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Evaluation of defoliation on leaf water relations, chlorophyll content, and grain yield of triticale (x *triticosecale* wittmack) genotypes under water stress

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ABSTRACT-Optimizing the source size and its utilization by the sink is one of the main factors enhancing the yield potential and decreasing water demand in crops when exposed to drought. To investigate the effect of defoliation on leaf water relations, chlorophyll content and yield components of five triticale genotypes including Sanabad, Juanillo, ET-83-3, ET-84-5 and ET-84-8 under well-watered (100% FC) and water stress (50% FC) conditions, a controlled experiment was carried out at Shiraz University in 2013. The results showed that ET-84-8 and Sanabad genotypes had higher chlorophyll content (ranged from 49.1 to 54.6 SPAD unit) under water stress. Among the triticale cultivars, water stress caused 21 to 42% decline in the rate of water loss (RWL). In all genotypes except ET-83-3 and Juanillo, the excised leaf water retention (ELWR) slowly decreased under water stress conditions. In all triticale genotypes except ET-84-8, water stress declined main shoot yield 21-22%, while in ET-84-8, it was only 9%. Interestingly, in ET-84-8, grain number per spike was not affected by moisture regimes. Sanabad cultivar, with 2.57 g/g had the highest initial water content (IWC) at defoliation of all leaves except the flag leaf and penultimate leaf treatment under water stress. Under defoliation and water stress, ET-84-8 and Sanabad genotypes showed a greater 100-grain weight ranged from 3.60 to 3.74 g. It was concluded that triticale cultivars were more sink-limited especially under water stress, and source restriction by defoliation which had less effects on main shoot yield could be used as a useful tool for lowering water consumption during grain filling.

INTRODUCTION

Triticale (X *Triticosecale* Wittmack) is an amphiploid hybrid between the female parent wheat (*Triticum aestivum* L.) and the male parent rye (*Secale cereals*) (Ammar et al., 2004). Pfeiffer (2003) suggested that under drought stress conditions and problematic soil regions, triticale showed distinct yield superiority and had adaptive advantages over wheat. Giunta et al. (1993) evaluated durum wheat and triticale genotypes under different moisture regimes in a typical Mediterranean climatic region and observed that grain yield of durum wheat reduced significantly under drought stress, while triticale had a slight and non-significant reduction in grain yield compared to the irrigation control. Triticale was found to have superior tolerance to low nutrient availability, water stress, frost, soil acidity, aluminium and other elemental toxicities and salinity (Lelley, 2006). The objective in the synthesis of triticale was to combine the desirable characteristics of the two species (Oettler, 2005).

Photosynthetically active areas of plant (source) and storage capacity of the grains (sink) after flowering are the main factors limiting grain yield of cereals (Bijanzadeh and Emam, 2011). Production and partitioning of dry matter in cereals is highly related to sink-source relationships under various environments (Bijanzadeh and Emam, 2010; Zhenlin et al., 1998). The control of grain filling has often been considered in terms of the supply of photosynthate (source limitation) or the capacity of the grain to accumulate available carbohydrate (sink limitation). Carbohydrates for grain filling are supplied concurrently from photosynthetic activity and from temporary storage reserves (Bijanzadeh and Emam, 2011). Sink capacity is a function of the number of grains per unit land area and their potential size (Schnyder, 1993).

Many studies have been reported in which the supply of assimilate per grain is modified by defoliation, shading, thinning or ear manipulation treatments to investigate whether grain filling is sink or source limited (Bijanzadeh and Emam, 2010; Dreccer et al., 1997). Ahmadi et al. (2009) reported that defoliation might change the photosynthetic characteristics of remaining leaves. Also, Joudi et al. (2006) showed that defoliation of wheat increased chlorophyll content and net photosynthetic rate of remained leaves, however, the rate of increasing depended on the type of cultivars.

In Southern parts of Iran, limited rainfall and water stress occur frequently after anthesis, and water stress is an important limiting factor which can cause major loss in crop productivity. Optimizing the source size after anthesis and its utilization by the sink is one of the major factors enhancing the yield potential in crops especially under water deficit conditions (Bijanzadeh and Emam, 2011). Ahmadi and Joudi (2007) reported that wheat grain yield is reduced depending on the degree of water deficit and defoliation intensity. Effect of source restriction on yield response and leaf water relation of triticale cultivars has not yet been fully understood, especially under drought stress in Iran. To decrease water consumption during grain filling of triticale by defoliation, this study was undertaken to investigate the effect of source manipulation on leaf water relations, chlorophyll content and yield components of triticale cultivars under water stress.

MATERIALS AND METHODS

A pot experiment was carried out to investigate the effect of defoliation intensity and water stress on leaf water relations, chlorophyll content and yield components of triticale cultivars at the greenhouse of College of Agriculture and Natural Resources of Darab, Shiraz University, Shiraz, Iran, during 2013. Experimental treatments were triticale genotypes, moisture regimes and defoliation. The experimental design was a completely randomized (RCD) one with four replicates. Five triticale genotypes including Sanabad, Juanillo, ET-83-3 (VICUNA_4/4/ERIZO7// YOGUI_1/GIRAF/3/FARAS), ET-84-5 (ERIZO_15/ FAHAD_3//POLLMER_2.1) and ET-84-8(ERIZO_ 6NIMIR_4//VICUNA_4/3MANATI_1) were sown in 10 kg pots filled with a silty loam soil (8% sand, 68.3% silt, and 23.7% clay, bulk density=1.3 g/cm^3, pH= 7.6, %OC=0.051, %N=0.16, P=35 mg kg^{-1}, K=590 mg kg^{-1}and EC=0.44 dS m^{-1}) and 22 mg kg^{-1} nitrogen was applied as urea fertilizer. For each cultivar, ten uniform seeds were sown in each 5kg pot (25cm width ×35cm height), and thinned to five seedlings at two-leaf stage. The greenhouse temperature was 25±5°C, with 70±10% relative humidity, and light intensity varied in the range of 650-750 µmol m^{-2} s^{-1}.

Before planting, the field capacity (FC) of the soil was determined (FC=28%) in the laboratory to set the moisture regimes as well-watered (100% FC) and water stress (50% FC). Pots were weighted every other day and irrigated according to 100% FC for well-watered treatment and 50% FC for water stress, from booting stage (ZGS45) to physiological ripening.

The source manipulation treatments included defoliation of all leaves (D$_1$), defoliation of all leaves except the flag leaf (D$_2$), and defoliation of all leaves except the flag leaf and penultimate leaf (D$_3$) and control (C). Plants were defoliated at booting stage (ZGS45; Zadoks et al., 1974). To avoid contribution of tillers in grain filling of main shoot, all plants were de-tillerd (Savin and Slafer, 1994).

To determine the RWC, at 10 days after anthesis (10DAA), after cutting the flag leaf of each plant and to avoid water loss, it was sealed in a plastic bag and transferred to the laboratory to measure fresh weight within 1 h after excision. Turgid weight was obtained after soaking leaves in distilled water for 5 h at room temperature (25±2°C). After soaking, leaves were blotted dry with tissue paper to determine turgid weight. Also, dry weight of leaf samples was obtained after oven drying for 72°C. Finally, the RWC was calculated according to Beadle et al.'s (1993) method by:

$$RWC = \frac{(W_0 - W_d)}{(W_t - W_d)} \times 100$$

Initial water content (IWC) was calculated as:

$$IWC = \frac{(W_0 - W_d)}{(W_d)}$$

w_0= fresh weight (g), W_d= dry weight (g) of leaves placed in an oven at 50º C for 24 h and re-weighed. W_t=turgid weight(g) (Yang et al., 1991).

To measure the rate of water loss (RWL), the flag leaves were collected and weighed (W1). Then, the leaves were wilted at 30ºC for 24 h and re-weighed (W2) and transferred to an oven at 50º C for 24 h and then weighed (W3). RWL was calculated by the equation suggested by Yang et al. (1991):

$$RWL = (\frac{W1 - W2}{W3})(\frac{t1 - t2}{60})$$

Where t_1 and t_2 are the time of measurement for initial and wilted weight (in minutes).

Also, for determining excised leaf water retention (ELWR), the flag leaves were collected and weighed, then kept at 30ºC for 5 hours and reweighed. ELWR was then calculated using the following equation (Wang and Clarke, 1992):

The SPAD meter was used to estimate chlorophyll content non-destructively (Barraclough and Kyte, 2001). It was a hand-held spectrometer which measured light (650 nm) absorbed by a single leaf. In this study, the SPAD chlorophyll meter (Opti-Sciences X. USA) was used to acquire a rapid estimate of flag leaf chlorophyll content.

$$ELWR = (1 - \frac{\text{weight of fresh leaves} - \text{weight of leaves after 5 hours}}{\text{weight of fresh leaves}}) \times 100$$

Water-related variables and the chlorophyll content were measured at anthesis stage (ZGS 64). The water related parameters were measured on three plants randomly selected from each pot.

Finally, plants were harvested at physiological maturity, oven-dried at 72 °C, and then main shoot grain yield and yield components including grain number per spike and 100-grain weight(g) were determined. The collected data were subjected to the analysis of variance by SAS 9.1 software (2002) and the means were separated using Fisher's LSD protected test at 0.05 probability level.

RESULTS AND DISCUSSION

Chlorophyll Content

Interaction effects of genotype × moisture regimes × defoliation on Chlorophyll content of flag leaf was significant at 0.05 probability level (data not shown). ET-84-8 and Sanabad genotypes showed higher chlorophyll content (ranged from 49.1 to 54.6 SPAD unit) compared to other cultivars when exposed to water stress (Fig.1). In contrast, water stress was associated with a decline in chlorophyll content of ET-84-5 and ET-83-3 cultivars. Ahmadi and Joudi (2007) reported similar changes in chlorophyll content among wheat cultivars. Furthermore, in a greenhouse experiment, Barraclough and Kyte (2001) reported that chlorophyll content of remained leaf of winter wheat (CV. Hereward) decreased significantly under water stress. In our study, it appeared that accelerated senescence of flag leaf and penultimate leaf under water stressed due tothe decrease of water content, and reduced chlorophyll content of flag leaf and penultimate leaf, compared to well-watered conditions.

Leaf Water Characteristics

In all triticale genotypesat 10 days after anthesis (DAA), water stress caused a significant reduction in relative water content of flag leaf (RWC) at the similar level of source restriction treatments (Table 1). In D_3 treatment, RWC in ET-83-3 decreased sharply from 71.4 to 38.4 (46.2% reduction) more than the other genotypes under water stress. Also, in all genotypes, no significant differences were found between D_2 and D_3 treatments and the presence of the penultimate leaf had no effect on RWC of flag leaf.

Bijanzadeh and Emam (2010) reported that some wheat cultivars with lower transpiration rate might maintain higher RWC in their leaves under water stress conditions.They also reported that source restriction by removal of transpiring leaves which were less effective in grain filling could be a useful tool to decrease water loss during grain filling under dry and semi-dry area conditions. Ahmadi and Joudi (2007) found that RWC of flag leaf was not affected by source restriction and defoliation increased transpiration rate of remaining flag leaf and bare soil evaporation as soil was exposed to sunlight. However, Matin (1999) reported that drought tolerant cultivars of barley usually maintained higher leaf RWC under drought stress. Similar to our results, Lonbani and Arzani (2011), too, reported highly significant differences among genotypes for RWC so that 'Moreno' and 'Prego' triticale cultivars showed the highest and Zoro' cultivars had the lowest RWC under water stress conditions. Schonfeld et al. (1998) observed a decline in the amount of RWC in wheat due to water stress and reported a higher RWC for the tolerant genotypes. Accordingly, ET-84-8 and Sanabad triticale genotypes were ranked as drought tolerant while Juanillo and ET-83-3 ranked as drought sensitive genotypes (Table 1).

For each moisture regime, the amount of initial water content (IWC) was not affected by defoliation treatment and water stress decreased IWC in Juanillo and ET-83-3 triticale genotypesmore than Sanabad and ET-84-8 (Table 1). On the other hand, D_2 and D_3 treatments of Sanabad with 2.57 and 2.41 g/g had higher IWC under water stress, respectively.

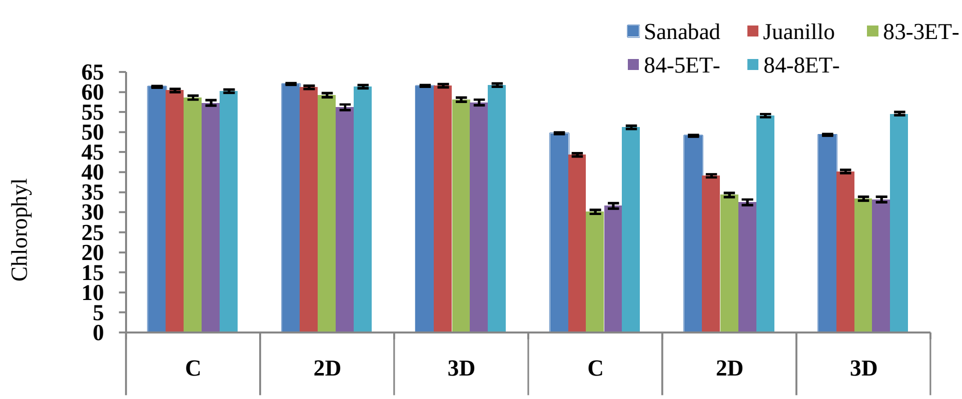

Fig. 1. Effect of moisture regimes and defoliation on flag leaf chlorophyll content (SPAD unit) of triticale cultivars at 10 days after anthesis (DAA). Control(c), defoliation of all leaves except the flag leaf (D2), and defoliation of all leaves except the flag leaf and penultimate leaf (D3). Vertical bars represent SE.

Table 1. Effect of moisture regimes and defoliation on relative water content (RWC), initial watercontent (IWC), rate of water loss (RWL), and excised leaf water retention (ELWR) of flag leaf of triticale cultivars at 10 days after anthesis (DAA).

Barley cultivars	Moisture regime	Source restriction	RWC (%)	IWC (g/g)	RWL (g/g.h)	ELWR (%)
Sanabad	Well-watered	C†	76.8	2.61	0.53	83
		D2	77.3	2.78	0.57	80
		D3	77.1	2.63	0.61	81
	Water stress	C	60.2	2.43	0.38	80
		D2	61.1	2.57	0.31	79
		D3	62.4	2.41	0.37	77
Juanillo	Well-watered	C	74.3	1.98	0.67	76
		D2	75.6	1.93	0.72	79
		D3	75.5	1.82	0.73	75
	Water stress	C	48.7	1.14	0.56	61
		D2	50.3	1.21	0.50	62
		D3	48.1	1.11	0.51	60
ET-83-3	Well-watered	C	71.2	1.73	0.76	83
		D2	72.3	1.77	0.84	80
		D3	71.4	1.56	0.83	86
	Water stress	C	41.3	1.09	0.61	59
		D2	39.2	1.13	0.56	55
		D3	38.4	1.11	0.53	57
ET-84-5	Well-watered	C	71.3	2.03	0.78	85
		D2	72.4	2.01	0.84	86
		D3	72.0	1.98	0.86	81
	Water stress	C	40.4	1.17	0.67	78
		D2	41.3	1.26	0.59	77
		D3	43.2	1.20	0.61	73
ET-84-8	Well-watered	C	78.3	1.96	0.51	86
		D2	80.1	2.11	0.58	84
		D3	79.2	1.94	0.50	83
	Water stress	C	63.2	1.88	0.33	81
		D2	65.2	1.90	0.30	83
		D3	64.1	1.84	0.36	82
LSD (0.05)			5.7	0.33	0.16	9

†Control (c), defoliation of all leaves except the flag leaf (D2), and defoliation of all leaves except the flag leaf and penultimate leaf (D3)

Among the triticale cultivars, water stress caused 21 to 42% decline in the rate of water loss (RWL). This may indicate some inhibiting mechanisms of water loss under water stress in all triticale genotypes (Table 1). Overall, under water stress, ET-84-8 and Sanabad decreased significantly RWL more than the other genotypes. GolestaniAraghi and Assad (1998) reported a significant decline in the RWL of wheat under water stress conditions. In a similar study, Lonbani and Arzani (2011) reported that triticale genotypes had lower RWL than wheat genotypes. This may indicate more efficient use of water by triticale genotypes compared to wheat genotypes. Wang and Clark (1992) indicated that parameters measured in the excised leaves at minimum stomatal aperture, such as IWC, RWL, and epidermal conductance showed genotypic differences in wheat and this might be related to yield in dry land environments. In contrast to our results, Haley et al. (2002) reported that the amounts of RWL for dry land and irrigated wheat were not different. Furthermore, Jaradat and Konzak (2003) suggested greater RWL for wheat genotypes in stressed environments.

In all genotypes except ET-83-3 and Juanillo, the excised leaf water retention (ELWR) decreased slowly when exposed to water stress (Table 1). Also, ELWR of ET-84-8, Sanabad and ET-84-5 ranged from 73% to 83% and were higher than Jaunillo and ET-84-3 significantly. Lonbani and Arzani (2011) declared that water stress increased excised leaf water retention (ELWR); this phenomenon showed that the probable mechanism for water retention in the leaf under stress conditions might be leaf rolling or the decrease in leaf area. They concluded that among the plant water relation parameters, ELWR could be a superior indirect selection criterion for grain yield. Wenzel (1997) observed that EWLR of sorghum genotypes were different under drought stress conditions, and concluded that EWLR was a satisfactory screening technique for drought resistance in sorghum genotypes.

Grain Yieldand Yield Components

Grain number per spike responded significantly to defoliation treatment in Juanillo and ET-83-3 (Table 2).

Interestingly, in ET-84-8 cultivar, grain number per spike was not affected by moisture regimes and D2 treatment with 46.5 grains per spike had the highest grain number per spike, compared to other genotypes, under water stress. Ina similar study, Alam et al. (2008) reported that defoliation of all leaves except the flag leaf after anthesis decreased the grain number per spike in wheat cultivars. In all triticale cultivars, water stress declined main shoot yield significantly;however, in ET-84-8 and Sanabad, the decrease rate was less than that of the other cultivars (Table 2). Overall, in each moisture regime, grain yield was not affected by source restriction treatments. It has previously been demonstrated that grain cereals might be more sink-limited, especially under water stress conditions (Emam and Seghatoleslami, 2005). Joudi et al., (2006) also, reported lower response of grain yield to changes in assimilate availability by source restriction. They concluded that this might be related to more sink limitation in some bread wheat cultivars. Under water stress and defoliation treatments, maximum main shoot yield was observed in ET-84-8 and Sanabad which ranged from 1.62 to 1.73 g. In ET-84-8 and Sanabad cultivars, D_1 treatment reduced main shoot yield only 6.1 and 5.7%, respectively, when plants were exposed to water stress, while main shoot yield in D_1 treatment of Juanillo cultivar reduced 15.6%.

Table 2. Interaction effects of moisture regimes and defoliation on yield components of triticale genotypes under well-watered and water stress (50% FC) conditions.

Barley cultivars	Irrigation regime	Source restriction	Grain number per spike	100-grain weight(g)	Main shoot yield(g)
Sanabad	Well-watered	C	47.1	4.12	1.94
		D1	43.3	3.99	1.72
		D2	46.5	4.01	1.86
		D3	46.6	4.03	1.87
	Water stress	C	45.7	3.77	1.72
		D1	45.1	3.60	1.62
		D2	45.4	3.72	1.68
		D3	45.3	3.74	1.69
Juanillo	Well-watered	C	44.6	4.1	1.82
		D1	40.1	3.88	1.55
		D2	40.3	3.96	1.59
		D3	40.8	3.99	1.62
	Water stress	C	40.4	3.50	1.41
		D1	36.1	3.31	1.19
		D2	37.8	3.38	1.27
		D3	37.9	3.39	1.28
ET-83-3	Well-watered	C	42.1	4.01	1.68
		D1	37.1	3.81	1.41
		D2	38.2	3.93	1.50
		D3	38.9	3.98	1.54
	Water stress	C	37.1	3.41	1.26
		D1	34.2	3.21	1.09
		D2	35.1	3.28	1.15
		D3	35.9	3.30	1.18
ET-84-5	Well-watered	C	40.4	4.04	1.63
		D1	38.1	3.78	1.44
		D2	38.3	3.84	1.47
		D3	38.4	3.86	1.48
	Water stress	C	36.2	3.33	1.20
		D1	32.8	3.11	1.02
		D2	35.3	3.23	1.14
		D3	35.6	3.29	1.19
ET-84-8	Well-watered	C	48.2	4.14	1.99
		D1	45.6	4.01	1.86
		D2	46.1	4.09	1.88
		D3	46.8	4.11	1.92
	Water stress	C	47.1	3.78	1.78
		D1	46.3	3.62	1.67
		D2	46.5	3.71	1.72
		D3	46.4	3.73	1.73
LSD (0.05)			1.2	0.11	0.13

[a]Control (c), defoliation of all leaves (D1), defoliation of all leaves except the flag leaf (D2), and defoliation of all leaves except the flag leaf and penultimate leaf (D3).

Our finding regarding Et-84-8 and Sanabad cultivars was in agreement with that of Emam and Dastfal (1997) who showed that cultivars with higher grain yield potential under well-watered condition had also higher grain yield under water stress as well. Interestingly, in all cultivars, penultimate leaf had no significant effect on main shoot yield (comparison of D_2 with D_3 treatments; Table 2).Guttieri et al. (2001) observed that moisture deficit induced reduction in 100-grain yield of wheat due to reduction in grain weight while the differential effect of moisture deficit on specific cultivars could be due to reduction in the number of grains per spike. In a similar study, Fayaz and Arzani (2011) reported that grain number per spike of triticale cultivarsranged from 2.84 for Roshan to 5.27 for Moreno under well-watered conditions and ranged from 2.27 for Roshan to 3.56 for Lasko under water stress conditions. Also, 100-grain weight varied from 2.89 g to 4.56 g for Prego and Alamos83 cultivars under well-watered conditions, respectively. Under water stress conditions, 100-grain weight decreased significantly and ranged from 2.23 g for Prego to 3.54 g for Alamos83. The lowest and highest reduction in grain yield due to water stress were also observed in Alamos83 (24%) and Prego (65.4%) cultivars, respectively. In spite of our results, Riaz and Choudhry (2003) reported that genotypes with higher 100-grain weight under well-watered conditions may not be superior in this trait under water stress conditions. Indeed, the limitation of moisture might force the plant to complete its grain filling in a relatively shorter duration (Emam and Seghatoleslami, 2005). The relationship between RWC and main shoot yield at 10DAA (R^2=0.73) was highly significant (Fig. 2a). Also, a significant positive relationship was found between flag leaf chlorophyll content and main shoot yield (R^2=0.84) (Fig. 2b). In a similar study, Bijanzadeh and Emam (2010a) reported a positive relationship between grain yield with RWC (R^2=0.78) and chlorophyll content (R^2=0.61) at 10DAA in five wheat cultivars.

CONCLUSIONS

Our results revealed that ET-84-8 and Sanabad genotypes might be suitable for source restriction and water stress conditions, since they did not show any significant reduction in 100-grain weight, number of grains per spike, and grain yield, when the assimilate availability was reduced by defoliation treatment. However, yield and yield components of ET-83-3, ET-84-5 and Juanillo cultivars were sensitive to water stress, indicating that in these cultivars reduced assimilate availability by water stress was associated with a decrease in sink size. Additionally, flag leaf water relations including RWC, IWC, RWL, and ELWR of ET-83-3 and Juanillo cultivars were more sensitive to water deficit, while ET-84-8 and Sanabad maintained higher chlorophyll content, RWC, RWL, and ELWR under water stress. It could be recommended that the selection and growing of cultivars such as ET-84-8 and Sanabad with small responses to source restriction, might be a good approach for yield potential improvement, particularly in regions with restricted water availability later in the growing season.

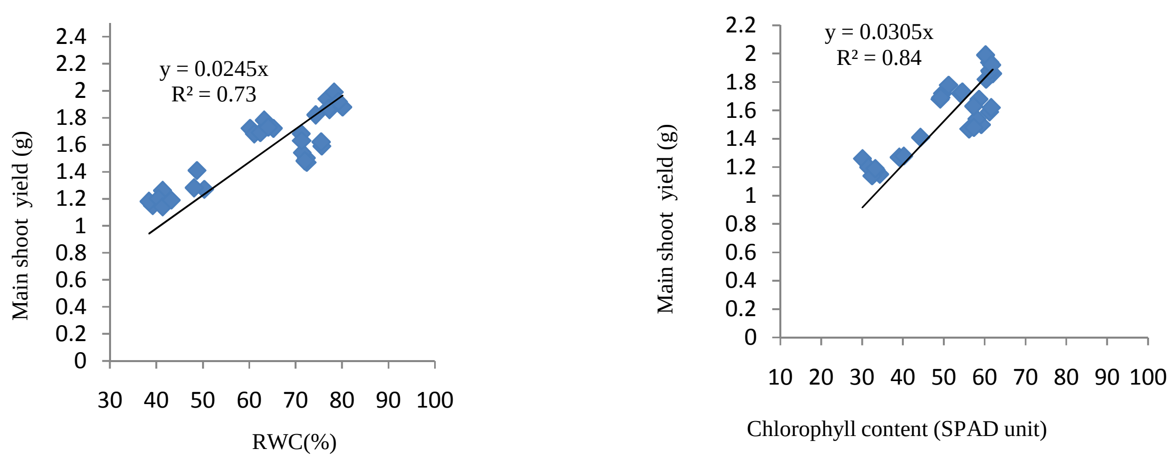

Fig. 2. Relationship between grain yield of triticale cultivars with RWC (a) and flag leaf chlorophyll content (b).

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ارزیابی روابط آبی برگ، محتوای کلروفیل و عملکرد دانه ژنوتیپ های تریتیکاله در شرایط کم‌آبی و برگ‌زدایی

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واژه‌های کلیدی:
مقدار کلروفیل
مقدار آب اولیه برگ
سرعت از دست دادن آب برگ
اندازه مبدا

چکیده- بهینه کردن اندازه مبدا و استفاده مواد پرورده آن در مقصد یکی از عوامل مهم در افزایش پتانسیل عملکرد و کاهش تقاضای آب درگیاهان زراعی در شرایط تنش خشکی می باشد. بمنظور بررسی اثرات برگ‌زدایی بر روابط آبی برگ پنج ژنوتیپ تریتیکاله شامل سناباد، جوانیلو، ET-۸۳-۳، ET-۸۴-۵ و ET-۸۴-۸ در شرایط آبیاری مطلوب (۱۰۰ درصد ظرفیت مزرعه) و تنش کم‌آبی (۵۰ درصد ظرفیت مزرعه)، آزمایشی گلخانه‌ای در سال ۱۳۹۲ در دانشگاه شیراز به اجرا در آمد. نتایج نشان داد که رقم ET-۸۴-۸ و سناباد محتوی کلروفیل بالاتری (در دامنه از ۴۹/۱ تا ۵۴/۶ واحد اسپد) در شرایط تنش کم‌آبی داشتند. در بین ارقام تریتیکاله تنش کم‌آبی باعث کاهش ۲۱ تا ۴۲ درصدی در سرعت از دست دادن آب برگ (RWL) شد. در همه ارقام به غیر از ET-۸۳-۳ و جوانیلو مقدار آب نگهداری شده در برگ(ELWR) به آرامی در شرایط تنش کم آبی کاهش یافت. در همه ارقام تریتیکاله به غیر از ET۸۴-۸، تنش کم‌آبی عملکرد ساقه اصلی را بین ۲۱ تا ۲۲٪ کاهش داد در حالی که این کاهش در رقم ET-۸۴-۸ تنها ۹٪ بود. جالب اینکه تعداد دانه در سنبله در رقم ET- ۸۴-۸ تحت تأثیر رژیم رطوبتی قرار نگرفت. همچنین وقتی همه برگ‌ها به غیر از برگ پرچم و برگ ماقبل پرچم حذف شدند، رقم سناباد با ۲/۵۷ گرم بر گرم دارای مقدار آب اولیه برگ (IWC) زیادتری بود. در شرایط تنش کم‌آبی و برگ‌زدایی، ارقامET-۸۴-۸ و سناباد وزن هزار دانه بیشتری (در دامن‌های از ۳/۶ تا ۳/۷۴ گرم) داشتند. می توان نتیجه گرفت که ارقام تریتیکاله بویژه در شرایط کم‌آبی مقصد- محدود بوده و اعمال محدودیت مبدأ از راه برگزدایی تأثیر کمتری در عملکرد دانه داشت، که این موضوع می‌تواند به عنوان ابزاری سودمند در کاهش آب مصرفی در دوره پر شدن دانه مورد استفاده قرار گیرد.