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## EVALUATION OF CANOLA GENOTYPES BASED ON DROUGHT TOLERANCE INDICES

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### ABSTRACT

For evaluation of study the effect of deficit irrigation on some drought resistance indices of canola genotypes, two separately experiments were done in factorial experiment basis of Random Complete Block design with three replications. This study was conducted during 2015-2016 in two provinces (Rostam and Basht). The factors to be studied include 20 canola genotypes and drought stress in two levels (normal irrigation after 80 mm evaporation from pan class A, irrigation stop in flowering stage). Basis grain yield in irrigation ( $Y_p$ ) and stress condition ( $Y_s$ ), calculated quantitative resistance indices such as: SSI, TOL, MP, STI and GMP. TOL was significantly affected by the genotype. Genotype and region had a significant effect on STI, GMP, MP and SSI.

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### Introduction

Drought stress, as the most important factor limiting growth and yield of crops, affects about 40 to 60 percent of global agricultural lands [1, 2]. The average annual yield loss of crops due to drought in the world is about 17 percent that can increase to more than 70 percent a year. Currently, approximately 70% of the world's population lives in areas that suffer from water shortage and this could increase to 67 percent by 2050 (Wallach, 2006). Iran is considered a dry and a semi-dry country: average annual rainfall of Iran is equivalent to one-third of the world average rainfall, rainfall patterns in much of the country is irregular and unpredictable, and the lack of available water resources is evident [3, 4] Due to limited water resources, it is recommended that deficit irrigation be used as an efficient option for increasing water productivity in projects. Another strategy to cope with this situation is using plant genetic engineering and breeding in projects to produce and introduce drought-tolerant genotypes [5].

After cereals, oilseed crops are the world's second food supply and in addition to having rich fatty acids, they contain protein. Unfortunately, in spite of good potential for the cultivation of oilseeds in Iran, our country is still one of the major importers of oilseeds, and only about 10% of the need of the country for vegetable oil is provided from domestic sources. Due to the increasing population, statistics indicate an increase in imports of vegetable oils to Iran (Ministry of Commerce statistics). Increase in the price of oilseeds in global markets requires that efforts for agronomic and breeding to develop crops of oilseed production in Iran as a strategic objective for food security. This is because annually a

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major part of foreign exchange is spent on imports of vegetable oils [6]. Hence, the need for a coherent and long-term planning with the aim of achieving self-sufficiency in edible oils production is undeniable.

**Materials And Methods**

To evaluate tolerance against water deficiency stress of canola genotypes, two separate experiments were conducted in randomized complete block design with 3 replications. Every experiment includes 20 genotypes canola. One experiment was conducted in the normal irrigation condition, (Irrigation on the basis of 80 mm evaporation from the pan class A) and the other experimental was conducted in water deficiency stress (water stress from the flowering stage forward). This study was conducted during 2015-2016 in two provinces (Rostam and Basht). The monthly average temperature and the average monthly rainfall of Rostam and Basht according to ten-year statistics of meteorology and soil analysis results are listed in the following tableS (Table 2, 3).

**Table 1.** Average monthly temperature and rainfall in Rostam and Basht

		Dec	Nov	Oct	Sep	Aug	Jul	Jun	May	Apr	Mar	Feb	Jan
<b>ROSTAM</b>	<b>Rain(m)</b>	58.31	126.18	5.45	0	17.3	3.5	0.01	15.2	33.26	53.16	82.11	96.06
	<b>Tem(°c)</b>	12.45	16.66	24.75	30.28	34.2	35.81	33.55	28.53	21.11	16.45	12.31	10.56
<b>BASHT</b>	<b>Rain(m)</b>	129.23	68.71	3.9	0.75	2.49	0.4	0	3.47	28.08	37.7	54.9	133.65
	<b>Tem(°c)</b>	13.8	18.95	27.15	32.72	36.7	37.3	35.3	31.07	24.1	18.42	13.86	11.70

**Table 2.** Results of soil test

	EC (mmoh.cm <sup>-1</sup> )	PH	O.C (%)	P (ppm)	K (ppm)	Clay (%)	Silt (%)	Sand (%)
<b>Rostam</b>	0.97	7.61	0.71	12.05	117	52.32	42.3	5.38
<b>Basht</b>	1.22	7.72	0.58	13.2	121	52.9	41.9	6.2

**Table (3).** The names of genotypes

<b>Genotype</b>	KRS64	KRS28	SS 29	SS 48	KRS 17	KRS 33	KRS 19	KS18	AS17	KS21
<b>Number</b>	1	2	3	4	5	6	7	8	9	10
<b>Genotype</b>	KS16	AS18	AS12	KS14	AS22	KS41	SS32	AS25	KS66	AS29
<b>Number</b>	11	12	13	14	15	16	17	18	19	20

Stress tolerance and susceptibility indexes: Using grain yield under two common conditions and drought stress, sensitivity and tolerance evaluation indexes of genotypes to stress were determined according to the following formulas [ 7, 8].

$y_s$  : yield of each genotype in stress

$y_p$  : yield of each genotype in a non-stress

$\bar{Y}_s$  :The mean yield of genotypes in stress

$\bar{Y}_p$  : The Mean yield of genotypes in a non-stress

Equation 1 ► Drought Tolerance Index  $Tol = y_p - y_s$

Equation 2 ► Mean Productivity  $M_p = \frac{y_p + y_s}{2}$

Equation 3 ► Stress Susceptibility index  $SSI = \frac{1 - (y_s / y_p)}{SI}$

Equation 4 ► Stress Intensity  $SI = 1 - \left( \frac{\bar{Y}_s}{\bar{Y}_p} \right)$

$$\text{Equation 5} \blacktriangleright \text{Stress Tolerance Index } STI = \frac{(y_p)(y_s)}{(\bar{Y}_p)^2}$$

$$\text{Equation 6} \blacktriangleright \text{Geometric Mean Productivity } GMP = \sqrt{(y_p \times y_s)}$$

Data analysis: After measuring and calculating traits listed in the test, the results were analyzed. To variance analysis and mean comparison, SAS software version 9.1 was used. Mean comparisons of traits measured were done using the least significant difference (LSD) at 5 percent. Charting was performed using Excel software.

## Results And Discussion

**Tolerance evaluation indexes and sensitivity of genotypes to drought stress:** In order to save on water consumption, it is necessary to produce and select varieties which has acceptable yield under soil moisture limiting conditions and also has the stability required to moisture changes. [9] on wheat and [10] on rapeseed reported that simultaneous evaluation of stress and non-stress conditions leads to the selection of higher yield genotypes in both mediums.[8] by evaluating mung bean genotypes yield in two mediums of stress and normal conditions, the plants' responses were divided into four groups: High-yielding genotypes in both stressed and non-stressed (Group A), high yield genotypes under non-stress conditions (Group B), high yield genotypes under stress conditions (Group C), and low yield genotypes in both mediums (Group D).

**Drought stress susceptibility index (SSI):** The results of this study showed that drought stress susceptibility index was affected by interaction genotype with the tested region (Table 4). Investigating this interaction showed that environmental changes can be effective in determination of drought stress susceptibility index of genotypes (Fig. 1). In region 1, the highest drought stress susceptibility index (1.54) was observed in genotype 18, while in region 2, the highest drought stress susceptibility index (1.32) was observed in genotype 17 (Fig 1). In this regard, the lowest drought stress susceptibility index was observed in genotype 14 in region 1 and 2 (0.49 and 0.78, respectively) (Fig. 1). According to the SSI index, lower yield genotype is more tolerant. Genotypes 1 and 2 are the most tolerant genotypes than drought stress.

**Drought Tolerance Index (TOL):** The results showed that drought tolerance index was significantly affected by tested genotypes (Table 4). As shown in Fig. 2, the highest drought tolerance index was observed in genotype 8. In addition, genotypes 7, 11, 17 and 17 were statistically classified in the highest drought tolerance index (Fig 2). The lowest drought tolerance index was observed in Genotype 14, which did not show statistically significant differences with genotypes 1, 2, 5, 6, 12, 13, 15, 19 and 20. The lower TOL index shows more tolerance of the genotype.

**Mean Productivity Index (MP):** The results of this study showed that the effect of the tested region and also tested genotypes were significant in the mean productivity index (Table 4). The mean productivity index in region 2 was far lower than region 1 and was about 21% less (Fig 3). This results shows that mean productivity index of trait is affected by medium. Mean productivity index among rapeseed genotypes showed that the highest mean productivity index was produced in genotypes 1 and 4, whereas the lowest mean productivity index was observed in genotypes 15, 18, 3, 11, 17 and 19 (Fig. 4). MP index is suitable for identifying high yield genotypes, but it is not suitable for identifying high yield genotypes under drought stress conditions Naderi et al (2000). Therefore, genotypes 1 and 4 can be identified as suitable genotypes.

**Drought Stress Tolerance Index (STI):** The results showed that the drought stress tolerance index in rapeseed was significantly affected by tested region and the genotype (Table 4). It was observed that drought stress tolerance index of rapeseed in region 2 was about 19% less than region 1 (Fig. 5). This results emphasized that the drought stress tolerance index can be influenced by growth medium and not merely genetic. Evaluation of drought stress tolerance indexes among genotypes showed that highest drought stress tolerance index was observed in genotypes 1 and 4, and the lowest drought stress tolerance index was observed in genotypes 3, 11 and 18 (Fig 6).

**Geometric Mean Productivity Index (GMP):** In this study, it was observed that geometric mean productivity index of canola was significantly affected by interaction of genotype and tested region (Table 4). The results showed that the geometric mean productivity index of rapeseed genotypes in region 1 was significantly higher than region 2 (Fig. 7). The genotype 1 in both regions was classified in the first grade in terms of the geometric mean productivity index.

**Table 4.** Variance analysis of stress indices

S.O.V	df	Mean squares				
		TOL	STI	SSI	MP	GMP
Region	1	0.28	0.33 <sup>*</sup>	0.001	13 <sup>**</sup>	15 <sup>**</sup>
Replication	4	0.49	0.03	0.05	0.29	0.2
Genotype	19	2/1 <sup>**</sup>	0.13 <sup>**</sup>	0.25 <sup>**</sup>	0.81 <sup>**</sup>	1.02 <sup>**</sup>
Genotype × region	19	0.28	0.014	0.06 <sup>*</sup>	0.09	0.11 <sup>*</sup>
Error	76	0.4	0.008	0.03	0.07	0.06
CV (%)	-	28.3	18.8	18.8	9.6	9.4
Coefficient of determination	-	0.57	0.83	0.70	0.84	0.88

\* Significant at 1% level, \*\* Significant at 5% level.

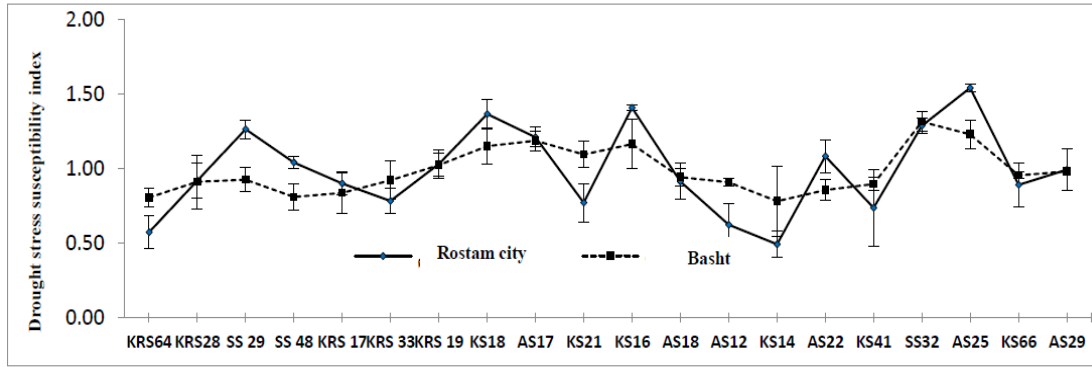


Fig 1. Interaction of Genotype and Region on SSI.

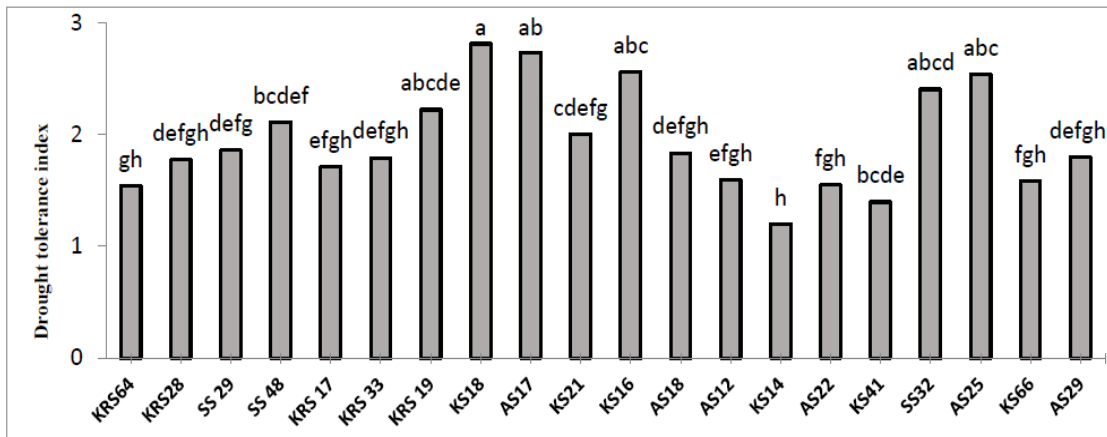


Fig 2. Drought tolerance index among canola genotypes genotypes.

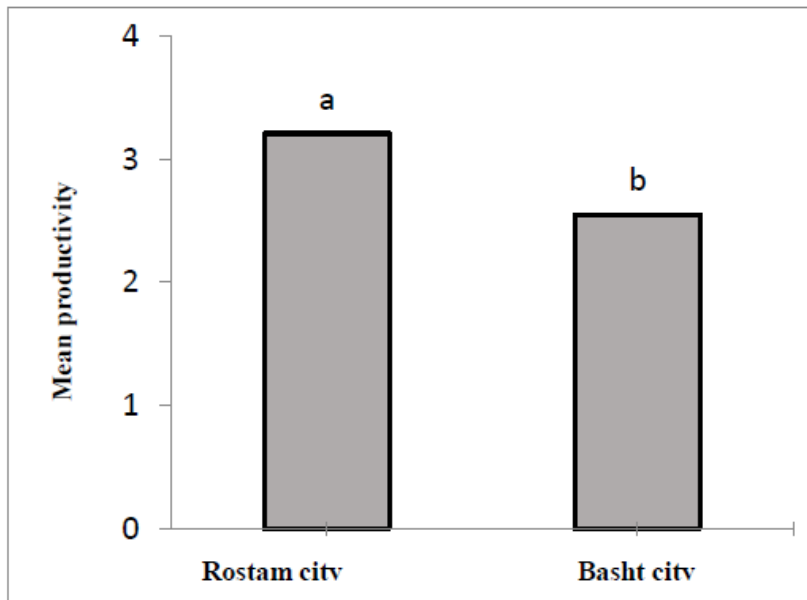


Fig 3. Mean productivity index in two regions

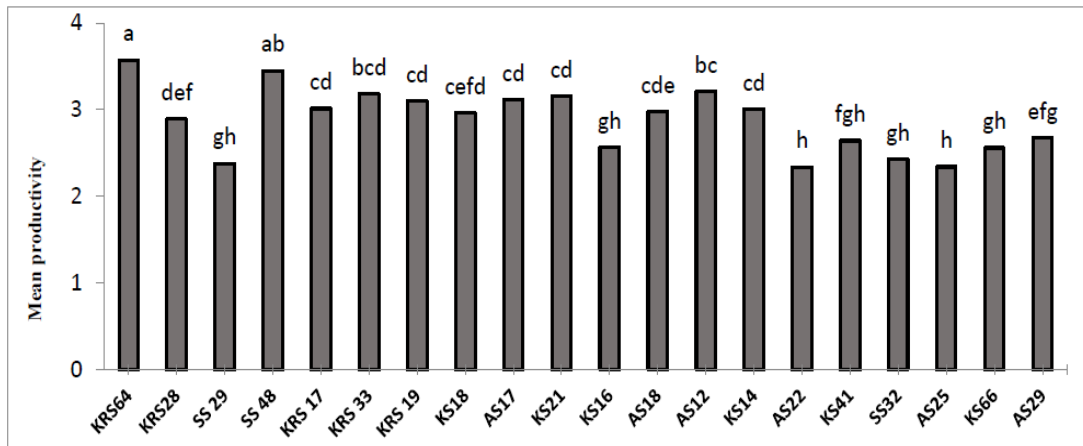


Fig 4. Mean productivity index among canola genotypes.

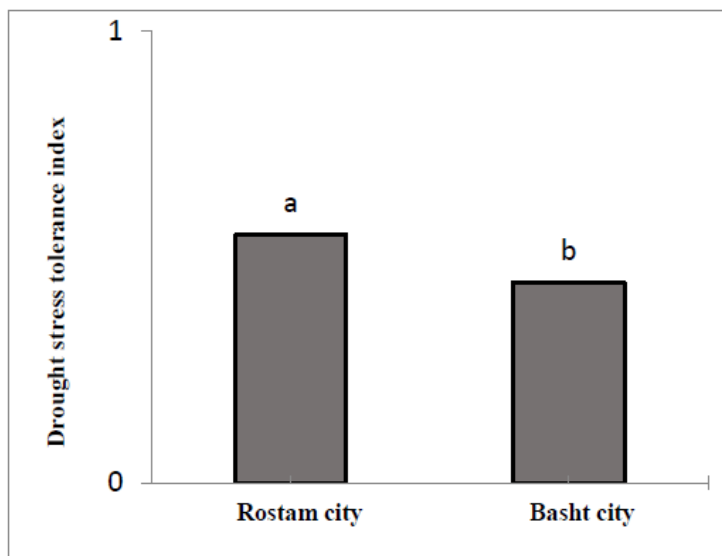


Fig 5. Drought stress tolerance index in two regions.

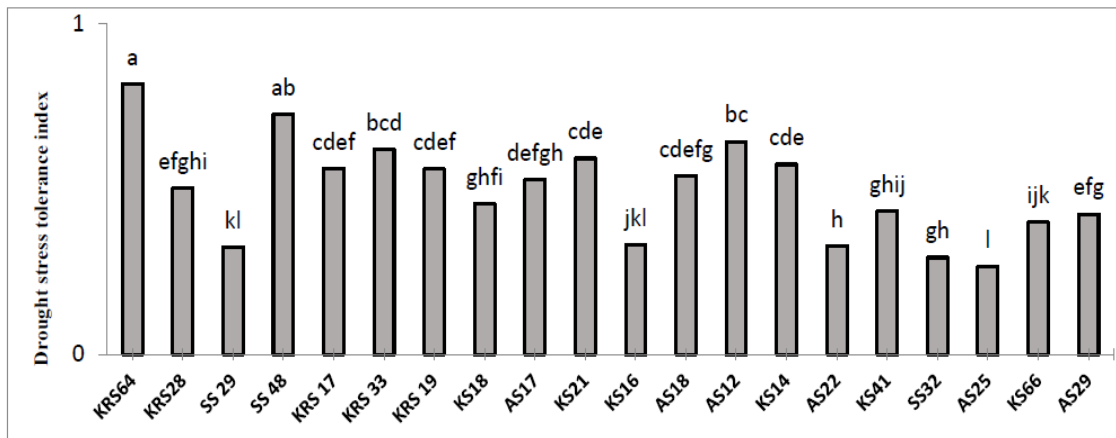


Fig 6. Drought stress tolerance index among canola genotypes.

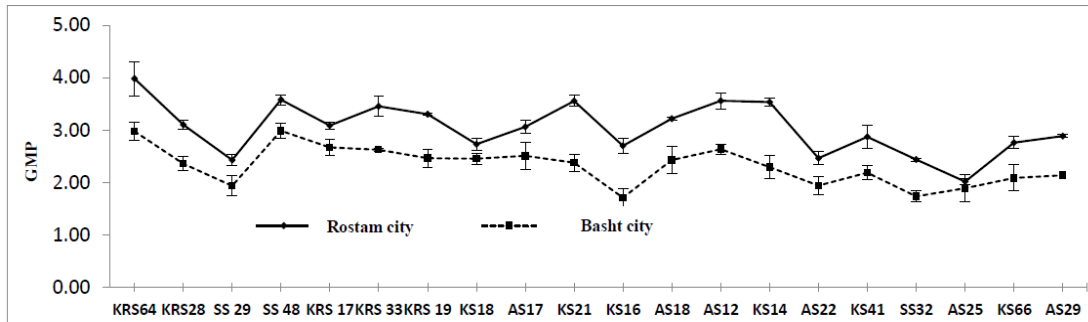


Fig 7. Interaction of Genotype and Region on GMP.

**Path analysis for yield and yield components under normal and drought stress conditions:** The yield components (number of pods, number of grains per pod and 1000 grain weight) and their formation technique ultimately determine the final yield in rapeseed. It has been reported that number of pod per plant and number of grains per pod, which are determined at flowering phase, are essential components of grain yield and are affected by various factors such as environmental stresses, water stress reduces their amounts (Puma et al., 1998). The Path analysis of yield and yield components of rape grain showed that highest direct effect on determining yield of canola in both normal and drought stress conditions was achieved through 1000 grain weight (Figures 8, 9). However, the direct effect of 1000-grain weight on determining yield was higher under drought stress conditions. In other words, the effect of 1000-grain weight in yield under drought stress conditions is more determinative than normal conditions. This result suggests that the mechanisms involved in filling grain (such as assimilates remobilization) under stress conditions are vital for optimal yield, and cultivars that are more able to fill the grain are more useful for stress conditions. Similar to this study, [11] also showed that 1000-grain weight was more effective in rapeseed grain yield than other yield components. These results were also consistent with the results of [12, 13] studied rapeseed genotypes under normal and stress conditions and then reported that 1000 grain weight had the most direct effect in determining rapeseed grain yield. These results were consistent with the findings of Siefert and Bullock (1977), Aser et al. (1999), [14], Tonektorck and Sifftsy (2007).

After determining the direct and higher effect of 1000-grain weight on determining yield, pods number per plant in the second phase was directly affected by the components of yield in determining rapeseed yield and the number of grains per pod had a direct lasting effect. Similar to 1000-grains weight, was seen that the direct effect of pods number under drought stress was higher than normal conditions. In other words, the effect of pod number on yield under drought stress conditions is more determiner. This results suggest that cultivars that have the ability to produce and maintain more pods are better and more useful for stress conditions. In other words, the production and protection of pods under drought stress conditions is a superior trait and can be the criterion for selection of cultivars for drought stress conditions because it directly plays a role in determining yield. In this regard, [15] suggested that the number of pods was more sensitive to drought stress than the grain yield components, and the number of pods decreased by increasing drought stress intensity. Therefore, genotype that can hold more pod under drought stress conditions will be a suitable genotype. The number of grains per pod had a less direct role in determining rapeseed yield and this role was less observed under stress conditions.

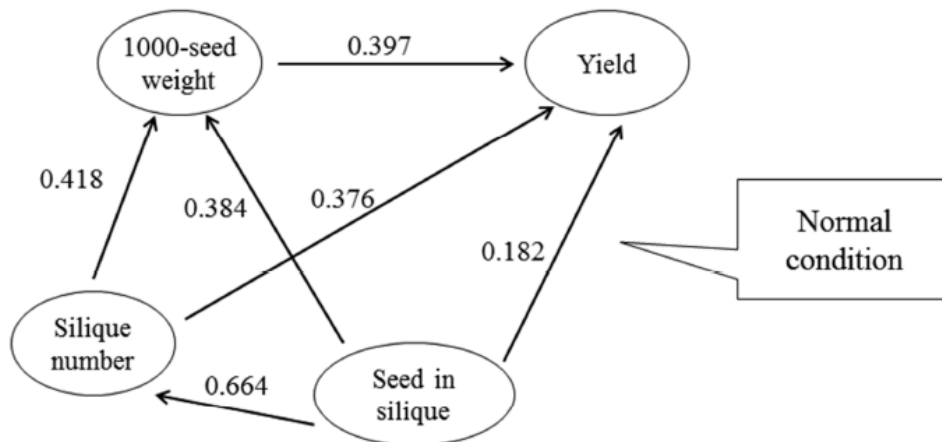


Fig 8. Path analysis for yield and yield components under normal conditions.

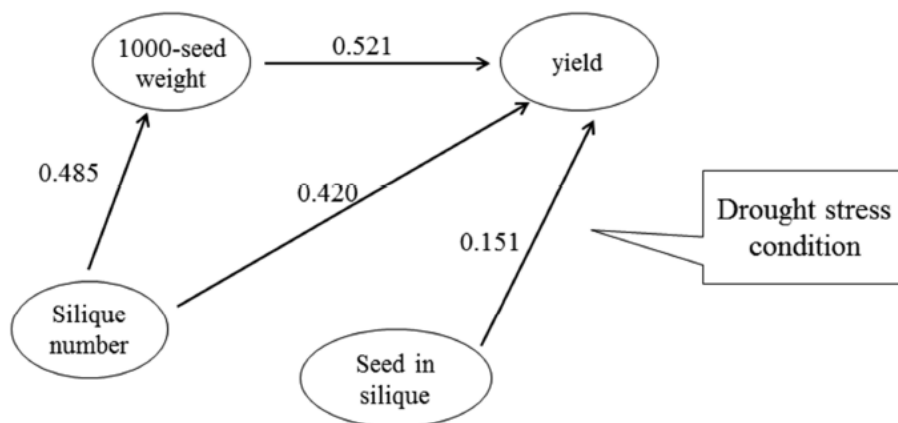


Fig 9. Path analysis for yield and yield components under drought stress conditions.

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