there is still plenty available for use as biomass; retention of unburned leave can increase nutrient conservation, reduce weed growth, conserve soil moisture and also defoliated leaves could be used as animal fodder after 9month of crop age without affecting sugarcane yield.
- Defoliation could also be used to renew, refresh and increase growth and photosynthetic rate in sugarcane plants under abiotic stress conditions. However, further research is required to strengthen the investigation and repeating similar research on different location are necessary to recommend to all Ethiopian sugar factories.

V. REFERENCES

[1]. Abdi, S., Fayaz.A and Ghadimzade.M. (2007).Effect of Different levels of Defoliation at Reproductive Stage on grain Yield and Oil Percent of Two Hybrid Sunflower. Agriculture and Natural Resources Science and Technology: p. 245-255.

[2]. Alados, C., Barroso, F.G., Garcia. L. (1997).Effects of Early Season Defoliation on Above-ground Growth of Anthyllis Cytisoides:P. 269- 283. A Mediterranean J. Arid Environ.

[3]. Alcântara, N., F. Gravina, G., A. Monteiro, M., M. Morais, F., B. Petter, F., A. (2011).Albuquerque Jaa. Análise De Trilha Do Rendimento De Grãos De Soja Na Microrregião Do Alto Médio Gurguéia. P: 107-112. Com. Scient.

[4]. Barimavandi, A., R., Sedaghathoor, S., and Ansari, R. (2010). Effect of Different defoliation Treatments on Yield and Yield Components in Maize (Zea mays) Cultivar of S.C704. P: 9-15. Australian Journal of Crop Science

[5]. Bull, T. (2000). The Sugarcane Plant.In "Manual of cane growing", M Hogarth, P Allsopp, eds. P: 71-83. Bureau of Sugar Experimental Stations, Indooroopilly, Australia

[6]. Casaroli, D. Fagan, E., B. Simon, J. Medeiros, S., P. Manfron, P., A. Neto, D., D. Lier, Q., J., V, Müller, L. Martin, T., N. (2007). Radiação Solar E Aspectos Fisiológicos Na Cultura De Soja - Uma Revisão.P: 102-120. Rev. da FZVA

[7]. Dagar, P., S., K. Pahuja, S., P. Kadian and S., Singh. (2002). Evaluation Of Phenotypic Variability In Sugarcane Using Principal Factor Analysis. P: 95-100 Indian Journal of Sugarcane Technology.

[8]. Dendooven, H (2004). The Development Of The Cultivated Sorghum. Crop plant evaluation, Cambridge University Press.

[9]. Doorembos, J. and A., H. Kassan. (1979). Yield Response To Water. Rome, FAO, (1979). (Irrigation and Drainage Paper 33).

[10]. Egharevba, P., N., Horrocks, R. D and Zuber, M., S. (1976). Dry Matter Accumulation In Maize In Response To Defoliation. P: 40-43. Agronomy Journal.

[11]. EIA, (Ethiopian Investment Agency).(2008). Investment Opportunity Profile For Sugar Cane Plantation And Processing In Ethiopia.EIA, Addis Ababa, Ethiopia.

[12]. ESESISC, (2008). Investment Opportunity Profile for Sugar Cane Plantation and Processing In Ethiopia

[13]. Gifford, R., M and Evans, L., T (1981). Photosynthesis, Carbon Partitioning And Yield. P: 485-509 Annual Review of Plant Physiology.

[14]. Gutiérrez-Miceli, F.,A. Morales-Torres, R. de Jesús Espinosa-Castañeda, Y. Rincón-Rosales, R. Mentes-Molina, J. Oliva-Llaven, M.,A. Dendooven, L. (2004).Effects OfPartial Defoliation Journal of Agronomy and Crop Science On Sucrose Accumulation, Enzyme Activity Jou Journal of Agronomy and Crop Science of Agronomy and Crop Science And Agronomic parameters InSugar cane (Saccharum spp.). P: 256–261.Journal of Agronomy and Crop Science.

[15]. Hassen, H. and Chauhan, S., S (2003). Effect Of Rate Of Maize Leaf Defoliation At Various Growth Stages On Grain, Stover Yield Components Indian Journal of Agricultural Research Of Maize And Under Sown Forage Production. P: 136-139. Indian Journal of Agricultural Research

[16]. Hodges, T. and E.T, T. Kanemasu. (1977). Modeling Daily Dry Matter Production Of Winter Wheat. P: 674-678. Agron. J.

[17]. Khan, N., A. Khan, M. Ansari, H., R. Samiullah, (2002a).Auxin And Defoliation Effects On Photosynthesis And Ethylene Evolution In Mustard.P: 43-51. Sci. Hort.

[18]. Khan, N., A., Singh, S. Nazar, R., Lone, and P., M. (2007). The Source-Sink Relationship In Mustard.

[19]. Liu, H., D. Y., U., F., H., He.W., M. Chu, Y. Dong, M. (2007).Are Clonal Plants More Tolerant To Grazing Than Co-Occurring Non-Clonal Plants In Inland Dunes?P: 502-506. Ecol. Res.

[20]. Marriott, C., A. Haystead, A. (1990). The Effect Of Defoliation On The Nitrogen Economy Of White Clover Re Growth And The Remobilization Of Plant Organic Nitrogen.P: 465-474. Ann. Bot.

[21]. Millard, P. Thomas, R., J. Buckland, S., T. (1990). Nitrogen Supply Affects The Remobilization Of Nitrogen For The Re growth Of DefoliatedLolium perenne L. P: 941-947. J. Exp. Bot.

[22]. Mondo, V., H., V. Carvalho, S., J., P. Dourado, Neto, D. Cicero, S., M. (2009). Comparação de métodos para estimativa de área foliar em plantas de milho. P: 233-246. Rev. Bras. De Milho e Sorgo.

International Journal of Advances in Engineering and Management (IJAEM)
Volume 2, Issue 3, pp: 09-18 www.ijaem.net ISSN: 2395-5252

[23]. Moriondo, M. Orlandini, S and Villalobos, F., J (2005).Modeling Compensatory Effects Of Defoliation On Leaf Area Growth And Biomass Of Sunflower (Helianthus annuus L.). P: 161-171. European Journal of Agronomy.

[24]. Nezami, A. Khazaei, H., R. Boroumand Rezazadeh, Z and Hosseini, (2008).Effects Of Drought Stress And Defoliation On Sunflower (Helianthus Annuus) In Controlled Conditions. P: 99-104. Dessert

[25]. O'Leary, G., J. (2000). A Review Of Three Sugarcane Simulation Models With Respect To Their Prediction Of Sucrose Yield. P: 97-111. Field Crops Res.

[26]. Ourry, A. Boucaud, J. Salette, J (1988). Nitrogen Mobilization From Stubble And Roots During Re Growth Of Defoliated Perennial Ryegrass.P: 803-809. J. Exp. Bot.

[27]. Saitoh, K. Isobe, S. Sequchi, Y. Kuroda, T. (2001).Effects Of Source And/or Sink Restriction On The Number Of Flowers, Yield And Dry Matter Production In Field-Grown Soybean.P: 365-372. Japanese J. Crop Sci.

[28]. SAS, (2004).GLM procedure SAS software (SAS, 2004).Ver 6.4th Edition. SAS Institute, Inc.

[29]. Steingraeber, F., C and Pauli, A., W. (1993).Leaf Removal In Grain Sorghum. 1. Effects Of Defoliation Treatments On Yield And Components Of Yield. P: 99-102. Agronomy Journal

[30]. Striker, G., G. Insausti, P. Grimoldi, A., A. (2008).Floodings Effects On Plants Recovering From Defoliation InPaspalum dilatatum and Lotus tenuis. P: 247-254. Ann. Bot.

[31]. Teruel, D., A., V. Baarbieri, and L., A. Ferraro. (1997). Sugarcane leaf area index modeling under different soil water conditions. P: 39-44. Sci. Agric. Piracicaba.

[32]. The Office of Agriculture Economy, (2008).Monthly Export For Sugar In Quantity And Value.

[33]. Viator, R., P., R., M. Johnson, C., C. Grimm, and E., P. Richard, Jr. (2006).Allelopathic, Autotoxic, And Hormetic Effects Of Postharvest Sugarcane Residue. P: 1526-1531. Agron. J.

[34]. Yang, Z and Midmore, D., J. (2004).Experimental Assessment Of The Impact Of Defoliation On Growth And Production Of Water-Stressed Maize And Cotton Plants. P: 189-199. Experimental Agriculture

[35]. Yangyeun, Z and Wongpicheth, D., J (2008). Experimental Assessment Of The Impact Of Defoliation On Growth And Production Of Water-Stressed Maize And Cotton Plants. P: 189-199. Experimental Agriculture.

[36]. Zhao, W. Chen, S., P.Lin, G., H. (2008).Compensatory Growth Responses To Clipping Defoliation In Leymus Chinensis (Poaceae) Under Nutrient Addition And Water Deficiency Conditions. P: 85-99. Plant Ecol.

APPENDEXE

List of tables

Table 1.Mean square values for the parameters recorded as affected by percent defoliation, stage of defoliation, and percent by stage of defoliation interaction of sugarcane grown at Arjo Dedessa in 2014/15 cropping season.

Characters	Sources of Variation				
	PD	ST	PD X ST	MSE	REP
Internodes number	70.88^{**}	3.19^{ns}	4.91^{*}	3.41	5.28
Internodes length	11.83^{**}	2.49^{ns}	3.45^{*}	2.72	3.15
Stem diameter	292.86^{**}	3.05^{ns}	12.89^{**}	10.39	90.04
Internodes weight	113476.73^{**}	2997.57^{ns}	12844^{**}	7548.7	1.34
Sugarcane height	0.032^{**}	0.0043^{ns}	0.061^{**}	0.012	0.02
Leaf area index	61.14^{**}	7.43^{**}	3.75^{**}	0.20	0.54
Biomass yield	14.97^{**}	3.70^{**}	1.08^{*}	0.43	4.30
Number of leaf	3.75^{**}	1.15^{*}	1.17^{*}	0.65	2.49
Brix %	16.82^{**}	1.03^{*}	2.03^{*}	0.58	0.97
Polarity %	22.99^{*}	4.58^{ns}	16.39^{*}	14.42	17.63
Purity %	575.65^{**}	533.36^{**}	366.68^{ns}	378.58	553.1
Sucrose %.	3.78^{**}	0.011^{ns}	0.25^{*}	0.22	0.40

***, ** and ns indicate significance at the 0.05 and 0.01 probability levels and non-significance level, respectively. PD = Percent of defoliation, ST = Stage of growth, PD x ST = Interaction of percent of defoliation and stage of growth, MSE = Mean square error and REP = Replication**

Table 2.Mean values for parameters internodes number, internodes length, stem diameter and internodes weight as affected by percent, stage of defoliation and their interaction effect of sugarcane grown at Arjo Dedessa in 2014/15 cropping season.

Parameter	Internodes number			Internodes length (cm)			Stem diameter (mm)			Internodes weight (gm)		
DF %	Stage of defoliation			Stage of defoliation			Stage of defoliation			Stage of defoliation		
	9	10	11	9	10	11	9	10	11	9	10	11
0	14.000	16.00	17.33	14.16	14.00	14.00	22.66	28.90	31.78	200.0	350.0	416.6
10	18.66	15.33	15.66	14.66	17.50	15.66	30.23	28.91	29.79	300.0	383.3	300.6
20	16.66	15.00	15.33	14.00	13.33	15.50	25.05	23.83	26.08	200.0	250.0	250.6
30	21.33	20.33	19.00	15.66	14.66	14.33	35.10	34.06	34.43	480.0	470.0	470.0
40	20.00	22.00	19.66	14.33	14.00	15.33	36.21	37.11	35.94	523.3	500.0	480.0
50	22.33	22.00	21.00	17.66	17.00	16.00	39.70	38.70	38.14	500.0	503.3	555.0
60	22.33	23.00	21.00	22.33	14.00	16.00	40.01	40.90	38.06	480.5	483.5	585.3
Mean	18.99			15.04			33.12			408.9		
CV %	9.73			10.96			9.73			21.24		
LSD 0.05	1.15			1.02			2.01			54.19		

***, ** and ns indicate significance at the 0.05 and 0.01 probability levels.**

Table 3. Mean value analysis for the Leaf area index, Number of leaf after defoliation, stalk length and Biomass yield as affected by percent defoliation by stage of defoliation interaction effect of sugarcane grown at Arjo – Dedessa 92014/15) cropping season.

Parameter	Leaf area index			new leaf after DF			Stalk height		
DF %	Stage of defoliation			Stage of defoliation			Stage of defoliation		
	9	10	11	9	10	11	9	10	11
0	5.75	5.36	5.43	0.57	0.51	0.57	1.57	1.75	1.58
10	6.44	5.52	5.75	1.52	0.52	0.57	1.81	2.12	1.88
20	6.67	5.98	6.67	1.52	1.15	1.00	1.86	1.54	1.85
30	0.83	0.60	0.61	0.52	0.57	0.57	1.83	1.84	1.81
40	0.67	0.62	0.48	0.57	0.52	1.00	1.82	1.83	1.88
50	0.83	0.58	0.71	0.52	0.57	1.15	1.87	1.88	1.84
60	0.74	0.66	0.51	1.15	0.57	1.52	1.86	1.85	1.79
Mean	2.45			0.69			1.81		
CV %	18.25			8.81			6.04		
LSD 0.05	0.27			0.50			0.10		

***, ** and ns indicate significance at the 0.05 and 0.01 probability levels and DF % = Defoliation %.**

List of Figure

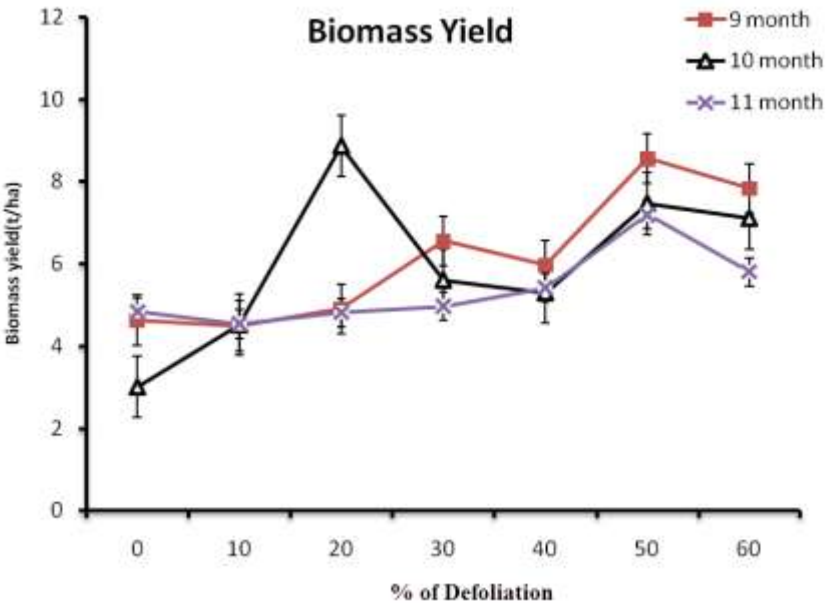

Figure 1.Biomass yield of sugarcane as affected by different stage of defoliation and percent leaf defoliation interaction grown at Arjo - Dedessa in 2014/15 cropping season.