International Scholars Journals

African Journal of Agricultural Economics and Rural Development ISSN 2375-0693 Vol. 9 (2), pp. 001-004, February, 2021. Available online at www.internationalscholarsjournals.org © International Scholars Journals

Full Length Research Paper

A study of response of Cumin (*Cuminum cyminum* L.) Landraces to drought stress

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Accepted 4 October, 2020

Cumin (*CUMINUM CYMINUM* L.) is a herbaceous and medicinal crop which is one of the most important export crops for countries such as Iran. This study was conducted to study the effects of drought stress on agronomic traits in cumin landraces of Iran. This experiment was conducted in simple lattice design, with two replications in drought stress and non-stress conditions. Nine land races (49 sub landraces) from different origins of Iran were studies in this experiment. The characteristics such as number of umbels per plant, number of seed per umbels, number of seeds per plant, dry matter weight, 1000- seed weight and seed yield were evaluated. The results showed that drought stress significantly influenced some studied traits. There were significant differences among land races for number of seeds per plant and seed yield (P<0.05). The landraces of Yazd, Southern-Khorasan and Pars had the highest seed yield among evaluated landraces. Also these cumin landraces could be proposed for cultivation in arid regions with hot climate. It seems that in drought stress condition number of seeds per plant was the greatest factor that is affected by drought stress. This result could be proposed that cumin is a drought tolerance crop.

Key words: Cumin, drought stress, seed, yield.

INTRODUCTION

Cumin (*Cuminum cyminum* L.) a herbaceous, annual and medicinal which is one of the most important export crops for countries such as India, Iran and some other Asian countries (Kafie et al., 2002; El-sawi and Mohamed, 2002). Environmental stresses, especially drought stress, plays an important role in reduction of plant growth stages and seed yield in arid and semi arid regions. Production of this plant is limited due to several biotic stresses of which wilt diseases is the most serious (Agarwal et al., 2010). Cumin needs low water for growth cycle, and grows in arid and semi-arid regions of the world (Singh and Goswami, 2000).

Generally *Umbeliferae* species including *Cuminum cyminum* have antimicrobial properties (Shetty et al., 1994; Singh and Goswami, 2000).

Cumin seed is generally used as a spicy food in the form of powder for imparting flavor to different food preparations (Kafie et al., 2002). It also has a variety of medicinal properties (Avatar et al., 1991). Paranshimic organs in cumin have oils, resins (therpenoeid saponini) and monoterpens (Aminpoor and Mousavi, 1996; Li and Jiang, 2004). The cumin seeds contain 3 to 4% volatile oil and about 15% fixed oil (Zarghari, 1982). The fruits contain 2.5 to 4% essential oil. In the essential oil, cumin aldehyde (*p*-isopropyl-benzaldehyde, 25 to 35%), furthermore perilla aldehyde, cumin alcohol, α- and β-pinene (21%), dipentene, *p*-cymene and β-phellandrene were found (Avatar et al., 1991; El-sawi and Mohamed,

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2002; Li and Jiang, 2004). Main essential oil of cumin is cumin aldehyde or cuminol ($C_{10}H_{12}O$) (Zarghari, 1982).

In view point of economic value, cumin has numerous uses from its seeds such as drug and spicy for about a thousand years ago (Agarwal et al., 2010). It is regarded as part of food culture in some of the countries with arid and semi-arid climates (Tuncturk and Tuncturk, 2006). Therefore, trade and consumption of the crop is almost limited to natural areas that produce it (Avatar et al., 1991). The areas of production create numerous business opportunities because the planting operations of cumin require many human resources, thus create employment prospects in those regions (Bahraminejad et al., 2011). West Asia is a predominant habitat of this plant (Kafie et al., 2002). Iran is one of the main producers of this plant (Kafie et al., 2002).

Cumin yield components include number of umbel per plant, number of seeds per umbel and 1000-seed weight. The number of umbel per plant explained alone about 96% of yield variation (Aminpoor and Mousavi, 1996). Different regions of cumin adaptation can vary in terms of yield and genetic components due to variation in genetic characteristics and ecological influence.

Drought stress in agricultural lands is one of the factors of environments, which limits the growth and yield of cumin and other crops in many arid and semiarid regions of the world (Shannon, 1984; Shao et al., 2008). Identifying proper selection criteria for drought tolerance is also a major problem. Rapid screening techniques based on heritable characteristics for selecting drought tolerance plants are needed. Some studies reported about the effect of drought stress on cumin genotypes (Tavoosi, 2000; Amini and MollFilabi, 2011). Tavoosi (2000) studied the effects of irrigation regimes on cumin yield and reported that moisture potential of soil on cumin reached 30 bars in last growing period but not any sign of wiltness was observed. These indicate that cumin is able to absorb water even in very low water potential. Tavoosi (2000) reported that cumin is able to absorb water even in very low water potential. The objective of this study was to evaluate the response of Cumin (*Cuminum cyminum* L.) Landraces to drought stress.

MATERIALS AND METHODS

In this study forty nine ecotypes of cumin was used. These ecotypes were subpopulations that were belonged to nine populations from different provinces of Iran was used. The most variation of Iranian cumin genotypes was laid out in a simple lattice design with two replications at the Agricultural Research of Agriculture at Kerman University in Iran (56°58´ longitude and 30°15´ latitude and, 1755 m Altitude from sea level) in stress and non-stress conditions. This location had arid and semi-arid climate. The pH of soil field experiment was 7.8 with clay- loamy texture (physical and chemical properties of soil in experimental field were presented in Table 1). The genotypes were planted in plots with 4 m length. The genotypes were sown at 12th of April in 2009. The row spacing was 50 cm and the distance between plants was 5 cm. All of the experimental plots were treated uniformly. In order to applying drought stress, in experiment with drought stress three irrigations (170 mm) has been done, but in experiment without drought stress five irrigations (300 mm) has been done. Amount of water has been calculated by Micheal and Ojha (1987) formula.

Plants were harvested, nearby 5 month after planting date. The studied traits were measured on the 20 randomly selected. The measured quantitative traits were including: number of umbel per plant, number of seed per umbel, number of seed per plant, 1000 - seed weight, dry matter weight and seed yield. Analysis of variance was done by using SAS software (SAS Inc., 1999).

RESULTS AND DISCUSSION

The results showed that drought stress had significant influence on evaluated traits. There were significant differences among land races for number of seed per plant and seed yield.

Number of umbels per plant

Drought stress had significant effect on number of umbels per plant (Table 2). Number of umbels per plant in drought stress was lower than normal situation (Table 3). Drought stress decreased the number of umbels per plant about 66.33% in comparison with control treatment. There were not significant differences among the land races for number of umbels per plant (Table 2). The landrace Yazd had the highest number of umbels per plant (21.25) (Table 4). The lowest umbel per plant (14.25) was obtained from Northern_Khorasan landrace (Table 4).

Number of seeds per umbels

Analysis of variance showed that the number of seed per umbels was significantly affected by drought stress (Table 2), so the number of seeds per umbels decreased under drought stress (Table 3). There were no significant differences among the land races for number of seeds per umbels. The highest number of seeds per umbels (15.5) was obtained in Khorasan-Razavi landrace while the lowest number of seeds per umbels (13.75) was determined in Pars and Semnan landraces (Table 4).

Number of seeds per plant

Drought stress had significantly effect on number of seeds per plant (Table 2). Drought stress decreased the number of seeds per plant about 57.77% in comparison with control treatment (Table 3). There were significant differences ($P<0.05$) among evaluated land races for number of seeds per plant (Table 2). The highest number of seeds per plant (253.75) was obtained from Yazd landrace and subsequently followed by from Southern-Khorasan (250.75) and Pars (220.75) landraces (Table 4). The lowest number of seeds per plant (161.25) was obtained from Northern-Khorasan land race (Table 4).

Table 1. Soil analysis result for physical and chemical characteristics of non salt soil.

Fe	Zn	K	P	pH	EC (dS/m^{-1})	OC (%)	Soil texture	Soil depth (cm)	Characteristic
6.02	0.42	200	6.5	78	0.52	0.82	Clay- loamy	0-30	Value

OC: Organic carbon; EC: Electrical conductivity.

Table 2. Combined analysis of variance of seed yield and its component of cumin landraces.

S.O.V.	df	Umbel /plant	Seed /Umbel	Seed yield/plant	1000–seed weight	Dry matter	Seed yield
Environment	1	747.11**	205.44**	73712.25**	5.27**	1.97**	3.16**
Replication× environment	2	140.27	60.55	65171.80	2.39	1.83	0.38
Genotype	8	18.50^{ns}	1.31^{ns}	3487.17*	0.06^{ns}	0.11^{ns}	0.08*
Genotype × environment	8	9.23^{ns}	5.31^{ns}	905.56^{ns}	0.08^{ns}	0.03^{ns}	0.01^{ns}
Residual	18	11.46	2.93	1068.74	0.05	0.07	0.03
C.V. (%)	-	18.63	11.71	16.89	5.80	17.37	19.03

**, * Significant at P<0.01 and P<0.05 respectively, ns: non-significant.

Table 3. Results of comparison of drought stress on seed yield and its component of cumin landraces.

Environment	Umbel /Plant	Seed /Umbel	Seed /Plant	1000–seed weight (g)	dry matter (g)	seed yield (g)
Non stress	22.72^{a}	17^{a}	256.06^{a}	4.47^{a}	1.81^{a}	1.22^{a}
stress	13.61^{b}	10.22^{b}	165.56^{b}	3.70^{ab}	1.34^{ab}	0.63^{c}

Common letters indicate no significant difference between treatment means for the same column.

Table 4. The results of drought stress effect on seed yield and its component of cumin landraces.

Landraces	Umbel /Plant	Seed /Umbel	Seed /Plant	1000–seed weight (g)	Dry matter (g)	Seed yield (g)
Khorasan-Razavi	16.50^{ab}	15.50^{a}	198.75^{ab}	3.17^{b}	1.59^{ab}	0.87^{a-c}
Southern-Khorasan	20^{ab}	14.75^{a}	250.75^{a}	4.07^{ab}	1.72^{a}	1.05^{ab}
Esfahan	17.50^{ab}	14.75^{a}	208^{ab}	4.05^{ab}	1.48^{ab}	0.69^{c}
Pars	19.50^{ab}	13.75^{a}	220.75^{ab}	4.29^{a}	1.61^{ab}	1.02^{ab}
Yazd	21.25^{a}	15^{a}	253.76^{a}	4.24^{ab}	1.74^{a}	1.15^{a}
Semnan	19.50^{ab}	13.75^{a}	182.25^{b}	3.95^{ab}	1.61^{ab}	0.84^{bc}
Golestan	16.75^{ab}	15^{a}	208.50^{ab}	4.11^{ab}	1.45^{ab}	0.94^{a-c}
Kerman	18.25^{ab}	14.50^{a}	213.25^{ab}	4.11^{ab}	1.74^{a}	0.97^{a-c}
Northern-Khorasan	14.25^{b}	14.50^{a}	161.25^{b}	4.10^{ab}	1.21^{b}	0.77^{bc}

Common letters indicate no significant difference between treatment means for the same column.

Dry matter weight

The result of analysis of variance showed that drought stress had significant effect on dry matter weight reduction (Table 2). There were not significant differences among the genotypes for dry matter weight (Table 2). According to the results, highest dry matter weight was obtained from Yazd and Kerman land races (1.74 g) and the lowest content of dry matter weight was denoted to Northern-Khorasan land race (Table 4). In general, our results indicated that drought stress limited the growth cumin and its biomass production, which was in agreement with the results of Bettaieb et al. (2011). Indeed, in order to diminish consumption and increase absorption of water, plants in dry conditions often decrease their biomass production and contribute more biomass to roots (Shao et al., 2008). Furthermore, a decrease in total dry matter may be to considerable decrease in plant growth, photosynthesis and canopy structure during water deficit (Shao et al., 2008).

1000 - Seed weight

Results showed that drought stress had a significant effect on 1000- seed weight (P<0.01), (Table 2), and it in condition with drought stress1000- seed weight was decreased in significantly in drought condition rather than normal condition (Table 3). Drought stress decreased 1000 - seed weight in about 20.81% in comparison with control treatment (Table 3). There were no significant differences among the genotypes for 1000 - seed weight (Table 2). The highest (4.29 g) and the lowest content (3.17) of 1000 - seed weight was obtained from Pars and Khorasan-Razavi landraces, respectively (Table 4). This result is inconsistence with the results of Kim et al. (2007) who reported that drought treatments did not affect the seed weight of sesame. It could be concluded that drought stress could have a major effect on post flowering stages by reduction of seed numbers, but not seed size.

Seed yield

Analysis of variance showed that, the effect of drought stress on seed yield was significant (P<0.01) (Table 2). Significant differences was observed (P<0.05) among evaluated land races for seed yield (Table 2). The highest and the lowest seed yield was obtained from Yazd (1.15 g) and Esfahan (0.69) landraces, respectively (Table 4). Under water shortage conditions, nutrient absorption and water uptake are limited, that led to decrease growth, leaf expansion, light absorption and photosynthetic potential of plant. And as a result, plant yield was being restricted (Amini and MollFilabi, 2011). These results are in agreement with those obtained by Ahmadian et al. (2009).

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