Remobilization at various grain sorghum genotypes response to impairment of plant photosynthesis using potassium iodide

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ABSTRACT

Remobilizations of storage material from vegetative organs to grains compensate economic yield, particularly in drought stress conditions. In this study, the effects of impaired in the photosynthetic on remobilization percentage of sorghum maturity groups were examined. Treatments were arranged in a split-plot design as randomized complete block with 6 genotypes of grain sorghum (including short-, mid- and full-season genotypes) as main plot, and 2 status of plant photosynthesis including not interfere with the photosynthetic (normal conditions) and impaired in the photosynthetic through dehydration of the leaves and green parts of plants using potassium iodide (KI) in three replications. The experiment was conducted at the Agriculture and Natural Resources Research Station of Toroq, Northern Iran during 2010. The results showed that grain yield, biological yield, harvest index, remobilization percent were significantly different across sorghum maturity groups. The greatest grain yield, biological yield, harvest index and number of grains per panicle were obtained at M5 genotypes (6104 kg ha-1, 16010 kg ha-1, 38% and 60, respectively). Highest remobilization percentage transferred of the 9early genotype of the 532 / 5gr/ m2 and the highest percentage remobilization and highest remobilization efficiency to the Genotype of mid groups and 9early groups the range respectively 39/99% and 69/08 % . biological yield treatment of this non disorder in photosynthesis rate was 70% compared to the increased disorder. Correlation analysis that there was positive and significant correlation between dry matter remobilization accumulation with remobilization efficiency (P <0.01), r = 0.920) and percentage remobilization (P<0.01), r = 0.640)

Key words: Remobilization, current photosynthesis activity, sorghum, potassium iodide.

Introduction

Iran, a country with arid and semiarid Mediterranean climate and farming systems that are under ecological conditions. Use plants that have the ability to cope with such conditions and have the potential and reliable, has a special role in the ecological systems that are ecologically special place of [13]. Potential production of sorghum grain, forage and dry matter, fourth after maize, rice and wheat is 27. in compared with other grains, calories, and digestibility of sorghum seeds is relatively high [35] of the recent Much advances in understanding the physiological affecting the crop yield and response to changes in a during the various stages is influenced by tense planting time [48]. Tolerant crops in Periods drought shown yield during growing season Performance the and by the power source or reservoir capacity or both limitations [28].agents and several factors on the relationship between source and sink during the various stages of development, including genotype, planting date, rainfall and fertilization affect [24]. In grains, during the period of growth, accumulation dry matter amount in plants is higher than the rate of consumption growth, this material often stem from different sugars are stored as excess photosynthetic In the next stage of growth usually begins two to three weeks after flowering to seed are transferred [41]. Thus, the two of carbohydrate source in photosynthesis during the grain filling material the company: current photosynthetic products that transmit directly to the seed, photosynthetic tissues stored in the storage and redistribution of the materials in the dark during the day At grain filling stage, provide. It should be noted that the grain material stored temporarily accumulated in the tissues of chlorophyll and then re-transmitted by the
seeds are transferred [11]. The activity of photosynthetic apparatus and a somewhat reduced rate accumulation dry matter in grain of production in the whole plant is more contribution of stem reserves in grain yield of about 3 percent in normal conditions to about 70 percent in the control of stress has been reported [43]. This phenomenon from the name to the a property buffer stems. Vardlaw on violin bring (1994) reported that the contribution of storage carbohydrates in the grain filling is 5%. The seed grain filling period of stress and adverse conditions for the photosynthesis of plants, there are compensatory mechanisms to ensure grain yield security, which is very useful and necessary [52]. In different genotypes and different environmental conditions is also a large movement of absorption can occur under conditions of soil fertility [34]. Uptake and remobilization, plant aging and the causes that induce the various stages of stored grain from the stalks and leaves of tissue to be moved [26]. Also according Boras et al [17] dependence on the reservoir grain capacity, the growth conditions during early grain filling is great. In conditions current photosynthesis during the grain filling stage reduced. Demand for stocks of stem increased. The leaf photosynthesis due to various stresses (drought, heat and foliar diseases) are reduced [12]. So one of the major sources of carbon for grain filling, stem reserves is. Even under normal conditions (without stress) and photosynthesis of the photosynthetic material may be sufficient to fill the seeds [20]. In barley After pollination, creating disturbances in the current photosynthesis (method to Shadow) was stored in the stem of the plant material used to fill the grain. These experiments also led to more than 93 percent of the wheat grain yield was obtained Symylat transmission [16, 31]. Kinry tests and Tyshlr [29] that on three varieties of sorghum Shadows with intense 7 to 8 days after pollination to physiological maturity cause stem dry weight decreased and sorghum leaf sheath to rate 20 to 33 percent Rate than they were at the time of pollination. role Current photosynthesis of grain yield can be considered as a selection mechanism, because this remobilization process in both the accumulation and transfer of energy this Spend. In other words, when materials result from current photosynthesis for grain filling will sufficethe moves are limited and Remobilization [9]. Photosynthetic materials that are stored in the grain of three source deliberately the current photosynthesis leaf, current photosynthesis green organs other than leaves and transfer photosynthetic material stored In other plant tissues are provided. Current photosynthesis and remobilization photosynthetic reserves vegetative tissues in the reproductive period to maximum reaches its amount, two source are important in grain filling. During the period of grain filling, photosynthesis is currently level Leaf strongly dependent on light absorption by the level Leaf after flowering. The origin in during the grain filling period of the old leaves have diminished and reduce its speed due to Increases water stress shortage. however, more time in developing seeds of grain filling are still a large demand for photosynthetic products. The vegetative tissues reserves can be a source of important carbohydrate during grain filling period is considered [30, 32]. According to researchers, the amount raised materials during the period of grain filling and participation this material the final weight grain affected figure cultivar and environmental conditions are [32, 42]. Important role in vegetative tissue to maintain grain yield in unfavorable environmental conditions during the grain filling period in Most studies of wheat [25], barley [11, 15], sorghum [18] and corn [33] has been approved. The researchers started remobilization with the onset leaf senescence and accelerating leaf senescence cause increased the photosynthetic rate remobilization reserves and also current photosynthesis disturbed, resulting in a significant decrease in the yield and yield components [53]. The best elements of old Leaf that decrease in photosynthetic capacity are, magnesium chlorate [15], potassium iodide [36] and potassium chlorate [12] are used for applications. Field direction Sieve tolerance to drought stress after pollination due to the high efficiency and low toxicity, which can be used. A simple and effective method for measuring Remobilization, measuring the weight loss stems there are between stages anthesis and maturity [40] [25]. Due to the climatic features such as high potential evapotranspiration, annual precipitation quantity and distribution of the during the crop growing season, the sentence the sorghum plant as compared to other products that can tolerate drought stress better And as an indicator of drought tolerance of crops has been identified [14]. Despite the importance of stem reserves in grain sorghum, the basic genetic differences for storage and there remobilization Carbohydrates among genotypes sorghum. The report also shows that there significant differences The figures in the trait of sorghum dry matter remobilization. Ghodsi et al [25] Faraji et al [23]. In their experiment, significant difference The adjective Percent remobilization between the figures All were used The carbohydrates in the stem before and during the period of pollination are Usually 10 to 30 percent of its dry weight of seed sent to And in some grains when exposed to environmental stresses may be transmitted to more than 70% reach [46, 49]. The amount and availability of the plant, one important factor in the time required to achieve high performance is a product The general assumption in mind that different varieties of sorghum Remobilization of dry matter are in the different conditions. and the purpose of this study Evaluation of characteristics affecting the production, accumulation and allocation of materials and The economic performance of sorghum genotypes and
grain and The role contribution of remobilization in the sorghum genotypes.

Materials and Methods

In the spring of 2010 through the Research Center for Agriculture Research Station Khorasan Natural Resources (with latitude 36 degrees 15 minutes North and longitude 59 degrees 28 minutes east and 985 meters above sea level) was performed. Field experiments using design split plot on block complete randomized with three replications was carried out. Main plots consisted of 21 sorghum genotypes grain (early, late, and Mid) and two plots of the disruption of the photosynthetic (normal conditions) and the impairment of photosynthesis by water strain the leaves and green parts using potassium iodide (KI3). About 8 to 10 days after pollination That period coincided with the beginning of grain growth and grain filling stage, linear growth with Splashing solution a concentration of 0/4% Active ingredient potassium iodide On all plant tissues of plant photosynthesis was done on prevention now. The preparation implant bed was done in May. Planting in the second half of May as rigid as anything and an irrigation leak with Using tubes hydro controlled fixed for each row. All fertilizer based on tests soil (including phosphorus and potash) 250 kg/ha before planting Triple phosphate 2 H2O) (CaH4 (PO4) and 150 kg/ha of sulphate potassium (KSO4) was used. Each sub plot consisted of four line six-meter, the distance in the was 75 cm. Final concentration for genotypes 13 / 3 plants per square meter after thinning operations was set. One third of urea nitrogen of 250 kg/ha Four-leaf stage after weeding and thinning operations and other one-third. Eight-leaf stage and the remaining one third was taken at the stage of flowering. destructive sampling to determine the dry weight of shoots, 40 days after emergence and within seven days of the end of the period was done. Phenological stages were measured and recorded at different stages of growth. at the end of two periods of growth (physiological maturity) and Before applying the spray test with potassium iodide (early grain filling fast) To measure dry weight, 10 plants randomly selected from each treatment .oven temperature 76C Celsius and the plants were placed for 48 hours. After a full investigation and removal of marginal plants and two and a half meters from the lateral line Each end and 2 rows of each plot and the marginal Remove the effects of a marginal area, 6 = 4 × 75 / 0 × 2 squares of And biological and grain yield of each treatment after harvest and was weighing the humidity 12%. For traits measured to determine shoot dry matter remobilization Through the following relationships using randomly selected plants In two stages (linear growth stage and physiological maturity) to [10] was performed.

DM = dry matter transferred to the air in the pollination of plants - (dry matter leaves + stems + straw at maturity).

Remobilization efficiency = dry matter (DM transferred \ the shoot dry matter at anthesis) × 100

Transferred to the dry seed = (seed dry matter at maturity \ DM Transferred) × 100

For calculation and statistical data analysis software MSTATC and EXCEL Duncan method was used to compare means.

Results and discussion

Dry matter transferred ARDM (g /m2):

Analysis of variance showed that the main effect resources changes main on amount dry matter transferred was significant (Table 1). The reason there's the genetic variation of efficiency and potential and dry matter to grain in the sorghum genotype [38]. Stady genotypes of the trait Remobilization photosynthesis genotype showed that genotype nine of the group early and mid genotype 15 (line promising M5) respectively 532 / 5 and 217/ 9 (grams per square meter) of the highest and lowest dry matter carried (table 2). Impairment in current photosynthesis in terms of the transfer dry matter amount 405/03 grams per square and amount 59/33% highest of the amount of non disorder (Table 3).

Impairment of current photosynthesis in the early nine genotypes of 573 grams per square meter, More The and genotypes mid range 15 to amount 121 g /m in the least amount transferred of dry matter in terms non disorder showed (Table 4). High rate dry matter transfer in treatment 9 in because sufficient storage matter in Vegetative parts, and the incidence conditions stress is that regard with dry matter yield and LAI of stage panicles plant is justified. Most amount remobilization material because physiological relationship between the capacity source and sink to transport this material, especially the balance between source and sink accumulation (Table 4). Genetic variation for this traits in different species agronomic and sorghum have been reported (16, 47,38, 28). Elkul and Bounty and Bidingr et al [9], the difference in the rate remobilization matter of the result genotypic differences announced and tests Bidingr et al [9] in the amount of barley 9 / 11 to 13/48 (gr per plant) was a significant difference between the amount of varieties in dry matter transfer from result genotypic differences were Kinery and Tishler [29] reported than more 90% of non-structural carbohydrate remobilization results in sorghum after leaves loss were used stems and root for respiration. Factor of the old leaves and disorde of photosynthesis current, cause increase transfer materials of grain amount 33/59 % of most non disorder (Table 3). In condition the rate of current photosynthesis during the grain
filling stage were reduced. Increased amount demand for consumer reserves to stem in this was stage at this point seems What to stage before pollination and grain filling stage between the reservoir size and the demand for reserves and stem the growth environment interaction exists [16]. Bloom et al announced the transfer of materials in conditions to drought stress similar in materials transfer by chemical defoliation or water elongation leaf is a result of this method can be used for breeding drought-resistant plants.

Correlation results (Table 5) showed that the amount transferred and a significant and positive correlation with the percentage of retranslocation efficiency ($P < 0.01$, $r = 0.920$) and percentage of transmission ($P < 0.01$, $r = 0.640$) found. But this trait negative and significant correlation with grain yield, biological yield, harvest index. These results suggest that although increasing the amount of material transported, of remobilization percentage and retranslocation efficiency on sorghum genotypes increases. The But biological yield and grain yield will not increase. The significant negative correlation this trait with grain yield in this study it was also confirmed (Table 4).

<table>
<thead>
<tr>
<th>Table 1: Analysis Aryans (mean square) and yield related traits Remobilization.</th>
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<td>Resource changes</td>
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<td>The photosynthetic status</td>
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<td>Genotype × condition photosynthetic</td>
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<td>Pilot error</td>
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* ** ns, respectively significant at the 0.05 and 0.01 are not significant.

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<th>Table 2: Comparison of main effects of genotype, status, photosynthesis, and the interaction effect.</th>
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* The same number of letters in each column are not significant at the 0.05% level.

<table>
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<th>Table 3: Comparison of original photosynthetic conditions on effect on grain sorghum genotypes.</th>
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<td>Status Photosynthetic</td>
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<td>No disorder</td>
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<td>disorder</td>
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* The same number of letters in each column are not significant at the 0.05% level.

Efficiency Remobilization (REE)(%): Results analysis of variance showed that the photosynthetic status (p<0.01) on the efficiency percentage of transfer was significant (Table 1).

Comparison results showed that the genotypes of nine early and 15 mid range of respectively 39%99 % and 22/52% highest and lowest percentage of transfer efficiency (Table 2).
The main effect of the status of current photosynthesis showed that treatment with the stress of this transition percentage to higher than normal rate it was 34/24 percent. In this study genotypes transmission efficiency also had a lower harvest index (Table 3). The results compared interactions, genotype mid lowest rate of remobilization efficiency to the extent 12% in condition non-disorder showed the highest rate of remobilization efficiency in condition disorder amount 44 percent to the figure 19 was devoted disorde of photosynthesis current, cause increase remobilization efficiency more of the amount 34/24 percent than condition of disorde (Table 4). Imam and Nicknejad [28] reported, the plants were under stress, photosynthesis is limited during the grain filling
period, more dependent on the material before flowering, the seeds need to supply of carbohydrates supplement the results of these experiments are consistent. disorde of photosynthesis current, cause increase efficiency of amount was 45 percent cause the circumstance use current retransmission. The study correlation between the traits correlation a significant and positive between between these traits with the amount dry matter transmission \( r = 0.920 \), and percentage remobilization \( r = 0.680 \), and also negative correlation and significant with grain yield, biological yield, harvest index, grain number per panicle, were observed (table 5). It seems there is a positive relationship between translocation efficiency with the rate matter transmission and remobilization percentage because increased amount dry matter transmission. which increases the amount transferred matter to the grain weight in remobilization percentage and increasing the amount dry matter transferred to dry matter in time pollination in this translocation efficiency that result remobilization percentage and translocation efficiency also increases. If the grain yield, the grain reserves in during grain filling result of current photosynthesis and current photosynthesis remobilization induced. If the reserves resulting from the remobilization of leaf damage condition acute and stress may this act to suppress the photosynthesis and the yield decreases, In such circumstances the relationship between yield and amount remobilization and transfer efficiency can be negative, in this case with low yield and fraction loss harvest index, the ratio has declined.

**Percentage remobilization of dry matter (REP) (%):**

Results Analysis of variance (Table 1) showed that genotypes \( p \leq 0.05 \) and photosynthetic conditions \( p \leq 0.01 \) there is a significant difference in percentage remobilization dry matter remobilization (Table 1). results of Comparison showed genotype mid 2 and 15 respectively in range 69% and 33% the had highest and lowest amount remobilization percentage (Table 2). ratio in no disorder Impairment photosynthesis of current cause increased remobilization percentage These results suggest a role in determining the photosynthesis of current in supply matter products of photosynthetic for grain filling which results [7] has been harmonized. The highest remobilization percentage in a state of disorder in the photosynthesis of current of rate 88/20% to genotype 2 mid allocated (Table 4). under stress conditions increased the percentage of material translocation , It can be concluded that the plant faced with more stress before anthesis reserves for transfer materials which indicating the importance of this transfer is in providing end-grain weight. Sung and Craig [48] reported that the allocation and activity material of photosynthetic under conditions stress and between genetic differences and hybrids exist. Which is consistent with the results experiment so differences observe in the percentage of material transferred in the genotypes (Table 2), is due to genetic differences. The study correlation between traits the examined (Table 5) trait percentage transferred at 1% of the with amount transferred material \( P < 0.01 \), \( r = 0.640 \) and the percentage transferred efficiency of this \( P < 0.01 \), \( r = 0.680 \) showed significant positive correlation. Increase the amount of dry matter transfer cuse increases the amount transferred material in grain weight and increases transferred percentage, It also increases than the amount transferred material at the time of pollination cause was increased dry matter remobilization efficiency. significant negative correlation with grain yield, biological yield, harvest index was 1%. Negative relationship between yield and percentage of transferred due to lower than the amount transferred to the grain weight with grain yield is increased.

**Grain yield (kg/ha):**

Analysis of variance showed main effects and interaction on sources of in grain yield \( P < 0.01 \) were significant (Table 1). Comparison results showed that the average mid genotypes 15 and 12, respectively amount 6110 and 2261 (kg per ha) Had the highest and lowest grain yield (Table 2). The grain yield on the level of impairment in the photosynthetic rate of 79/04 % The ratio on disorder in increase in photosynthesis Increase was (Table 3).

Genotype interactions in the Status Photosynthetic confirmed genotype mid in terms of disruption of Current photosynthesis and 3 groups of early Impairment of photosynthesis in terms of the order amount 9752 and 761 / 1 kg per hectare had the highest and lowest yield (Table 4). Yield to a large amount transfer of material stored before pollination prior to grain depends on the maximum amount of dry matter and nitrogen accumulation before pollen is 38.Increased availability asimylat before the pollen because changes positive grain growth and grain filling are period. Results showed Boras and Gambin and Whan et al [51] in it was experiments current photosynthesis share in sorghum grain yields 79/04%, at this time remobilization of stem reserves as supporting a process that can yield decrease much to compensate. Loss due to impairment of photosynthesis in the laboratory and Rio and Blanco (1999) 47%, Nicolas and tumor (1993) 32%, Bloom et al 42% by Kuruz and colleagues (2002) in 55 wheat genotypes between 11 to 61 percent was announced. The results of the correlation between grain yield positive and significant at level 5% with the dry leaves and peduncle length (Table 5). This trait significant and positive correlation at 1% with biological yield, harvest index. Increase in weight of plant parts including stems, leaves, panicles and
seeds, which ultimately increases the total weight of the plant. The Due to the increased use of further and growth increased plants that ultimately produce higher yields. Also negative correlation and significant (P < 0.01) with the amount matter transferred, percent of remobilization, percentage of remobilization efficiency showed. Craufurd and peacock (1993) reported that high plant weight at time maturity will increase yield. Which with results this experiment consistent, so that genotypes mid with high biological, has also had a high yield, which is consistent with the results of this trial, so genotypes mid 15 and 6 with high biological yield, grain yield was also higher.

**Biological yield (kg/ha):**

Analysis of variance showed a main effect on the photosynthetic status (P < 0.01) genotype and the interaction between genotype and and photosynthetic conditions in biological yield (P < 0.05) was significant. (Table 1).

Maximum and minimum biological yield related to genotype 15 of the mid group and 9 of the early groups of respectively Rate 16,010 and 10,450 kg/ha (Table 2). The treatment of impaired photosynthesis (Table 3) biological yield Rate 70% than non-interference which now shows reduced Effect photosynthesis on the dry weight of plant. Impairment of photosynthesis so that the reduced weight of all plant parts including cluster, stems and leaves, which are the components of the overall biological yield. Most biological yield of the genotype of the mid range 15 Rate 18 410 kg/ha. In case of non-interference in the photosynthetic lowest biological yield of the genotype mid and of early, 13 to 3 and early 7472, and 7473 kg/ha treatment disorder had (Table 4).

Results beheshti and behbudi fard state That Most biological yield Sepidhe figure Rate 22/85 t/ha at least non disorder In current photosynthesis And lowest biological yield the genotype M2 Treatment Impairment of the photosynthetic rate had 14/48t/ha. biological yield of the positive and significant correlation at 1% with grain yield, harvest index, and also biological yield of the rate material transferred, Percent Remobilization, and transmission efficiency of this showed correlation a negative and significant at 1% (Table 5).

Increase in weight of plant parts including stem, leaf, panicle and grain Eventually the plant will increase the total weight Due to the use of resources and environmental conditions and plant growth eventually led to the production of higher performance.

**Harvest index (%):**

In this study it was that in the photosynthetic and interaction between genotype of level (P < 0.01) were significant (Table 1). Genotypes in terms of harvest index, Differences were significant at level 5% that it can be attributed to non-uniform changes in grain yield and biological yield (Table 2). Comparison results indicate that the genotypes Naumber 15 and Naumber genotypes 9 between the respectively mid of early 60/38 and 13/22 and had the highest the lowest harvest index (Table 2). These genotypes were in the tested was variable in the Harvest index. Variation in harvest index to differences in during filling grain and remobilization Asmylathay before pollen is dependent on the genotype. Results Beheshti and behbudi fard (1389) showed the highest harvest index online promising M 2 to the 36% of the cultivars and lines M 5, alchemy and dawn, respectively, with the harvest index by 26 percent, 28 percent and 28 percent in the next group were. The experimental results (44, 29, 3). There are significant genetic differences between varieties of crops that they are indeed affected by environmental conditions. Impairment of current photosynthesis, the reduced harvest index of 37/52 % Than Was not impaired was attributed to the disorder. Effect Urgent current photosynthesis the ratio of yield to total plant dry weight shows This reduction in harvest index during the report and the Rio Blanco (1999) was 38% (Table 3). In terms non-use Of current photosynthesis Genotype 15 Of Group mid To Rate 54/35%, and in eight genotypes of late to the 8 / 85% in terms Of current photosynthesis respectively. The highest and the lowest harvest index (Table 4). Because of the low harvest index of the genotypes tested genotypes can be attributed mainly to the low number of grains per panicle. Harvest index Positive correlation and significant at Level1% with grain yield, biological yield was So increasing the grain yield and biological yield confirms the positive correlation with harvest index. This trait of The amount transferred, Efficiency of remobilization, Percent remobilization, And showed a significant negative correlation

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