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Effect of Halo, Hydro and Hormonal- priming on germination, seedling growth, seedling vigor and seed yield of carrot (*Daucus carota*) seed

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Abstract: **Field and laboratory experiments were conducted at Holeta Agricultural research center with the objective to determine the effect of halo, hydro and hormonal priming on germination, seedling growth seedling vigor and seed yield of carrot crop. The treatments consist of one carrot variety (AUA) and priming media KNO_3(2%), Salicylic acid 2% and distil water at timing of 12, 24, 36 hour and dry seed as control treatment. The experiment was carried out using Randomized Complete Block Design for field experiment in three replications and Completely Randomized Design for laboratory experiment in four replications. Analysis result showed that highly significance difference was observed among the priming treatments for improving days to fifty percent emergence, significant difference was observed for days to maturity and no difference observed for the other field parameters. Similarly, highly significant difference observed for speed of germination, standard germination, seedling length, vigor index one and significance difference was observed for vigor index two. Carrot seed primed by Salicylic acid for 24 hr. took significantly lesser days 13 days to 50% emergence and carrot seed primed by KNO_3 for 24hr, by distil water for 12 hr and 24hr significantly reduced days to number of 50% emergence by 23.08% over control treatment. from field and laboratory experiment priming treatment improve most of the measured variables of carrot seed over the control treatments. Concerning priming medias both at field and laboratory experiment hydro priming was better followed by hormonal and halo priming on most of the measured parameters.**

Keywords: **Carrot seed, Germination, Seed priming, Seed quality.**

1. INTRODUCTION

Carrot (*Daucus carota* L.), is herbaceous species and blogs to a member of the Apiaceae family (Rubatzky., 1999). Carrot is botanically biennial plants that means it grows vegetative in the first season and produces seed in the second. For root production the plant is grown as an annual. Low temperatures, as well as various stress factors, will sometimes cause flower production to be initiated, particularly in certain selections of some varieties. Carrots are grown in the tropics where high elevations give cool night temperatures and in temperate regions of the world. (De Lannoy, 2001). Carrots do best under cool conditions (10° to 25°C), and their seeds also germinate quite well, though slowly, under cool conditions. Temperature and soil moisture influence the shape, color and quality of carrots. The best quality carrots are obtained when weather conditions favor regular uninterrupted growth. Plant growth is optimal between temperatures of 15° to 20°C, and the roots also develop the best color and flavor at such temperatures.

Rapid and uniform field emergence is essential prerequisites to increase yield and products quality, especially for direct-seeded vegetables such as carrot. Emergence and stand establishment of carrot seeds are often slow and erratic, particularly under stress conditions.

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Seed priming has been successful in improving seed vigor of many vegetable and agronomic crops, leading to rapid and uniform germination and seedling emergence. It can improve vigor especially under adverse conditions such as low/high temperatures, reduced water availability and salinity (McDonald, 2000). Poor crop stand establishment is one of the major abiotic constraints in tropical and temperate areas. There are so many reasons like low quality seed, inadequate seedbed preparation, untimely sowing, poor sowing technique; abiotic stresses such as drought, high/low temperature, salinity and adverse soil properties (e.g., crusting) etc. Seed priming is one the means by which some of these constraints can be alleviate efficiently. It is a simple, low-cost, low-risk intervention that can be a useful technology for farmers and make a positive impact on farmers' livelihoods by increasing the rate of crop emergence, increasing rates of crop development, reducing crop duration and increasing production as well as productivity. Therefore, treatments carried out before sowing, as seed priming, can be very useful for faster and synchronized germination (reducing crop duration), better performance and raising yields under adverse conditions (Bennett et al., 1992.) Beneficial effects from priming have been reported for several vegetable seeds included carrot (Pelluzio et al., 1999; Balbinot & Lopes, 2006). However, for several crops, the positive effects of priming are more evident under field stress conditions, such as low and high temperatures (Demir & Oztokat, 2003; Bittencourt et al., 2004). In Ethiopia there is limited information on effect of priming on reducing germination time, better growth performance, seedling vigor and seed yield of carrot seed. Therefore, the objective of the study was to determine the effect of halo, hydro and hormonal-priming on germination, seedling emergence, seedling vigor and seed yield of carrot.

2. MATERIALS AND METHODS

Experiments were conducted in Laboratory and in the field at Holeta Agricultural Research Center during the year 2019 to 2020. The treatments consist of one variety of carrot namely AUA and priming media KNO_3 2%, Salicylic acid 2% and distil water at timing of 12, 24 and 36 hr. The size of each plot was 3x2.10m (6.3m^2). The space between blocks was 1.5 m, the space between rows in each plot was 60 cm and spacing between plants was 30cm. The experiment was laid out in factorial arrangement using Randomized Complete Block Design (RCBD) (for field experiment) in three replication and Completely Randomized Design (for laboratory experiment) in four replications.

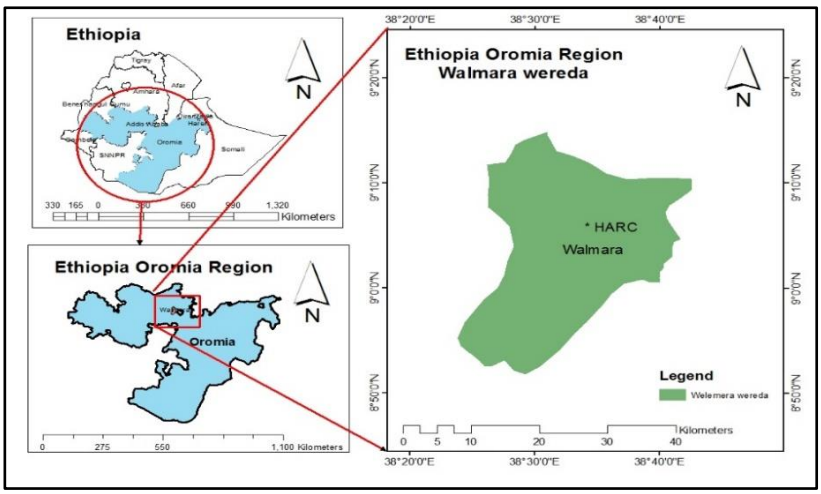

Figure 1: Map of study area

2.1. Experimental procedure and field management

The land was prepared for planting by tractor, disked and harrowed. The seeds of carrot variety namely AUA were soaked in KNO_3 2%, Salicylic acid 2% and Distil water for 12, 24 and 36 hr. For each treatment 10-gram seed and 35 ml solution and solvent were used for the experiments. Carrot seed variety was used as control where halo, hydro and hormonal-priming treatments were not applied. After giving treatment for 12, 24 and 36 hours the seed was removed from solvent and solutions then it was kept in filter paper to remove the remaining solution. All the primed seeds were again re-dried at room temperature until they gain their original seed moisture content. Seed was sown in mid-week of July 2019 in rows by placing the seeds at an appropriate distance as per the treatments with the help of tape meter and then covered it manually with the soil. After recording the root yield and other data carrot stickling were transplanted for seed yield and

other related data. All cultural practices such as weeding fertilizer application were applied uniformly to all plants. The crop was harvested manually when the crop reached physiological maturity and sun dried to adjust the moisture contents of the seed.

2.2. Data Collected

The field data collected were day to 50% emergence, days to maturity, carrot root length, root width, root weight, core diameter, stand count at harvest and yield per hectare. The laboratory data collected was speed of germination, germination percentage, shoot length, root length, vigor index-I, vigor index-II and seedling dry weight.

2.3. Data Analysis

Data were subjected to Analysis of Variance (ANOVA) using Gomez and Gomez (1984) with computer software SAS statistical package, Version 9.3**.** Treatment's mean was compared using Tukey's Studentized Range (HSD) test at 5% level of significance.

3. RESULTS AND DISCUSSION

3.1. Field Experiment

Average mean of days to 50% emergence, days to maturity, root length, root width, root weight, core diameter, stand count at harvest and yield of carrot crop was presented in Table1. The result showed that highly significance difference ($P<0.01$) was observed for 50% emergence and significant difference ($P<0.05$) was observed for days to maturity and non-significant difference was observed for root length, root width, root weight, core diameter, stand count at harvest and yield of carrot crop. Seed priming increased the germination rate (reduce number of days to 50% emergence). From table 1 blow carrot seed primed with Salicylic acid 2% for 24hr took significantly lesser days 13 days to 50% emergence followed by carrot variety primed with KNO_3 for 24hr, with distil water for 12hr and with distil water for 24hr which took 13.33days. On the other hand, significantly delayed emergence was exhibited on unprimed carrot variety which took 17 days to 50% emergence. In other word Carrot seed primed by salicylic acid for 24hr significantly increased germination rat or reduced number of days to 50% emergence by 24.99 % over control and carrot seed primed by KNO_3 for 24hr, by distil water for 12hr and 24hr significantly reduced days to number of 50% emergence by 23.08%.

Similarly, priming treatments synchronized days took to maturity as compared to the unprimed treatments. Lesser days to maturity (120 days) was took for carrot variety primed with KNO_3 for 12hr, Salicylic acid for 12hr, Salicylic acid for 36hr and distil water for 12hr whereas, delayed maturity was observed for control treatments (124.33days). Farooq *et al*., 2005 reported that the faster emergence rate after priming for tomato seed may be due to increased rate of cell division in the root tips of seedlings. Marcio, et al., 2009 also concluded that primed carrot seed germinated more rapidly and showed better performance in the field and under temperature stress in comparison to unprimed seeds. According to Eisvand, *et al*., 2011 obtained results, hydro-priming treatment increased the emergence rate more than hormonal treatments (gibberellins and salicylic acid). Statically there were no significance difference among the treatments in improving root length, root width, root weight, core diameter, stand count at harvest and yield of carrot crop as showed in Table1 but, numerical there was difference among treatments.

Table 1: Average mean of days to fifty percent emergence, days to maturity, root length, root width, root weight, core diameter, stand count at harvest and yield of carrot crop.

Treatments	DE50% (days)	DM (days)	CRL (cm)	CRW (cm)	RW (Kg)	CD (cm)	SCAH	Yield (k.g)
(T1) Unprimed	17.33A	124.33A	16.45	3.22	0.11	0.26	30.00	1218.7
(T2) AUA+KNO_3+12hr	14.00BC	120.0BC	16.98	3.34	0.09	0.33	29.67	1381.8
(T3) AUA+KNO_3+24hr	13.33C	123AB	14.74	3.53	0.10	0.31	30.00	1441.8
(T4) AUA+KNO_3+36hr	14.33BC	122.67AB	18.37	3.01	0.10	0.38	31.33	1196.7
(T5) AUA+SA+12hr	13.67C	120.0C	16.39	3.19	0.10	0.30	31.68	1745.2
(T6) AUA+SA+24hr	13C	121.67BC	18.89	3.15	0.13	0.34	33.67	1388.0
(T7) AUA+SA+36hr	16AB	120.0C	15.04	2.75	0.12	0.29	28.67	1630.5

(T8) AUA+Dw+12hr	13.33C	120.0C	19.97	3.81	0.18	0.37	33.00	1239.9
(T9) AUA+DW+24hr	13.33C	121..67BC	16.21	3.53	0.16	0.38	27.33	1324.5
(T10) AUA+DW+36hr	14.33BC	121.33BC	17.45	2.99	0.11	0.34	30.00	1341.3
Mean	14.27	121.53	17.05	3.25	0.12	0.33	30.53	1390.83
Tukey's HSD	2.005**	2.197*	NS	NS	NS	NS	NS	NS
CV	8.19	1.05	16.07	13.57	26.77	22.29	10.03	24.10

Note, NS, * and ** indicates non-significant, significant and highly significant at 5% level of probability respectively. *Means in the same column followed by similar letters are not significantly different from each other at 5% level of probability. D50%E=Days to fifty percent emergence, DTM=Days to maturity, CRL= Carrot Root Length, CRW= Carrot Root Width, RW =Root Weight, CD= Core Diameter and SCAH= Stand Count at Harvest.

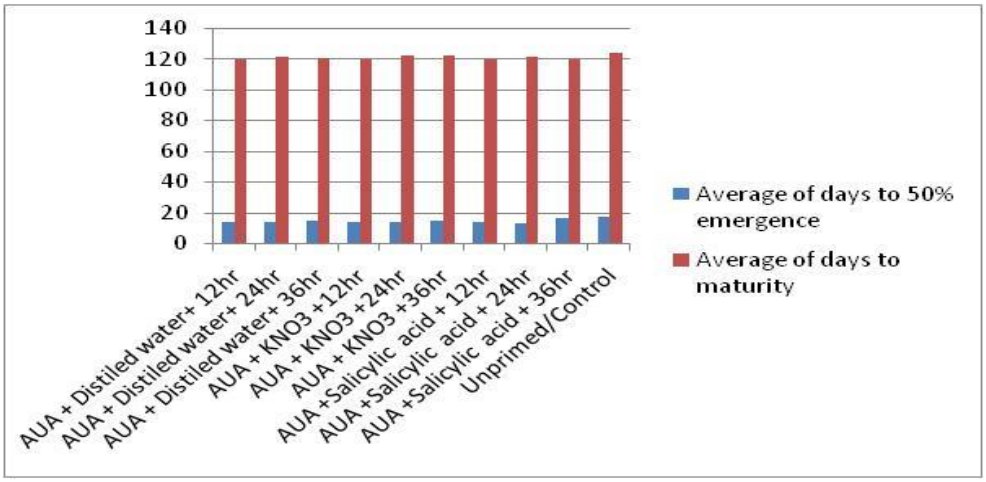

Fig 1: Effect of priming treatments on days to fifty percent emergence and days to maturity of carrot crop.

3.2. Laboratory experiment

Average mean of speed of germination, standard germination, average shoot length, average root length, seedling dry weight, vigor index one and vigor index two of carrot crop was presented in Table2. The result showed that highly significance difference ($P<0.01$) was observed for speed of germination, standard germination, average shoot length, average root length and vigor index one and significance difference ($P<0.05$) was observed for vigor index two and non-significant difference was observed for seedling dry weight of carrot crop. The highest (19.87) speed of germination was recorded for carrot seed primed with water for 36hr whereas the lowest (17.22) speed of germination was recorded for unprimed carrot seed. Sung F., 1993 reported that seed priming resulted anti-oxidant increment as glutathione and ascorbate in seed these enzymes make more germination speed via reduction of lipid per oxidation activity. The probable reason for early emergence of primed seed might be due to completion of pre-germination metabolic activities making the seed ready for radicle protrusion. Priming treatments also improve the germination percentage of carrot seed. The highest (85%) germination percentage was recorded for carrot seed primed with water for 24hr followed by carrot seed primed with salicylic acid for 12hr record (84%) whereas the lowest (77%) germination percentage was recorded for carrot seed primed with KNO_3 for 12hr and for unprimed carrot seed. The present finding was in agreement with the previous finding of (Selvarani, 2011) who reported that hydro primed carrot seed for 36hr increase/improve percentage of radicle protrusion, days for 50% germination, days for maximum germination, speed of germination and germination percentage by 10, 22, 25, 11 and 12 over the control respectively. Nascimento. *et.al*., 2013 also reported that at 35ºC unprimed and primed carrot seed germination percentage was 35% and 65%, respectively. The higher germination percentage in case of primed seed might be due to break down of dormancy and removal of germination inhibitors. Hydro-priming affects DNA and RNA synthesis, ATP availability, alpha-amylase activity and embryo's better growth. Hence, germination with better rate, growth consistency, seeding vigor and development leads to better plant growth (Basra *et al*., 2006 and Harris *et al*., 1999). The mean performance of seedling shoot length ranged from 4.91cm to 6.15cm with mean value of 5.37 cm. Maximum shoot length (6.15cm) was recorded for carrot seed primed with water for 24hr and the shortest 4.91cm and

4.93cm were recorded for carrot seed primed with salicylic acid for 36hr and 24hr respectively. Similarly, the mean performance of seedling root length ranged from 3.78 cm to 6.09 cm with mean value of 4.96 cm. Maximum root length (6.09cm) was recorded for carrot seed primed with water for 24hr whereas the shortest seedling root length 3.78 cm and 3.93 cm were recorded for carrot seed primed with KNO_3 for 36hr and carrot seed primed with salicylic acid for 36hr respectively. This result is consistent with the findings of (Eisvand, *et al*., 2011) who reported that on two of carrot cultivar hydro priming treatment increase both shoot and root length of seedling as compared to hormonal treatments. (Sanches *et al*., 2001) also found that the root length of cucumber and pepper increased due to hydro-priming effects.

According to Afzal *et al.* (2002) an increased weight of primed seed lots and increase in root length was due to activation of cell respiration, repairs of macromolecules, movements of acquired materials, activation of cell cycling, the result of higher embryo-cell wall extensibility and weakening of seed coat structure for radical emergence. The increased shoot and root length with osmo priming treatments might be due to increased nuclear replications in shoot and roots. The highest seedling dry weight (35.35mg) was recorded for carrot seed primed with water for 12hr whereas the lowest seedling dry weight (17.25mg) was recorded for carrot seed primed with salicylic acid for 12hr whereas the other treatments record an intermediate result. Concerning the vigor index the highest vigor index one (525.82) was recorded for carrot seed primed with water for 24hr which was at par with carrot seed primed with water for 12hr which recorded (491.23) whereas the lowest vigor index one (402.41) was recorded for carrot seed primed with KNO_3 for 36hr followed by unprimed treatment and carrot seed primed with salicylic acid for 36hr which recorded 405.57 and 406.25 respectively. The highest vigor index two (2927.50) was recorded for carrot seed primed with water for 12hr whereas the lowest vigor index two (1457.30) was recorded for carrot seed primed with salicylic acid for 12 hr. This finding was in agreement with that Eisvand, *et al*., 2011 who reported that in two of carrot cultivar hydro priming increase vigor index as compared to hormonal priming treatments namely gibberellins and salicylic acid. This parameter depends on germination percentage and seedling dry weight. However, the present study showed that priming treatments showed an increment in germination percentages and seedling dry weight which increases SVI-2. The increase in seedling vigor due to salicylic acid may be due to enhanced oxygen uptake and the efficiency of mobilizing nutrients from the cotyledons to the embryonic axis (Karthiresan *et al*., 1984) and decreased catalase and peroxidase levels as recorded in pea seedlings (Srivastava and Dwivedi, 1998). Similarly, Dornbos, 2002 concluded that seedling dry weight represents logical and relevant estimate of seed vigor, what is more seedling dry weight was affected by shoot and root length of seedling, so increased shoot and root length due to water and osomopriming in turn could enhance vigor index two.

Table 2: Average mean of speed of germination, standard germination, shoot length, root length, seedling dry weight, vigor index one and vigor index two of carrot crop.

Treatments	SPG	SG%	ASL (cm)	ARL (cm)	SDW (mg)	VI1	VI2
(T1) Unprimed	**17.22C**	77.0C	5.20CD	4.61BC	22.80	405.57C	1771.7BC
(T2) AUA+KNO_3+12hr	18.21ABC	77.0C	5.51BCD	5.14AB	27.53	428.36C	2112.0ABC
(T3) AUA+KNO_3+24hr	19.41AB	78.0C	5.42BCD	5.13AB	27.75	425.99C	2151.1ABC
(T4) AUA+KNO_3+36hr	17.85BC	79.0BC	5.05CD	3.78C	22.10	402.41C	1745.8BC
(T5) AUA+SA+12hr	18.5ABC	84.0A	5.61ABC	5.27AB	17.25	478.53AB	1457.3C
(T6) AUA+SA+24hr	17.98BC	83.0A	4.93D	4.69BC	25.75	412.58C	2130.0ABC
(T7) AUA+SA+36hr	19.47AB	82.0AB	4.91D	3.93C	27.75	406.25C	2273.3ABC
(T8) AUA+Dw+12hr	19.61AB	83.0A	5.83AB	5.71AB	35.35	491.23A	2927.5A
(T9) AUA+DW+24hr	19.54AB	85.0A	6.15A	6.09A	29.53	525.82A	2487AB
(T10) AUA+DW+36hr	19.87A	83.0A	5.14CD	5.29AB	22.23	433.49BC	1843.2BC
Mean	18.77	81.08	5.37	4.96	25.80	441.02	2089.95
Tukey's HSD	1.535^{**}	3.475^{**}	3.475^{**}	1.032^{**}	NS	49.19^{**}	794.6^{*}
CV	5.67	2.97	7.16	14.40	26.99	7.72	26.33

Note, NS, * and ** indicates non-significant, significant and highly significant at 5% level of probability respectively. Means in the same column followed by similar letters are not significantly different from each other at 5% level of probability. SPG=Speed of germination, SG= Standard germination, ASL= Average Shoot Length, ARL= Average Root Length, SDW= Seedling dry weight, VI1= Vigor index one and VI2= Vigor index two.

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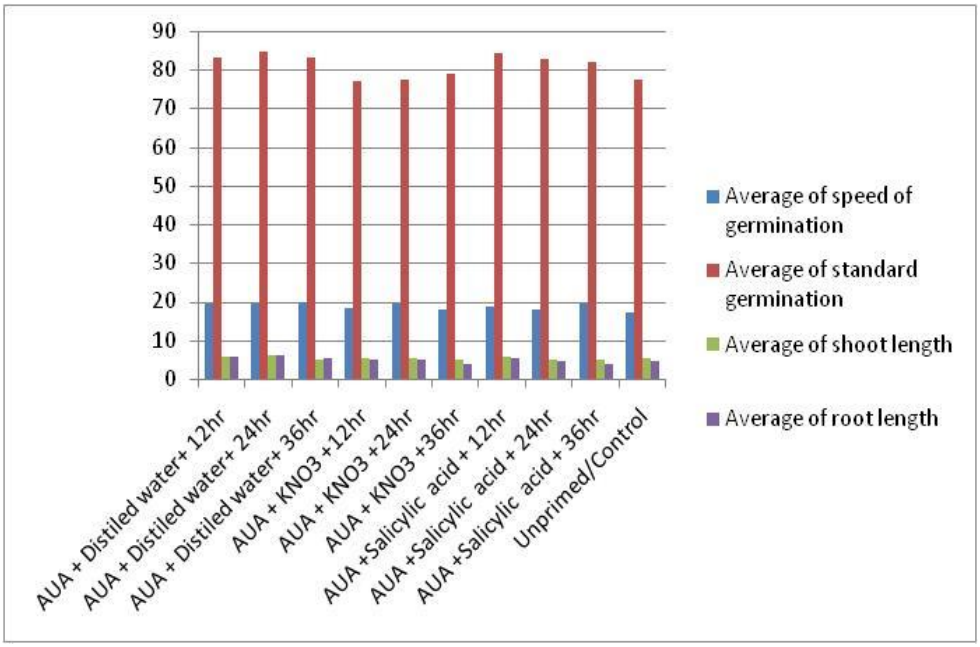

Fig 2: Effect of priming treatments on speed of germination, standard germination, shoots and root length of carrot crop.

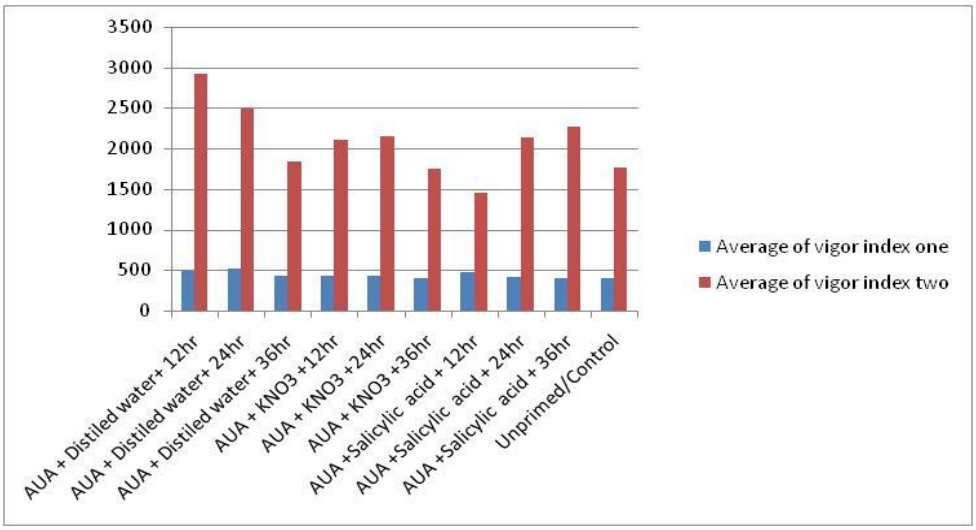

Fig 3: Effect of priming treatments on average means of vigor index one and vigor index two of carrot crop.

4. CONCLUSION

Priming has been described as a pre-sowing technique that can improve seed performance by reducing the time to germination and seedling emergence and also by increasing the uniformity of germination under adverse environmental condition. In our work both from field and laboratory observation priming treatments improve/enhance most of the measured parameters over the unprimed carrot seed.

Under field conditions, there was highly significance difference among priming treatments in improving 50% emergence and days to maturity and statically there were no difference among the treatments in improving root length, root width, core-diameter, stand count at harvest and yield per hectare of carrot seed. Similarly, under laboratory experiment there was highly significance ($P<0.01$) difference among priming treatments in improving/enhancing speed of germination, standard germination, shoot length, root length, vigor index one and significance difference ($P<0.05$) was observed for vigor index two of carrot seed. Generally, from Field and laboratory experiments priming treatment improve most of the

measured parameters of carrot seed over the unprimed one. Concerning priming media hydro priming was better in improving most of the measured parameters both at field and laboratory experiment followed by hormonal and halo priming on most and each of the measured parameters. Hence, better to recommend for seed growers hydro priming prior to seed sowing because, simple to use, cost effective and easily available for carrot seed growers to overcome the problems of poor crop emergence and establishments under adverse environmental conditions. However, this study was done only for one season at one location using only one varieties of carrot crop. So that, to give conclusion and recommendations furthermore studies could be made on multiple varieties, priming medias types and concentration and durations of soaking in research centers and other carrot growing region of the country.

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