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Effect of Polymer and Pesticide Seed Coatings on Winter Canola Seed Germination at Various Osmotic Potentials

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Abstract: One of the major constraints of winter canola (*Brassica napus* L.) production is poor seed germination and field stand establishment. It has been reported that use of polymer seed coatings improve stand establishment in some crops including spring canola. The objective of this study was to evaluate the effect of three polymers [CelGard, Spectrum 511 and DiscoClear] each at three concentrations (0.33%, 0.66% and 0.99%), with and without pesticide Helix and Apron on seed germination of winter canola. The study was carried out in the laboratory under normal and water stress conditions. Results showed that certain polymer/ concentration/ pesticide seed coating combinations have potential to increase the seed germination in winter canola. Efficiency of polymer seed coatings depends upon the cultivar and environmental (soil type, water stress etc.) conditions. Results also showed that polymer CelGard at 0.33% concentration for cv. Abilene and Spectrum 511 at 0.66% concentration for cv. Jetton effectively increased seed germination under normal and water stress conditions. Seeds coated with Helix and Apron pesticides significantly improved germination under water stress conditions.

Key words: *Brassica napus* L · Canola · Polymer coating · Osmotic potential · Apron · Helix

INTRODUCTION

Canola seed is nutritionally superior, contain 40% oil and its meal has 35-40% protein. It is highly accepted as oil seed crop with least saturated fat in USA. However, country is not able to meet the demand of canola oil and more than 30% is imported from Canada. Import of canola oil can be reduced or avoided by growing winter canola in the southeastern USA. One of the major limitations in production of canola is problem of obtaining a desired field stand. The establishment of a uniform and vigorous stand is essential to withstand biotic and abiotic stresses and for other agronomic practices to effectively increase yield [1]. The stand failure may be due to small seed size, planting depth, soil moisture stress or diseases and insect infestations in the soil. Most common measures taken to increase field stands include tillage/cultural practices, proper seed placement, good seed soil contact, optimum date of planting, adequate seeding rate and pre-sowing seed treatment. Coating seed with polymers, fungicide and insecticides may enhance seedling establishment and may prevent stand failures. Polymers are environmentally compatible and facilitate very accurate application of fungicides and insecticides. Many organic and inorganic polymers are known to improve the plant ability by regulating needed moisture to spark germination [2]. Polymers are most widely used in small seed crops as it increase the seed size and facilitate the handling and planting e.g., carrot, sugar beet, tomato, Bermuda grass etc. The mustard (*Brassica juncea* L.) seeds when coated with starch polymer 'Jalshakti' under rainfed conditions showed a significant increase in the germination, field stand establishment and overall development of plants [3]. Polymer seed coating also increased the consumptive water use efficiency in mustard [3]. Polymer seed coating has also been reported to facilitate the early sowing of spring crops in cold regions especially corn, soybean and canola [4, 5].

Enhancement of seed coating with fungicide reduces seed infection and thus increases stand establishment of the crop [6]. Polymer coating along with bio-protectant matalaxyl and *Trichoderma* strains protect the vegetable seeds from fungi and increase germination and root growth in crops [7]. Many polymer seed coatings have been developed, which effectively prevent the seed from taking up water for two to three weeks and reduces the effect of drought and the chilling injury. Once seed passed the damage of chilling then it is safe for the crop to establish well [8]. Currently, very little information is available regarding the use of polymer seed coatings to

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improve seed germination in winter canola. Therefore, this study was undertaken to determine the effect of various polymer coatings with and without pesticide on seed germination in winter canola at normal and moisture stress conditions.

MATERIALS AND METHODS

Seed Preparation: Seed of two promising winter canola cultivar "Abilene" and "Jetton" were used in this study. Seeds were cleaned by an air separator to remove light, immature seed, or empty hull, chaff etc. Since, seed in a lot with uniform size is very important for vigorous and uniform crop stand, the above seed after cleaning were passed through sieves to get a uniform sized seed of 3.5-4.0 mm in diameter.

Seed Coating with Polymers and Pesticides: Approximately, one pound of uniform sized seeds of each cultivar were obtained in separate bag for each treatment. The polymer seed treatment consists of three polymers: DiscoClear (Incotec, CA, USA) [9]; CelGard (Celpril, CA, USA) [10]; and Spectrum 511 (GTG Enterprises, U.K) [11]. Each polymer treatment was applied at three concentrations 0.33%, 0.66% and 0.99% of polymer solution to the total seed weight. To compare treated seeds, one bag of one pound seed of each cultivar was kept untreated as control. These treated /untreated seed samples were subdivided into three parts for pesticide treatment i.e., no pesticide, Helix, [(2,6-dimethylphenyl)-methoxyacetylamino]-propionic acid methyl ester, an insecticide and fungicide and Alliegiance (Apron), N- (2,6-dimethylphenyl)-N- (methoxyacetyl)-DL-alanine methyl ester, a fungicides. The pesticides Alliegiance (Apron) at the rate of 0.50 oz/lb of seed and Helix at the rate of 23 oz/lb of seed were centricoated on dried but polymer treated/ untreated seeds. These polymers and pesticide coatings were applied with a centricoater seed coating machine (Cimbria Heid, Stockeray, Australia) [12]. After the application of polymers and/or pesticide, the seeds were air dried for approximately 30 minutes. Then seeds were placed in a plastic bag and labeled accordingly. Each cultivar had 30 treatments.

Standard Germination[1] *test* : Four replicates of 50-seed each from coated and uncoated treatments were placed on wet blotter paper in a randomized complete block (RCB) design and then placed in a germinator at 20-30°C. Normal seedlings were counted three and seven days after planting and the results were expressed as percentage germination of total seed planted [13].

Seed Germination under Water Stress Condition: Using polyethylene glycol (PEG8000), solutions with four osmotic potential of -0.2, -0.3, -0.4 and -0.6 MPa were prepared [14] and were used to evaluate germination percentage of polymer coated/uncoated seeds. Four replications of 50-seeds each were planted on Whatmann No. 1 filter paper and placed in 100 x 15 mm round Petri dish. PEG solution of 3.5 ml was added to each petri dish at the beginning of the experiment and then additional 1.5 ml of the solution was added four days after planting. The petri dishes were placed in a germinator set at a temperature of 20-30°C. A germinated seed with two healthy cotyledons and a fully developed radical was considered to be a normal seedling. All normal seedlings were counted on three, five and seven days after planting and the results were expressed as percentage germination of total seeds planted [13].

Statistical Analysis: Data collected on all observations were statistically analyzed using an analysis of variance (ANOVA) procedure [15]. The general linear Model (GLM) procedures of the Statistical Analysis System [16] were used for comparing means by Fisher's least significant difference test.

RESULTS

Effect of Polymer with and Without Pesticide Seed Coatings on Standard Germination: In this study data obtained showed that among the cultivars, uncoated seeds of Abilene had significantly high standard germination (93%) than Jetton (90%). Abilene seeds when coated with polymer CelGard gave significantly high standard germination (95%) than other polymer treatments i.e., Spectrum 511 (91%), DiscoClear (91%) and control (93%). The polymer spectrum 511 (90%) and DiscoClear (91%) coated seeds gave significantly high standard germination than polymer CelGard (82%) for Jetton. However, control performed at par (90%) with Spectrum 511 and DiscoClear in Jetton (Fig. 1). Various polymers concentrations had no significant effect on standard germination of both cultivars. However, higher standard germination was observed when seeds were coated at 0.33% concentration of all the three polymers in comparison to 0.66% and 0.99% polymer concentration in both the cultivars except i.e., Spectrum 511 at 0.99% concentration in Jetton and DiscoClear at 0.99% concentration in Abilene (Fig. 2).

[1]Standard germination is the emergence and development from the seed embryo of those essential structures which, for the kind of a seed in question, are indicative of the ability to produce a normal plant under favorable conditions.

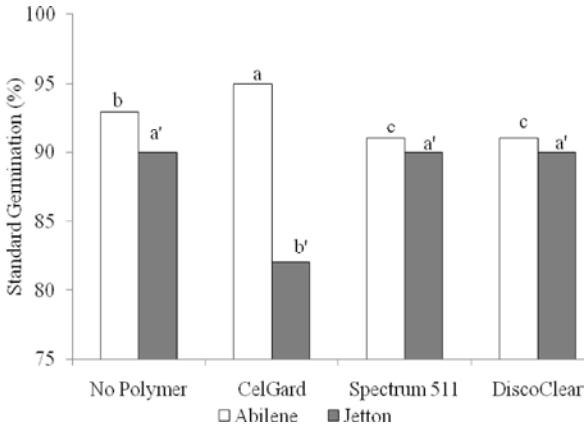

Fig. 1: Effect of polymer seed coatings on canola standard germination. The treatments with same letter are not significantly different according to Fisher's least significant test.

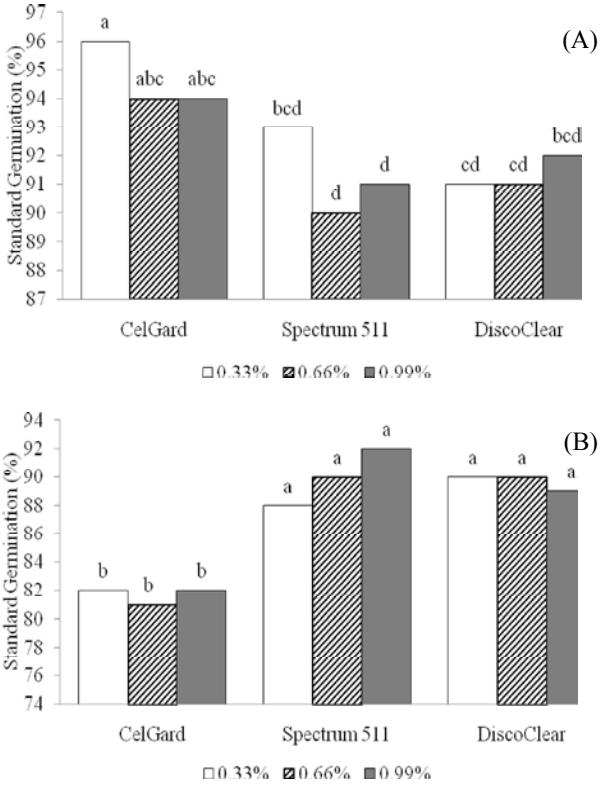

Fig. 2: Effect of polymer concentrations on standard germination of canola cultivar (A) Abilen; (B) Jetton. The treatments with same letter are not significantly different according to Fisher's least significant test.

All the pesticide coated seeds of Abilene had standard germination 93%. In Jetton, seeds without pesticide coating and seeds coated with helix had 88%

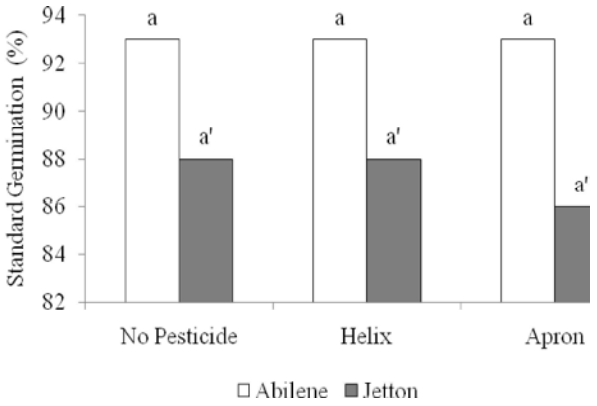

Fig. 3: Effect of pesticide seed coatings on canola standard germination. The treatments with same letter are not significantly different according to Fisher's least significant test.

and seed coated with Apron had 86% standard germination (Fig. 3). The polymer and pesticide interaction showed that in cv. Abilene, all the three pesticides i.e., no-pesticide, Helix and Apron alone and with CelGard gave significantly high standard germination than Spectrum 511 and DiscoClear. Uncoated seeds and seeds coated with Helix and Apron performed at par with their respective polymer treatments (Fig. 4A). Similarly, the difference between standard germination of all the three pesticide treatments within a polymer was statistically non significant in Jetton. However, uncoated and seeds coated with Spectrum 511 and DiscoClear gave significantly high standard germination with all the three pesticide coatings than the CelGrad with and without pesticide coated seeds (Fig. 4B).

Effect of Various Osmotic Potentials and Polymer with and Without Pesticide Coatings on Canola Seed Germination

Osmotic Potential (OP): The results showed that seed germination of coated and uncoated seeds of canola was significantly influenced with the change in OP. The OP and cultivar interaction showed that Abilene gave significantly high germination at each OP level than Jetton, however, the trend in both cultivars was same. Seed germination was significantly higher for -0.2 MPa OP than all other OP levels and the control for both the cultivars (Fig. 5). Osmotic potential of -0.3 and -0.4 MPa greatly reduced germination compared to the control and -0.2 MPa for both cultivars. Osmotic potential of -0.6 MPa almost prevented the germination (6% for Abilene and 2% for Jetton).

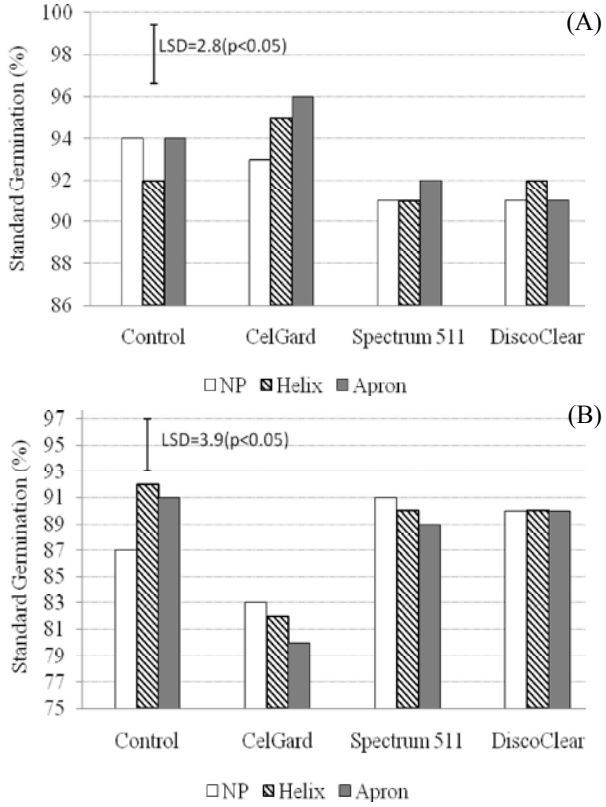

Fig. 4: Effect of polymer with and without pesticide seed coatings on standard germination (A) Abilene; (B) Jetton. Least significant difference (LSD) the confidence bar on graph is at P<0.05 and NP is no pesticide treatment.

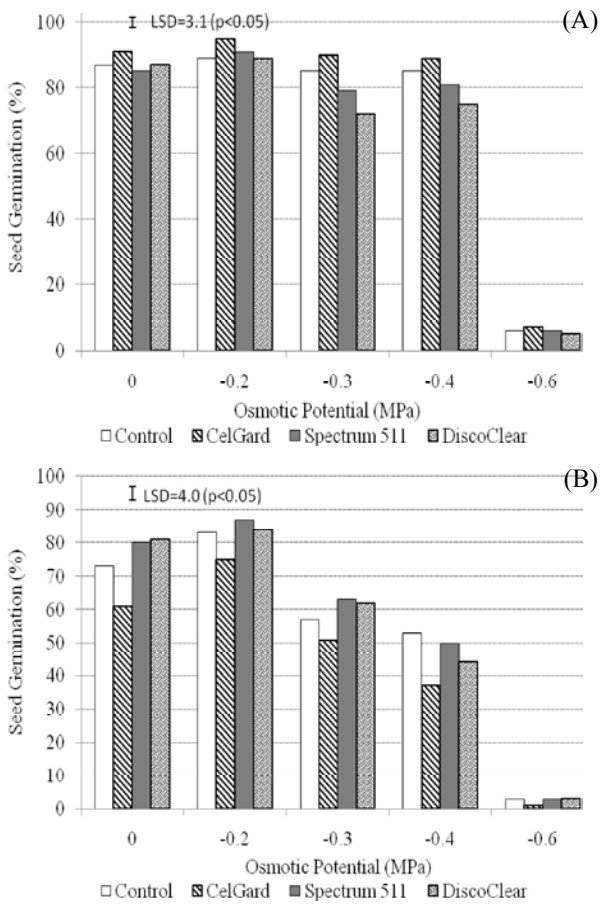

Fig. 5: Effect of polymer seed coatings on canola seed germinations at various osmotic potential levels (MPa). (A) Abilene and (B) Jetton. LSD is Least Significant difference.

Polymer Seed Coatings: Polymer seed coatings significantly influenced the seed germination of canola cultivars. The polymer CelGard gave significantly higher seed germination than control and other polymer treatments for Abilene at all the OP levels (Fig. 5A). In Jetton, polymer Spectrum 511 coated seeds gave significantly high seed germination than CelGard and control at 0, -0.2 and -0.3 MPa OP. DiscoClear coated seed also performed at par with Spectrum 511 at 0.0 (81%), -0.2MPa (84%) and –0.3 MPa (62%) OP. Control seeds gave high germination (53%) at -0.4 MPa OP however, it was at par with Spectrum 511 (Fig. 5B).

Polymer concentrations and OP interaction showed significant effect on seed germination of both canola cultivars. In cv. Abilene, polymer CelGard gave high seed germination than other Spectrum511 and DiscoClear at all the three concentrations (Table 1). However, all polymer concentrations, performed statistically equal at different OP levels except at no water stress where CelGard at the 0.99% concentration gave significantly low seed germination (87%) than at 0.33% (94%) and 0.66% concentration (93%). Spectrum 511 at 0.33% concentration performed better than 0.66% and 0.99% concentration at all the OP levels except at -0.6 MPa where 0.99% concentration gave the highest seed germination. However, Spectrum 511 gave significantly low seed germination at 0.99% concentration (81%) at 0.0 MPa OP and 0.66% and 0.99% concentration (76 and 75%, respectively) at -0.3 MPa OP than 0.33% concentration. DiscoClear at 0.99% concentration gave high seed germination than 0.33% and 0.66% concentration at various OP levels except at -0.2MPa where 0.33% gave high seed germination (92%) and at -0.6 MPa, where 0.66% concentration gave comparatively high seed germination (8%).

In cv. Jetton, the seeds coated with CelGard at 0.33% concentration gave high seed germination than 0.66% and 0.99% concentration at all the OP levels except at -0.6 MPa

Table 1: Effect of polymer concentrations on canola seed germination.

		Seed Germination (%)							
		Abilene Jetton							
		Polymer concentration (%)				Polymer concentration (%)			
Polymer	Osmotic Potential (MPa)	0.33	0.66	0.99	¶$LSD_{0.05}$	0.33	0.66	0.99	¶$LSD_{0.05}$
CelGard	0.0	94	93	87	5.4	65	63	53	7.0
	-0.2	96	95	93		79	72	73	
	-0.3	90	93	88		55	52	45	
	-0.4	90	90	85		42	39	31	
	-0.6	9	9	4		1	1	1	
Spectrum 511	0.0	85	88	81		75	84	80	
	-0.2	91	90	90		85	89	88	
	-0.3	84	76	75		66	62	62	
	-0.4	81	81	81		46	51	52	
	-0.6	3	7	8		1	4	4	
Disco-Clear	0.0	86	87	87		85	85	73	
	-0.2	92	85	89		86	84	82	
	-0.3	72	70	74		66	61	60	
	-0.4	75	73	77		46	49	38	
	-0.6	5	8	3		3	3	3	

¶Least Significant difference at P<0.05

Table 2: Effect of polymers with and without pesticide seed coatings on canola seed germination

		Seed Germination (%)							
		Abilene				Jetton			
		Pesticide				Pesticide			
Polymer	Osmotic Potential (MPa)	NP*	Helix	Apron	¶$LSD_{0.05}$	NP*	Helix	Apron	¶$LSD_{0.05}$
Control	0.0	89	84	89	5.4	80	66	72	7.0
	-0.2	89	88	89		81	86	80	
	-0.3	80	89	86		36	68	67	
	-0.4	80	87	86		38	62	58	
	-0.6	7	7	5		3	7	0	
CelGard	0.0	92	93	89		64	55	62	
	-0.2	95	95	95		78	73	73	
	-0.3	87	90	94		44	34	75	
	-0.4	83	92	90		33	31	48	
	-0.6	8	9	4		3	0	0	
Spectrum 511	0.0	88	85	82		81	77	82	
	-0.2	89	92	92		84	87	91	
	-0.3	62	87	87		45	68	77	
	-0.4	75	87	79		31	63	55	
	-0.6	5	6	6		2	5	2	
Disco-Clear	0.0	90	86	84		80	82	82	
	-0.2	86	88	92		84	86	83	
	-0.3	53	79	85		47	62	78	
	-0.4	65	89	72		15	69	49	
	-0.6	5	5	6		1	4	2	

¶Least Significant difference at P<0.05. *No pesticide treatment.

where germination was close to one percent at all the concentrations. At all the OP levels CelGard at 0.33% and 0.66% concentration performed at par. Seed coated with Spectrum 511 at 0.66% concentration gave high seed germination than 0.33% and 0.99% concentration, but -0.3 MPa OP, highest seed germination (66%) was observed at 0.33% concentration. However, germination at all three Spectrum 511 concentrations were statistically equal at all the OP levels except at 0.33% concentration at no water stress. The seeds coated with DiscoClear at 0.33% concentration gave high seed germination at all the OP levels. DiscoClear coated at 0.33% and 0.66% concentrations performed statistically equal at all water potential levels. Overall, seeds coated with DiscoClear at 0.33% concentration at low or no water stress levels (0.0, -0.2, -0.3 MPa) and Spectrum 511 at 0.66% concentration at high water stress (-0.4 and -0.6 MPa) gave significantly high seed germination than CelGard in Jetton (Table 1).

Polymer with and Without Pesticide Coatings: The polymer with and without pesticide coatings, significantly influenced the seed germination of both winter canola cultivars under normal and water stress conditions (Table 2). The seeds of cv. Abilene coated with pesticide Helix gave significantly high seed germination ($P< 0.05$) at all the OP levels. The seeds without pesticide coatings and coated with Apron at no water stress and -0.2 MPa gave the highest germination (89%) which was at par with Helix coating (88%). At -0.3 and -0.4 MPa OP, Helix coated seeds gave significantly high seed germination than no pesticide treated seeds (Table 2). Apron coated seeds performed at par with Helix at all the OP levels.

In cv. Abilene, the seeds coated with CelGard gave high seed germination when coated along with Helix at all the OP levels. At -0.2 MPa only CelGard and CelGard along with Apron coated seeds performed statistically equal with CelGard and Helix coated seeds i.e., 95%. At -0.3 MPa OP CelGard and Apron treated seeds gave significantly high seed germination (94%) than no pesticide coating however it was at par with CelGard and Helix coated seeds. In polymer Spectrum 511 and DiscoClear, seeds coated along with Apron and Helix gave significantly high seed germination than without pesticide coated seeds at all the negative OP levels. At no water stress, Spectrum 511 and DiscoClear alone gave significantly high seed germination (88 and 90%, respectively) than their respective Apron treatments however, it was at par with their respective Helix treated seeds (Table 2).

In Jetton, Helix coated seed gave significantly high seed germination at -0.2, -0.3 and -0.4 MPa OP (86, 68 and 62%, respectively) than uncoated seeds. At 0.0 MPa OP uncoated seeds gave significantly high seed germination (80%) than only Helix (66%) and Apron (72%) coated seeds. Apron and Helix treated seeds performed at par and significantly higher than uncoated seeds at all the negative OP levels except -0.2 and -0.6 MPa. The seeds coated with CelGard gave high seed germination when centricoated along with Apron at the entire OP levels except -0.6 MPa. At 0.0, -0.2 and -0.6 MPa only CelGard coated seeds gave higher seed germination (64, 78 and 3%, respectively) however, it was at par with Helix and Apron treatments. Spectrum 511 coated seeds along with Apron and Helix gave significantly high seed germination than no pesticide coated seeds at all the OP levels except no water stress where only Spectrum 511 coated seeds gave higher seed germination (81%) which was at par with Helix and Apron coated seeds. DiscoClear coated seeds when coated along with Helix gave significantly high seed germination at all the OP levels except at -0.3 MPa. Seeds coated with DiscoClear and Apron performed at par with DiscoClear and Helix except at -0.3 and -0.4 MPa OP. Both Helix and Apron treatment along with DiscoClear gave significantly high seed germination than no pesticide coating (Table 2).

DISCUSSION

Canola oil contains least amount of saturated fat ($\geq$7%) among the edible oils [17]. US-Food and Drug Administration approved canola oil as safe for human consumption in 1985 and since then its consumption has dramatically increased. However, it was observed that, early frost as well as low temperatures reduces both the rate and final percentage of germination, causing delayed and reduced seedling establishment of canola [18]. Polymer seed coatings are used in seed industry to enhance the seed quality and to protect the seed from the adverse effect of cold and wet soils and has been successfully used in early sowing of spring crops in cold regions especially corn, soybean and canola [4, 5]. Therefore, in this study, we evaluated the effects of various polymer coatings with and without pesticide on seed germination in winter canola under normal and moisture stress conditions.

Our results showed that certain polymer/ concentration/ pesticide seed coating combinations have potential to increase the seed germination in winter canola. The non-significant differences in standard germination of treatments may be due to the fact that this

experiment was conducted under ideal conditions in the laboratory that enable seeds to perform at its full potential. Also, Abilene had high initial germination than Jetton. There was no significant difference in the standard germination of coated and uncoated seeds, however, polymer CelGard with Abilene and polymer Spectrum 511with Jetton gave little advantage over the no polymer coating and their other respective polymer seed coatings. Almeida *et al.* (2005) [19] studied the effect of polymer seed coatings on germination and vigor of broccoli seeds and observed no different in standard germination and quality of coated and uncoated broccoli seeds. Seeds coated at 0.33% polymer concentration gave slightly high standard germination in comparison to higher concentrations. The difference among pesticide coatings was not significant.

Seeds germination of coated and uncoated seeds in both the winter canola cultivars was negatively influenced by increase in water stress (OP). Similar results have been observed by the previous researcher Schneider and Gupta [20]. They reported that increase in water stress delay as well as reduce the seed germination and ultimately affect the final plant population of corn. The polymer coated seeds gave high seed germination than the uncoated seeds under water stress conditions. Willenbrog *et al*. [21] observed that polymer coated seeds increase the median germination time and decreased the final germination as compare to film coated and uncoated seeds in fall planted canola. In cv. Abilene seeds coated with CelGard gave high seed germination as compare to other polymer coated and uncoated seeds. In cv. Jetton seeds coated with Spectrum 511 and DiscoClear gave high seed germination as compare to CelGard and uncoated seeds at all the osmotic potential levels. Similarly, in *Phaselous vulgaris* seed coating with film coating formulation 'SB2000' at the rate of 0.5% by weight or greater enhanced seed germination under water stress [22]. All the polymer seeds coating only with few exceptions when coated at 0.33% concentration gave high seed germination as compare to 0.66% and 0.99% concentration. The thickness of the polymer coating depends upon the concentration of the polymer used. As the thickness increases it could reduce the rate of imbibitions and ultimately affect the seed germination. Seeds when coated along with pesticide Helix or Apron especially under water stress conditions gave high seed germination than no pesticide treatment. Under water stress conditions rate of germination become slow and seeds stay in wet conditions for longer period. The pesticide seed treatment i.e., Helix and Apron protect the seeds against fungal diseases like *Pythium*, *Fusarium* and *Rhizocatonia* spp. It enabled them to survive for longer period as compare to untreated seeds. Polymer coating along with bio-protectant matalaxyl and *Trichoderma* strains protect the vegetable seeds from fungi and increase germination and root growth in crops [7]. In Conclusion, polymer seed coatings have ability to improve seed germination in winter canola especially under water stress conditions. Use of pesticide coatings along with polymer seed coatings protect the seed from fungal and insect attacks and enhance the seed germination.

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