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Impact of seed priming on germination performance of fresh and aged seeds of Canola

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Abstract
Priming fresh and naturally aged canola seeds with different substances and observing the seed germination properties are involved in this work. Fresh seeds and aged seeds of canola cv. “süzer” were treated with distilled water, -0.8 MPa polyethylene glycol (PEG) 6000 and 50 mM thiamine for 8 hours. Storage of canola seeds showed the loss of germination capacity compared to fresh seeds. Present findings indicate that priming can improve germination and germination speed both in fresh and aged seeds of canola. Germination percentage increased in aged seeds with distilled water priming and thiamine priming. Mean germination times were lower in the primed seeds. Seedling growth didn’t improve with priming in both ages. It was concluded that germination performance improvement of aged seeds is possible with suitable priming.

Keywords
Thiamine, PEG6000, Hydropriming, Oil seed, Storage

Introduction
Growers and seed suppliers carry over seed lots from previous years to the following planting seasons. There is always a doubt about poor seed quality due to the storage conditions of a given seed lot. The main reasons of faster decline in seed vigour of oil seed crops are lipid autoxidation and increase in free fatty acids due to inadequate storage moisture conditions and seed bed, that induce low germination speed and seed vigour, etc ending up with poor plant stand. These two reasons cause inactivation of enzymes, denaturation of proteins and disruption of nucleic acids. Storage conditions and seed quality are very important than seed age (Elias and Copeland, 1994).

Main agricultural target for a better canola production is to get rapid and uniform germination and seedling emergence after seeds are sown. Seeds are important input cost for canola growers.

The canola germination, emergence and establishment is more sensitive compared to other oil seed crops under environmental stresses due to small seed size. Small seeds have limited food reserves causing, a short time between germination and emergence to establish a satisfactory plant stands. The producers are recommended to select seeds that have high germination speed and vigour within 3-4 months before seeding. When canola is slow or late in crop canopy formation, competing with weeds is becoming hard and reduces the herbicide performance (Mohler, 2001; Kim et al., 2011; Harker et al., 2012). High or low temperatures are the most importing constraints in winter canola cultivation especially entering the winter at rosette stage provides resistance against low temperature. For that reason high quality seed is a key factor in winter canola cultivation.

Inadequate soil moisture in seedbed is a major problem for canola seeds to establish new crops, especially for areas having less rainfall during sowing time. Rapid germination and seedling emergence play an important part in high yield for canola cultivation.

Quality of seeds could be divergent based on storage conditions, especially if the seeds belong to different years (seed age), that effect their longevity potential (short-lived or long-lived). To increase seed invigoration of long stored or stored at unfavourable conditions hydropriming and osmopriming (hormonal priming, matri-priming and other priming) techniques are used (Windauer et al., 2007). Deterioration of seed with storage is another domain of enzyme activity which could be improved with priming. Active oxygen species like oxygen peroxide (H_2O_2), superoxide anion ($O_2^{\bullet -}$) and hydroxyl radical ($OH^{\bullet}$) accumulation are related to deterioration. In order to increase seed defence system against seed deterioration related to active oxygen species and their reaction with polyunsaturated fatty acids found in cell membrane seed priming process could be helpful in many plants (Farooq et al., 2019; Khan et al., 2020).

These techniques are not only used for aforementioned stored seeds, but also newly harvested seeds. The advantages of seed priming have been revealed in both optimal and unfavourable conditions (jisha et al. 2013) for many oil seed crops such as corn, soybean and sunflower (Shrestha et al., 2019; Langeroodi and Noora, 2017; Bourioug et al., 2020).

Pre-sowing seed treatments have been used in various field crops and canola to hasten germination and improve field emergence uniformity. Polyethylene glycol (PEG), water and thiamine used successfully for many crops.

Several reports indicated uniform field emergence better crop stand as a result of improved germination and initial quality characters with different seed priming. Stored seeds have less protein content connected to oxidation of the amino acids with increased respiration. Seed deterioration due to storage conditions can be repaired with priming (Bray, 1995). Improving canola emergence significantly reduce herbicide inputs and increase seed yield.

The objective of the study was to test the impact of different priming techniques on canola seeds of different ages in terms of seed vigour tests and seedling growth parameters.

Materials and Methods

Germination tests

One year old naturally aged and fresh seeds of a canola cultivar, Süzer, were used in this experiment. The seeds were obtained from Trakya Agricultural Research Institute. Osmotic potential of PEG-6000 was adjusted -0.8 MPa according to Michel and Kaufmann (1973) and the molecular weight of the thiamine were adjusted to 50 mM before the start of the treatment of the canola seeds.

Both fresh and aged seeds were treated with different priming solutions viz., (i) immersed in distilled water for 8 hours (hydropriming); (ii) immersed in solution of -0.8 MPa polyethylene glycol (PEG) 6000 for 8 hours, (iii) immersed in 50 mM thiamine for 8 hours. The unprimed seeds were used as control. The priming treatments were conducted at 20 °C under dark conditions for 8 hours in incubator and then treated seeds were dried at room temperature (22 ±1 °C, 45% relative humidity) for two days.

Four replicates of 50 seeds (50 x 4 = 200 seeds) were germinated between three layered rolled filter paper with 21 ml distilled water. The rolled papers with seeds were put into sealed plastic bags to avoid moisture loss. Seeds were kept in 20 ± 1 °C in dark for germination for 10 days. A seed was considered germinated when the emerging radicle was 2 mm. Germination percentage was recorded every 24 h for 10 days. Mean germination time (MGT) was calculated for the speed of germination according to ISTA (2003) rules. Shoot length, root length, seedling fresh and dry weight were measured in 10 seedlings selected randomly from each replicate after the 10th day. Dry weight was measured after drying samples in an oven at 70 °C for 48 hours.

Experimental design

The experimental design was two factors factorial (seed age × seed treatment) arranged in a completely randomized design with four replicates. The main factor was seed ages (1 year old and fresh seeds), the sub factor was seed treatments (control, hydropriming, priming with PEG 6000 and thiamine). Data for germination percentage were subjected to arcsine transformation before ANOVA was made with MSTAT-C program (Michigan State University). The differences among the means were compared with Duncan's multiple range test ($P<0.05$).

Results and discussions

Seed is the most important part in crop life. Low quality seeds are inappropriate and lead to decrease in efficiency of other inputs. Seed aging is one of the reasons of leading low quality and seed vigour naturally declines during storage. In this study it is clear that priming can increase seed quality.

Results clearly showed that the mean germination time was 1.34 days in fresh seeds and 1.92 days in the one-year-old seeds (Table 1). Germination percentage was higher in fresh seeds (99.38 %) compared to one-year-old seeds (82.63%)

This study revealed that hydropriming and thiamine priming caused partial increases in the germination percentage of aged seeds of canola compared to control. Germination percentage was higher in fresh seeds compared to the one year old seeds. Hydropriming and priming with thiamine showed 93.75% and 94.25% germination respectively (Table 1).

A two-way interaction was discovered for MGT, GP and seedling fresh weight (Table 1). Among seed treatments hydropriming shortened the mean germination time in both seed age compared to control. In both seed ages, hydropriming and treatment with thiamine showed high germination percentage (Table 2). The hydroprimed seeds had shorter time for seed germination, due to faster water absorption and earlier beginning of metabolism processes (Kaya et al., 2006; Sağlam et al., 2010). One year old seeds had the highest root length, seedling fresh weight and seedling dry weight.

Primed seeds of both age with thiamine showed improvement compared to non-primed seeds. Especially one-year old canola seeds primed with thiamine had shorter mean germination time and higher germination percentage compared to other treatment, but not other growth parameters were affected by the thiamine priming (Table 2). It could be attributed to thiamine priming of canola seeds that increased activity of thiamine dependent physiological reactions in germination (Neumann et al., 1999). Thiamine molecule is an incipient thiol and high uptake of exogenous thiamine into canola seeds might also stimulate the thiol metabolism like antioxidative characteristics of thiol compounds to reduce oxidative stress (Neumann et al., 1999).

Priming with distilled water and thiamine increased germination percentage of aged seeds, but without any significant difference in priming treatments of fresh seeds (Table 2).

Seedlings were shorter in PEG priming and thiamine priming compared to control and hydropriming. Also hydropriming produced more taller seedlings. Roots were longer in PEG priming.

Aged seeds price can be lower than fresh seeds and farmers can use aged seeds by increasing seed amount for sowing. Also improved priming technology to increase germination percentage of the aged seeds is needed. Germination performance improvement of aged seeds with priming treatments has been demonstrated as an effect of repair mechanisms happening during priming. The seeds in ageing process deteriorate and need repair during imbibition in order to germinate (Nascimento and Aragão, 2004). It therefore seems that aged seeds became more vigorous with appropriate priming treatments.

Table 1. Germination parameters of canola cv. Süzer at two different seed aging levels and priming treatments

Factor	Treatment	Mean Germination Time	Germination Percentage	Seedling Length	Root Length	Seedling Fresh Weight	Seedling Dry Weight
		days	%	cm	cm	mg plant^{-1}	mg plant^{-1}
Seed Age	Fresh (F)	1.34 b	99.38 a	6.69	7.41 b	51.38 b	2.00 b
	One year (O)	1.92 a	82.63 b	6.75	5.03 a	62.44 a	3.25 a
Priming	Non-Primed (N)	1.83 a	89.75 b	6.79 ab	6.18 ab	60.63 a	2.88
	Distilled-Water (D)	1.46 c	93.75 a	7.28 a	5.53 b	57.13 ab	2.63
	PEG 6000 (P)	1.73 a	86.25 b	6.41 b	7.28 a	56.63 ab	2.63
	Thiamine (T)	1.43 b	94.25 a	6.40 b	5.89 b	53.25 b	2.38
Summary of ANOVA							
Seed Age (A)		**	**	NS	**	**	**
Priming (P)		**	**	*	**	*	NS
A x P		*	**	NS	NS	**	NS

***p<0.01,* **p<0.05,* ns, not significant

Table 2. Germination parameters of fresh and one year old canola cultivar “süzer” exposed to different priming treatments

Seed Age	Priming	Mean Germination Time	Germination Percentage	Seedling Length	Root Length	Seedling Fresh Weight	Seedling Dry Weight
		days	%	cm	cm	mg plant^{-1}	mg plant^{-1}
Fresh	Non-Primed	1.63 bc*	99.00 a**	6.71	5.08	54.50 cd**	2.25
	Distilled Water	1.04 d	100.00 a	7.33	3.92	57.00 bc	2.00
	PEG 6000	1.57 c	99.50 a	6.23	6.36	47.75 d	2.00
	Thiamine	1.14 d	99.00 a	6.49	4.78	46.25 d	1.75
One Year	Non-Primed	2.03 a	80.50 c	6.88	7.28	66.75 a	3.5
	Distilled Water	1.87 ab	87.50 b	7.22	7.15	57.25 bc	3.25
	PEG 6000	1.89 ab	73.00 d	6.59	8.21	65.50 ab	3.25
	Thiamine	1.72 bc	89.50 b	6.32	7.00	60.25 abc	3.00

***p<0.01,* **p<0.05*

Conclusions

Hydropriming with thiamine and hydropriming results are very encouraging and showed improved germination of aged seeds. Winter canola cultivation is hard due to high or low temperature stresses that have an uneven effect on seed germination. Slow germination delays emerging and this also delays rosette stages which is an important phase for winter hardiness. Increasing seed germination and slow seed germination speed is very important point in winter canola cultivation. In order to increase seed vigour in aged or low vigour seeds of canola to have better stand in field, priming with suitable methods should be improved.

Compliance with Ethical Standards

Conflict of interest

The author declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Author contribution

The author read and approved the final manuscript. The author verifies that the Text, Figures, and Tables are original and that they have not been published before.

Ethical approval

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