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Development of Seed Physiological Quality in Winter Oilseed Rape (*Brassica napus* L.) Cultivars

Kazem GHASEMI-GOLEZANI, Parisa SHEIKHZADEH-MOSADDEGH, Mohamad Reza SHAKIBA, Abolghasem MOHAMADI, Safar NASROLLAHZADEH

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

Abstract

Stage of maturity at harvest is one of the most important factors that can influence the quality of seeds. This research was carried out in 2008- 2009 to evaluate the development of physiological seed quality in three winter oilseed rape (*Brassica napus* L.) cultivars ('Modena', 'Opera' and 'SLM_{046}'). Seeds were harvested serially in 9-10 stages during their development and maturation. Maximum seed weight (mass maturity) was achieved at 48-54 days after flowering, when seed moisture content was 41-50%. However, maximum seed quality as measured by seed viability, germination percentage, germination rate and seedling dry weight was obtained 10 to 22 days after mass maturity. Thereafter, seed quality of all cultivars was started to decrease, due to ageing. Maximum germination rate of 'SLM_{046}' and maximum seedling dry weight of 'Opera' were significantly higher than those of other two cultivars. These variations in seed quality parameters were attributed to differences in genetic constitution among oilseed rape cultivars. It was concluded that high quality seeds of winter oilseed rape cultivars could be produced with 14-16% moisture content, which is suitable for direct and mechanical harvesting, threshing and storage without further drying.

Keywords: mass maturity, seed germination, seedling dry weight, seed viability

Introduction

Oilseed rape with 40-45% oil percentage is one of the valuable and important oil crops (Noori *et al.,* 2007). High quality seed lots may improve grain yield of this crop in two ways: first because emergence of seedlings from the seedbed are rapid and uniform leading to the production of vigourous 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). In addition, cold acclimation capability and winter survival of seedlings from good quality seeds are high, ensuring a satisfactory stand of winter crops (Ghassemi-Golezani *et al.*, 2008a, b; 2009).

Stage of maturity at harvest is one of the most important factors that can influence the quality of seeds (Demir *et al.,* 2008). Harvesting too early may result in low yield and quality, because of the partial development of essential structures of seeds (Keller and Kollmann, 1999; Elias and Copeland, 2001; Ekpong and Sukprakarn, 2008; Wang *et al.*, 2008). Whereas, harvesting too late may increase the risk of shattering and decrease the quality of seeds due to ageing. Adverse environmental conditions such as raining may also result in sprouting of seeds on mother plants (Ellis and Pieta Filho, 1992; Elias and Copeland, 2001; Wang *et al.*, 2008). Therefore, successful seed production depends on detection and implication of optimal time of harvesting. This time is a pre requisite for the production of maximum number of high quality seeds (Demir and Balkaya, 2005; Wang *et al.*, 2008).

Maximum seed quality may be achieved at the end of seed filling period (Harington, 1972; Browne, 1978; Tekrony and Hunter, 1995; Tekrony and Egli, 1997) or slightly after this phase (Pieta Filho and Ellis, 1991; Ellis *et al.*, 1993; Zanakis *et al.*, 1994; Sanhewe and Ellis, 1996; Demir and Samit, 2001; Lehner *et al.*, 2006; Ghassemi-Golezani and Mazloomi-Oskooyi, 2008; Ghassemi-Golezani and Hosseinzadeh-Mahootchy, 2009). The end of seed filling phase described as physiological maturity (Harington, 1972) or mass maturity (Ellis and Pieta Filho, 1992). Low quality of seeds can potentially decrease the rate and percentage of germination and seedling emergence, leading to poor stand establishment in the field and consequently yield loss in many crops such as corn (Cruz-Garcia *et al.*, 1995; Moreno-Martinez *et al.*, 1998), wheat (Ganguli and Sen-Mandi, 1990), cotton (Iqbal *et al.*, 2002), barley (Copeland and Mc Donald, 2001; Samarah and Al-Kofahi, 2008) garden pea (Hampton and Scott, 1982). Therefore, it is necessary to examine and identify suitable techniques for production of high quality seeds from different crops. This research was carried out to investigate the changes in seed quality of winter rapeseed cultivars at different stages of development and maturity in order to determine the appropriate time for harvest and quality improvement.

Materials and methods

An experiment was conducted to evaluate seed development and quality in winter oilseed rape cultivars at the Research Farm of the Faculty of Agriculture, University of Tabriz, Tabriz, Iran (Latitude 38°05'N, Longitude 46°17'E, Altitude 1360 m above sea level) in 2008. The climate is characterized by mean annual precipitation of 245.75 mm per year, mean annual temperature of 10°C, annual maximum temperature of 16.6°C and mean annual minimum temperature of 4.2°C. Soil type is sandy loam with EC of 0.63 d/Sm and pH of 8.1.

Seeds of three winter oilseed rape cultivars including 'Modena', 'Opera' and 'SLM_{046}' were obtained from the Department of Oilseed Crops, Institute of Seed and Crop Breeding, Karaj, Iran. These seeds were treated with 2 g/kg Benomyl and then were sown by hand in about 1.5 cm with a density of 133 seeds per m^2 in winter and decreased to 64 plants per m^2 in spring 2009. Each plot consisted of 12 rows of 6 m length, spaced 25 cm apart. Experimental design was split plot, based on randomized complete block design with four replications. Cultivars were located in main plots and different harvests (9-10 stages) were assigned to sub plots. All plots were irrigated immediately after sowing and subsequent irrigations were carried out as required. Weeds were controlled by hand weeding during crop growth and development.

After seed formation, plants of 0.5 m^2 from each plot were harvested at 9-10 stages. Then seeds were detached from the plots and seed moisture content was determined in accordance with ISTA rules (1985). Subsequently, seeds were ambient air dried at 20-24°C, and 100 seed weight of each sample was determined. Seed samples within separate sealed bags were then placed in a refrigerator at 3-5°C.

Seed quality tests were carried out at the Seed Technology Laboratory of the University of Tabriz. Four replicates of 25 seeds from each sample were tested for germination between moist rolled filter papers. The rolled papers with seeds were put into the plastic bags to avoid moisture loss. These rolled papers were incubated at 10°C for 10 days. Germination (protrusion of radicle by 2 mm) was recorded in daily intervals. Seed germination rate for each treatment was calculated according to Ellis and Roberts (1980). At the end of each test the numbers of normal and abnormal seedlings were counted and percentages of viability and germination were calculated. Seedlings were then cut from the storage tissues and dried in an oven at 75°C for 24 hours and mean seedling dry weight for each replicate was determined.

Analysis of variance of the data appropriate to the experimental design and comparison of means at $P \leq 0.05$ were carried out, using MSTATC software. Excel software was used to draw figures.

Results

In all cultivars, 100 seed weight increased with increasing days after flowering to a point where maximum weight was obtained (Fig. 1). After achieving the maximum weight (mass maturity), changes in seed weight was negligible. Maximum seed weights for 'SLM_{046}' and 'Modena' were obtained at 53 and 54 days after flowering, respectively. However, Maximum seed weight of 'Opera' was achieved five- six days earlier than other cultivars. Mean seed weight of this cultivar was higher than that of 'Modena' and 'SLM_{046}' at all stages of development and maturity. Whereas, the seed weight of 'Modena' was the lowest (Fig. 1).

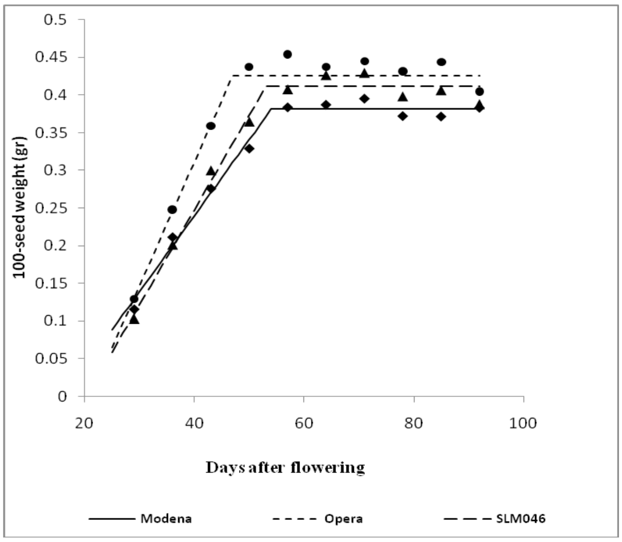

Fig. 1. Changes in 100 seed weight of three winter oilseed rape cultivars at different stages of seed development

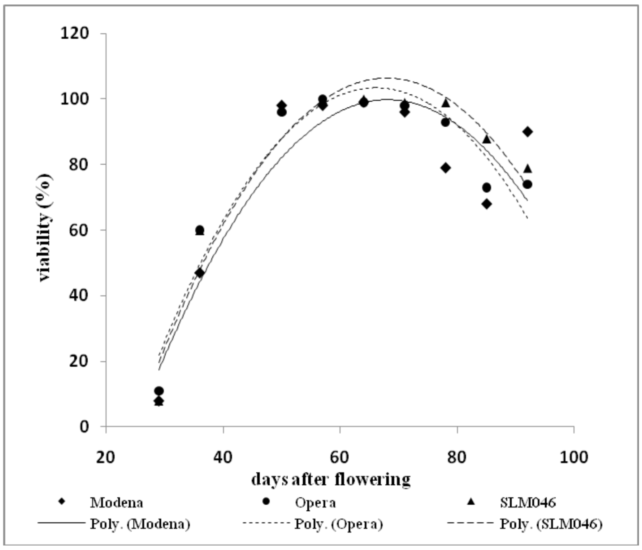

Fig. 2. Changes in seed viability of three winter oilseed rape cultivars at different stages of seed development

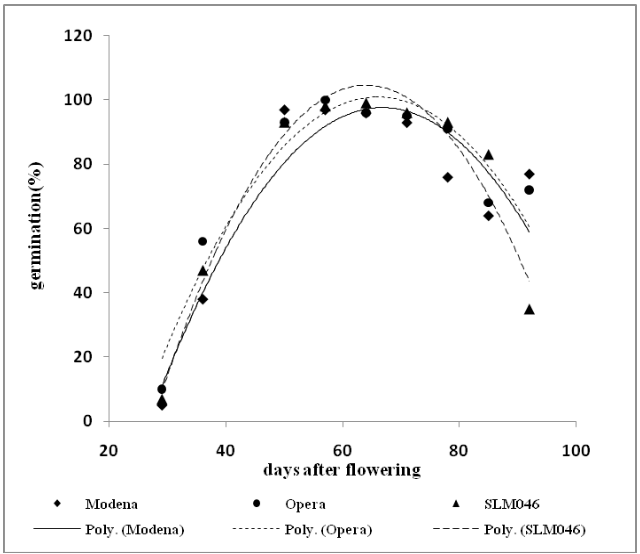

Fig. 3. Changes in percentage of seed germination of three winter oilseed rape cultivars at different stages of seed development

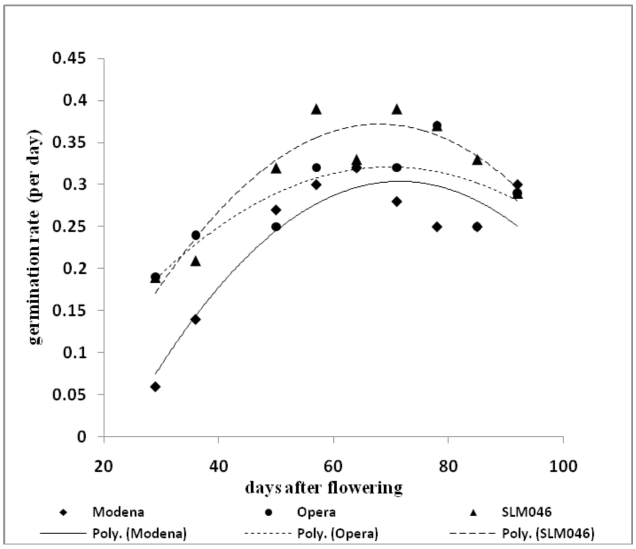

Fig. 4. Changes in germination rate of three winter oilseed rape cultivars at different stages of seed development

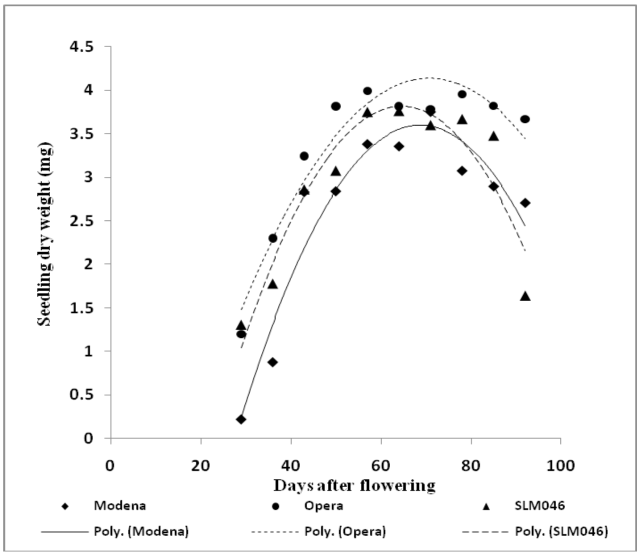

Fig. 5. Changes in seedling dry weight of three winter oilseed rape cultivars at different stages of seed development

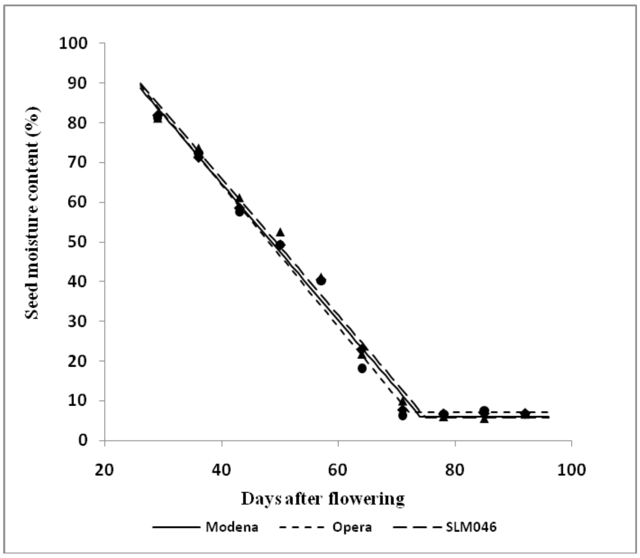

Fig. 6. Changes in seed moisture content of three winter oilseed rape cultivars at different stages of seed development

Seed viability of all three winter oilseed cultivars at early stages of seed filling was very low, but it was increased with progressing seed development (Fig. 2). This improvement continued until maximum seed viability was obtained at 68, 68 and 65 days after flowering for 'Modena', 'SLM_{046}' and 'Opera', respectively. Thereafter, seed viability started to decrease (Fig. 2).

Seed germination enhanced as a result of seed development. Maximum percentage of seed germination for 'SLM_{046}', 'Modena' and 'Opera' was achieved at 63, 66 and 66 days after flowering, respectively. After that, percentage of seed germination started to decrease. Reduction of seed germination percentage for 'SLM_{046}' was fast and started earlier than that for other cultivars (Fig. 3).

Germination rate of winter oilseed rape cultivars increased with increasing days after flowering up to the maximum point. Thereafter, rate of germination of all cultivars gradually decreased. Maximum germination rate was achieved at 67, 69 and 70 days after flowering for 'SLM_{046}', 'Opera' and 'Modena', respectively (Fig. 4).

Seedling dry weights of all cultivars increased progressively with seed development up to 64, 68 and 70 days after flowering for 'SLM_{046}', 'Modena' and 'Opera', respectively. Then, seedling dry weights started to decrease with increasing days after flowering. This reduction for 'Opera' was occurred six and two days later than that for, 'SLM_{046}' and 'Modena', respectively. Reduction of seedling dry weight for 'Opera' at later stages of seed development was also slower than that for other cultivars (Fig. 5).

Seed moisture content for all winter oilseed rape cultivars at early stages of seed development was very high, but decreased with increasing days after flowering. Seed moisture content at mass maturity was about 41, 43.5 and 50% for 'Modena', 'SLM_{046}' and 'Opera', respectively (Fig. 6).

Analysis of variance of the data for maximum seed weight and other quality parameters showed that cultivar had only significant effects maximum germination rate ($P\leq 0.05$) and seedling dry weight ($P\leq 0.01$). The highest germination rate and seedling dry weight was recorded for 'SLM_{046}' and 'Opera', respectively (Tab. 1).

Discussion

Tab. 1. Comparison of means of maximum germination rate and seedling dry weight of three winter oilseed rape cultivars

Cultivar	Germination rate (per day)	Seedling dry weight (mg)
'Modena'	0.309 b	3.700 b
'Opera'	0.326 b	4.145 a
'SLM_{046}'	0.373 a	3.845 b

Different letters in each column indicate significant difference at $P\leq 0.05$

Seed maturation in oilseed rape is an important process during which morphological (seed size and color), physiological (dry weight, moisture content and germination), chemical (oil, protein and carbohydrate) and functional (vigor and viability) changes occur from the time of fertilization until the seeds are ready for harvest (Şeker, 2002; Demir and Balkaya, 2005). Maximum seed weight (mass maturity) occurred at 48-54 days after flowering, depending on cultivar (Fig. 1). However, maximum seed quality as measured by seed viability, germination percentage, germination rate and seedling dry weight was obtained 10 to 22 days after mass maturity (Fig. 2, 3, 4 and 5). These results contradict the suggestions that seed quality is maximum at the end of the seed filling phase (Harington, 1972; Browne, 1978; Tekrony and Hunter, 1995; Tekrony and Egli, 1997), but are in agreement with those reported for rice (Ellis *et al.*, 1993), wheat (Lehner *et al.*, 2006), tomato (Demir and Samit, 2001; Demir *et al.*, 2008), common been (Ghassemi-Golezani and Mazloomi-Oskooyi, 2008) and faba been (Ghassemi-Golezani and Hosseinzadeh-Mahootchy, 2009). Low seed quality at the early stages of seed development was due to immaturity, while the decline in quality parameters at later stages (Fig. 2, 3, 4 and 5) caused by seed aging on mother plant (Ghassemi-Golezani and Mazloomi-Oskooyi, 2008).

Significant differences in germination rate and seedling dry weight among oilseed rape cultivars (Tab. 1) can be attributed to variation in genetic constitution, which may strongly influence seed vigour (Perry, 1980; Ghassemi-Golezani *et al.*, 2010). Field performance of high vigor seeds are much better than that of low vigor seeds, ensuring rapid, uniform and satisfactory stand establishment under a wide range of environmental conditions (Hampton and Scott, 1982; Ghassemi-Golezani *et al.*, 1996a, b; 2008b).

Seed moisture content of winter oilseed rape cultivars at mass maturity stage was high (41-50%), similar to that reported for wheat (37-39%) (Schnyder and Baum, 1992; Calderini *et al.*, 2000), maize (35-36%) (Egli and Tekrony, 1997; Borras and Westgate, 2006), soybean (60%) (Fraser *et al.,* 1982) and sunflower (38%) (Rondanini *et al.*, 2007). However, maximum seed quality of winter oilseed rape cultivars was obtained 10 to 22 days after mass maturity, depending on cultivar and quality test (Fig. 2, 3, 4 and 5).

Conclusions

In general, seed quality of oilseed rape cultivars was high at moisture contents of 14-16%, which is suitable for direct and mechanical harvesting, threshing and storage without further drying.

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