International Journal of
AGRICULTURE AND BIOSCIENCES

www.ijagbio.com P-ISSN: 2305-6622 E-ISSN: 2306-3599 editor@ijagbio.com

RESEARCH ARTICLE

Evaluation on Remobilization of Photosynthesis Materials in Conditions of Source and Sink Limitation in Corn Hybrid K.S.C. 704

Maryam Sakhravee, Mojtaba Alavifazel* and Shahram Lak

Department of Agronomy, Science and Research Branch, Islamic Azad University, Khuzestan Iran

ARTICLE INFO

Received: June 20, 2013
Revised: June 25, 2013
Accepted: June 27, 2013

Key words:
Corn
Current photosynthesis
Remobilization
Source and sink limitation

***Corresponding Address:**
Mojtaba Alavifazel
mojtaba_alavifazel@yahoo.com

ABSTRACT

In order to study the effect of remobilization of photosynthesis materials in restricted conditions of source and sink on corn hybrid K.S.C. 704, an experiment was conducted in Ahvaz during the summer 2011 on the randomized complete block design (RCBD) with three replications. Restricted condition of source and sink included; cutting the leaves above the maize, cutting the leaves below the maize and cutting half of the maize and not cutting the leaves as control. The results indicated that the change in the amount of current photosynthesis affected the remobilization. A significant decrease in amount of current photosynthesis was observed in the treatments of cutting leaves and also in eliminating lower leaves of the maize. Increasing amount of remobilization in treatments of cutting the leaves above the maize can be due to extreme decrease in amount of current photosynthesis, in which the plant tries to increase its remobilization so to compensate somehow the decrease. This is while the total current photosynthesis and remobilization was less comparing with the control. In other words, increasing the amount of remobilization in condition of cutting the leaves does not achieve compensating decrease in current photosynthesis. Cutting 50 percent of the corn – due to extreme decrease in number of grains and sink limitation- did not fulfill increase of remobilization, yet sink limitation led to decrease of remobilization. Cutting 50% of the maize caused more decrease in biologic yield which is due to the greater role of maize in total yield as a sink for preserving nutrients.

Cite This Article as: Sakhravee M, M Alavifazel and S Lak, 2013. Evaluation on remobilization of photosynthesis materials in conditions of source and sink limitation in Corn Hybrid K.S.C. 704. Inter J Agri Biosci, 2(6): 356-360. www.ijagbio.com

INTRODUCTION

The growth process of the corn

Crops in different stages of growth would pass all the stages from germination to harvest and in this respect environmental factors, variety and agronomic operations affect them (Sanjari, 1989). The growth stages of the corn includes: germination, vegetative growth, flower formation (crown flower in main stem and maize in lateral branches), flowering (crown flower formation and pollination), partial decrease in vegetative and reproductive growth, grain filling duration and physiological maturity in which seed cord change is seen in black color. Growth pattern in all varieties is almost the same but the time of each stage is dependent on; genotype, growth season, implantation date, climate conditions and the amount of reachable nutrients (Sarmadnia and Kucheki, 1993). For the corn variables which are compatible with their climate conditions, the whole growth period (from implantation to grain maturity) might be different from 65 days in tropical regions to 12b months in high regions. Yet this can be dependent on genotype and growth season duration affected by temperature, moisture and on-time availability of nutrition (Hoseinzade, 1996).

The influence of environmental factors, especially environmental tensions such as defoliation, can affect vital mechanisms like photosynthesis, remobilization, respiration and yield. The maximum photosynthesis is yielded in the stages of spike appearance to maturity of milky grains, and in this stage the maximum work is devoted to younger leaves located on 1/3 above the stem (Hoseinzade, 1996). Absorption surface is evaluated by Leaf Area Index (LAI) and it is extremely dependent on production surface per hectare. The active duration of each leaf is dependent on location of the stem and environmental conditions. Except the importance of the leaves, self-adjustment mechanism of the plant and changing status of the sink & source, some plant organs such as young leaves (while growing) are considered to be consumers, but when the growth of these organs is completed they can be material supplier for the other parts.

Two physiological factors are affecting grain growth;

1. Current photosynthesis
2. Remobilization of accumulated components in organs before flowering (Tomison, 2005).

In some especial growth stages photosynthesis materials are produced more than consuming need of the growth process. These materials in a process can turn to storage compounds and in next stages (for instance in the stage of seed production in which current photosynthesis is not able to fulfill all requirements of the sink) these storage compounds can retransfer to grain in form of remobilization. On the other hand it refers to transferring materials from the place where they have already been stored in, to another place. Remobilization of materials includes the following biologic and physiological processes below:

1. Consuming nutrients stored in vacuoles
2. Breaking stored protein
3. Breaking cell components such as chlorophyll and enzymatic proteins

Remobilization of nutrients is performed through the following stages below;

1. Creating the possibility of materials movement
2. Short way- alter from symplast to phloem exudates
3. Loading in phloem exudates
4. Transferring in phloem exudates

On the other hand some factors are relevant in developing remobilization process:

1. Especial need of seeds and fruits to nutrients
2. The nutrients status of vegetative organs
3. The ratio of source to sink (Khodabandeh, 1993).

In studying methodologies of source and sink limitations we can mention the following methods:

1. Defoliation: with defoliation we restrict the source
2. Grain removal: through grain removal we can decrease or limit the sink. In defoliation also we cut the leaves above and below the maize so to be able to attain final yield through restricting the source
3. The next treatment was the upper side of the maize that here the sink will be restricted and the final results shall be analyzed (Naderi, 2011).

MATERIALS AND METHODS

Study site and experiment

This research has been conducted in Shahid Salemi farm of Ahvaz in agronomic year of 2011. The studied land was located in northern suburb of ahvaz with 48 degrees and 40 eastern minutes longitude, and 31 degrees and 20 northern minutes latitude.

This experiment was also conducted on the randomized completely block design (RCBD) with three replications. Source and sink limitation was performed through cutting the leaves above the maize (a1), cutting the leaves below the maize (a2) and splitting the maize in half (a3). Cutting the leaves was also performed by means of a clipper and the leaves were cut from lamina of the leaf to pod of the stem. This action was done during the pollination stage and before grain filling. In order to prevent evaporation of the maize, we got use of paraffin in the cutting areas and afterwards the crusts of the corn were closed by strips.

Data collection and analysis

In order to study and determine physiological features such as current photosynthesis and remobilization under treatment condition of the experiment, we had sampling in two stages of flowering and maturity afterwards though the following equations we did the calculations:

gr/m = the amount of remobilization of storage materials

Dry weight of the organ at the maturity level – dry weight of the vegetative organ at the beginning of browning stage

gr/gr remobilization efficiency =

$$\frac{(gr/m^2)\ \text{the amount of remobilization of storage materials}}{gr/m^2\ \text{dry weight of front organs at the beginning of silks browning}}$$

1% contribution of nutrients remobilization =

$$\frac{gr/m^2\ \text{remobilization amount}}{gr/m^2\ \text{grain yield}} \times 100$$

$$gr/m^2\ \text{current photosynthesis amount} = gr/m^2\ \text{grain yield} - gr/m^2\ \text{remobilization amount}$$

$$gr/gr\ \text{current photosynthesis efficiency} = \frac{gr/m^2\ \text{current photosynthesis amount}}{gr/m^2\ \text{dry weight of vegetative organs at the beginning of silks browning}}$$

(%) = 100 – contribution of nutrients remobilization

Leaf surface was measured through determining its length and maximum width by getting use of ruler, and then the product was determined in fixed coefficient of 75%.

In order to measure dry weight, all harvested parts were put in ventilated oven with 75^0C for 48 hours and then the samples were taken out of the oven and by means of scale they were weighted in 1% accuracy after that in order to determine economic and biological yield, after physiologic maturity the harvest was conducted.

Afterwards all statistical calculations – including variance analysis and average comparison- were conducted by means of Duncan's multiple-range test and regression analysis through SAS software (Ver.9.2, SAS Institute, 1992.) also for drawing the tables we got use of EXCEL software (Microsoft Office, Ver.2003)

RESULTS AND DISCUSSION

The effect of source and sink limitation on amount of remobilization

According to variance analysis table, the effect of source and sink limitation on remobilization amount was significant in 1% level (Table 1) and the maximum remobilization due to sink and source limitation was related to cutting the leaves above the maize (with 283.02 grams per squared meter), and the minimum amount was that of cutting 50 percent of the maize treatment (with 56.005 grams) (Table 2). There is considerable debate as to whether the supply of assimilates from the maternal plant (the source) or the ability of the reproductive sink to accumulate these assimilates limits the growth and composition of maize kernels (Borras *et al*., 2002; Gambin *et al*., 2006). What is clear is that the assimilate supply can be altered by N availability and by genotype, and that both can affect yield and grain composition (Uribelarrea *et al*., 2004).

Table 1: The results of variance analysis of effective traits in remobilization of stored materials in – per grain shown in mean squares

Sources of variables	Degree of Freedom	Current phothosentesis proportion	Current phothosynthesis efficiency	The amount of current phothosynthesis	Remobilization proportion	Remobilization efficiency	The amount of remobilization
replication	2	1.19**	0.000049**	194**	1.19**	0.000042**	64**
Source and sink limitation	3	1766.96**	0.127**	163903**	1766.96**	0.048**	99681**
errors	6	0.42	0.000381	283	0.42	0.000463	74
Changes (coefficient %)		0.15	0.029	1.65	1.42	1.14	2.86

*Significant at 0.05 level of significance, ** Significant at 0.01 level of significance and ns non significant

In treatment of cutting the upper and lower leaves of the corn, due to cutting the main parts of photosynthesis, the ration of remobilization has had a significant increase comparing with control. It seems because the upper leave of the corn have been younger and have had more photosynthesis potentiality, the surface of these leaves have had more chance of remobilization comparing with the lower leave of the corn. Increasing efficiency and remobilization in treatments of cutting the leave above the maize and cutting the lower leaves in proportion with control can represent the limitation conditions of the source. The efficiency and remobilization in cutting the maize in proportion with control can be another reason that proves sink limitation in this research, because if the sink is not restricted we could witness that the weight of the grains is increased through increasing remobilization.

Increasing remobilization amount in treatments of cutting the leave above the maize can be due to extreme decrease in current photosynthesis in which the plant has been increasing remobilization so to compensate some parts of the lack. Comparing with the control, the total of current photosynthesis and remobilization is less, which means remobilization in the condition of cutting the leaves does not have the possibility of compensating current photosynthesis decrease.

In maize, N assimilates, which are supplied as arying proportions of amino acids, have different compositions in the cob than in the developing kernel tissues as a result of preconditioning by the cob prior to use by the kernels (Seebauer *et al*., 2004).

According to table 2, cutting 50% of the maize – due to extreme decrease in number of grains and sinks limitation- did not increase remobilization, which means sink limitation led to decrease of remobilization.

The effect of source and sink limitation on remobilization efficiency

According to the results indicated in table2, comparing the effect of source and sink limitation on remobilization efficiency was significant in 1% level and the treatments of cutting the leaves below and above the maize had the maximum remobilization efficiency with 0.19 g/g and cutting 50% of the maize had the minimum remobilization efficiency with nearly 0.04 g/g.

By cutting the leaves the remobilization efficiency will be increased. This is because the need of plant for receiving photosynthesis materials must be compensated.

Materials storage in grains happens through two sources of “current photosynthesis” and “remobilization of stored materials”. The first source is considered to be the main source and the second one is the secondary source. Before pollination, some factors such as environment temperature, moisture availability for the plant and the possibility of growth in leaf surface are very important. The capacity of grain growth is considered to be one of the genetic features of the plant which can affect some factors like grain growth velocity from pollination stage to maturity.

According to the results indicated in table2, decrease of remobilization in treatment of cutting 50% of the maize can significantly decrease remobilization. Also through increasing the remobilization in upper leaves of the corn we can witness increase in efficiency of remobilization as well.

The effect of source and sink limitation on proportion of remobilization

According to table2, comparing the effect of source and sink limitation on proportion of remobilization was significant in 1% level and the maximum remobilization proportion was related to cutting the leaves above the maize with 37.43%, also the minimum amount was seen in 50% maize treatment with 8.01%. The minimum significant difference among these two treatments was so trivial. By cutting the leaves above the maize– which have an essential effect on providing photosynthesis materials- proportion and efficiency of current photosynthesis would be decreased and as a result remobilization proportion will be increased as well. Decrease of proportion and efficiency of photosynthesis can lead to increase of remobilization which is due to compensating the need of the plant.

In this research, because of decreasing sinks by cutting 50% of the upper side of the maize also due to low amount of materials caused by current photosynthesis, the amount of remobilization was increased. Lak and Hashemi (2006) and Hanvi (1992) reported results similar to findings of this research.

The effect of source and sink limitation on amount of current photosynthesis:

According to table1, the effect of source and sink limitation on amount of current photosynthesis and the effect of source and sink limitation and implantation pattern on remobilization proportion were significant in 1% level. The maximum current photosynthesis was in “not cutting the leaves or the maize” treatment with 774.57 g/m^2, and the minimum amount of current photosynthesis was related to “cutting the leaves above the maize” with 476.93 g/m^2.

In treatments of cutting the leaves (especially in upper leaves of the corn because they are younger and more active also they have a better position for absorbing sunlight) the current photosynthesis was less.

Table 2: Comparison of the mean of the effect of source and sink limitation on remobilization of preserved materials in vegetative organs to grain by LSD method

Treatment	Remobilization amount (gram per square meter)	Remobilization efficiency (gram per gram)	Remobilization amount (percent)	Current photosynthesis amount (gram per square meter)	Current photosynthesis efficiency (gram per gram)	Current photosynthesis contribution (percent)
Source and sink limitation						
Cutting upper leaves of the maize (S1)	283.02	0.19	37.43	476.93	0.19	62.56
Cutting lower leaves of the maize (S2)	261.62	0.19	33.64	515.40	0.19	66.36
Cutting 50 percent of maize (S3)	56.005	0.04	8.01	643.38	0.04	91.98
No cutting of maize leaves (S4) (control)	151.20	0.11	16.23	774.57	0.11	83.76
LSD (one percent)	60.94	0.11	1.11	29.53	0.0341	1.13

LSD: the minimum of significant difference of the mean between the two treatments at the level of 1 percent

Cutting 50% of the maize -along with having all the leaves- seems to decrease its need to nutrients, this is due to cutting the maize in half and subsequently significant decrease in number of grains of the corn. The amount of current photosynthesis is also less comparing with control. The control treatment – due to balance of the source and sink- had more current photosynthesis.

The effect of source and sink limitation on current photosynthesis

According to table (1) of variance analysis, the effect of source and sink limitation on photosynthesis efficiency is significant at the level of 1%. We have witnessed maximum efficiency with the amount of 0.19 at the time of cutting the above and lower leaves, and minimum efficiency with the amount of 0.04 g/g at the time of cutting 50 % of the maize.

In this study, the complementary role of current photosynthesis and remobilization in grain filling is shown, and by changing the amount of current photosynthesis, remobilization is also affected. In the treatment of cutting the leaves above the maize, it seems that cutting young, active leaves which are on the upper part of the stem and has better and more access to sunlight, causes significant decrease in current photosynthesis, and cutting lower leaves of the maize compared to the upper ones shows less decrease in current photosynthesis.

When cutting 50% of the maize, although the amount of current photosynthesis is more than the treatment of cutting leaves, it seems that the cause of grains limitation had less current photosynthesis in absorbing photosynthetic materials compared to the control treatment. It means that although the contribution of current photosynthesis in total weight of the grain in this treatment was higher, preserving produced nutrients in grains was not possible. Thus sink limitation and source and sink interaction causes the decrease of current photosynthesis in this treatment, and the amount of remobilization in the treatment of cutting maize can better show source limitation in the conditions of this experiment; ultimately this leads to significant decrease of grain yield in this treatment.

Sarmadnia and Kuchaki (1987) reported that conditions before flowering stage determine the size and efficiency of photosynthesis, and conditions after flowering stage determine the real yield during grain filling period.

Photosynthesis contribution

Considering table 1 of the effect of source and sink limitation on current photosynthesis contribution, the highest yield was related to cutting 50% of the maize with 91.98%, and the lowest amount was related to not cutting leaf and maize with 83.76%.

In the treatment of cutting 50% of the maize, due to the decrease of the number of grains, the contribution of current photosynthesis in filling the remained grains was higher compared to other treatments, though due to imbalance between source and sink in this treatment, there was less current photosynthesis compared to the control.

Conclusion

In sum, the results of this study show that by changing the amount of current photosynthesis, remobilization is also affected. In cutting upper leaves of the grain it seems that cutting young leaves which have better access to sunlight, causes a significant decrease in current photosynthesis, and cutting lower leaves of the maize compared to the upper ones shows less decrease in current photosynthesis. In addition, cutting 50% of the maize caused more decrease in biologic yield which is due to the greater role of maize in total yield as a sink for preserving nutrients.

REFERENCES

Borras L, JA Cura, ME Otegui, 2002. Maize kernel composition and post-flowering source-sink ratio. Crop Science 42: 781-790.

Gambin BL, L Borras, ME Otegui, 2006. Source-sink relations and kernel weight differences in maize temperate hybrids. Field Crops Res, 95: 316-326.

Hoseinzade Moghadam H, 1996. Studying the effect of head-cutting of bushes on some of the growth properties of yield and the possibility of dual-purpose usage of corn, Master’s degree thesis, Faculty of Tehran University.

Hanway JJ, 1992. How acornplant develops. Low a coop Ext Ser Spec, Rep//48.

Khodabandeh N, 1993. Cereals, third edition, Tehran publication.

Lak Sh, 2006. Studying the effect of water shortage on agro physiological traits on corn yield of 704 single-cross hybrid in comparison with the difference of nitrogen and bush density in Ahvaz climatic conditions, Islamic Azad University, Research Sciences Unit of Ahvaz.

Naderi A, 2011. Physiology booklet, Research sciences unit of Khuzestan.

Sarmadnia Gh, A Kuchaki, 1993. Crop Physiology, Jihad Daneshgahi publication of Mashhad.

Sanjari A, 1989. Maize morphology, Agricultural research center of natural resources of Khuzestan province.

Seebauer JR, SP Moose, BJ Fabbri, LD Crossland, FE Below, 2004. Amino acid metabolism in maize earshoots. Implications for ssimilate preconditioning and nitrogen signaling. Plant Physiol, 136: 4326-4334.

Thomison PR, 2006. Early season defoliation effects on top cross high-oil corn production. Agronomy Journal, 97: 823-831.

SAS Institute, 1992. SAS/STST users guide. SAS Institute Inc, Cary.

Uribelarrea M, J Carcova, ME Otegui, ME Westgate. 2002. Pollen production, pollination dynamics, and kernel set in maize. Crop Science 42: 1910-1918.