Indian Journal of Ecology (2024) 51(2): 346-352
DOI: https://doi.org/10.55362/IJE/2024/4241

Manuscript Number: 4241
NAAS Rating: 5.38

Germination and Vigour Enhancement through Combined Application of Osmo-priming and Organic Seed Pelleting in Carrot (*Daucus carota* L.)

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Abstract: The objective of the current study was to examine the effect of seed priming and pelleting on germination and vigour in European carrot cv. Early Nantes. The carrot seed primed for 4 days in PEG 6000 solution with an osmotic potential of -1.2 MPa (P_4) had the highest germination, seedling length, seedling dry weight, seedling vigour index-length, seedling vigour index-mass and speed of germination. Among the pelleted seeds, *Melia azedarach* leaf powder pelleted seeds showed maximum values for parameters *viz*., germination, seedling length, seedling dry weight, seedling vigour index- length, seedling vigour index- mass and speed of germination. The combined application of seed priming for 4 days in PEG 6000 solution having osmotic potential of -1.2 MPa and pelleted with *Melia azedarach* leaf powder showed greater value for most of the seed quality parameters and enhanced the germination and vigour in carrot.

Keywords: Germination, Seed vigour, Priming and pelleting of seeds, Seed quality, Carrot

Carrot (*Daucus carota* L.) a popular winter season root vegetable of the Umbelliferae family primarily originates from Afghanistan (Rubashevskaya 1931). The compound umbel inflorescence, a characteristic feature of the Umbelliferae family results in non- uniformity in seed size and seed quality. Carrots often have very extended vegetative and flowering periods. The flowers are produced at various mother plant locations, and the seeds are produced at various plant developmental stages. As a result, seeds of various seed qualities are produced. The position of the seeds on the mother plants determines the maternal type of heterogeneity, which commonly occurs (Panayotov 2005). Seed sowing is also hindered due to the presence of the beard on carrot seed rendering it difficult for machine as well as manual sowing and also carrot seed emergence and stand establishment are usually erratic and delayed. These inherent issues with the carrot seed lot causes uneven crop stand and plant growth.

Seed priming is a pre-sowing treatment of seeds that creates a physiological condition more favorable for better and even seed germination. In the early phases of germination, seed priming regulates hydration, which initiates the regular metabolic process prior to the radicle protrusion (Johnson and Puthur 2021). On the other hand, seed pelleting with different leaf powder can slow down the irreversible process of seed deterioration during storage. The leaf powders' anti-oxidant, fungicidal, and insecticidal qualities aid in the retention of the seed quality during storage. Seed priming complemented with seed pelleting maintains the desired seed size and smoothen the seed surface thus evading seed bearding in carrot. Seed quality is also enhanced through seed pelleting by the presence of additives *viz.* filler material like botanical leaf powder (Prakash et al 2018). Seed priming initiate various physiological and biochemical processes leading to seed germination. A special benefit is provided to seeds by pelleting in combination with priming technology, which promotes quicker, more uniform germination, and strong seedling growth (Weissmann et al 2022). Along with seed pelleting, primed seeds have multiple role of advancing stage of seed germination and improving seedling performance in horticultural crops. By quick and uniform germination rate, it also prevents seed losses and may result in lesser cost of cultivation. The present investigation was taken up to study the effect of seed priming and pelleting on seed germination and vigour characteristics in carrot.

MATERIAL AND METHODS

Experimental detail: The laboratory experiment was conducted during 2017 by adopting completely randomized design factorial at Dr YSPUHF, Solan (HP).Seeds of Early Nantes, a variety of European carrot were used for the current study. Freshly harvested carrot seeds were graded by using round-holed sieves by shaking manually to remove the small seeds and other impurity from the seeds. This experiment comprised five priming treatment of polyethylene glycol *viz.,*PEG 6000 -1.0 MPa 2 days (P_1), PEG 6000 -1.0 MPa 4 days (P_2), PEG 6000 -1.2 MPa 2 days (P_3), PEG 6000 -1.2 MPa 4 days (P_4) and control (non-primed) (P_5). Seven different pelleting treatments were applied to each of the five primed seed lots. The carrot seeds were pelleted with *Lantana camara*leaf powder + clay (PL_1), *Eucalyptus* species leaf powder + clay (PL_2), *Melia azedarach*leaf powder + clay (PL_3),*Vitex negundo* leaf powder + clay (PL_4), clay alone (PL_5), Gum Arabica (PL_6) and unpelleted seed (PL_7) was considered as control. Except for the control, gum acacia was used as an adhesive for all pelleting treatments. So the experiment encompassed 35 treatment combinations.

Seed Priming

Preparation of priming solution*:* Polyethylene glycol 6000 (PEG 6000) solution of different osmotic potential -1.0 MPa and -1.2 MPa were used for priming. PEG -1.0 MPa solution was prepared by dissolving 284 g of PEG 6000 in 1 liter of water and PEG 6000 -1.2 MPa solution, 314 g of PEG 6000 in one liter of water**.** The concentration of the PEG 6000 solution was calculated using the Michel and Kaufmann (1973) equation:

$$\psi = (-(1.18 \times 10^{-2})C - (1.18 \times 10^{-4})C^2 + (2.67 \times 10^{-1})CT + (8.39 \times 10^{-1})C^2T)*10^{-1}$$

Where,

C is the PEG concentration in g kg^{-1} of H_2O and T is the temperature in °C.

Priming procedure: Seeds of carrot were primed in polyethylene glycol (PEG 6000) solution of different osmotic potential of -1.0 MPa (284 g L^{-1}) and -1.2 MPa (314 g L^{-1}) at 20ºC for two and four days. PEG 6000 solutions with varying osmotic potential were stirred at a regular interval to promote aeration during priming. The moisture content of the seeds during priming process was 40-45% fresh weight basis. Primed seeds were rinsed in distilled water for two minutes after priming, and then surface dried using blotter paper and the primed seeds were dried back to original moisture content (10%). The moisture content of primed seeds was determined in by oven method at 105 ± 3^0C for 24 hours (Brasil 1992).

Seed pelleting: For seed pelleting different botanicals leaves were collected from university campus and nearby areas. The leaves were powdered using a grinder and fine leaf powder was obtained by sieving through 0.10 mm wire mesh after grinding. Clay was employed as a filler material, botanical leaf powder was blended with clay in a certain ratio (1:4 by volume) and gum arabica (5%) was used as an adhesive. The seed pelleting process was carried out using SATEC equipment. The seven different pelleting treatments were applied to each of the five primed seed lots. For an efficient and homogeneous coating, 50 g of seeds were placed in a revolving drum and a mixture of filler materials and botanical powder acting as an inert substance sprinkled on seed in rotating drum. In relation to the amount of seed, the thickness of the pelleted seed is determined by the adhesive content. Therefore, the required amount of pelleting mixture was uniformly applied to the seed. The seeds of 3 mm size were pelleted and dried in the shade for two days.

Seed germination and vigour: Immediately after seed priming and pelleting seed quality characteristics were recorded. For analyzing germination and other vigour characteristics, the observations were made by using a *between paper method*, whereas speed of germination was computed by *top on paper* method. According to ISTA (2010) recommendations, 100 seeds of each treatment combination in four replication were germinated in *between paper* (B.P.) media by following placement of the rolled paper towel in the BOD germinator at 20° C. On the 14th day after the completion of the germination period, only normal seedlings were counted. In accordance with the standard protocol (ISTA 2010) the germination was evaluated as, normal seedlings, dead seed, abnormal seedlings.

$$\text{Germination percent} = \frac{\text{Total number of normal seedlings germinated}}{\text{Total number of seed}} \times 100$$

Ten normal seedlings from each replication of each treatment were randomly selected on the 14th day of germination testing and seedling length were measured by measuring scale in centimeter. Seedlings were dried in an oven for 24 hours at 80° C. to determine seedling dry weight. The seedling vigour index-length was calculated by using the formula *viz.,* Standard germination (%) x Seedling length (cm) and the seedling vigour index- mass was calculated: Standard germination (%) x Seedling dry weight (g) (Abdul-Baki and Anderson 1973). Based on Maguire (1962), the speed of germination was computed:

$$\text{Speed of germination} = \frac{X_1}{Y_1} + \frac{X_2 - X_1}{Y_2} + \cdots\cdots\cdots + \frac{X_n - X_{n-1}}{Y_n}$$

Where; X_1, X_2 and X_n are number of seeds germinated on first , second and n^{th} day, respectively and Y_1, Y_2 and Y_n are number of days from sowing to first, second and n^{th} count respectively. Speed of germination is measured by top of paper method. The critical difference at a 5% level of significance was computed to compare the mean value of different treatments.

RESULTS AND DISCUSSION

Germination: Germination percent due to the effect of different priming and pelleting treatments in carrot seeds differed significantly (Table 1). The highest germination (86.05 %) was observed in PEG 6000 -1.2 MPa for 4 days primed seed (P_4), followed by PEG 6000 -1.0 MPa for 2 days primed seed (P_1) and the lowest germination (76.71 %) was observed in non-primed seed (P_5). Among the pelleted seeds, the highest germination (88.60 %) was in *Melia azedarach* leaf powder pelleted seeds (PL_3) over (PL_7) unpelleted seed. Combined effect of both priming and pelleting indicated that treatment combination of PEG 6000 -1.2 MPa for 4 days primed seed and pelleted with *Melia azedarach* leaf powder (P_4 x PL_3) resulted in highest germination (93.50 %)), which was at par with PEG 6000 -1.2 MPa for 2 days primed seed with *Vitex negundo* leaf powder(P_3 x PL_4) pelleted seed . However, the lowest germination (66.00 %) was recorded in treatment combination P_5x PL_7 (Control). Seed priming and seed pelleting both enhanced seed germination and vigour of carrot seeds. The osmopriming improves germination in carrot seed. In addition to its role in increasing the rate of seed germination, osmo priming activates synthesis of enzymes including DNA and RNA and mobilizes reserve food material. It also causes rapid expansion in development of embryo and removes hindrances in germination. These findings are in agreement with the findings of Sadeghi et al (2011) in Soybean, Dorna et al (2014) in pansy, Govinden-Soulange and Levantard (2008) in tomato and Kumar et al (2017) in chick pea. The increased seed germination in seeds pelleted with various botanicals may be due to higher moisture holding potential of colloids and higher protoplasm viscosity leading to permeable cell membrane that promote easier moisture entry, activating the quick seed's reserve food material hydrolysis in comparison to untreated seeds. Prakash et al (2018) observed the enhanced seed germination due to pelleting in black gram seed by pungum leaf powder. Pelleting of seeds with different leaf powders had also caused enhanced germination in chilli (Jerlin et al 2008), okra (Ramesh and Muthukrishnan 2015) and red gram (Anbarsan et al 2016).

Seedling length: The effect of both priming and pelleting on mean seedling length varied significantly, the highest seedling length (16.70 cm) was in the PEG 6000 -1.2 MPa for 4 days primed seed (P_4) followed by PEG 6000 -1.0 MPa for 4 days primed seed (P_2), as opposed to the shortest seedling length (14.64 cm) in unprimed seed (P_{14}). Among pelleted seeds, P_3 resulted into highest seedling length (18.32 cm) whereas, the lowest seedling length (14.56 cm) was in unpelleted seed (PL_7). Interaction effects revealed that treatment combination P_4 x PL_3*i.e.*PEG 6000 -1.2 MPa for 4 days primed seed with *Melia azedarach* leaf powder resulted in production of the longest seedling (20.30 cm). However, the smallest seedling length (11.40 cm) was observed in combination, P_5x PL_7 *i.e.* non primed unpelleted seed (Table 2).

Seeds primed with PEG solution results in elevated levels of various enzymes viz, catalases, peroxidase, amylase, and invertase in seeds, increased levels of RNA, sugar and protein causing higher length of seedling. Zheng et al (2015) observed better germination and faster growth by virtue of enhanced amylase and total soluble sugar both under normal and drought situations. Similar results have been observed for greater seedling length in bitter gourd (Thirusenduraselvi and Jerlin 2009) and in cucumber (Lima and Filho 2010). The enhanced seedling length in botanical leaf pelleted seeds might be due to the activity of numerous growth promotors and transfer of secondary metabolites to the growing seedling. These are in agreement with the report by Satish kumar et al (2014) in brinjal, Ramesh and Muthukrishnan

Table 1. Effect of combined application of seed priming and pelleting on germination (%) in carrot cv. Early Nantes

Treatments	PEG 6000 -1.0 MPa for 2 days (P_1)	PEG 6000 -1.0 MPa for 4 days (P_2)	PEG 6000 -1.2 MPa for 2 days (P_3)	PEG 6000 -1.2 MPa for 4 days (P_4)	Control (Non primed) (P_5)	Mean
Lantana camara + clay (PL_1)	87.50	80.00	80.50	80.00	78.00	81.20
*Eucalyptus*species + clay (PL_2)	87.00	77.00	78.00	85.50	84.50	82.40
Melia azedarach + clay (PL_3)	87.50	89.00	85.00	93.50	88.00	88.60
Vitex negundo + clay (PL_4)	79.50	77.50	92.50	87.50	76.50	82.70
Clay (PL_5)	83.30	77.00	74.50	84.85	66.50	77.23
Gum arabica (PL_6)	85.50	79.50	78.50	87.50	77.50	81.70
Control (Unpelleted) (PL_7)	75.28	76.50	75.50	90.50	66.00	76.76
Mean	83.65	79.50	80.64	87.05	76.71	

CD (p=0.05) =P- 0.96, PL-1.14, P x PL-2.55

(2015) in okra and chilli, and Prakash et al (2018) in black gram. Confirmatory revealed that antifungal and antioxidant effect of the botanicals in controlling physiological deterioration of seeds and translocation of nutrients to the heterotrophic seedling (Panwar et al 2023).

Seedling dry weight: Priming and pelleting treatment applied to carrot seeds also significantly increased the seedling dry weight over control (Table 3). Highest seedling dry weight (1.80 mg) was in seed primed withPEG 6000 -1.2 MPa for 4 days (P_4) and lowest seedling dry weight (1.69 mg) was in non-primed seed (P_5). Among the pelleted seed, the highest seedling dry weight (1.84 mg) was in PL_3*i.e. Melia azedarach* leaf powder pelleted seeds and lowest seedling dry weight (1.68 mg) was observed in PL_7*i.e.* unpelleted seed. Interaction effect showed that treatment combination of PEG 6000 -1.2 MPa for 4 days primed seed with *Melia azedarach* leaf powder seed (P_4 x PL_3) resulted in highest seedling dry weight (2.24 mg). However, the lowest seedling dry weight (1.52 mg) was in treatment combination P_5 x PL_7 *i.e.* control.

Activity of dehydrogenases (seed viability indicator) and peroxidises known as free radical scavenging enzyme had caused increased seedling dry weight in primed seeds (Nagarajan et al 2003). These findings are in line with that of Govinden-Soulange and Levantard (2008) in tomato, Sadeghi et al (2011) in Soybean, Dorna et al (2014) in pansy and Kumar et al (2017) in chick pea.Geetha and Balamurugan (2011) recorded increased seedling dry weight in mustard as a result of seed pelleting with leaf powder of *Propis julifora*. Ramesh and Muthukrishnan (2015) also observed similar trend in okra

Table 2. Effect of combined application of seed priming and pelleting on seedling length (cm) in carrot cv. early nantes

Treatments	PEG 6000 -1.0 MPa for 2 days (P_1)	PEG 6000 -1.0 MPa for 4 days (P_2)	PEG 6000 -1.2 MPa for 2 days (P_3)	PEG 6000 -1.2 MPa for 4 days (P_4)	Control (Non primed) (P_5)	Mean
Lantana camara + clay (PL_1)	15.56	15.86	15.36	12.40	16.90	15.22
*Eucalyptus*species + clay (PL_2)	16.42	14.54	15.20	15.28	15.34	15.36
Melia azedarach + clay (PL_3)	18.06	18.24	17.24	20.30	17.78	18.32
Vitex negundo + clay (PL_4)	13.70	14.90	19.36	16.94	14.42	15.86
Clay (PL_5)	16.48	17.34	16.42	16.50	13.94	16.14
Gum arabica (PL_6)	15.24	17.94	11.48	16.24	12.72	14.72
Control (Unpelleted) (PL_7)	11.13	14.66	16.40	19.22	11.40	14.56
Mean	15.23	16.21	15.92	16.70	14.64	
CD (p=0.05)						
P	0.2316					
PL	0.2740					
P x PL	0.6127					

Table 3. Effect of combined application of seed priming and pelleting on seedling dry weight (mg) in carrot cv. early nantes

Treatments	PEG 6000 -1.0 MPa for 2 days (P_1)	PEG 6000 -1.0 MPa for 4 days (P_2)	PEG 6000 -1.2 MPa for 2 days (P_3)	PEG 6000 -1.2 MPa for 4 days (P_4)	Control (Non primed) (P_5)	Mean
Lantana camara + clay (PL_1)	1.70	1.72	1.72	1.72	1.70	1.71
*Eucalyptus*species + clay (PL_2)	1.72	1.74	1.74	1.70	1.72	1.72
Melia azedarach + clay (PL_3)	1.74	1.76	1.72	2.24	1.74	1.84
Vitex negundo + clay (PL_4)	1.68	1.72	1.82	1.70	1.70	1.72
Clay (PL_5)	1.72	1.56	1.70	1.70	1.72	1.68
Gum arabica (PL_6)	1.74	1.68	1.74	1.74	1.72	1.72
Control (Unpelleted) (PL_7)	1.72	1.68	1.70	1.78	1.52	1.68
Mean	1.72	1.69	1.73	1.80	1.69	
CD (p=0.05)						
P	0.0176					
PL	0.0208					
P x PL	0.0466					

and chilli pepper seed pelleted with *Annona squamosa* leaf powder leading to an increase in seedling dry weight.

Seed vigour index- length: Priming and pelleting affected significantly seed vigour of carrot seeds. Maximum seed vigour index-length (1462.69) was in PEG 6000 -1.2 MPa for 4 days primed seed (P_4) followed by P_2 *i.e.* PEG 6000 -1.0 MPa for 4 days primed seed (1292.76) and the lowest (1133.02) seed vigour index-length was recorded in non-primed seed (P_5). Among the pelleting materials, PL_3 *i.e. Melia azedarach* leaf powder pelleting resulted into the highest seed vigour index-length (1626.25), where, the lowest (1138.65) seed vigour index-length was in PL_7*i.e.* unpelleted seed. Interaction effects revealed that combination P_4 x PL_3 *i.e.* PEG 6000 -1.2 MPa for 4 days primed seed and pelleted with *Melia azedarach* leaf powder pelleted seeds recorded the highest seed vigour index-length (1897.98). However, the lowest seed vigour index-length (736.16) was in control (P_5 x PL_7) (Table 4).

Seed vigour index- mass: The maximum seed vigour index- mass (156.97) was with PEG 6000 -1.2 MPa for 4 days primed seed (P_4) and the lowest (130.14) was in non-primed seed (P_5). Amongst the pelleting, PL_3 *i.e. Melia azedarach* leaf powder pelleted seeds resulted into the highest seed vigour index- mass (163.53), while, the lowest (129.55) was in unpelleted seed. Interaction effect due to priming and pelleting resulted that treatment combination P_4 x PL_3*i.e.* PEG 6000 -1.2 MPa for 4 days primed seed with *Melia azedarach* leaf powder pelleting recorded the highest seed vigour index- mass (209.46). However, the lowest seed vigour index- mass (100.33) was observed in combination P_5 x PL_7*i.e.* control (Table 5).

The increase in seed vigour is due to osmotic priming resulting in mobilization of the seed reserve, enzyme activation, enzyme re-synthesis, DNA and RNA replication (Sadeghi et al 2011). Priming has resulted in increased seed vigour index- mass in tomato Govinden-Soulange and Levantard (2008), in pansy (Dorna et al (2014), in chick pea Kumar et al (2017) and in Soybean Sadeghi et al (2011). Due to presence of micronutrients, saponins and gibberellic substances in the botanicals like *Melia azedarach*, *Azadirachta indica* leaf powders, increased seedling vigour has been reported (Vanangamudi et al 2010). Enhanced vigour has also been reported through seeds pelleted with various leaf powder in French bean (Babu et al 2005), in *Cenchrus* (Geetha and Krishnasamy 2011), in tomato (Shashibhasker et al 2011), in okra (Ramesh and Muthukrishnan 2015, in red gram (Anbarsan et al 2016), and black gram (Prakash et al 2018). Seed pelleting of red gram seed with botanical leaf powder has to increase seed germination and vigour (Anbarsan et al 2016).

Speed of germination: The speed of germination (24.61) with PEG 6000 -1.2 MPa for 4 days primed seed (P_4) was found maximum followed by PEG 6000 -1.2 MPa for 2 days primed seed (P_3) and the lowest speed of germination (22.27) was recorded in PEG 6000 -1.0 MPa for 2 days primed seed (P_2) (Table 6). Amongst the pelleting, PL_3 *i.e. Melia azedarach* leaf powder pelleted seeds resulted into the highest speed of germination (25.92), while the lowest speed of germination (20.23) was observed in PL_7*i.e.* unpelleted seed. Interaction effect revealed that combined treatment of P_4 x PL_6*i.e.* PEG 6000 -1.2 MPa for 4 days primed seed with Gum Arabica pelleting recorded the highest speed of germination (28.33).

Table 4. Effect of combined application of seed priming and pelleting on seedling vigour index-length (SVI-L) in carrot cv. early nantes

Treatments	PEG 6000 -1.0 MPa for 2 days (P_1)	PEG 6000 -1.0 MPa for 4 days (P_2)	PEG 6000 -1.2 MPa for 2 days (P_3)	PEG 6000 -1.2 MPa for 4 days (P_4)	Control (Non primed) (P_5)	Mean
Lantana camara + clay (PL_1)	1361.49	1268.79	1236.48	991.99	1318.18	1235.39
*Eucalyptus*species + clay (PL_2)	1428.82	1119.61	1185.77	1306.40	1296.20	1267.36
Melia azedarach + clay (PL_3)	1580.14	1623.04	1465.34	1897.98	1564.76	1626.25
Vitex negundo + clay (PL_4)	1089.22	1154.64	1791.02	1482.26	1103.05	1324.04
Clay (PL_5)	1372.73	1335.15	1222.83	1400.16	926.95	1251.56
Gum arabica (PL_6)	1302.99	1426.54	901.26	1420.96	985.81	1207.51
Control (Unpelleted) (PL_7)	858.22	1121.58	1238.20	1739.09	736.16	1138.65
Mean	1284.80	1292.76	1291.56	1462.69	1133.02	
CD (p=0.05)						
P	23.3937					
PL	27.6810					
P x PL	61.8965					

Table 5. Effect of combined application of seed priming and pelleting on seedling vigour index-mass (SVI-M) in carrot cv. early nantes

Treatments	PEG 6000 -1.0 MPa for 2 days (P_1)	PEG 6000 -1.0 MPa for 4 days (P_2)	PEG 6000 -1.2 MPa for 2 days (P_3)	PEG 6000 -1.2 MPa for 4 days (P_4)	Control (Non primed) (P_5)	Mean
Lantana camara + clay (PL_1)	148.75	137.63	138.45	137.60	132.61	139.01
*Eucalyptus*species + clay (PL_2)	149.55	133.97	135.71	145.35	145.33	141.98
Melia azedarach + clay (PL_3)	152.25	154.86	146.20	209.46	154.88	163.53
Vitex negundo + clay (PL_4)	133.53	133.28	168.31	148.78	130.10	142.80
Clay (PL_5)	143.28	120.12	126.65	144.21	114.41	129.74
Gum arabica (PL_6)	148.75	133.54	136.60	152.28	133.33	140.90
Control (Unpelleted) (PL_7)	129.47	128.53	128.35	161.09	100.33	129.55
Mean	143.65	134.56	140.04	156.97	130.14	
CD (p=0.05)						
P	2.1720					
PL	2.5699					
P x PL	5.7465					

Table 6. Effect of combined application of seed priming and pelleting on speed of germination in carrot cv. Early Nantes

Treatments	PEG 6000 -1.0 MPa for 2 days (P_1)	PEG 6000 -1.0 MPa for 4 days (P_2)	PEG 6000 -1.2 MPa for 2 days (P_3)	PEG 6000 -1.2 MPa for 4 days (P_4)	Control (Non primed) (P_5)	Mean
Lantana camara + clay (PL_1)	24.22	21.49	22.22	22.65	22.40	22.60
*Eucalyptus*species + clay (PL_2)	23.33	21.33	24.33	23.33	24.20	23.30
Melia azedarach + clay (PL_3)	27.22	26.22	26.65	27.22	22.30	25.92
Vitex negundo + clay (PL_4)	22.42	22.62	25.33	24.22	22.64	23.45
Clay (PL_5)	22.30	24.33	26.33	25.27	25.20	24.69
Gum arabica (PL_6)	23.93	20.53	23.20	28.33	23.10	23.82
Control (Unpelleted) (PL_7)	20.13	19.34	22.33	21.22	18.12	20.23
Mean	23.36	22.27	24.34	24.61	22.57	
CD (p=0.05)						
P	0.230					
PL	0.272					
P x PL	0.609					

However, the lowest speed of germination (18.12) was observed in combination P_5 x PL_7*i.e.* control.

Seed priming of dry seeds with PEG 6000 results in quick radical emergence, rapid and early germination due to completion of various metabolic activities (Arif 2005). The attributed reasons may be rapid imbibition and reduction of the inbuilt physiological heterogeneity and molecular attributes related to germination and enhanced peroxidase activities and increased rate of respiration and repair mechanisms linked with seed inhibition. These results are in line with the findings of Sadeghi et al (2011) in soybean. Pelleting with various leaf powder have also been reported to enhance seed germination in tomato (Shashibhasker et al 2011), in okra and chilli (Ramesh and Muthukrishnan 2015) and blackgram seed (Prakash et al 2018).

CONCLUSION

The carrot seed primed for 4 days in PEG 6000 solution having osmotic potential of -1.2 MPa was best among the various priming treatments and showed noticeable effects on germination and vigour of carrot seed over non-primed seed. For the majority of the germination and vigour characteristics among the pelleting treatments, seed pelleted with *Melia azedarach* leaf powder showed significantly higher values. Additionally, treatment combination ofcarrot seed primed for 4 days in PEG 6000 solution having osmotic potential of -1.2 MPa and pelleted with *Melia azedarach* leaf powder resulted higher values for germination and vigour which ultimately leads to the good crop stand under field condition and will ultimately help the farmers in achieving higher production and productivity.

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Received 21 September, 2023; Accepted 12 March, 2024