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EVALUATION OF SPRING RAPESEED (*BRASSICA NAPUS* L.) CULTIVARS FOR DIFFERENT PLANTING DATES AND IRRIGATION REGIMES

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ABSTRACT

The effects ofplanting date andirrigation regimes on some physiological and agronomical traitsof spring rapeseed (*Brassica napus* L.) cultivars were studied through field experiments conducted in Takestan, Iran during 2011-2013. Experiments were laid out in RCBR factorial split plot with two irrigation levels (I_1: normal irrigation (non-water stress) and I_2: interruption of irrigation from the pod formation stage (water stress)) and three planting dates (D_1: February 24, D_2: March 6, and D_3: March 16) as main plots and three spring cultivars including V_1: RGS003, V_2: Sarigol, V_3: Zarfamas subplots. The results of experiments revealed that water stress and postponing the planting date significantly had a negative influence on rapeseed cultivars.The highest seed yield, biomass yield, seed oil content, leaf relative water content and chlorophyll a and b content obtained in first planting date under normal irrigationby RGS003 althoughin these condition proline content, glucosinolate content, erucic acid content, stomatal resistance, and canopy temperaturehad the lowest means.RGS003 showed superiority in comparison to other cultivars in all planting dates and irrigation regimes as produced higher yields and oil than Sarigol and Zarfamwith lower unfavorable compounds of glucosinolate anderucic acid in all optimum and not optimum conditions.

Key words: Rapeseed (*Brassica napus* L.), Irrigation regimes, Planting date,Physiological traits.

INTRODUCTION

At present, low water availability is the main environmental factor limiting plant growth and yield worldwide. Futureglobalclimatechanges arelikely make water scarcity an even greater limitation to plant productivity across an increasing amount of land (Chaves *et al*., 2003, Hamdy *et al*., 2003). Water stress negatively affects many plant processes, such as photosynthesis, transpiration, stomatal conductance, and metabolite accumulation (Larcher, 2003; Ohashi *et al*., 2006), and causes substantial reductions in plant productivity (Yordanov *et al*., 2000; Reddy *et al*., 2004). Plants respond to drought by closing their stomata, which reduces leaf transpiration and prevents the development of excessive water deficits in their tissues. The drawback of the stomatal closure for plants is that their carbon gain is lowered and their growth is impaired. It is reported that the most rapeseed yield reductions obtained when water stress occurred at flowering and then at pod development stage (Masoud Sinaki *et al*., 2007; Movahhedy-Dehnavy *et al*., 2009).Also plantingdate is another key point in rapeseed productionaffecting crop yield and other agronomic traits. Most previous studies have revealed that late sowing results in lower yields (Hocking and Stapper 2001; Oz 2002; Ozer 2003; Robertson *et al*. 2004; Uzun *et al*. 2009). The greatest drawback for late sowing date is that irrespective of sowing time the flowering period falls in June, when evapotranspiration reaches high values and a long water stress period starts (Koutroubas *et al*., 2004; 2009; Yau, 2007). Moreover, various diseases tend to spread and intensify towards and after flowering. Therefore, plants are subjected to several biotic and abiotic stresses during the seed filling period that diminish photosynthesis and crop nitrogen uptake limiting their production.

Due to increasing population and edible oil consumption, it is necessary to increase the research on oilseed crops. The main objective of this study were assessing the effects of irrigation regimes and planting date on spring rapeseed (*Brassica napus* L.) cultivars, as a potential oilseed crop, in order to find the most appropriate cultivar in each condition which leads us to higher yields and lesser production costs.

MATERIALS AND METHODS

Two field studies were carried out at the research farm of Takestan Branch of Islamic Azad University, Takestan, Iran (36°04′11″N 49°41′45″E)using factorial split plot experiment laid out in RCBD design with three replications during the 2011-2012 and 2012-2013 crop years. Treatments were included three agents: Planting date in three levels (D_1: February 24, D_2: March 6, and D_3: March 16) andIrrigation in two levels (I_1: normal irrigationin other wordsirrigation after 80 mm evaporation from class A pan (non-water stress) and I_2: interruption of irrigation from the pod formation stage (water stress)) which were randomized on the main plots and spring Cultivars including V_1: RGS003, V_2: Sarigol, V_3: Zarfam which were randomized in the subplots. Each experimental plot consisted of 6 rows, 6 m long with 30 cm spaced between rows and 5 cm distance between plants on the rows. According to soil analysis, N, P, and K fertilizer rates recommended. P and K were applied pre-plant and N fertilizer applied in three stages: one-third pre-plant, one-third in stem elongation stage and one-third in flowering stage. The plants were thinned after complete emergence as keeping distances on row about 5 cm. Also the crop was kept free from weeds by applying 2.5 L ha^{-1}Terfelan pre-plant. Cabbage aphid controlled during spring season using Ekatin at a rate of 1 L ha^{-1}.The final harvest was performed at physiological maturity.At harvest stage four middle rows were used for sampling and measuring biomass yield, seed yield, harvest index, seed oil content, proline content, leaf relative water content, canopy temperature, stomatal resistance, chlorophyll a content, chlorophyll b content, glucosinolate content, and erucic acid content. Combined analysis of variance (ANOVA) was performed for these traits after two years of experiment. Also Duncan's Multiple Range Test (DMRT) ($P = 0.05$) was used to conduct means comparison.

RESULTS AND DISCUSSION

Leaf relative water content: The simple effects of treatments and the interaction effects of planting date× irrigation and irrigation× cultivar on leaf relative water content were significant at $P = 0.01$. Also the interaction effect of planting date× irrigation× cultivar on this trait was significant at $P = 0.05$ (Table 1). The study of triple effects of treatments on leaf relative water content revealed that the highest leaf relative water contenton average 97.98% obtained by RGS003 in first planting date under normal irrigation and the lowest leaf relative water contenton average 70.02% obtained by Zarfam in last planting date under water stress condition. RGS003 also produced the highest leaf relative water contentin all planting dates and irrigation regimes (Table 2).Water shortage in plant leaves caused the reduction of leaf relative water content in water stress condition. Norouzi *et al*. (2008) also reported the reduction of relative water contentunder water stress condition.

Chlorophyll a and b content: The simple effects of treatments on chlorophyll a content were significant at $P = 0.01$. Also the interaction effects of planting date× cultivar, irrigation× cultivar and planting date× irrigation× cultivar on this trait were significant at $P = 0.05$ (Table 1). The study of triple effects of treatments on chlorophyll a content revealed that the highest chlorophyll a content on average 1.217 mg/g fresh weight obtained by RGS003 in first planting date under normal irrigation and the lowest chlorophyll a content on average 0.67 mg/g fresh weight obtained by Zarfam in last planting date under water stress condition. RGS003 also produced the highest chlorophyll a content in all planting dates and irrigation regimes (Table 2).The simple effects of planting date and irrigation on chlorophyll b content were significant at $P = 0.01$. Also the simple effect of cultivar and all interaction effects of treatments on this trait were significant at $P = 0.05$ (Table 1). The study of triple effects of treatments on chlorophyll b content revealed that the highest chlorophyll b content on average 0.723 mg/g fresh weight obtained by RGS003 in first planting date under normal irrigation and the lowest chlorophyll b content on average 0.084 mg/g fresh weight obtained by RGS003 in last planting date under water stress condition. Generally the highest chlorophyll b content on first planting date under both irrigation regimes and on second planting date under normal irrigation regime obtained by RGS003, on second planting date under water stress condition and on last planting date under normal irrigation regime obtained by Sarigol, and on last planting date under water stress condition obtained by Zarfam (Table 2). Kazemi Nasab *et al*. (2005), Din *et al*. (2011), and Fazeli *et al*. (2005) also reported chlorophyll content reduced in water stress condition. Certainly this reduction of chlorophyll content in water stress condition is due to destruction of chloroplasts and reduction of producing pigments. Chlorophyll is the center of energy producing system in plants and any significant changes in chlorophyll concentration could seriously affect plant life cycle (Shweta and Agrawal, 2006). According to Schutz and Fangmeier (2001) water stress could speed up chlorophyll shattering.

Proline content: The simple effects of treatments and the interaction effect of planting date× irrigation on proline content were significant at $P = 0.01$. Also the interaction effects of planting date× cultivar, irrigation× cultivar and planting date× irrigation× cultivar on this trait were significant at $P = 0.05$ (Table 1). The study of triple effects of treatments on proline content revealed that the highest proline content on average 26.97 µmol/g fresh weight obtained by Zarfam in last planting date under water stress condition and the lowest prolinecontenton average 8.92 µmol/g fresh weight obtained by RGS003 in first planting date under normal irrigation. Zarfam also produced the highest proline content in all planting dates and irrigation regimes (Table 2). Proline is an amino acid, which appear most commonly in response to stress and play role as an osmolyte for osmotic adjustment, also proline contributes to stabilizing structures (e.g., proteins and membranes) in plant cells in many crops under stress conditions (Ozturk and Demir, 2002). Norouzi *et al*. (2008) reported water stress is leading to proline accumulation in the rapeseed leaves, and it had an important contribution to osmotic adjustment of the genotypes under water stress. Din *et al*. (2011) also reported drought stress significantly enhanced accumulation of proline in the leaf of canola cultivars at the flower initiation stage.They reported canola cultivars accumulating greater proline produced higher grain yield under drought stress. Proline accumulation during drought stress is an adaptive response that enhances survival and tissue water status.

Stomatal resistance: All simple and interaction effects of treatments on stomatal resistance were significant at $P = 0.01$ (Table 1). The study of triple effects of treatments on stomatal resistance revealed that the highest stomatal resistance on average 26.95 s cm^{-1} obtained by Zarfam in last planting date under water stress and the lowest stomatal resistance on average 1.61 s cm^{-1} obtained by RGS003 in first planting date under normal irrigation. Zarfam also produced the highest stomatal resistance in all planting dates and irrigation regimes (Table 2). Plants respond to drought by closing their stomata, which reduces leaf transpiration and prevents the development of excessive water deficits in their tissues. The drawback of the stomatal closure for plants is that their carbon gain is lowered and their growth is impaired.

Canopy temperature: The simple effects of treatments and the interaction effects of planting date× irrigation and planting date× cultivar on canopy temperaturewere significant at $P = 0.01$. Also the interaction effects of irrigation× cultivar and planting date× irrigation× cultivar on this trait were significant at $P = 0.05$ (Table 1). The study of triple effects of treatments on canopy temperaturerevealed that the highest canopy temperature on average 29.53º C obtained by Zarfam in last planting date under water stress condition and the lowest canopy temperatureon average 16º C obtained by RGS003 in first planting date under normal irrigation. Zarfam also had the highest canopy temperaturein all planting dates and irrigation regimes (Table 2).

Biomass yield: All simple and interaction effects of treatments on biomass yield were significant at $P = 0.01$ except the interaction effect of planting date× irrigation× cultivar which was significant at $P = 0.05$ (Table 1). The study of triple effects of treatments on biomass yield revealed that the highest biomass yield on average 15670 kg ha^{-1} obtained by RGS003 in first planting date under normal irrigation and the lowest biomass yield on average 2694 kg ha^{-1} obtained by Zarfam in last planting date under water stress condition. RGS003 also produced the highest biomass yield in all planting dates and irrigation regimes (Table 2). The biological yield of oilseed rape is the product of the growth rate and the duration of the vegetative period. Long growing season increases incoming radiation. At the same time, photosynthesis of crop increased which positively affected crop growth and leaf expansion (Diepenbrock, 2000). Gan *et al.* (2009) and Sinaki *et al*. (2007) also showed the reduction of biomass yield under water stress condition. Biomass reduction in water stress condition is caused by preventing from physiological activities such as transpiration, photosynthesis, tissues elongation or enzymes activities and also shorter growing season caused by stress. Faraji *et al.* (2009) reported 21% reduction of dry matter of rapeseed cultivars under water stress condition.

Seed yield: The simple effects of treatments and the interaction effects of planting date× irrigation and planting date× irrigation× cultivar on seed yield were significant at $P = 0.01$. Also the interaction effects of planting date× cultivar and irrigation× cultivar on this trait were significant at $P = 0.05$ (Table 1). The study of triple effects of treatments on seed yield revealed that the highest seed yield on average 3329 kg ha^{-1} obtained by RGS003 in first planting date under normal irrigation and the lowest seed yield on average 258 kg ha^{-1} obtained by Zarfam in last planting date under water stress condition. RGS003 also produced the highest seed yield in all planting dates and irrigation regimes (Table 2). It appears that water stress hampered flowering and reduced the probability of developing flower to pod and its occurrence during flowering and pod formation resulted in pod abortion. Din *et al*. (2011) reported greater reduction in yield under drought stress at flowering stage in comparison to pod filling stage. Faraji *et al.* (2009) also reported 18% reduction of seed yield of rapeseed cultivars under water stress condition. Sinaki *et al*. (2007) found significant variation in seed yield and its components by drought stress applied at different developmental stages in various canola cultivars.Sowing date determines the crop quality and quantity via affecting on length of vegetative and reproductive growth periods and putting a balance among them.Late sowing date results shortening of the flowering period and decrease of seed yield. Also delay on sowing date caused flowering period falls in June when evapo-transpiration reached high values thus caused the crop to experience water stress (Yau, 2007). In general during the flowering period, the crop is especially susceptible to drought stress, but cultivars were found to possess varying sensitivity. Morrison and Stewart (2002) reported the genetic difference among rapeseed cultivars from the seed yield point of view.

Harvest index: All simple and interaction effects of treatments on harvest index were significant at $P = 0.01$(Table 1). The study of triple effects of treatments on harvest index revealed that the highest harvest index on average 24.6% obtained by Sarigol in last planting date under water stress condition and the lowest harvest index on average 7.35% obtained by

Zarfam in second planting date under water stress condition. Generally in first planting date under both irrigation regimes RGS003, in second and third planting date under normal irrigation RGS003 and under water stress condition Sarigol had the highest harvest index (Table 2).

Seed oil content: The simple effects of treatments and the interaction effect of planting date× irrigation on seed oil content were significant at *P* = 0.01. Also the interaction effects of planting date× cultivar, irrigation× cultivar and planting date× irrigation× cultivar on this trait were significant at *P* = 0.05 (Table 1). The study of triple effects of treatments on seed oil content revealed that the highest seed oil contenton average 41.89% obtained by RGS003 in first planting date under normal irrigation and the lowest seed oil contenton average 38.42% obtained by Zarfam in last planting date under water stress condition. RGS003 also produced the highest seed oil contentin all planting dates and irrigation regimes (Table 2). Nasri *et al.* (2008) also reported reduction of seed oil content and yield of 5 rapeseed cultivars under water stress.

Erucic acid content: All simple and interaction effects of treatments on erucic acid content were significant at *P* = 0.01 (Table 1). The study of triple effects of treatments on erucic acid content revealed that the highest erucic acid content on average 1.616% obtained by Zarfam in last planting date under water stress condition and the lowest erucic acid content on average 0.3001% obtained by RGS003 in first planting date under normal irrigation. Zarfam also produced the highest erucic acid content in all planting dates and irrigation regimes (Table 2).

Glucosinolate content: All simple and interaction effects of treatments on glucosinolate content were significant at *P* = 0.01 (Table 1). The study of triple effects of treatments on glucosinolate content revealed that the highest glucosinolate content on average 30.64 mg/g dry weight of meal obtained by Zarfam in last planting date under water stress condition and the lowest glucosinolate content on average 18.06 mg/g dry weight of meal obtained by RGS003 in first planting date under normal irrigation. Zarfam also produced the highest glucosinolate content in all planting dates and irrigation regimes (Table 2).

Table 1- Combined analysis of variance for assessed traits (2011-2013)

S.O.V.	D.F.	*SY*	*BY*	*HI*	*SOC*	*PC*	*GC*
Year	1	209088^{ns}	7203883.787**	17.658^{ns}	103.469**	23.241^{ns}	33.835**
Error	4	53037.306	26955.593	7.055	0.029	12.975	0.289
Planting date	2	20213870.333**	385136018.787**	119.864**	24.901**	592. 941**	321.646**
Year× Planting date	2	12009^{ns}	229205.62^{ns}	0.073^{ns}	0.014^{ns}	0.333^{ns}	0.195^{ns}
Irrigation	1	31924106.704**	592905522.231**	163.467**	44.48**	1492.613**	451.127**
Year× Irrigation	1	18934.259^{ns}	352832.676^{ns}	0.099^{ns}	0.026^{ns}	0.087^{ns}	0.269^{ns}
Planting date× Irrigation	2	2142588.259**	36731585.898**	301.6**	1.059**	137.735**	40.44**
Year× Planting date× Irrigation	2	1267.815^{ns}	21872.509^{ns}	0.18^{ns}	0.001^{ns}	0.086^{ns}	0.023^{ns}
Error	20	5901.017	163006.459	1.279	0.153	5.643	0.604
Cultivar	2	9612429.361**	109148918.731**	410.776**	9.395**	126.63**	141.342**
Year× Cultivar	2	5729.694^{ns}	64850.065^{ns}	0.245^{ns}	0.006^{ns}	0.085^{ns}	0.085^{ns}
Planting date× Cultivar	4	59630.528*	2107753.231**	63.655**	0.121*	4.558*	14.719**
Year× Planting date× Cultivar	4	36.361^{ns}	1248.981^{ns}	0.038^{ns}	0.001^{ns}	0.002^{ns}	0.009^{ns}
Irrigation× Cultivar	2	145934.509*	2745529.454**	103.809**	0.436*	7.01*	8.89**
Year× Irrigation× Cultivar	2	88.731^{ns}	1642.898^{ns}	0.06^{ns}	0.001^{ns}	0.01^{ns}	0.005^{ns}
Planting date× Irrigation× Cultivar	4	518454.898**	1414764.287*	39.046**	0.126*	4.342*	5.574**
Year× Planting date× Irrigation× Cultivar	4	297.12^{ns}	845.648^{ns}	0.024^{ns}	0.001^{ns}	0.002^{ns}	0.003^{ns}
Error	48	31513.065	493836.356	2.551	0.278	2.451	1.328
Total	107	-	-	-	-	-	-
C.V. (%)	-	19.83	16.64	19.63	11.31	18.24	15.02

*, ** significant at 5 and 1% respectively, ns: not significant

S.O.V.	D.F.	*EAC*	*LRWC*	*SR*	*CaC*	*CbC*	*CT*
Year	1	0.026^{ns}	473.763**	6.453**	0.066*	0.001^{ns}	31.579**
Error	4	0.004	0.539	0.029	0.005	0.044	0.561
Planting date	2	2.195**	824.616**	1062.133**	0.409**	0.813**	328.966**
Year× Planting date	2	0.001^{ns}	0.527^{ns}	0.637^{ns}	0.001^{ns}	0.013^{ns}	0.204^{ns}
Irrigation	1	3.557**	7059.984**	3885.001**	1.274**	2.388**	747.867**
Year× Irrigation	1	0.002^{ns}	3.929**	2.32*	0.001^{ns}	0.003^{ns}	0.454^{ns}
Planting date× Irrigation	2	0.389**	128.174**	281.416**	0.021^{ns}	0.233*	40.248**
Year× Planting date× Irrigation	2	0.001^{ns}	0.071^{ns}	0.168^{ns}	0.001^{ns}	0.008^{ns}	0.02^{ns}
Error	20	0.004	0.428	0.375	0.012	0.074	1.997
Cultivar	2	1.275**	159.366**	207.599**	0.118**	0.003*	122.624**

Year× Cultivar	2	0.001^{ns}	0.107^{ns}	0.122^{ns}	0.001^{ns}	0.009^{ns}	0.08^{ns}
Planting date× Cultivar	4	0.246**	6.552^{ns}	16.747**	0.012*	0.041*	8.357**
Year× Planting date× Cultivar	4	0.001^{ns}	0.005^{ns}	0.01^{ns}	0.001^{ns}	0.01^{ns}	0.008^{ns}
Irrigation× Cultivar	2	0.386**	28.864**	80.788**	0.025*	0.001*	7.385*
Year× Irrigation× Cultivar	2	0.001^{ns}	0.021^{ns}	0.047^{ns}	0.001^{ns}	0.009^{ns}	0.005^{ns}
Planting date× Irrigation× Cultivar	4	0.081**	1.227*	5.96**	0.002*	0.008*	3.446*
Year× Planting date× Irrigation× Cultivar	4	0.001^{ns}	0.004^{ns}	0.003^{ns}	0.001^{ns}	0.009^{ns}	0.001^{ns}
Error	48	0.008	5.047	0.928	0.006	0.039	2.184
Total	107	-	-	-	-	-	-
C.V. (%)	-	13.72	12.61	19.61	17.86	14.85	16.66

*, ** significant at 5 and 1% respectively, ns: not significant

Table 2. Interaction effect of irrigation, planting date and cultivar on assessed traits (2011-2013)

Planting date	Irrigation	Cultivar	*SY* (kg ha^{-1})	*BY*(kg ha^{-1})	*HI* (%)	*SOC* (%)	*PC* (µmol/g fresh weight)	*GC* (mg/g dry weight of meal)
February 24	Normal	RGS003	3329 a	15670 a	21.78 b	41.89 a	8.92 k	18.06 l
		Sarigol	3231 ab	15350 a	21.57 b	41.84 a	9.43 k	18.74 kl
		Zarfam	2830 c	13600 b	21.38 b	41.12 b	9.83 k	19.43 i-l
	Stress	RGS003	2630 cd	14100 b	19.11 cd	40.91 b	17.83 gh	19.83 h-k
		Sarigol	1922 f	12460 c	15.81 gh	40.13 c	20.1 ef	21.44 fg
		Zarfam	1279 h	10920 d	12 i	39.83 c	22.87 cd	21.87 ef
March 6	Normal	RGS003	3073 b	15240 a	20.66 bc	41.54 ab	14.03 j	18.91 jkl
		Sarigol	2510 d	14280 b	18.01 def	40.97 b	14.98 ij	20.26 g-j
		Zarfam	2212 e	12450 c	18.18 de	40.23 c	16.22 hi	20.44 f-i
	Stress	RGS003	1584 g	10180 de	15.98 fgh	39.94 c	21.42 de	23.14 de
		Sarigol	1290 h	8182 f	16.43 e-h	39.11 d	23.15 cd	26.12 c
		Zarfam	367 jk	5202 h	7.35 k	38.88 de	25.43 ab	29.64 a
March 16	Normal	RGS003	1973 f	11940 c	16.92 efg	40.23 c	18.67 fg	20.97 fgh
		Sarigol	1422 gh	10030 e	14.49 h	39.89 c	21.22 de	24.42 d
		Zarfam	560 j	7843 f	7.37 k	39.13 d	24.17 bc	26.94 bc
	Stress	RGS003	1054 i	6435 g	16.98 efg	39.22 d	22.13 d	24.36 d
		Sarigol	970 i	4058 i	24.6 a	38.86 de	24.48 bc	27.9 b
		Zarfam	258 k	2694 j	9.88 j	38.42 e	26.97 a	30.64 a

Any two means sharing a common letter do not differ significantly from each other at 5% probability

Planting date	Irrigation	Cultivar	*EA* (%)	*LRWC* (%)	*SR* (s cm^{-1})	*CaC* (mg/g fresh weight)	*CbC* (mg/g fresh weight)	*CT* (ºC)
February 24	Normal	RGS003	0.3001 h	97.98 a	1.61 j	1.217 a	0.723 a	16 j
		Sarigol	0.3329 gh	97.17 ab	1.68 j	1.205 a	0.636 ab	16.8 ij
		Zarfam	0.3616 gh	96.55 ab	1.76 j	1.181 a	0.639 ab	17.32 hij
	Stress	RGS003	0.3989 fgh	87.43 d	4.99 h	1.061 b	0.632 ab	20.2 g
		Sarigol	0.4871 f	84.17 e	7.09 g	1.012 bc	0.513 ab	22.12 ef
		Zarfam	0.5085 f	82.72 e	9.58 f	0.961 bcd	0.489 ab	23.38 de
March 6	Normal	RGS003	0.3339 gh	96.03 ab	2.44 ij	1.197 a	0.674 ab	17.62 hij
		Sarigol	0.3993 fgh	95.42 ab	2.66 ij	1.178 a	0.614 ab	18.25 hi
		Zarfam	0.4326 fg	94.82 b	3.03 i	1.155 a	0.599 b	18.97 gh
	Stress	RGS003	0.5019 f	78.65 f	12.79 e	0.972 bcd	0.182 cd	22.97 de
		Sarigol	0.9479 c	75.03 gh	18.71 d	0.9 de	0.212 cd	25.92 c
		Zarfam	1.156 b	72.57 hi	22.2 c	0.837 ef	0.187 cd	28.18 ab
March 16	Normal	RGS003	0.4436 fg	91.83 c	5.35 h	1.048 b	0.413 bc	20.7 fg
		Sarigol	0.6917 de	89.47 cd	7.57 g	0.988 bcd	0.525 ab	24.18 d
		Zarfam	0.7813 d	87.2 d	10.12 f	0.94 cd	0.493 ab	26.35 c
	Stress	RGS003	0.6444 e	77.08 fg	17.78 d	0.938 cd	0.084 d	24.18 d
		Sarigol	1.174 b	73.27 h	24.07 b	0.802 f	0.142 d	27.07 bc
		Zarfam	1.616 a	70.02 i	26.95 a	0.67 g	0.199 cd	29.53 a

Any two means sharing a common letter do not differ significantly from each other at 5% probability

Traits in *italic*, *SY, BY, HI, SOC, PC,GC, EAC, LRWC, SR, CaC, CbC,* and *CT*are assigned for seed yield, biomass yield, harvest index, seed oil content, proline content, glucosinolate content, erucic acid content, leaf relative water content, stomatal resistance, chlorophyll a content, chlorophyll b content, and canopy temperature, respectively.

Conclusions: This study revealed significant reduction in seed yield, biomass yield,seed oil content, relative water content and chlorophyll a/b contentand increment in proline content, glucosinolate content, erucic acid content, stomatal resistance, and canopy temperatureof rapeseed as a consequence of succeeding water stress during the reproductive stage and postponing the planting date.Among assessed cultivars RGS003 showed superiority in comparison to other cultivars in all planting dates and irrigation regimes. Therefore,if water stress happened during the growth season or early planting was not possible for any reason, RGS003 could stands and yields more than Sarigol and Zarfam cultivars with lower unfavorable compounds of glucosinolate anderucic acid.

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