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Original Article

The effect of forage removal height on assimilate redistribute in barley cultivars of dual-purpose

S. F. Ghorabi[1],
M. Alavi Fazel*[2],
Sh. Lack[3]

[1]*M.S. Agronomy student, Department of Agronomy, College of Agriculture, Khouzestan Science and Research Branch, Islamic Azad University, Ahvaz, Iran*
[2]*Department of Agronomy, College of Agriculture, Khouzestan Science and Research Branch, Islamic Azad University, Ahvaz, Iran*
[3]*Department of Agronomy, College of Agriculture, Khouzestan Science and Research Branch, Islamic Azad University, Ahvaz, Iran*

***Corresponding Author:**
mojtaba_alavifazel@yahoo.com

ABSTRACT

A trial study was set to investigate the effect of forage removal height on assimilateredistribute in barley cultivars of dual-purpose.A factorial experiment was assigned as a randomized completed block design with four replications in Hamidiye at southwestern Ahvazin 2011-2012. Forage treatments were included at height cutting at 5, 10, 15 centimeter stem cutting above the soil surface at the beginning of stem elongation at growth steps 30 and 31 of Zadux (5-6 fix) and no cutting (control) and three barley cultivars including Jenoob, 10 serasari (Zahak), and Nimrooz. The obtained results showed that by cutting more parts of the crop, remobilization, remobilization share, current photosynthesis, and grain yield decreased and the share of current photosynthesis and the yield of dry forage increased. The highest amounts of grain yield (3614.58 kgha^{-1}), remobilization (86.84g/m^2), remobilization share (24.42%), and current photosynthesis (274.61g/m^2) belonged to the treatment with no cutting (control) and the highest yield of dry forage (3607.58 kgha^{-1}) and current photosynthesis share (80.46%) belonged to the forage cutting height of 5 cm above the soil surface. Among the barley cultivars, 10 serasari (zahak) cultivar had the highest grain yield (3742.37 kgha^{-1}), remobilization (72.51g/m^2), current photosynthesis (302.97 g/m^2), and current photosynthesis share (80.47%); however, the Jenoob cultivar had the highest yield of dry forage (2558/81 kgha^{-1}), and remobilization share (24.49%). In general, 10 serasari (Zahak) cultivar, in the treatment of no cutting had the highest grain yield and Nimrooz cultivar at cutting height of 5 cm above the soil surface had the highest yield of dry forage.

KEYWORDS: cutting height, green fodder, grain yield, barley cultivars, remobilization

INTRODUCTION

Due to some features such as being rich in energy and ease of transport and storage, grains are more suitable than other plants for feeding. Moreover, these crops are the most compatible species of plants which at least one of them could be produced in many parts of the world. Grains could be produced in inappropriate environmental conditions in spite of their yield reduction. Of course, their yield increases as the environmental conditions get better. At present, more than half of arable lands of the world are dedicated to cultivation of grains and mainly about half of all nutritional needs of human beings particularly in Asia is directly supplied by the grains. In comparison with other crops, grains have a major role in producing other livestock products such as meat and milk (Noormohamadi et al, 1998).Cereals straw could also be used to feed the livestock. Also, it is sometimes possible to harvest green fodder at grains vegetative growth stage and thus supply a part of winter forage need (Mojadam, 1998). Harvesting cereal crops green fodder before stem elongation in a way that grain yield is not reduced or the reduction is compensated for due to the value of produced forage is known as cultivation of dual purpose cereal crops. Since this method protects ranges at the beginning of growth season when they are very sensitive and since it is a good replacement for the forage of the livestock that are grazing in jungles, it greatly helps to protect forests and pastures and is entirely in line with the objectives of sustainable development of natural resources. Supplying the forage in this way with regard to the time of its consumption plays a remarkable role in providing the needed protein and protecting the grasslands of the country. The harvest of cereal crops is usually followed by the reduction of economic grain yield; however, if the forage harvest is associated with good management and observance of certain points, an acceptable grain yield is achieved with regard to the nutritional value of grain, in addition to appropriate product (Mojadam, 1997). On another experiment carried out on irrigated barley, Delgado (1989) and Khaldoon (1989) reported that defoliation and application of barely as forage reduced the grain yield as much as 6.5% in comparison to the control treatment. In another research on 6-row and 2-row barley, Scott et al. (1989) concluded that the ship grazing in the field reduced the grain yield by 10% in comparison to the control treatment. They said this decrease resulted from the decrease of number of spikes per area unit. Pumphery (1970) examined the response of semi-dwarf winter wheat to forage clipping and concluded that the grain yield significantly reduced by grazing in mid of tillering stages to the mid of stem elongation. Investigating the effects of defoliation on the grain yield of winter yield, Sharrow et al.(1990) found that cutting the plant shoots decreased the grain yield 22% in relation to the control (without forage cutting). In examining the possibility of dual purpose application of seven modified barley cultivars, Saberi(1992) concluded that generally the grain yield of searched treatments decreased from 29% (the lowest in Cober cultivar) to 38% (the highest in C.C 89 cultivar) in comparison to the control treatment. Remobilization ability is the second element determining assimilates contribution to cereal crops grain yield (Ehdaei et a., 2006)which is determined by factors such as the reservoir size, cultivar, and environmental conditions (Blum, 1999). Rio et al (1999) examined assimilates remobilization to the grain in dual-purpose cultivation conditions and reported that forage cutting increased the share of assimilates remobilization to the grains while the rate of remobilization and current photosynthesis greatly dramatically decreased. Considering the fact that there are about 10 million fixed and mobile livestock which are grazing in Khuzestan in the winter every year, there is a serious shortage of forage in this season and planting some cereal crops such as dual-purpose barley (harvesting grains and forage) could be a good way to supply the livestock forage (Lack, 2001). With regard to different responses of various genotypes of barley to different levels of forage cutting height in dual-purpose planting conditions, the evaluation of common genotypes in each area is necessary in terms of forage and grain production potential at different levels of forage cutting height. This research was carried out to investigate the effect of different levels of forage cutting height on grain and forage production and also dry matter remobilization to the grains of barley genotypes in Khuzestan in dual-purpose planting conditions.

MATERIALS AND METHODS

This research was assigned asrandomized completed block design with four replications in Hamidiye at southwestrn Ahvaz in 2011-2012. In this research the green fodder cutting height included three levels of B1: forage stem cutting 5 cm above the soil surface, B2: forage stem cutting 10 cm above the soil surface, and B3: forage stem cutting 15 cm above the soil surface and B4: no cutting(control) and three barley cultivars including 10 serasari (Zahak), Nimrooz, and jenoob. Each plot dimensions were 1.2 x 5 m and there were six planting rows in each plot. The distance between rows was 20 cm and the distance between plots was 1.5 m. The seeds were planted manually with the density of 400 seeds per square meter. The forage clipping was according to 5-6 fix stages that is the emergence of the first node on the stem. The harvest time was selected in such a way that in none of the treatments of cutting height, the apical meristem was cut. Some wet forage of each plot was immediately put in a plastic bag and was weighed by a scale to determine its yield. To determine the dry weight of forage, 200 g forage was randomly taken after the harvest and was placed in the oven in 75$^{\circ C}$ temperature for 48 hours and the weight of dry forage was calculated through the following equation:

Dry weight of forage in cutting area=

$$\left(\frac{\textbf{total weight of fresh forage} \times \textbf{dry weight of sample in the oven}}{\textbf{200}}\right)$$

After pollination and before grain filling stage 6 plants from each plot were harvested as samples and after eliminating the margins. Then their dry weight was calculated separately by placing them in the oven in 75$^{\circ C}$ temperature for 48 hours. At the end of growth stage, grain yield and dry weight of vegetative organs (difference between total yield of dry matter and grain yield) was calculated through the following equations ((Alizade (2002), Ehdaei et al. (1991), Papacosta and Gayianas (1991), Van Stanford and Mackown (1987), Hashemi Dezfuli et al. (2005).

DMRR (g.m^{-2}) = DWVS (g.m^{-2}) – DWVM (g.m^{-2})
DMRR = Dry matter remobilization rate)
DWVS = Dry weight of vegetative organs at the beginning of the silk browning
DWVM = Dry weight of vegetative organs at the maturity stage

$$\text{DMRC (\%)} = \left(\frac{\text{DMRR (g.M}^{-2})}{\text{Gy (g.M}^{-2})}\right) \times 100$$

DMRC = Dry matter remobilization contribution)
CPR (g.m^{-2}) = Gy (g.m^{-2}) – DMRR (g.m^{-2})
CPR = Current photosynthesis rate
CPC (%) = 100 – DMRC (%)
CPC = Current photosynthesis contribution

Final harvesting was done after physiological maturity of plants in the field. To do so, after eliminating marginal lines of each plot, in an area of 1.6 m^2 from the lines of the middle row the plants were clipped on the floor and after striking the spikes of each plot separately, the grains were separated and the grain yield was calculated in kgha^{-1}. Data was analyzed by MSTAT-C software and the diagrams were drawn using Excel and the means were calculated by LSD test at 5% probability level.

RESULTS AND DISCUSSION

Grain yield

According to the ANNOVA results the effect of cutting height, various cultivars and interactive effect on grain yield were significant at 1% probability level (Table 1). Positive correlation between cutting height from the floor and grain yield indicated that the decrease of cutting height from the soil surface reduced the grain yield significantly. The highest grain yield belonged to the lack of green fodder cutting (control) and the lowest grain yield belonged to the forage stem cutting 5 cm above the soil surface (Table 2). Intensive forage cutting (cutting height near the floor) decreased the grain yield by decreasing the number of spikes in area unit and number of grains per spike and weight of 1000-grain. Serious decrease of leaf area and less capability of re-growing due to cutting more forage could lead to the decrease of grain yield. Results of the experiments conducted by Alazmani et al. (2012), Dehghani et al. (2012), and Kei et al. (2002) also emphasized the decrease of grain yield due to the forage clipping. Among the cultivars, the highest grain t yield was related to 10 serasari (Zahak) cultivar in no cutting treatment by 4252.50kgha^{-1} and the lowest was related to Nimrooz cultivar in forage stem cutting 5 cm above the soil surface by 2580.75 kgha^{-1}. In examining the interactive effects of two factors, the highest grain yield belonged to 10 serasari (Zahak) cultivar in no cutting treatment by 4252.50 kgha^{-1} and the lowest belonged to Nimrooz cultivar in forage cutting height 5cm above the soil surface by 2580.75 kgha^{-1}. With regard to the important role of current photosynthesis and remobilization in the grain yield every kind of stress and decreasing factor will highly affect the grain yield. As the results of the research showed, applying the forage cutting treatment reduces the rate of current photosynthesis due to the reduction of green area of the plant and also the rate and contribution of remobilization is reduced due to the decrease of vegetative part clipping which is the reservoir source of the plant while the current photosynthesis contribution increases due to the decrease of plant ability in using assimilates.

Table 1. ANNOVA of barley cultivars traits affected by various levels of forage cutting height

Changes sources	d.f.	Mean square Grain yield	Dry forage yield	Remobilization rate
Replication	3	20623.076 *	3347.68 ^{ns}	67.218 **
Cultivar	2	3156897.896 **	531240.77 **	22.660 ^{ns}
Cutting height	3	1312286.688 **	31765677.46 **	2535.86 **
Cultivar × Cutting height	6	96123.479 **	148883.88 **	19.060 ^{ns}
Error	33	5644.410	7273.54	12.107
Changes coefficient (%)	-	2.30	3.63	4.89

* , ** mean significant at 5% and 1% level of probability respectively, ns means not significant.

Table 2. Mean comparison of barley cultivars traits affected by various levels of forage cutting height and cultivar

treatments	Grain yield (kgha^{-1})	Dry forage yield (kgha^{-1})	Remobilization rate (gr/m^2)
Forage cutting height			
5 cm	2844.66	3607.58	54.978
10 cm	3192.08	3240.33	63.448
15 cm	3419.58	2561.5	79.318
no cutting (control)	3614.58	0.00	86.847
LSD	96.84	126.94	4.16
cultivar			
10 serasari	3742.37	2284.25	72.517
Nimrooz	3198.37	2214	70.358
Jenoob	2862.06	2558/81	70.569
LSD	111.82	109.93	5.17

Means were compared with control treatment separately by LSD tests at 5% probability level.

DRY FORAGE YIELD

According to the ANNOVA results, the effect of cutting height, different cultivars, and the interactive effect of these two factors on the yield of dry forage was significant at 1% probability level (Table 1). As it was predictable, with the decrease of forage cutting height and increase of plant vegetative part which was clipped in relation to other levels of forage cutting dry forage yield increased in area unit. Reports by Christian Sinn et al. (1989), Alavi Fazel (2001), Keramat(1998), and Lack et al. (2005) approve of above results. The highest yield of dry forage belonged to forage cutting height 5cm above the soil surface and the lowest yield belonged to the one 15 cm above the soil surface (table 2). The highest dry forage yield was related to the Jenoob cultivar and the lowest belonged to the Nimrooz cultivar (Table 2). The forage yield superiority of the Jenoob cultivar could be related to the larger average of plant height in this cultivar than that of Nimrooz one. The investigation of interactive effect of cultivar and forage cutting height showed that the highest yield belonged to the Nimrooz cultivar in forage stem cutting 5 cm above the soil surface by 4037 kgha^{-1} and the lowest was related to the Jenoob cultivar in forage stem cutting 15 cm above the soil surface by 2477.25 $kgha^{-1}$.

REMOBILIZATION RATE

According to the ANNOVA results, the effect of forage cutting height on remobilization rate was significant at 1% probability level (Table 1). Investigating assimilates resources in grain weight has a significant role in better comprehension of the effect of forage cutting height on photosynthesis resources and their restrictions. Mean comparison of remobilization rate at different levels of forage cutting height showed that applying the cutting treatment reduced the rate of remobilization and as the cutting height was closer to the floor, the reduction was more. It seems like that the increase of the leaves area before pollination increased the stem assimilates and the plant used them more during the pollination stage. Royo et al. (1999) reported that forage cutting decreased remobilization rate in spring and autumn triticale cultivars. They believed that the decrease of assimilates remobilization rate under the forage cutting conditions was associated with the decrease of plant dry matter at pollination stage. The results of the research were consistent with the findings of Mojadam (2009). In forage cutting height treatment the highest rate of remobilization belonged to the control treatment (no cutting) and the lowest rate belonged to the forage cutting height 5cm above the soil ground (Table 2).The effect of different cultivars and the interactive effect of two factors on remobilization rate were insignificant (Table 1). Mean comparison results showed that the highest rate of remobilization was related to 10 serasari (Zahak) cultivar and the lowest rate was related to Nimrooz cultivar (Table 2). The highest remobilization rate belonged to 10 serasari (zahak) cultivar and control treatment (no cutting) by 88.75 g/m^2 and the lowest remobilization rate belonged to the Jenoob cultivar in forage cutting height 5 cm above the ground by 51.82 g/m^2.

Table 3. ANNOVA of barley cultivars traits affected by different levels of forage cutting height

Changes sources	d.f.	Mean square		
		Remobilization contribution	Current photosynthesis rate	Current photosynthesis contribution
Replication	3	13.838 **	400.327 **	13.852 **
Cultivar	2	99.567 **	310.382 **	99.543 **
Cutting height	3	68.231 **	4031.242 **	68.202 **
Cultivar × Cutting height	6	9.094 **	855.350 **	9.092 **
Error	33	1.341	61.296	1.342
Changes coefficient (%)	-	5.28	3.06	4.48

* , ** mean significant at 5% and 1% level of probability respectively, ns means not significant.

Table 4. Mean comparison of barley cultivars traits affected by various levels of forage cutting height and cultivar

treatments	Remobilization contribution (percent)	Current photosynthesis rate (g/m^2)	Current photosynthesis contribution (percent)
Forage cutting height			
5 cm	19.722	231.155	80.462
10 cm	20.077	255.760	79.913
15 cm	23.519	262.643	76.472
no cutting (control)	24.424	274.611	75.567
LSD	1.72	10.09	1.72
cultivar			
10 serasari	19.511	302.971	80.479
Nimrooz	21.801	249.519	78.189
Jenoob	24.494	215.637	75.496
LSD	1.49	11.65	1.49

Means were compared with control treatment separately by LSD tests at 5% probability level.

REMOBILIZATION CONTRIBUTION

According to the ANNOVA results, the effect of cutting height, different cultivars, and the interactive effect of two factors on remobilization contribution were significant at 1% probability level (Table 3). In remobilization contribution as well as remobilization rate as the cutting height from the ground decreases, the remobilization contribution decreased too and as the cutting height was closer to the ground the reduction would be more. A major reason of such reduction is the stress exerted on the plant. The highest remobilization contribution belonged to the control treatment (no cutting) and the lowest belonged to the forage cutting height 5 cm above the ground (Table 4). The results were consistent with those of Mojadam (2009). The highest remobilization contribution was related to the Jenoob cultivar and the lowest was related to10 serasari (Zahak) cultivar (Table 4). The reason could be the fact that The Jenoob cultivar is more vulnerable to stress than 10 serasari (Zahak) cultivar and thus the assimilates remobilization contribution to grain filling is further in the Jenoob cultivar. The highest remobilization contribution belonged to the Nimrooz cultivar in the control treatment (no cutting) by 27.95% and the lowest belonged to 10 serasari (Zahak) cultivar in forage cutting height, 10 cm above the ground by 17.83%.

CURRENT PHOTOSYNTHESIS RATE

According to the ANNOVA results, the effect of forage cutting height, different cultivars, and the interactive effect of two factors on current photosynthesis rate were significant at 1% probability level (Table 3). The highest current photosynthesis rate belonged to the control treatment (no cutting) and the lowest belonged to the treatment of forage cutting height 5 cm above the ground (table 4). As the cutting height from the ground decreased, the current photosynthesis rate decreased too. It seems like that the effect of forage cutting on current photosynthesis is normally negative, because by removing the vegetative part of the plant, the green leaf area of the plant decreases and the plant has smaller leaf area to receive the sun light. The results of the research are consistent with the findings of Mojadam (2009). The highest rate of current photosynthesis belonged to 10 serasari (Zahak) cultivar by 302.97 g/m^2 and the lowest rate belonged to the Jenoob cultivar (Table 4). It seems like that the features of10 serasari (Zahak) cultivar such as more full paws and proper cover at ground surface, resistance to lodging and more compatibility with hot dry climate of the south of Iran are the main reasons of this difference. Considering the interactive effect of forage cutting height and cultivar, the highest rate of current photosynthesis was related to 10 serasari (Zahak) cultivar and control treatment (no cutting) by 336.49 g/m^2 and the lowest rate was related to the Nimrooz cultivar and the treatment with 5 cm height from the ground by 202.35 g/m^2.

CURRENT PHOTOSYNTHESIS CONTRIBUTION

According to the ANNOVA results, the effect of forage cutting height, different cultivars, and the interactive effect of two factors on current photosynthesis rate were significant at 1% probability level (Table 3). The highest current photosynthesis contribution belonged to the treatment of forage cutting height 5 cm above the ground and the lowest contribution belonged to the control treatment (no cutting) (Table 4). As the forage cutting height decreased the current photosynthesis contribution increased which could be due to the decrease of assimilates remobilization to the grains and the plant dependence on photosynthesis. The highest current photosynthesis contribution belonged to10 serasari (Zahak) cultivar and the lowest contribution belonged to the Jenoob cultivar (Table 4). It seems like that in current photosynthesis contribution as well, the features of10 serasari (Zahak) cultivar such as more full paws and proper cover at ground surface, resistance to lodging and more compatibility with hot dry climate of the south of Iran are the main reasons of this difference. The highest current photosynthesis contribution belonged to 10 serasari (Zahak) cultivar and the treatment of forage cutting height 10 cm above the ground by 82.16% and the lowest contribution belonged to the Nimrooz cultivar and no cutting by 72.04%.

CONCLUSION

On the whole, the results of the research showed that the decrease of forage cutting height from the ground significantly increased the forage grain yield, but it decreased the barley grain yield. Even though different cultivars of barley didn't show the same response, 10 serasari (Zahak) cultivar in control treatment (no cutting) had the highest grain yield and the Nimrooz cultivar at forage cutting height 5 cm above the ground had the highest yield of dry forage. Therefore, the Nimrooz cultivar in forage cutting height 1o cm above the ground could be recommended for dual-purpose planting based on the conditions of this experiment.

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