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Evaluation of Physiological Indices, Yield and its Components as Screening Techniques for Water Deficit Tolerance in Oilseed Rape Cultivars

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ABSTRACT

Water deficit is an important factor limiting crop production worldwide. Drought stress can be managed by improving the availability of soil moisture conserved and selecting drought tolerant genotypes. Several physiological indices including stomatal conductance (K_l), relative water content (RWC), leaf temperature (T_l) and crop temperature stability (CTS) along with yield, its components and seed glucosinolate content were measured in five oilseed rape genotypes of *Brassica napus* L. (Talayeh, Fornax, Okapi, Regent×Cobra and SLM046) under non-stress and water deficit conditions imposed from late flowering (80% flowering) to maturity in a loam soil at the Research Center for Agriculture and Natural Resources of East Azarbaijan, Iran (46°2′E, 37°58′N) over two successive years (2001-2003). According to the significant decrease of K_l and RWC and significant increase of T_l caused by water deficit in both years, it seems that, these indices could reflect the drought effects occurring from late flowering in oilseed rape crops. K_l and T_l values also differed significantly among genotypes and therefore these indices could be used to screen oilseed rape genotypes for tolerance against late season drought. Water deficit significantly decreased the number of pods per plant and seed yield in Talayeh and Fornax. Significant positive correlation was observed between these traits during both years (r=0.88 and 0.89, respectively). It seems that when water deficit occurs from late flowering, decreased seed yield mainly via decreasing number of pods per plant is observed in oilseed rape. Okapi and SLM046 showed lower T_l value (30.6 and 29.7°C, respectively), a higher K_l value (0.350 and 0.355 cm s^{-1} respectively) and seed yield (5,241 and 5,245 Kg ha^{-1}, respectively) under the water deficit condition. Okapi and SLM046 are therefore more suitable for cultivating in areas with late season water deficit stress.

Keywords: Leaf temperature, Oilseed rape, Relative water content, Seed yield, Water deficit.

INTRODUCTION

Water deficit is a major limiting factor in crop production worldwide. In most cropping situations, soil moisture deficit builds up during the late phase of crop growth when many field crops are particularly sensitive. Oilseed rape is no exception to this (El Hafid *et al.,* 1998). The most critical time for water supply is during the flowering and seed filling stages (Richards and Thurling, 1978). Since yield and drought tolerance are controlled at separate loci (Morgan, 1984), it may be possible to identify and transfer the physiological traits responsible for drought resistance to high-yielding and agronomically acceptable cultivars (Kumar and Singh, 1998). Interspecific and intraspecific variation were found in *Brassica napus* L. for the response to drought (Richards and Thurling, 1978; Rao and Mendham, 1991) and several physiological characters which may contribute to continued growth under water deficit stress have been identified. For

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Table 1. Weather records for two growing seasons in Khosroshahr Station.

Month	Mean Temperature (°C)			Rainfall (mm)			Relative Humidity (%)		
	2001	2002	2003	2001	2002	2003	2001	2002	2003
April	-	9.7	8.9	-	79.9	71.9	-	61.4	62.6
May	-	13.1	14.7	-	61.6	13.2	-	61.8	51.1
June	-	20.7	19.9	-	-	14.3	-	38.5	54.8
July	-	25.1	27.3	-	-	-	-	38.9	42.8
August	-	25.4	-	-	-	-	-	38.9	-
September	22.3	22.3	-	-	-	-	31.8	40.4	-
October	17.5	18.5	-	5.3	4.5	-	39.0	47.4	-
November	5.3	10.3	-	52.3	12.9	-	66.1	59.6	-
December	3.1	0.4	-	26.6	22.5	-	78.2	81.0	-
January	1.8	-1.5	-	11.6	7.8	-	71.6	77.9	-
February	-	1.4	-	0	14.6	-	74.0	77.3	-
March	6.9	4.1	-	32.4	39.8	-	61.0	65.8	-

The values are related to experimental periods.

Table 2. Soil characteristic in the experimental field.

Soil depth (cm)	FC [a] (%)		WP [b] (%)		AWC [c] (%)	
	2001/02	2002/03	2001/02	2002/03	2001/02	2002/03
0-25	21.5	22.0	12.0	13	9.5	9.0
25-60	22.5	22.5	12.0	12.5	10.5	10.0
60-90	16.0	16.5	9.0	9.5	7.0	7.0

[a] Field capacity; [b] Wilting point, [c] Available water capacity.

example, osmotic adjustment is considered to be an adaptive trait by which an increase in the solute content of cells can lead to maintenance of turgor and turgor-related processes at low water potentials (Kumar *et al*., 1984; Singh *et al*., 1990; Kumar and Elson, 1992; Kumar and Singh, 1998). As water deficit develops, stomata close progressively, transpiration decreases and canopy temperature rises. Kumar *et al*. (1984), Singh *et al*. (1985) and Kumar and Singh (1998) have reported close associations between osmotic adjustment and both stomatal conductance and canopy temperature in oilseed *Brassica* species. Singh *et al*. (1985) stated that transpirational cooling (canopy temperature minus air temperature) could effectively be used as a technique to screen *Brassica* genotypes for drought tolerance under a receding soil moisture condition. Pasban Eslam *et al*. (2000) reported that late season drought in oilseed rape, reduce crop temperature stability (differences between daily minimum and maximum air to crop temperature) and they indicated significant positive correlation of crop temperature stability with stomatal conductance, water potential, relative water content and seed yield. They suggested that this index may be more accurate than leaf temperature. Kumar and Singh (1998) showed a significant correlation among seed yield with osmotic adjustment, transpirational cooling and stomatal conductance in oilseed *Brassica* species. Lehman *et al*. (1993) studying bentgrass clones suggested that relative water content would better predict maintained growth under increasing water deficit than the simple measure of leaf water pontential.

Richards and Thurling (1978) found that late season drought lead to abortion of more than 50 percent of the pods in *B. napus* L. and *B. rapa* L., however, the remaining pods had more and heavier seeds. Jensen *et al*. (1996) reported that water deficit stress occurring during both the vegetative growth and pod filling stages in oilseed rape, decreased number of seeds per m^2, oil yield,

Table 3. Mean of traits measured on oilseed rape genotypes during 2001-2003.

Stress level	Genotype	K_l [a]	RWC [b]	T_l [c]	CTS [d]
		(cm s^{-1})		(°C)	
2001-2002					
Non-stress	Talayeh	0.52	0.81	26.9	1.17
	Fornax	0.52	0.78	27.3	1.26
	Okapi	0.63	0.82	27.5	1.26
	Regent×Cobra	0.49	0.82	27.1	1.22
	SLM046	0.72	0.83	27.6	1.17
Stress	Talayeh	0.25	0.70	30.9	1.13
	Fornax	0.25	0.66	30.5	1.16
	Okapi	0.34	0.63	30.4	1.12
	Regent×Cobra	0.22	0.65	31.1	1.11
	SLM046	0.39	0.66	30.4	1.15
LSD(0.05) [e]		0.054	0.108	0.497	0.093
2002-2003					
Non-stress	Talayeh	0.56	0.87	26.5	1.16
	Fornax	0.53	0.84	27.3	1.26
	Okapi	0.73	0.89	27.0	1.25
	Regent×Cobra	0.50	0.86	26.8	1.23
	SLM046	0.62	0.88	27.2	1.18
Stress	Talayeh	0.27	0.72	31.7	1.15
	Fornax	0.24	0.82	30.8	1.40
	Okapi	0.36	0.83	30.7	1.14
	Regent×Cobra	0.24	0.79	30.8	1.12
	SLM046	0.32	0.79	29.0	1.24
LSD(0.05)		0.054	0.076	0.677	0.253

[a] Stomatal conductance; [b] Relative water content; [c] Leaf temperature, [d] Crop temperature stability, [e] Least significant difference.

harvest index and seed yield. Irrigation after anthesis in oilseed rape increased the number of seeds per pod and harvest index and thus gave better seed yield (Rao and Mendham, 1991).

The glucosinolate content of seeds is an important quality attribute of oilseed rape, and it is increased by drought (Jensen *et al.*, 1996). Thus the correlation of seed glucosinolate with physiological indices may be useful to select for drought tolerance varieties having low seed glucosinolate under stress.

In spit of several reports about the drought stress effects on *B. Rapa* L. and *B. juncea* L. genotypes especially in temperate and warm areas, limited studies have reported on cold tolerant fall oilseed rape genotypes. Also late season drought is the main challenge against development of fall oilseed cultivation in cold areas of Iran. The objectives of this study were to evaluate the physiological indices in relation to the screening of cold tolerant oilseed rape genotypes for drought tolerance and to study yield and its component in *B. napus* L. genotypes under water deficit stress occurring during seed filling stage.

MATERIALS AND METHODS

The experiment was carried out at the research farm of Research Center for Agriculture and Natural Resources of East Azarbaijan, Iran (46°2′E, 37°58′N) over two years (2001-2003). The prevailing weather characteristics during the growing season are summarized in Table 1. The experiment was factorial based on a randomized complete

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block design with three replications. Five genotypes productive and suitable for cold areas of Iran -Talayeh, Fornax, Okapi, Regent×Cobra and SLM046- were evaluated under non-stress and water deficit conditions in a loam soil. Water stress was applied on MAD (mean allowable depletion). Plants were irrigated at 25 and 40 percent available soil water depletion in non-stress and stressed plots, respectively (Table 2). The stress was imposed from late flowering (80% flowering) to maturity. To prevent precipitation on stressed plots, polyethylene rain shelters were used during rainy periods (one time for 2 hours during the first year). The plot size was 5×2.1 m seeds were sown at the bottom of furrows in a 30+60 cm system (one pair of rows in each furrow with 30 cm spacing, and 60 cm spacing between two paired rows) on 11 September. Plants were thinned to a spacing of 10 cm within rows, four weeks after sowing. Crop management practices were operated as needed during the growing season.

The youngest fully-expanded leaves were used for various measurements and the characteristics were measured five days from late flowering (26 May) until leaf senescence (20th and 26th June for stress and non-stress plots, respectively. Stomatal conductance (K_l) was determined with an AP_4 prometer (Delta-T Devices, UK). Relative water content (RWC) was obtained by floating the leaf discs (3 discs from each leaf with a 20 mm diameter) on distilled water for 4 hours at 5°C under dim light. The turgid weight (TW) was then determined after floating, and the dry weight (DW) after the samples were dried for 24 hours at 80°C. Fresh weight (FW), TW and DW were used to calculate RWC as *RWC= FW-DW/TW-DW* (Jensen *et al*., 1996; Lazcano- Ferrat and Lovatt, 1999). A hand-held infrared thermometer (Class 2, Testo, Germany) was used to measure leaf temperature (T_l). For this characteristic ten measurements were taken on each plot and averaged for statistical analysis (Ray *et al*., 1998). We used the following relationship to determine crop temperature stability (CTS) as *CTS= Ta(max.) – Ta(min.)/Tc(max.)-Tc(min.), where Ta(max.)-Ta(min) and Tc(max.)–Tc(min.)* are the differences between maximum and minimum air and crop leaf temperatures a during 24 hour period, respectively (Pasban Eslam *et al*., 2000). Measurements of K_l, RWC and T_l were made at 1,200 to 1,400 hours when *Brassica* species tend to show the greatest genetic variability in response to drought stress (Singh *et al*., 1990).

Finally, the seed yield, its components and the percentage of seed oil were measured. Also, seed glucosinolate content was determined by high performance liquid chromatography (Kaushik and Agnihotri, 1999).

Statistical evaluation of the data were performed using the MSTAT-C and SPSS software packages.

RESULTS

Leaf Traits

Water deficit decreased K_l and RWC and increased T_l significantly in all genotypes over two years. However, stress significantly decreased CTS in the first year. Among the genotypes, Okapi and SLM046 showed higher amounts of K_l in both irrigation treatments and years. The lowest values of leaf temperature under a stress condition belonged to these genotypes in both years. SLM046 showed the lowest increase of T_l affected by drought. Differences among the genotypes for K_l and T_l were significant, but not for RWC (Table 3).

Yield and Yield Components

Water deficit imposed from late flowering to maturity significantly decreased the number of pods per plant and seed yield in Talayeh and Fornax in both years. Water deficit significantly decreased the 1,000-seed weight, seed oil percentage and harvest index during 2001-2002. Genotypes were

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significantly different in terms of the number of pods per plant, number of seeds per pod and 1,000-seed weight in 2001-2002 and seed oil percentage in both years. Okapi and SLM046 emerged a higher number of pods per plant and seeds per pod in both irrigation treatments in 2001-2002 (Table 4). The highest number of pods per plant belonged to Fornax in both irrigation treatments in 2002-2003. In all water conditions and years, Regent×Cobra had the highest percentages of seed oil (Table 4). Okapi and SLM046, especially under water deficit, showed the highest seed yields among genotypes.

Correlations between Traits

Correlations between K_l, RWC and T_l in both years and between these traits and CTS in 2002-2003 were significant (Table 5). Seed yield was positively correlated with K_l and RWC and negatively With T_l. Seed glucosinolate content was negatively correlated with K_l and positively with T_l in 2001-2002. The correlation coefficient for the number of pods per plant with seed yield was both positive and significant (Table 5).

DISCUSSION

Since K_l and RWC were decreased and T_l was increased significantly by water deficit stress in both years (Table 3), it seems that these indices could reflect the stress effects occurring from late flowering on the oilseed rape crop. K_l and T_l significantly differed among genotypes (Table 3). Okapi and SLM046 had higher amounts of K_l and lower amounts of T_l under water stress during two years (Table 3). Both genotypes, especially under the water deficit condition, produced the highest seed yield (Table 4). Therefore K_l and T_l could be used to screen oilseed rape genotypes for tolerance against water deficit during the seed filling stage. The results showed a significant correlation between K_l, RWC and T_l in both years (Table 5); Pasban Eslam *et al*. (2000) reported a similar correlation in *B.napus* L. and *B.rape* L. Since the correlation of seed yield with K_l and RWC was positive and significant and its correlation with T_l was negative and significant (Table 5), it seems that screening the oilseed rape genotypes by these characteristics may give rise to higher yields under a drought stress environment. Kumar and Singh (1998) also reported a significant correlation of seed yield with osmotic adjustment, transpirational cooling and K_l in oilseed *Brassica* species. In our study seed glucosinolate content was negatively correlated with K_l and positively with T_l in 2001-2002 (Table 5). Thus, selection of oilseed rape genotypes by these indices, may also select for low seed glucosinolate under drought conditions. Singh *et al*. (1985) and Kumar and Singh (1998) suggested that transpirational cooling could be used to screen large numbers of germplasm lines of *Brassica* species for drought tolerance. Golestani Araghi and Assad (1998) reported that T_l and stomatal resistance are beneficial drought resistance indicators in wheat. It has been revealed more accurately that RWC predicts the growth maintained under increasing water deficit than the simple measure of water potential in Bentgrass (Lehman *et al*., 1993). El Hafid *et al*. (1998) indicated that stomatal resistance, RWC and greater osmotic adjustment are possible measures to determine the drought resistance of a spring durum wheat cultivar.

In the present study, water deficit during the seed filling period significantly decreased CTS only in first year (Table 3), and there were no significant differences among genotypes for CTS. However, Pasban Eslam *et al*. (2000) noted that CTS which reflects crop temperature stability under daily air temperature alterations, and higher stability of crop temperature under drought periods, could be an indicator of water absorption and the evaporative ability of a plant under stress condition. To obtain more

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Table 4. Mean yield, and its components, of oilseed rape genotypes during 2001-2003.

Stress level	Genotype	Number of pods/plant	Number of seeds/pod	1000-seed weight (g)	Oil content (%)	Harvest index	Seed yield (Kg ha^{-1})	Glucosinolates (µmol g^{-1})
2001-2002								
Non-stress	Talayeh	181.0	29.0	3.73	39.5	0.30	5876	12.2
	Fornax	185.7	29.0	3.61	40.1	0.30	5578	14.3
	Okapi	191.3	31.3	3.23	40.3	0.29	5822	17.7
	Regent×Cobra	170.3	27.0	3.63	42.2	0.30	5105	15.1
	SLM046	193.3	30.3	3.46	40.1	0.27	6070	17.0
Stress	Talayeh	161.3	29.7	3.41	38.0	0.28	4670	11.1
	Fornax	166.3	27.7	3.35	39.6	0.28	4168	15.7
	Okapi	175.3	30.0	3.11	40.3	0.29	5371	21.1
	Regent×Cobra	142.0	27.0	3.54	40.4	0.27	4146	17.2
	SLM046	176.7	30.0	3.18	38.7	0.27	5832	15.5
LSD(0.05)		7.649	1.554	0.269	1.506	0.054	1205.0	10.95
2002-2003								
Non-stress	Talayeh	145.3	28.7	4.25	44.6	0.31	5362	17.6
	Fornax	178.3	30.3	4.32	45.3	0.30	5734	10.8
	Okapi	160.7	33.3	3.90	46.1	0.36	5604	14.2
	Regent×Cobra	117.3	32.0	4.40	46.9	0.32	4976	13.6
	SLM046	168.3	32.3	3.78	44.8	0.30	5570	12.3
Stress	Talayeh	80.7	30.7	4.48	43.4	0.29	3932	20.7
	Fornax	101.3	32.0	4.26	45.0	0.29	4353	18.3
	Okapi	99.0	33.3	3.96	45.8	0.30	5111	21.1
	Regent×Cobra	100.7	28.7	4.15	45.9	0.28	4048	21.5
	SLM046	99.3	32.7	4.26	45.7	0.29	4657	12.6
LSD(0.05) [a]		35.330	4.019	0.817	1.338	0.076	1038.0	9.355

[a] Least significant difference.

Table 5. Correlation coefficients among the traits measured on oilseed rape genotypes during 2001-2003.

Trait			(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
(1)	K_1 [a]	I		0.87**	-0.88**	0.68*	0.88**	0.51	0.18	0.33	0.42	0.84**	0.08
		II		0.85**	-0.89**	-0.01	0.87**	0.22	-0.49	0.21	0.81**	0.89**	-0.63*
(2)	RWC [b]	I			-0.94**	0.75*	0.66*	0.23	0.52	0.37	0.54	0.61*	-0.28
		II			-0.84**	0.18	0.79**	0.23	-0.56	0.45	0.67*	0.86**	-0.54
(3)	T_1 [c]	I				-0.80**	-0.71*	-0.15	-0.53	-0.50	-0.73*	-0.66*	0.16
		II				-0.07	-0.82**	-0.03	0.22	-0.33	-0.62	-0.83**	0.76**
(4)	CTS [d]	I					0.65*	0.20	0.26	0.40	0.65*	0.46	-0.14
		II					0.12	0.36	0.14	0.14	0.07	0.07	-0.40
(5)	Number of pods/plant	I						0.71*	-0.11	0.07	0.43	0.88**	0.10
		II						-0.01	-0.43	0.09	0.49	0.89**	-0.71*
(6)	Number of seeds/pod	I							-0.56	-0.42	0.01	0.71*	0.18
		II							-0.43	0.31	0.41	0.26	-0.29
(7)	1000-seed	I								0.30	0.39	-0.06	-0.60
	Weight	II								-0.18	-0.38	-0.50	0.11
(8)	Oil content	I									0.49	0.01	0.44
		II									0.43	0. 25	-0.26
(9)	Harvest	I										0.38	-0.10
	Index	II										0.60	-0.32
(10)	Seed yield	I											0.07
		II											-0.67*
(11)	Glucosinolate	I											
		II											

*, ** : Significant at 0.05 and 0.01 probability levels, respectively.
[a] Stomatal conductance; [b] Relative water content; [c] Leaf temperature, [d] Crop temperature stability.
I and II 2001-2002 and 2002-2003, respectively.

reliable results, however, it is better to evaluate a large number of *B.napus* L. genotypes under stress conditions over several seasons.

Since water deficit significantly decreased the number of pods per plant and seed yield (Table 4), and there was a significantly positive correlation among these traits (Table 5), it seems that occurring water deficit from late flowering, decreases seed yield mainly via decreasing the number of pods per plant in oilseed rape. Limitation of carbohydrate supplies to pods can lead to pod abortion in oilseed rape during the late flowering and pod filling stages (Habekotte, 1993). Drought occurring at flowering stage, significantly increases the rate of pod abortion, thus decreasing final seed yield in soybean (Liu *et al*., 2003; 2004). Elias and Copelan (2001) reported that weather conditions, especially precipitation, affected both the initiation of pod formation and the duration between pod formation and maturity in oilseed rape. Richards and Thurling (1978) indicated that late season drought could lead to abortion of more than 50 percent of pods in *B. napus* L. and *B. rapa* L., however remaining pods had more and heavier seeds. Results showed that water deficit significantly decreased the 1,000-seed weight, seed oil percentage and harvest index during 2001-2002 (Table 4). Jensen *et al*. (1996) revealed that water deficit stress occurring during both vegetative growth and pod filling stages in oilseed rape, decreased the number of seeds per m^2, oil yield, harvest index and seed yield. Findings about the adverse effects of drought on 1,000-seed weight, harvest index and seed oil percent in oilseed rape are reported (Richards and Thurling, 1978). It seems that when the plant growth stage that is confronted with drought, the stress level and its duration are usually the main factors affecting those characteristics. Water deficit stress increased seed glucosinolate (Table 4), but the amounts were always below acceptable levels (20μ mol g^{-1}) in terms of European Union Standards for marketing oilseed rape (Jensen *et al*., 1996).

Among the genotypes Okapi and SLM046 had higher and lower values of K_l (in both irrigation patterns) and T_l under stress conditions, respectively (Table 3). These genotypes demonstrated higher amounts of pod per plant and seeds per pod in both irrigation conditions in 2001-2002 (Table 4). Finally Okapi and SLM046, especially under water deficit, had the highest seed yield (Table 4). Therefore among the studied genotypes, Okapi and SLM046 are more suitable to cultivation in areas with late season water deficit.

This study demonstrated the need for a further assessment of water deficit tolerance mechanisms in oilseed rape with clear drought cycles and measurements at specific stages of crop growth, using a suitable range of genotypes. An economically viable oilseed rape line to extend the crop rotation in dryer cropping areas appears possible, given the wide genotypic variation available.

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ارزیابی شاخص های فیزیولوژیک، عملکرد و اجزای عملکرد به عنوان تکنیک گزینش برای تحمل به خشکی در پنج رقم کلزا

ب. پاسبان اسلام

چکیده

کمبود آب مهم ترین عامل محدود کننده تولید گیاهان زراعی در سطح جهان می باشد . به وسیله توسعه دسترسی به رطوبت خاک و گزینش ژنوتیپ های متحمل، می توان تنش خشکی را مدیریت نمود . در این تحقیق شاخص های فیزیولوژیک متعددی شامل هدایت روزنه ای (K_1)، مقدار آب نسبی (RWC) ، دمای برگ (T_1) و پایداری دمای گیاه زراعی (CTS) و نیز عملکرد دانه، اجزای عملکرد و مقدار گلوکوزینولات دانه بر روی ۵ ژنوتیپ کلزا از *Brassica napus* L. (طلایه، فورناکس، اکاپی، ریجنت × کبرا و اس ال ام ۰۴۶) تحت شرایط بدون تنش و تنش خشکی اعمال شده از اواخر گل دهی (۸۰٪ گل دهی) تا رسیدگی دانه، مورد ارزیابی قرار گرفتند . آزمایش در مرکز تحقیقات کشاورزی و منابع طبیعی آذربایجان شرقی، ایران (۴۶ درجه و ۲ دقیقه شرقی، ۳۷ درجه و ۵۸ دقیقه شمالی) در طی دو سال (۱۳۸۲-۱۳۸۰) در یک خاک لوم به اجرا در آمد . در هر دو سال آزمایش، خشکی باعث کاهش معنی دار K_1 و RWC و افزایش معنی دار T_1 گردید . بنابراین به نظر می رسد که شاخص های مذکور بتوانند اثرات تنش خشکی رخ داده از اواخر دوره گل دهی بر روی گیاهان کلزا را منعکس نمایند . همچنین با توجه به وجود اختلاف معنی دار مقادیر K_1 و T_1 در بین ژنوتیپ های کلزا، به نظر می رسد بتوان از این شاخص ها در گزینش ارقام متحمل به خشکی اواخر فصل استفاده نمود . تنش خشکی تعداد خورجین در بوته و عملکرد دانه را به طور معنی داری کاهش داد .بین این خصوصیات در طی هر دو سال آزمایش همبستگی مثبت و معنی داری دیده شد (به ترتیب r برابر است با ۰/۸۸ و ۰/۸۹) . به نظر می رسد وقوع تنش خشکی از اواخر گل دهی کلزا، عملکرد دانه را به ویژه از طریق کاهش تعداد خورجین در بوته، دچار افت می کند .تحت شرایط تنش کمبود آب، اکاپی و اس ال ام ۰۴۶ مقادیر پایین تر دمای برگ (به ترتیب ۳۰/۶ و ۲۹/۷ درجه سانتی گراد) و مقادیر بالاتر K_1 (به ترتیب ۰/۳۵۰ و ۰/۳۵۵ سانتی متر بر ثانیه) و عملکرد دانه (به ترتیب ۵۲۴۱ و ۵۲۴۵ کیلوگرم در هکتار) را نشان دادند . در نهایت چنین نتیجه گیری می گردد که اکاپی و اس ال ام ۰۴۶ از شایستگی بیشتری برای کشت در مناطقی با تنش خشکی اواخر فصل برخوردارند .

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