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Influence of seed priming on ground cover and grain yield of spring and winter rapeseed cultivars

Kazem Ghassemi-Golezani^{1*}, Sakineh Jabbarpour², Saeid Zehtab-Salmasi¹

¹Department of Plant Eco-Physiology, Faculty of Agriculture, University of Tabriz, Tabriz, Iran

²Department of Agriculture, Islamic Azad University, Maku Branch, Maku, Iran

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Abstract

This research was carried out during 2007-2008 to investigate the effect of salt priming (0.8% NaCl with electrical conductivity of 15.3 dSm⁻¹ and 0.8% KNO₃ with electrical conductivity of 12.5 dSm⁻¹ for 8 hours at 20±1°C) on a spring rapeseed (Hayola 401) and three winter rapeseed (Okapi, Opera and Talayeh) cultivars under different irrigation intervals. The field experiments were arranged as split plot for spring rapeseed and split plot factorial for winter rapeseeds on the bases of RCB design in three replicates. Irrigation treatments were irrigation after 70, 100 and 130 mm evaporation from class A pan for spring cultivar and irrigation after 80, 120 and 160 mm evaporation for winter cultivars. Seed priming (particularly priming with KNO₃) of winter rapeseed cultivars improved grain yield per unit area through enhancing rate and percentage of seedling establishment, ground cover and grains per plant. However, salt priming had no significant effect on field performance of spring rapeseed. Irrigation intervals with 130 mm evaporation decreased ground cover of spring rapeseed, but had no significant effect on yield components and grain yield per plant and per unit area. Almost similarly, field traits of winter rapeseed cultivars were not significantly affected by irrigation treatments. In general Talayeh had the highest ground cover, compared with Okapi and Opera. Poor stand establishment of the latter cultivars was largely compensated by production of more, but smaller grains by Okapi and larger grains by Opera. Consequently, grain yield per unit area did not differ significantly among cultivars.

*Corresponding Author: Ghassemi-Golezani ✉ golezani@gmail.com, sakinehjabarpoor@yahoo.com

Introduction

High quality seed lots may improve grain yield of crops in two ways: first because emergence of seedlings from the seedbed are rapid and uniform leading to the production of vigorous plants (Roberts and Osei-Bonsu, 1988; Ghassemi-Golezani, 1992; Begnami and Cortelazzo, 1996) and second because percentages of seedling emergence are high, so optimum stand establishment can be achieved under a wide range of environmental conditions (Perry, 1980). Seed quality may be improved by production techniques or by seed pretreatments with water (hydro-priming), osmotic solutions (osmo-priming) and matric materials (matri-priming) (Hur, 1991; Harris *et al.*, 1999; Kaya *et al.*, 2008; Pill *et al.*, 1991). Seed priming is a pre-germination treatment in which seeds are held at a water potential that allows imbibition, but prevents radicle extension (Bradford, 1986). This is a suitable method to enhance seed and seedling vigor, leading to better stand establishment and yield (Ghassemi-Golezani *et al.*, 2008c; Ghassemi-Golezani *et al.*, 2010a,b; Khalil *et al.*, 2010). The effects of seed priming are associated with the repairing and building-up of nucleic acids, increasing synthesis of proteins as well as repairing of the membranes (McDonald, 2000). Priming also enhances the activities of anti-oxidative enzymes in treated seeds (McDonald, 1999; Wang *et al.*, 2003; Hsu *et al.*, 2003).

The beneficial effects of priming have been reported for many field crops such as barley (Ghassemi-Golezani and Abdurrahmani, 2012), wheat (Parera and Cantliffe, 1994), sugar beet (Sadeghian and Yavari, 2004), soybean (Khajeh-Hosseini *et al.*, 2003), pinto bean (Ghassemi-Golezani *et al.*, 2010a), lentil (Ghassemi-Golezani *et al.*, 2008a), chickpea (Ghassemi-Golezani *et al.*, 2008c), sunflower (Singh and Rao, 1993; Singh, 1995) and sorghum (Moradi and Younesi, 2009). However, response of winter rapeseed cultivars to seed priming, particularly salt priming is not well documented. Thus, this research was aimed to investigate the effects of salt priming on ground cover and grain yield of spring and winter

rapeseed cultivars under different irrigation treatments.

Materials and methods

Seeds of a spring rapeseed cultivar (*Brassica napus* L. cv. Hayola-401) with 99% germination and three winter rapeseed cultivars including Okapi, Opera and Talayeh with 95%, 88.3% and 97.3%, respectively, were obtained from Agricultural Jihad Organization, Iran. These seeds were divided into three sub-samples. A sub-sample was kept as control (unprimed) and the two other sub-samples were prepared for priming treatments. Seeds of a sub-sample were soaked in 0.8% NaCl solution with electrical conductivity of 15.3 dSm⁻¹ and seeds of another sub-sample were pretreated by 0.8% KNO₃ solution with electrical conductivity of 12.5dSm⁻¹ for 8 hours. Priming treatments were performed in an incubator adjusted on 20±1°C under dark conditions. After priming, seeds were washed with tap water for 1 min and then dried back to the primary moisture at room temperature of 20-22°C. All the seeds were treated with Benomyl at a rate of 2 g kg⁻¹ before sowing.

A field experiment was conducted for spring rapeseed at the Research Farm of the Faculty of Agriculture, University of Tabriz (longitude 46 ° 17' E, latitude 38 ° 3', Altitude 1360 m above sea level) and another experiment was carried out for winter rapeseed in a farm located at the east of Makue (latitude 39° 15' E, longitude 44° 44' N, Altitude 955 m above sea level), Iran. Soils type was sandy loam with an EC of 0.63dSm⁻¹ and a pH of 8.1 for spring rapeseed and sediment loam with an EC of 1.6dsm⁻¹ and a pH of 8.2 for winter rapeseed. The mean annual precipitation and maximum and minimum temperatures were 218.45 mm, 15.8 °C and 2.51 °C for Tabriz and 290 mm, 16.3°C and 5.6°C for Makue, respectively.

Seeds were hand sown in about 1.5 cm depth with a density of 100 seeds m⁻² on 8 May and 16 September 2007 in Tabriz and maku, respectively. Each plot consisted of 8 rows with 3 cm length, spaced 25 cm apart. The field experiments were arranged as split

plot for spring rapeseed and split plot factorial for winter rapeseed on the bases of RCB design in three replicates, with Irrigation treatments (I_1 , I_2 and I_3 : irrigation after 70, 100 and 130 mm evaporation from class A pan for spring rapeseed and irrigation after 80, 120 and 160 mm evaporation for winter rapeseed) in main plots and salt priming in spring experiment and salt priming with cultivars in winter experiment in sub-plots. Irrigation treatments were applied after seedling establishment. Weeds were controlled by hand weeding during crop growth and development. The number of emerged seedlings in an area of 1 m^2 within each plot was counted in daily intervals until seedling establishment stabilized. Method of Ellis and Roberts (1980) was applied to calculate mean emergence time. After seedling establishment, ground cover was measured in later spring (2007) for spring rapeseed and later autumn (2007) for winter rapeseed, by viewing the canopy through wooden frame ($50 \times 50 \text{ cm}$ dimensions) divided into 100 equal sections. The sections were counted when more than half of each filled with oilseed rape green area. At maturity, the plants of 1 m^2 in the middle part of each plot were harvested and grains per pod, 1000 grain weight and grain yield per unit area were determined. Analysis of variance of the data appropriate to the experimental design and comparison of means at $p \leq 0.05$ were done using

MSATAC software. Excel software was used to draw figures.

Results

Spring rapeseed

Analysis of variance of the data showed that the effects of salt priming on field traits of spring rapeseed were not significant. The effect of irrigation was only significant for ground cover, but it has no significant effect on other traits (Tab. 1). Irrigation intervals with 130 mm evaporation significantly decreased ground cover percentage, compared with other irrigation treatments (Fig. 1).

Winter rapeseed

Analysis of variance of the data showed that seedling emergence percentage was significantly affected by cultivar and salt priming ($P \leq 0.01$). The effect of salt priming on emergence time was also significant ($P \leq 0.01$), but cultivar had no significant effect on this trait ($P > 0.05$). Mean emergence percentage for Talayeh was significantly higher than that for Okapi and Opera, but differences in mean emergence time among cultivars were not statistically significant. The highest emergence percentage and the lowest emergence time were achieved by salt-priming with KNO_3 , followed by NaCl priming. Seedlings from unprimed seeds emerged later and were less than those from salt-primed seeds (Tab. 3).

Table 1. Analysis of variance of the effects of irrigation and salt priming on field traits of spring rapeseed cultivar.

MS						
Source of variation	df	Ground cover	Grains Per plant	1000 grain weight	Grain yield per plant	Grain yield
Replication	2	120.04 ^{ns}	728402.78 ^{ns}	0.529 ^{ns}	4.47 ^{ns}	17132.89 ^{ns}
Irrigation (I)	2	1964.04 ^{**}	206845.41 ^{ns}	0.275 ^{ns}	0.322 ^{ns}	34608.91 ^{ns}
Error	4	101.87	1352362.58	0.164	2.14	7438.64
Salt priming (P)	2	64.59 ^{ns}	382430.63	0.055 ^{ns}	1.41 ^{ns}	1234.52 ^{ns}
I × P	4	23.43 ^{ns}	661406.61 ^{ns}	0.093 ^{ns}	1.46 ^{ns}	4782.39 ^{ns}
Error	12	209.87	392541.13	0.067	0.987	2263.80
C.V%	-	22.98	25.54	7.19	20.53	18.12

ns,* and **: No significant and significant at $p \leq 0.05$ and $p \leq 0.01$ respectively.

Ground cover, grains per plant and 1000 grain weight of winter rapeseed were significantly influenced by

cultivar, but the effects of cultivar on grain yield per plant and per unit area were not significant. The

effects of salt priming on grains per plant and grain yield per unit area were significant, but other traits were not significantly affected by seed priming. Water limitation had no significant effects on field traits.

The interaction of salt priming \times cultivar was significant for ground cover and grains per plant (Tab. 2).

Table 2. Analysis of variance of field traits for winter rapeseed cultivars affected by salt priming and irrigation treatments.

MS						
Source of variation	df	Ground cover	Grains Per plant	1000 grain weight	Grain yield per plant	Grain yield
Replication	2	438.93 ^{ns}	273762.82 ^{ns}	0.075 ^{ns}	8.13 [*]	80304.46 ^{ns}
Irrigation (I)	2	16.26 ^{ns}	985956.67 ^{ns}	0.122 ^{ns}	1.81 ^{ns}	793.36 ^{ns}
Error	4	450.57	1005813.84	0.187	0.79	25892.42
Cultivar (C)	2	664.04 [*]	3821614.09 ^{**}	4.942 ^{**}	6.93 ^{ns}	19683.83 ^{ns}
I \times C	4	7.07 ^{ns}	819140.48 ^{ns}	0.079 ^{ns}	0.79 ^{ns}	8074.18 ^{ns}
Salt priming (P)	2	469.00 ^{ns}	1807146.69 [*]	0.048 ^{ns}	1.10 ^{ns}	67181.57 [*]
I \times P	4	280.98 ^{ns}	60070.74 ^{ns}	0.059 ^{ns}	5.28 ^{ns}	28821.24 ^{ns}
C \times P	4	542.87 [*]	1637558.10 [*]	0.063 ^{ns}	4.86 ^{ns}	13847.79 ^{ns}
I \times C \times P	8	99.82 ^{ns}	462704.30 ^{ns}	0.059 ^{ns}	3.31 ^{ns}	21326.53 ^{ns}
Error	48	189.54	668825.46	0.198	5.62	17229.16
C.V%	-	15.70	36.49	10.46	35.95	36.14

ns, * and ** : No significant and significant at $p \leq 0.05$ and $p \leq 0.01$ respectively.

Table 3. Means of field traits for winter rapeseed affected by salt priming and cultivar.

Treatments	Seedling emergence (%)	emergence time (day)	Ground cover (%)	Grains Per plant	1000 grain weight (g)	Grain yield (gm ⁻²)
Cultivar						
Okapi	52.67 ^b	5.84 ^a	83.44 ^b	2494.59 ^a	3.83 ^c	328.73 ^a
Opera	51.56 ^b	6.09 ^a	86.52 ^{ab}	1862.09 ^b	4.69 ^a	334.71 ^a
Talayeh	65.56 ^a	5.70 ^a	93.15 ^a	1914.25 ^b	4.25 ^b	384.75 ^a
Priming						
unprimed	49.78 ^b	6.28 ^a	82.93 ^a	1794.73 ^b	4.23 ^a	295.08 ^b
NaCl	59.26 ^a	5.85 ^b	90.59 ^a	2133.04 ^{ab}	4.30 ^a	363.86 ^{ab}
KNO ₃	60.74 ^a	5.50 ^c	89.59 ^a	2317.39 ^a	4.23 ^a	391.6 ^a

Different letters in each column for each treatment indicate significant difference at $p \leq 0.05$.

Salt priming significantly enhanced the mean ground cover of Okapi, but had no significant effect on this trait in Opera and Talayeh (Fig. 2). The highest ground cover percentage was recorded for Talayeh, followed by Opera and Okapi (Tab. 3). Okapi produced the highest grains per plant, but the smallest grains, compared with other cultivars. Although Opera had the least grains per plant and the

highest 1000 grain weight, the number of grains per plant was statistically similar for Opera and Talayeh. Mean grains per plant and grain yield per unit area increased due to salt priming. The highest improvement in these traits was achieved by KNO₃ priming (Tab. 3). Salt priming enhanced the number of grains per plant in Okapi and Talayeh, but had no effect on this trait in Opera (Fig. 3).

Discussion

Salt priming had no significant effects on field performance of spring rapeseed. Seed quality of spring rapeseed was high with 99% germination. This result indicates that salt priming had no effect on high quality seeds. Nascimento and Aragao (2004) reported that seed priming of two cultivars of muskmelon (aged at 43°C and 100% RH for 0, 20 and 40 hours) increased germination performance in seeds of low vigor, but had no effect on high vigor seeds. Also in leek (Bray, 1995) and Lettuce (Perkines-Veazie and Cantliffe, 1984), positive effects of seed priming was only reported for low vigor seeds. In contrast, salt priming of winter rapeseed cultivars enhanced rate and percentage of seedling emergence in the field. Seed priming with KNO₃ was the superior treatment in this regard (Tab. 3). Therefore, salt priming particularly with KNO₃ can ensure satisfactory stand establishment of rapeseed cultivars in the field. Similar effects of salt priming on seedling establishment were reported for lentil (Ghassemi-Golezani *et al.*, 2008a), cucumber (Ghassemi-Golezani and Esmailpour, 2008) and sunflower (Hussain *et al.*, 2006).

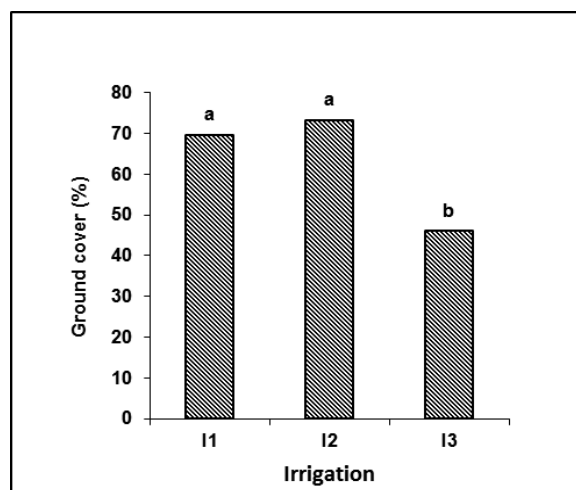


Fig. 1. Mean ground cover percentage of spring rapeseed cultivar affected by different Irrigation treatments

I₁, I₂ and I₃: irrigation after 70, 100 and 130 mm evaporation from class A pan

Different letters indicate significant difference at $p \leq 0.05$

Variations in seedling emergence percentage among winter rapeseed cultivars (Tab. 3) are closely

associated with differences in initial quality of their seed lots. Thalayeh had the highest seedling establishment in the field, compared with Okapi and Opera (Tab. 3). Optimum stand establishment of Talayeh led to the highest ground cover of this cultivar in the field, compared with Okapi and Opera (Tab. 3). Poor stand establishment of the latter cultivars was largely compensated by production of more, but smaller grains by Okapi and larger grains by Opera. Consequently, grain yield per unit area did not differ significantly among cultivars (Tab. 3). Low seedling emergence from unprimed seeds of Okapi resulted in lower ground cover of this cultivar, compared with other cultivars. Salt priming increased ground cover of Okapi more than other cultivars (fig. 2). Optimum stand establishment and early achievement of maximum ground cover are essential for the efficient use of resources like water and light (Nasrullahzadeh *et al.*, 2007; Ghassemi-Golezani *et al.*, 2008b, c; Ghassemi-Golezani *et al.*, 2010b). There is a linear relationship between ground cover and light interception (Burstall and Harris, 1983). Therefore, it is a reliable index to estimate crop performance under different environmental conditions (Ghassemi-Golezani *et al.*, 2008b; Ghassemi-Golezani and Mardfar, 2008).

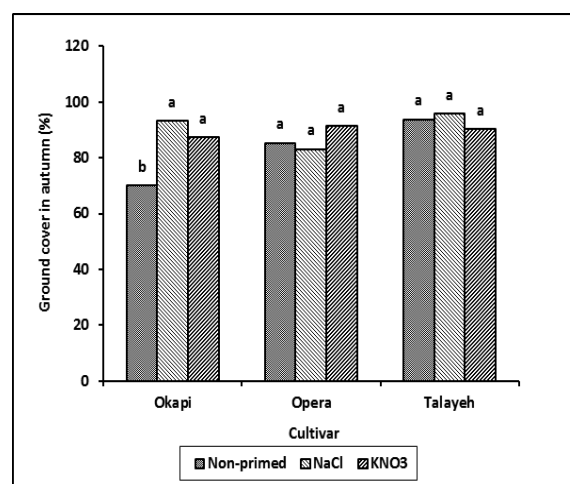


Fig. 2. Mean ground cover percentage of winter rapeseed cultivars affected by salt priming. Different letters indicate significant difference at $p \leq 0.05$.

Irrigation intervals with 130 mm evaporation decreased ground cover of spring rapeseed, but had no significant effect on yield components and grain yield per plant and per unit area (Tab. 1). Almost

similarly, field traits of winter rapeseed cultivars were not significantly affected by irrigation treatments (Tab. 2). These results suggest that spring and winter rapeseed cultivars can well-tolerate irrigation intervals up to 130 and 160 mm evaporation from class A pan, respectively.

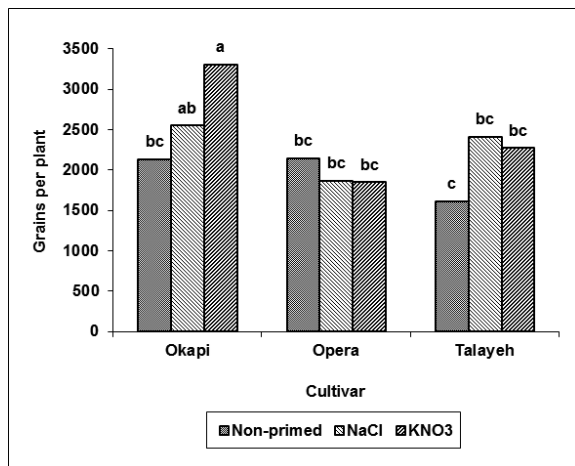


Fig. 3. Mean grains per plant of winter rapeseed cultivars affected by salt priming. Different letters indicate significant difference at $p \leq 0.05$.

The effects of salt priming on increasing seedling establishment, ground cover and grains per plant of winter rapeseed led to considerable improvement in grain yield per unit area (Tab. 3). Enhancement in number of grains per plant, due to seed priming, was only observed in Okapi and Talayeh (Fig. 3). The highest improvement in grain yield per unit area was achieved by KNO₃ priming (32.7%), followed by NaCl priming (23.3%). The superiority of KNO₃ priming over NaCl priming was also reported for watermelon (Sachs, 1977; Nerson, *et al.*, 1985; Demir and Van de Venter, 1999; Demir and Ozokat, 2003), muskmelon (Bradford, 1985), cucumber (Ghassemi-Golezani and Esmaeilpour, 2008) and isabgol (Ghassemi-Golezani *et al.*, 2012). This advantage may be related to more nitrogen and potassium accumulation in seeds treated with KNO₃ (Alevarado and Bradford, 1988; Bellti *et al.*, 1993).

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