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Seed Vigor and Field Performance of Winter Oilseed Rape (*Brassica napus* L.) Cultivars

Kazem GHASSEMI-GOLEZANI, Javad BAKHSHY, Yaeghoob RAEY, Ayda HOSSAINZADEH-MAHOOTCHY

University of Tabriz, Faculty of Agriculture, Department of Agronomy and Plant Breeding, Tabriz, Iran; golezani@gmail.com

Abstract

The effect of seed vigor on field performance of two oilseed rape cultivars ('Licord' and 'Okapi') was investigated in 2008 at the Research Farm of the University Tabriz, Iran. The experiment was arranged as factorial based on RCB design with three replications. A sub-sample of seeds of each cultivar was kept as control. The other two sub-samples of each cultivar with about 15% moisture content were artificially deteriorated at 40°C for 9 and 12 days ('Licord') and 7 and 10 days ('Okapi'). Consequently, three seed lots for each cultivar with different levels of vigor were provided. The results showed that the mean emergence time increased with decreasing seed vigor. However, the highest percentage of seedling emergence was obtained for the high quality seed lot and decreased with decreasing seed lot vigor. Decreasing seed vigor led to significant reduction in ground cover of both cultivars; mainly due to poor stand establishment. Ground cover of 'Licord' was higher than that of 'Okapi'. Plants from high vigor seed lots of both cultivars had higher leaf chlorophyll content index at early stages of growth, compared with those from low quality seed lots. Grains per plant, 1000 grain weight and grain yield per plant for plants from deteriorated seed lots were higher than those from high-vigor seed lot. However, these advantages in individual plant performance were not sufficient to compensate for low stand establishment. Consequently, grain yield per unit area significantly improved with increasing seed vigor of oilseed rape cultivars, even within the range of acceptable germination.

Keywords: grain yield, ground cover, oilseed rape, seed vigor, stand establishment

Introduction

Seed vigor is one of the important parameters of seed quality which can potentially influence crop yield through affecting seedling establishment, particularly under adverse environmental conditions (Ghassemi-Golezani *et al*., 2010; Perry, 1980a). Maximum seed vigor on the mother plant is attained at the end of seed filling phase (Harrington, 1972; Tekrony and Hunter, 1995; Tekrony and Egli, 1997) or slightly after this phase (Demir and Ellis, 1992, 1993; Ellis and Pieta Filho, 1992; Ghassemi-Golezani and Mazloomi-Oskooyi, 2008; Pieta Filho and Ellis, 1991; Sanhewe and Ellis, 1996). Seeds can then retain their high quality for some time and thereafter begin to deteriorate on the mother plant or during storage, loosing viability and vigor (Ellis and Pieta Filho, 1992; Ghassemi-Golezani and Hosseinzadeh-Mahootchy, 2009).

The rate of seed deterioration is positively related to ambient temperature, relative humidity and seed moisture content (Ellis and Roberts, 1981; Roberts, 1986). Membrane disruption is one of the main reasons of seed deterioration. The major causes of membrane disruption are increase in free fatty acid level and free radicals productivity by lipid peroxidation (Grilli *et al.,* 1995). Free fatty acid act as detergents and can damage lipid bilayer especially of mitochondria leading to reduce energy production (Booth and Bai, 1999) and free radicals have potential to damage membrane, enzymes, protein, DNA and ultimately cellular repair mechanism (Wilson and McDonald, 1986). When deterioration is advanced, rate and uniformity of seed germination and seedling emergence and tolerance to environmental stresses decreases (Roberts and Osei-Bonsu, 1988).

Sowing of high vigor seeds would result in high performance of crops in the field via improving seedling vigor (Ghassemi-Golezani, 1992) seedling establishment (Finch-Savage, 2000) and winter survival of seedlings (Ghassemi-Golezani *et al*., 2008a). Rapid emergence of seedlings from high vigor seed lots could lead to the production of large and vigorous seedlings (Ghassemi-Golezani *et al*., 2008a) with high leaf chlorophyll content (Ghassemi-Golezani *et al*., 2008b). Seed deterioration have been reported to reduce field emergence, growth and yield of soybean (Vieira *et al*., 1999), wheat (Ganguli and Sen-Mandi, 1990; Ram and Wiesner, 1988;), cottonseed (Iqbal *et al*., 2002) and barley (Matthews and Collins, 1975; Perry, 1980a; Kim *et al*., 1989; Samarah and Al-Kofahi, 2008). This research was aimed to evaluate the beneficial effects of sowing high quality seeds on field performance of two winter oilseed-rape cultivars.

Materials and methods

Seeds of two oilseed rape (*Brassica napus* L.) cultivars ('Okapi' and 'Licord') were obtained from the Agricultural Research Center of Khoy, Iran. Seeds of each cultivar were divided into three sub-samples. A sub-sample was kept as control with 98% viability (V_1). The other two sub-samples with about 15% moisture content were artificially deteriorated at 40°C for 9 and 12 days ('Licord') and 7 and 10 days ('Okapi'), reducing seed viability to 85 and 71% (V_2 and V_3, respectively). Consequently, three seed lots for each cultivar with different levels of vigor were provided.

Four replicates of 25 seeds from each sample were tested for germination between double layered rolled filter papers at 20±1°C for 7 days. At the end, normal and abnormal seedlings were counted (ISTA, 1999) and percentage viability for each seed lot was determined.

The field experiment was carried out at the Research Farm of the University of Tabriz (latitude 38°5′N, longitude 46°17′E, Altitude 1360 m above sea level) in 2008. The experiment was arranged as factorial based on randomized complete block design in three replicates. Factors were two oilseed rape cultivars and three seed lots (V_1, V_2 and V_3). Seeds were treated with 1.5 g/kg Benomyl and then were sown at mid-September 2008 in 2.5 cm depth with a density of 114 seeds/m^2. Each plot had 6 sowing rows of 6 m long spaced 25 cm apart. All plots were irrigated immediately after sowing and subsequent irrigations were carried out as required. Weeds were controlled by hand during crop growth and development.

Seedling emergence in each plot was counted in daily intervals until no more emergences were observed. Subsequently, mean emergence time and percentage of seedling emergence were calculated. Ground cover was measured every week in spring 2009 by viewing the canopy through a wooden frame (50 cm × 50 cm), divided into 100 equal sections. The sections were counted when more than half of each filled with oilseed rape green area. Chlorophyll content index of leaves was measured every two weeks by a chlorophyll meter (CCM- 200). At maturity, ten plants were harvested from each plot and grains per plant, 1000 grain weight and grain yield per plant were determined. Finally, plants from 1 m^2 in the middle of each plot were harvested and grain yield per unit area was recorded.

Analysis of variance of the data appropriate to the experimental design was conducted, using SPSS software. Means of each trait for different treatments were compared according to Duncan multiple range test at $P \leq 0.05$. Excel software was used to draw figures.

Results

Although the effect of seed vigor on field emergence time was not significant ($P>0.05$), but mean emergence time increased with increasing seed deterioration (Tab. 1). Seedling emergence percentage significantly ($P \leq 0.01$) affected by seed vigor, but cultivar had significant effects on both emergence time ($P \leq 0.05$) and percentage ($P \leq 0.01$). However, the interaction of seed vigor × cultivar for these traits was not significant ($P>0.05$). The highest percentage of seedling emergence was obtained for the high vigor seed lot and it was decreased with decreasing seed lot quality. Seedlings of 'Okapi' emerged later and had the lowest emergence percentage, compared with those of 'Licord' (Tab. 1).

Tab. 1. Means of seedling emergence time and percentage, ground cover and chlorophyll content index of two oilseed rape cultivars affected by seed vigor

Treatment	Emergence time (day)	Emergence (%)	Ground cover (%)	Chlorophyll content index
Seed vigor				
V_1	7.39 a	83.76 a	43.17 a	27.22 a
V_2	8.47 a	60.81 b	34.25 b	26.37 a
V_3	8.98 a	50.14 b	24.85 c	25.53 a
Cultivar				
'Licord'	7.56 b	73.97 a	41.51 a	24.96 b
'Okapi'	9.00 a	55.84 b	26.67 b	27.78 a

Different letters at each column indicate significant difference at p≤ 0.05.
V_1, V_2 and V_3: Seed lots with 98, 85 and 71% viability, respectively

Ground green cover of oilseed rape cultivars from differentially deteriorated seed lots increased with progressing crop growth up to about 36-37 weeks after sowing and thereafter started to decrease (Fig. 1). Plants from the high vigor seed lots of both cultivars had the highest ground cover at almost all the stages of growth, followed by those from the less and severely deteriorated seed lots. The largest difference among plants from various seed lots was observed when maximum ground cover was achieved. Ground cover of 'Licord' at the similar stages of growth and development for different seed lots was higher than that of 'Okapi' (Fig. 1, Tab. 1).

Plants from high vigor seed lots (V_1) of both cultivars had higher leaf chlorophyll content index (CCI) at early stages of growth in the spring, compared with those from low vigor seed lots. However, this advantage gradually diminished and at about 36-37 weeks after sowing disappeared. Thereafter CCI of these plants was less than that of plants from V_3 seeds in 'Licord' and V_2 and V_3 seeds in 'Okapi' (Fig. 2). In general, mean CCI of the plants from seed lots with different viability percentages was statistically similar, but mean CCI of 'Okapi' was higher than that of 'Licord' (Tab. 1).

Seed vigor had significant effects on grains per plant, 1000 grain weight ($P \leq 0.05$), grain yield per plant and per unit area ($P \leq 0.01$). These traits were not significantly affected by cultivar ($P>0.05$). Grains per plant, 1000 grain weight and grain yield per plant for plants from deteriorated seed lots were higher than those from high-vigor seed lot. However, the highest grain yield per unit area was recorded for plants from high-vigor seeds followed by those from less and severely deteriorated seeds (Tab. 2).

Viability percentage had significant negative correlation with grains per plant, 1000 grain weight and grain yield per plant, but positive correlation with emergence percentage and grain yield per unit area. Emergence percentage had the highest positive correlation with ground cover and grain yield per unit area. Grains per plant, 1000 grain weight and grain yield per plant positively correlated with each other, but the relationship between grain yield

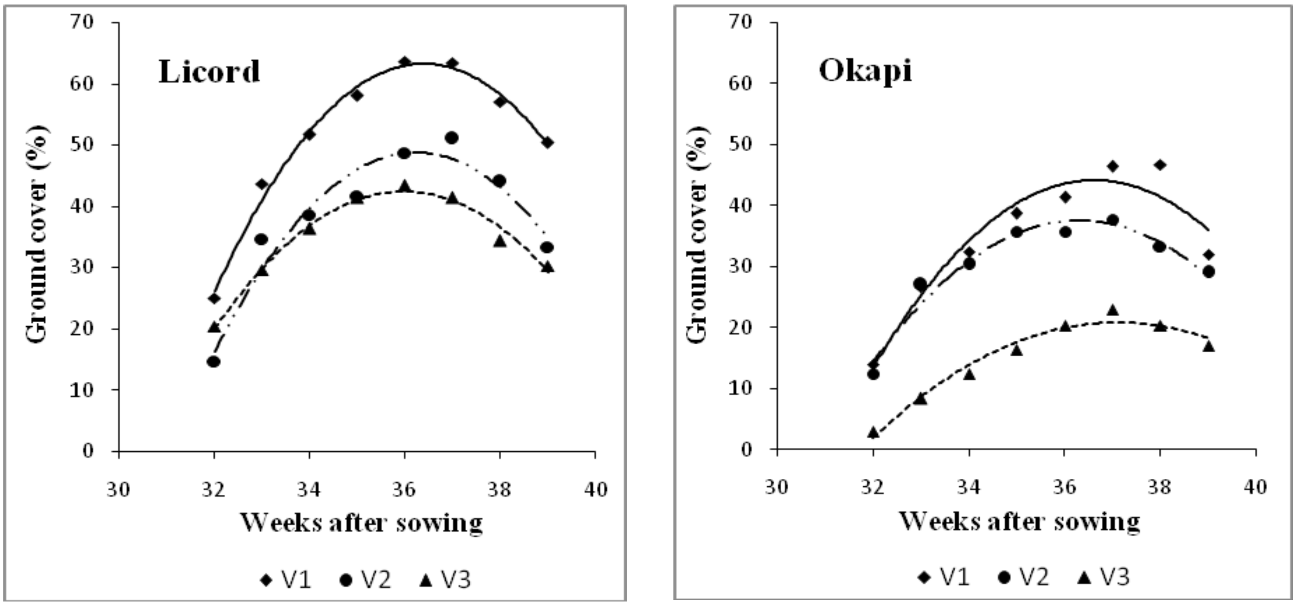

Fig. 1. Changes in ground cover percentage of winter oilseed rape cultivars at different stages of growth affected by seed vigor (V_1, V_2 and V_3: 98, 85 and 71% viability, respectively)

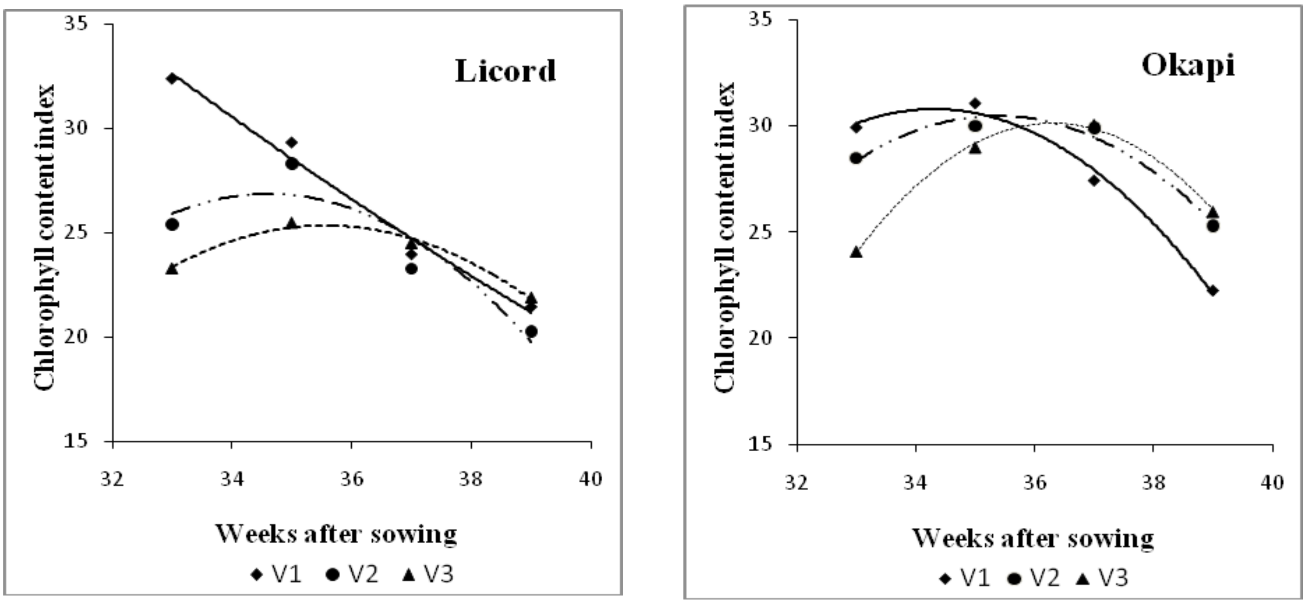

Fig. 2. Changes in chlorophyll content index of winter oilseed rape cultivars at different stages of growth affected by seed vigor (V_1, V_2 and V_3: 98, 85 and 71% viability, respectively)

per plant and grain yield per unit area was negative. Chlorophyll content index (CCI) had no significant correlation with any of the traits (Tab. 3).

Discussion

Prolonged seedling emergence time due to seed deterioration (Tab. 1) could be the result of membrane damage (McDonald and Nelson, 1986; Khan *et al.,* 2003), protein denaturation (Nautiyal *et al*., 1985), solute leakage (McDonald and Nelson, 1986; Ferguson *et al.,* 1990), disruptions in RNA, DNA and protein synthesis (Perry, 1980b; Bewley and Black, 1994; McDonald, 1999) and decline in seed vigor prior to viability loss (Roberts and

Tab. 2. Means of yield and yield components for three seed lots and two cultivars of winter oilseed rape

Treatment	Grains per plant	1000 grain weight (g)	Grain yield (g/plant)	Grain yield (^{2}m/g)
Seed lot				
V_1	1778 b	3.915 b	4.56 c	337.32 a
V_2	2002.75 b	4.09 b	5.6 b	248.99 b
V_3	2589.15 a	4.44 a	6.26 a	170.08 c
Cultivar				
'Licord'	2205.822 a	4.090 a	5.499 a	262.322 a
'Okapi'	2040.778 a	4.211 a	5.457 a	241.936 a

Different letters at each column indicate significant difference at p≤ 0.05.
V_1, V_2 and V_3: Seed lots with 98, 85 and 71% viability, respectively

Tab. 3. Correlation coefficients of seed viability and field traits of winter oilseed rape

Traits	1	2	3	4	5	6	7	8	9
1- Viability (%)	1								
2- Emergence time (day)	-0.545	1							
3- Emergence (%)	0.823*	-0.893*	1						
4- Ground cover (%)	0.777	-0.823*	0.947**	1					
5- CCI	0.235	0.258	-0.067	-0.246	1				
6- Grains per plant	-0.908*	0.283	-0.587	-0.528	-0.563	1			
7- 1000 grain weight (g)	-0.929**	0.438	-0.766	-0.823*	-0.150	0.853*	1		
8- Grain yield (g/plant)	-0.970**	0.520	-0.797	-0.680	-0.392	0.906*	0.847*	1	
9- Grain yield (g/m^2)	0.826*	-0.786	0.867*	0.716	0.341	-0.763	-0.668	-0.866*	1

*, **: Significant at $p \leq 0.05$ and $p \leq 0.01$, respectively

Osei-Bonsu,1988). Deterioration of seeds within the seed lots caused reductions in viability percentage and seedling establishment (Tab. 1). Since seed viability percentage of 'Licord' and 'Okapi' was similar, the superiority of the former cultivar in accelerating seedling emergence and improving plant establishment can be attributed to the effects of genetic constitution on seed and seedling vigor. Poor and scattered stand establishment can potentially decrease crop yield in the field (Ghassemi-Golezani *et al*., 2010).

Rapid and uniform emergence and optimum stand establishment of the plants from high vigor seed lot (Tab. 1) led to the highest ground cover of both oilseed rape cultivars at all the stages of growth and development (Fig. 1). Optimum ground cover also related with the early emergence and superior establishment of vigorous seedlings in chickpea (Ghassemi-Golezani *et al*., 2008c). Ground cover of the plants from the seed lots with similar viability percentages was higher for 'Licord' than for 'Okapi' (Fig. 1), suggesting that the genotypic difference between cultivars is also an important factor influencing seedling vigor (Perry, 1980b) and ground cover. There is a linear relationship between ground green cover and light interception (Burstall and Harris, 1983). Therefore, it is a reliable index to estimate crop performance, particularly under adverse conditions (Ghassemi-Golezani *et al*., 2008c; Ghassemi-Golezani and Mardfar, 2008).

Rapid emergence of seedlings could lead to the production of vigorous plants (Ghassemi-Golezani *et al*., 2008a) with high chlorophyll content in their leaves (Ghassemi-Golezani *et al*., 2008b) as it was shown for plants from high vigor seed lots of oilseed rape cultivars at the early stages of growth (Fig. 2). Decline in leaf chlorophyll content of these plants at later stages of growth closely related with decreasing light availability for shaded leaves, due to high density (Tab. 1). When plants are shaded by neighbors, reduction of irradiance can cause some reaction such as declining of chloroplast and chlorophyll a/b ratio (Evans and Pooter, 2001). Chlorophyll a/b ratio tends to decrease with decreasing light availability (Lei *et al*., 1996).

Because of poor stand establishment, plants from low vigor seed lots had the opportunity to use the environmental resources more efficiently leading to the production of comparatively more and larger grains per plant and higher grain yield per plant (Tab. 2). Saha and Sultana (2008) also reported that increased grain yield per plant in soybean cultivars under lower plant stand per unit area were due to lower competition among plants for moisture, nutrient and sunlight. However, these advantages in individual plant performance were not sufficient to compensate for low plant establishment as indicated by 26.19% and 49.58% loss in grain yield per unit area for plants from V_2 and V_3 seed lots, respectively (Tab. 2). This is also reflected in negative correlations of grains per plant, 1000 grain weight and grain yield per plant and positive correlations of seedling emergence percentage and grain yield per unit area with seed viability percentage (Tab. 3).

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