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RESEARCH ARTICLE

Effect of Blended NPS Fertilizer, Root Type and Root Treatment on Quality of Carrot (*Daucus Carota*. L) Seed at Haramaya, Eastern Ethiopia

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Abstract

Carrot is an important vegetable crop in Ethiopia. However, the quality of the crop is low mainly due to low soil fertility (low amount of soil nutrients), inappropriate production method, and pathogen infection resulting low yield and low quality of carrot seed. Therefore, this study was conducted in 2017 to assess the effect of blended NPS fertilizer, root type and root treatments on quality of seed of Haramaya I carrot variety. The field experiment consisted of five levels of blended NPS (0, 75, 100, 125 and 150kg ha^{-1}), three levels of root treatments (Ash, Mancozeb and Distilled water) and two level of root type (whole root and cut root). Complete randomized design with four replications used for laboratory experiment, whereas randomized complete block design (RCBD) in factorial arrangement with three replications was used for field experiment. The result of analysis revealed that the three main factors (blended nitrogen, phosphorus and sulphur; root type and root treatment) had highly significant ($P<0.01$) effect on almost all quality parameters (seed purity, thousand seed weight, seed germination, speed of seed germination and seedling vigour index). Similarly, the interaction of root type and root treatment had also shown highly significant ($P<0.01$) effect on seed germination and speed of germination of seed from secondary umbels. The highest thousand seed weight of primary (1.82g) and germination of seed (95.88%) were obtained from application of 150kg blended NPS fertilizer. Similarly, the highest speed of germination of primary umbel seeds (28.6) were obtained from the interaction effect of cut root with Mancozeb. In conclusion, the result of the study showed that application of 150kg blended nitrogen, phosphorus and sulphur (NPS) ha^{-1} fertilizer with cut root and Mancozeb enhanced quality of carrot seed.

Keywords: Umbel; Umbellets; Germination; Seed yield; Seed vigour

Introduction

Carrot (*Daucus carota* L.) is a winter crop and is one of the important root vegetable crops cultivated throughout the world. Its fleshy edible roots are used as human food and animal feed [1]. Carrot is rich in beta-carotene which is a source of vitamin A and is an excellent source of iron, calcium, phosphorus, and folic acid and vitamin B. It is also rich in sugar content [2] and some important medicinal values [3-5].

Carrots (*Daucus carota* L.) are one of the more complex crops to produce seed, because it is a biennial and the seed production requires two years with specific overwintering storage requirements (vernalization) [6,7]. Whereas the Haramaya University researchers were taking the task of improving the crop from farmers saved seeds and in 2014 the University released the first improved carrot variety in Ethiopia named as Haramaya I [8]. Haramaya I carrot variety has not vernalization requirement and seed can be produced using root to seed and seed to seed methods. This is a good opportunity for the country to save the foreign currency that is spending to purchase commercial carrot seeds from abroad since the entire carrot production is dependent on imported seeds. However, the production of high quality commercial carrot seed production to substitute the imported seeds need the development of methods for quality seed production, but it is not determined yet. The genetic information of the crop is transmitted through seeds from one generation to the other. Therefore, the quality of seed in any crop is one of the important factors to obtain high yield. Similarly, therefore, for Haramaya I carrot variety the use of high quality and genetically pure seeds is critical to increase the productivity of the crops [8].

To save the foreign currency and to increase carrot production in the country, timely supply of quality seed should be ensured. This is only possible through development of carrot seed production method and using chemical treatments and makes it available for growers [9].

The production of quality seed is depending on the application of best possible agronomic practices in addition to the genetic potential of the variety. This is because, the seed production agronomic practices (fertilizer rates, production method, chemical treatments etc.) depends on the variety, and the environment where it grow. In carrot, other than agronomic practices, the seed quality has variation depending on the umbels where the seeds collected [6,10].

The production of high quality seed is influenced by the amount of nutrient applied [11]. Large nitrate concentration in soil tends to improve shoot: root ratio [12]. Great variation in nitrogen uptake may be related to different climatic conditions, soil type, nutrient concentration, and well-developed root system which enable the plants to absorb nitrogen efficiently from the soil [13]. Carrots require adequate available phosphorus for satisfactory growth. The deficiency of phosphorus causes reduction in yield, with a concomitant increase in dry matter, sugar and carotene contents of carrot root [14].

Different authors reported that 0-110 and 50-100kg N and P_2O_5 ha^{-1}, respectively, to be appropriate rates to produce maximum carrot seed yield with the required quality [11,5]. The blended NPS fertilizer is in use to substitute the earlier DAP fertilizer in Ethiopia (CSA) [15,16]. However, the rates of fertilizer to be applied, the appropriate method of root type and root treatment have not yet been studied for the newly released variety (Haramaya I). Moreover, the interaction effect of blended NPS fertilizer, root type and root treatment is not studied. Therefore, it was felt necessary to conduct research to determine the amount of blended NPS fertilizer and its interaction affect with root type and treatment on seed quality of Haramaya I carrot variety. This experiment therefore, was initiated to assess the effect of blended NPS fertilizer, root type and root treatment on quality of Haramaya I carrot variety seeds.

Materials and Methods

Description of Experimental Site

The experiment was conducted at rare research station of Haramaya University in 2017 under irrigation. The University is located at latitude of 9° 24' 10.8" N, longitude of 42° 3' 30.07" E and at altitude of 1980 meter above sea level (m.a.s.l). The rain season of the area is bimodal type with an average annual rainfall of 790 mm. The mean annual temperature is 16.9 °C with mean minimum and maximum temperature of 3.8 and 25 °C, respectively. The mean relative humidity is 50%, varying from 20 to 81% and the soil type of the area is well-drained deep alluvial sandy loam that contains 14g/kg organic matters, 1.14 g/kg total nitrogen, 0.01g/kg available phosphorus, 0.47g/kg total potassium and pH of 7.2 [17] and percent sand, silt, and clay contents of 63, 20, and 17, respectively [18].

Treatments and Experimental Design

The Field experiment was conducted using (5x3x2) factorial combination of five blended NPS fertilizer (0, 75, 100, 125 and 150kg NPS/ha), three root treatments (ash, distilled water Mankozeb fungicide) and two root types (whole and cut roots) using carrot variety Haramaya I. The carrot variety Haramaya I was developed using 100kg DAP and 100kg Urea without research results based recommendation, since the variety was new. The DAP fertilizer is substituted by NPS blended fertilizer. Therefore, the 100 kg NPS fertilizer was considered as 100kg DAP equivalence to set rates of fertilizer in treatments combinations. Urea at 100 kg ha^{-1} was applied for all treatments.

A total of 30 treatments in factorial arrangement (5x3x2) were laid out in randomized complete block design (RCBD) with three replications in field experiment. The treatments were assigned randomly to each plot consisting of four rows of 3m length each row accommodating 10 plants. Plants were spaced 30cm apart and the spacing between rows was 75cm. A distance of 1 and 1.5m was maintained between plots and replications, respectively. A total of 20 plants in each plot were used for data collection leaving plants at two border rows and end of each row in both sides. Therefore, the total plot size was 3 m x 3 m (9 m^2) with 3 m x 1.5 m (4.5 m^2) net plot size. The whole rates of NPS fertilizer was applied once during planting while the Urea fertilizer was applied in two splits, half rates during root transplanting and the remaining half was applied after 6 weeks of the first Urea fertilizer application. However, for laboratory experiment (seed quality test), a total of 30 treatments (5x3x2) in completed randomized design (**CRD**) with four replications were used.

Experimental Procedure

Land Preparation and planting

The experimental land was opened with a power tiller followed by repeated plugging and cross plugging. Then the clods were broken into small pieces and the land was leveled. Thus the land was prepared to a good tilth. During land preparation weeds and stables of the previous crops were collected and removed from the field. The roots were grown on well prepared nursery and after 14 weeks of seed sowing, roots were harvested. Three days after harvesting, roots with a diameter of 2.48 to 3.18 and root length of 18.02 to 19.76cm (average root size of the variety) were selected. The vegetative parts of the roots were cut 5 cm above intact point and removed. For cut root planting treatment, 1/3 of the lower portion of the roots was removed. The roots treated with Mancozeb were kept in the solution of Mancozeb fungicide at 2g per liter of water for 5 minutes and roots these which received ash treatment were coated with well sieved ash. For the root that treated with distilled water, the root were dipped in distilled water for 5 minutes; then water was drained by keeping roots vertically supported with wall of the working room. The roots that received the different

treatments were transplanted to the field in the afternoon. The roots were planted leaving a little portion of the roots above the ground level at the spacing of 75 and 30cm between the rows and plants, respectively.

Irrigation and Other Agronomic Practices

The first irrigation was applied just after planting. The subsequent irrigation water applications were applied at interval of 5 days, keeping in view the establishment and growth of plants as well as weather conditions. The plots were irrigated by watering can. This irrigation system reduces the mixture of fertilizer from one plot to another plot. Weeding was practiced by hoeing and hand weeding four times throughout the experiment period and mulching was done once with grass cover at 5cm thickness.

Harvesting of Seed

The umbels were harvested at different dates by pruning shear as they turned to dark brown color. The umbels were kept for 3 days under sun and seeds were collected by hand threshing and winnowing. The seeds were then dried, cleaned very carefully, weighed, and finally stored in polythene bags. Seeds from different branches of plants of the same treatment group were bulked and a representative samples were taken to determine 1000 seed weight and to carry out germination and vigor tests.

Data Collection

The data was collected both from field and laboratory experiments. The data collection procedures and measurements were presented below.

Seed Quality Test

The seed quality test or analysis was carried out in laboratory using the carrot seed obtained from experimental plots. The experiment was conducted in a Completely Randomized Design (**CRD**) with four replications as per ISTA rules for seed quality test [19].

Physical quality: 40g seeds from each plot and replication were randomly taken as the representative and the seed samples of similar treatments obtained from each replication were mixed. After thoroughly mixed the sample seeds of each treatment, 40g out of the total seed samples from each treatment was taken as working sample. This working sample was divided into four equal parts (10g each) in which the seed physical quality test was conducted. Each partition of the seed samples (10g of four replicates) were considered as a replication. The working sample was separated into pure seed, other seeds and inert matter by keeping on purity work board with the help of spatula (ISTA) [19]. The purity and other purity components were determined in percent.

1000 seed weight (g): was measured by weighting 1000 seeds randomly taken from the total seeds harvested in each plot. The thousand seed weight for primary and secondary umbels were measured from 1000 seeds randomly taken from the total seeds harvested from sample plants and umbels.

Seed moisture content (%): was determined by high constant temperature oven method, which was carried out in four replications independently drawn 10g working samples from each treatment, which was weighed with a sensitive electronic balance. The sample was beat temperature of 130 °C for one hour. The seed samples were kept in the oven for drying when it reached the required temperature. At the end of drying period, the container was transferred in to the desiccators, the desiccators were closed and the sample allowed for cooling. The seed samples after cooling were then weighed and the moisture content was calculated by the following formula.

$$MC(\%) = \frac{(M2 - M3)}{(M2 - M1)} \times 100\%$$

where
MC = seed moisture content
M1 =weight of the empty container with its lid
M2= weight of the container with its cover and seed before drying
M3= Weight of the container with its cover and seeds after drying

Standard germination and speed of germination test

Standard germination: The standard germination, vigor and other quality test were examined by taking seed from pure seed fraction that was sorted during seed physical test indicated above. Four hundred (400) pure seeds were taken from each pure seed component of each treatment and divided into four replicates of 100 seeds each .The seeds were sown in germination box (13 x 18 cm) lined with two layers of filter paper or blotter paper. The sample was kept in seed germinator at 20 °C temperature. The first count was done on 7th day after placing of seeds on germination box and the final count was done on 14th day. Seedlings were evaluated as normal, abnormal seedling, hard, fresh and dead seeds according to ISTA manual. The result of the germination test was calculated as percentage for each portion of quality parameters in each replication. The quality of the samples seeds were expressed as a percentage of number of normal seedlings [19].

$$\textbf{Germination}(\%) = \frac{\text{Total number of normal seedlings}}{\text{Total number of seeds Planted}} \times 100\%$$

Speed of germination: One hundred seeds were taken from each sample and divided into four replicates and kept at 20 °C temperature for 14 days in the seed germinator. Germination was evaluated as the percentage of seeds producing normal seedlings as defined by (ISTA) [20]. Normal seedlings was counted and removed from germination box at each day, and the speed of germination (GS) was calculated [21] as follows:

$$\textbf{Speed of germination} = \frac{\text{Number of normal seedlings} + \ldots + \text{number of normal seedlings}}{\text{Days of first count..days of final count}}$$

Seedling vigor

Shoot and root length of seedlings (mm): were determined by measuring average shoot and root length of 10 randomly taken seedlings in millimeter after completion of germination period (14 days) from each treatment and replication. The shoot and root length of the seedlings were measured from the point of the embryo attachment to the tip of shoot and root. The averages of shoot and root length were computed by dividing the total shoot or root lengths by the total number of seedlings on which measurement was done [22]. The shoot and root lengths were registered separately and the total seedling length were registered as the sum of shoot and root lengths.

Seedlings dry weight (mg): was determined from 10 randomly taken seedlings which were used for measuring seedlings shoots and root lengths. The seedling was placed in paper bags, dried at 80 °C for 24 hours, and weighed [23]. The seedlings were dried and weighed to the nearest milligram and the average seedling dry weight was calculated.

Seedling Vigor Index I and II: was calculated according to Abdul and Anderson [24]. The seedling vigor index I was calculated by multiplying the standard germination with the average sum of shoot length and root length after 14 days of germination, seedling vigor index II was calculated by multiplying the standard germination with mean seedling dry weight after (drying at temperature of 80 °C for 24 hours), indicated with the following formula:

Seedling Vigor Index I = Standard germination × mean seedling length (Roots +Shoots length)

Seedling Vigor Inex II = Standard germination × mean seedling dry weight

Field emergence index: Four replication of 50 counted seeds of all treatments were sown in a pot filled with soils obtained from the farm where the carrot roots were produced for each treatment. The emergence data was recorded daily until no further emergence. The field emergence index was calculated by dividing the number of seedlings emerged on each day with the number of days in which they were emerged [25].

$$\textbf{Emergence index} = \frac{\text{Number ofseedlings emerged}}{\text{Days of first count}} + .. + \frac{\text{Number of seedling emerged at final count}}{\text{Days of final count}}$$

Field emergence (%): The total seedlings emerged from the soil was summed up at the end of field emergence index experiment and it was calculated as field emergence in percent.

$$\textbf{Field emergence}(\%) = \frac{\text{Total numberof emerged seeedlings}}{\text{Total numberof seeds planted}} \times 100\%$$

Seed health testing

Seed sample was studied for association of different fungal and bacterial seed borne pathogen. The seed borne pathogens were tested by using agar plate method (for internal pathogens). The seeds were treated with 5% sodium hypo-chlorite (NaOCl) solution for five minutes. Ten seeds were placed at equal distance on petridishes which replicated four times and then incubated at a temperature of 28 °C with alternating cycles of light and dark period of 12 hours for eight days. Then slides were prepared in order to identify the seed borne pathogens. Identification was based on morphological traits including colony features, structures, and spores using stereo and compound microscopes. Percentage of seed infection by each pathogen was calculated as:

$$\textbf{Seed infection}(\%) = \frac{\text{Number of infected seeds}}{\text{Tota l number of seeds}} \times 100\%$$

Data Analysis

Data were subjected to Analysis of variance (ANOVA) as per the experimental designs for each experiment using Genstat (15th edition) software (Genstat) [26]. The significant differences among treatments were separated by using LSD (Least Significant Difference) at 5% level of significance.

Results and Discussion

Seed Quality as Influenced by blended NPS Fertilizer, Root Type and Root Treatment

Seed Purity: The analysis of variance revealed that the two main factors (NPS and Root type) had highly significant (P<0.01) effect on physical purity of carrot seeds (Table 1).The carrot plants which received 150 and 125 kg ha^{-1} blended NPS fertilizer had shown the highest (96.21% and 95.42%) seed purity with non-significant difference, respectively, whereas the lowest was obtained from plants that did not received fertilizer.

Character			
NPS fertilizer (kg/ha^{-1})	**Physical Purity of seed (%)**	**1000 seeds weight from primary (g)**	**1000 seeds weight from secondary umbels (g)**
0	92.42^{c}	1.35^{e}	1.31^{e}
75	93.54^{b}	1.51^{d}	1.40^{d}
100	94.38^{b}	1.59^{c}	1.46^{c}
125	95.42^{a}	1.71^{b}	1.57^{b}
150	96.21^{a}	1.82^{a}	1.65^{a}
LSD (5%)	0.91	0.07	0.06
Root type			
Whole root	93.38	1.58	1.48
Cut root	95.40	1.60	1.48
LSD (5%)	0.57	0.04	0.04
CV (%)	1.7	6.4	5.6

Mean values in column of each character and treatment with similar letter(s) have nonsignificant difference at P<0.05. LSD (5%) = least significant difference at P<0.05; CV (%) = Coefficient of variation in percent, N=Nitrogen, P=Phosphorus, S=Sulphur

Table 1: Effect of blended NPS fertilizer on physical purity and thousand seeds weight of Haramaya I carrot variety

However, plants which received 75 and 100kg ha^{-1} blended NPS had non-significant difference for physical purity of the seed. The cut root used for planting had shown significantly higher (95.4%) physical purity than whole root used for planting (Table 1). To some extent every seed lot had a mixture of pure seed, inert matter, other crop seeds and weed seeds (Khare and Bhale) [27]. Unlike other crops, carrot seed is not harvested at one time, since its umbel mature unevenly. Therefore when carrot seed matured it harvested based on its umbel order. Primary umbels mature earlier than secondary and higher order umbels (Hoad, *et al.*, Khare and Bhale) [27,28]. In the current study, the high physical quality of the seed was observed from the plant that received higher rates of blended NPS fertilizer and cut root used for planting, which might be due to the harvesting behavior of the crop and larger sized and uniform seeds produced that can be easy to identify from seed lot.

Thousand Seed weight: The carrot plants which received 150 kg blended NPS fertilizer had shown the highest thousand seed weight of primary umbel (1.82g) and thousand seed weight of secondary umbel (1.65g), respectively. Similarly plants that did not receive fertilizer had shown the lowest thousand seed weight of primary (1.35g) and secondary umbels (1.31g), respectively (Table 1). Thousand seed weight increased as blended NPS rate increase, indicating the positive effect of blended NPS fertilizer on thousand seed weight of carrot. Thus increasing blended NPS fertilizer further from 0-75 , 75-100, 100-125 and 125-150kg blended NPS ha^{-1} the thousand seed weight of primary umbels by about 11.85%, 5.3%, 7.55% and 6.43% respectively and higher by 6.87%, 4.3% 7.53% and 5.1%, for secondary umbels ,respectively. This might be due to the larger seed size in primary and secondary umbels produced from high blended NPS that led to high mean thousand seed weight of primary and secondary umbels through facilitating leaf growth and photosynthetic activities. This result is in agreement with Robert, *et al.* and Khangi, *et al.* [29,30] who reported that an increase in 1000 seed weight with increasing seed size.

Speed and percentage of germination (%)

The three main factors (blended NPS, root type and root treatment) had highly significant (P<0.01) effect on percentage of germination and speed of germination on carrot seed. Interaction of root type and root treatment had also shown highly significant (P<0.01) effect on seed germination and speed of germination of secondary umbel (Table 2). The highest percentage of germination (95.88%) of seed was observed from 150kg blended NPS fertilizer ha^{-1} application and it was higher by 4% than control (0 kg NPS fertilizer). Similarly, the cut root used for planting had shown significantly higher percentage germination and

germination of seeds in primary umbel as compared to whole root used (Table 2). Seed obtained from cut root planting materials was higher by 1.8% in percentage germination than whole root. Moreover, significantly the highest (96.46%) germination in seeds of primary umbels was registered from plant that received 150 kg followed by 125kg blended NPS fertilizer (96.21%). However, germination of seed obtained from primary umbels that did not received fertilizer had nonsignificant difference with plant that received 75 kg ha^{-1} blended NPS fertilizer. Moreover, the plant that received 125 kg NPS fertilizer had non-significant difference with plant that received 150 kg ha^{-1} blended NPS fertilizer on germination of seed obtained from primary umbel (Table 2). The carrot plants which received 150 kg ha^{-1} blended NPS fertilizer had shown the highest (94.71%) germination of seeds of secondary umbel, speed of germination (25.58), speed of germination of seeds in primary umbels (24.21) and speed of germination of seeds in secondary umbels (27.96). However, speed of germination and speed of germination of seeds in primary umbel of plant that did not received fertilizer had non-significant difference with plant that received 75 kg ha^{-1} blended NPS fertilizer (Table 2).

At each level of blended NPS fertilizer, there was an increased in percentage of germination of secondary umbels and speed of germination, this might be due to large sized and higher thousand seed weight obtained by the application of high rate of fertilizer which enhanced the speed of germination. This study is in line with earlier finding of Rodet, *et al.* [22], who reported that superior umbels usually produce seeds with higher germination vigour. Similarly, cut root used for planting had shown significantly higher percentage of germination of secondary umbels and speed of germination as compared to whole root used. The mancozeb used for root treatment had shown significantly higher speed of germination as compared to other root treatment. However, germination of seeds in secondary umbel at plant treated with Mancozeb had non-significant with plant that treated with distilled water. The speed of germination of seed obtained from Mancozeb treated root was higher by about 4% and 3.6% than root treated with distilled water and ash, respectively (Table 2).

Blended NPS fertilizer (kg ha^{-1})	Germination (%)	Germination in seeds of primary umbels (%)	Germination of seeds in secondary umbels (%)	Speed of germination	Speed of germination of seeds in primary umbels	Speed of germination of seeds in secondary umbel
0	92.17^{d}	95.04^{c}	91.58^{e}	22.04^{d}	21.38^{d}	24.62^{e}
75	93.25^{c}	95.5^{bc}	92.25^{d}	22.71^{d}	21.88^{d}	25.42^{d}
100	93.83^{bc}	95.62^{b}	93.00^{c}	23.62^{c}	22.75^{c}	26.38^{c}
125	94.50^{b}	96.21^{a}	93.79^{b}	24.62^{b}	23.38^{b}	27.2^{b}
150	95.88^{a}	96.46^{a}	94.71^{a}	25.58^{a}	24.21^{a}	27.96^{a}
LSD (5%)	0.732	0.46	0.59	0.68	0.55	0.49
Root type						
Whole root	93.07	95.167	92.267	22.91	22.38	25.53
Cut root	94.78	96.367	93.867	24.53	23.00	27.12
LSD (5%)	0.73	0.29	0.37	0.43	0.35	0.31
Root treatment						
Ash	93.90^{a}	95.80^{a}	92.83^{b}	23.45b	22.6^{ab}	26.02^{b}
Mancozeb	93.92^{a}	95.88^{a}	92.95^{a}	24.32a	23.02^{a}	27.12^{a}
Distilled water	93.95^{a}	95.62^{a}	93.46^{a}	23.37b	22.52^{b}	25.82^{b}
LSD (5%)	0.57	0.36	0.46	0.68	0.43	0.38
CV (%)	1.4	0.8	1.1	5	4.2	3.2

Mean values in column of each character and treatment with similar letter(s) have non-significant difference at P<0.05. LSD (5%) = least significant difference at P<0.05; CV (%) = Coefficient of variation in percent, N=Nitrogen, P=Phosphorus, S=Sulphur.

Table 2: Effect of NPS fertilizer, root type and root treatments on percentage speed of germination of carrot seeds

The highest speed of germination of carrot seed might be due to the healthy and large sized seeds obtained when the root treated with Mancozeb chemical as compared to other chemical treatments used. In the current study finding, the higher germination of seeds in secondary umbel and speed of germination of seeds produced from cut root might be due to the quality seeds obtained from cut root that germinates in fast rate. Mostafezur [23] found high percentage and rates of germination from the seed obtained from cut root used for planting than whole root.

The result of current study also in line with Nagarajan and Gadita [24], who observed that the seed from cut root were superior in quality than seed from whole root plant in both primary and secondary umbels. In the current study finding the percentage of germination and seed of germination for seed obtained from plant that received higher rates of fertilizer and seed from cut root might be due to larger sized, healthy and weighty seed obtained. Many authors (Ahmad, Humpton and Takrony, Mostafezur) [23,25,26] recorded significantly higher germination percentage and seed of germination for seed that had large size and weighty seed from primary and secondary umbels which is almost similar with the current study finding. From the interaction of root type and root treatment, the significantly highest (95.2%) germination percentage of seed was observed for plants grown from cut root treated with

distilled water and it was higher by about 2.7% than seeds obtained from whole root treated with distilled water. However, germination percentage of seed observed from whole root treated with ash had no significant difference with plants grown from whole root treated with distilled water. Similarly, significantly the highest (28.6) speed of germination in seeds of secondary umbel was observed for plants grown from cut root treated with Mancozeb. However, speed of germination of seed obtained from secondary umbel of plant from whole roots treated with ash had non-significant difference with plants grown from whole roots treated with Mancozeb and distilled water (Table 3). The higher germination and speed of germination in the current finding might be due to large sized and heavy weight seed obtained due to root cutting and water and ash treatment used.

	Germination (%)		Speed of germination in seeds of secondary umbel	
	Root type		Root type	
Root treatments	Cut root	Whole root	Cut root	Whole root
Ash	94.85^{ab}	92.95^{de}	26.35^{b}	25.70^{c}
Mancozeb	94.3^{bc}	93.55^{d}	28.60^{a}	25.25^{c}
Distilled water	95.2^{a}	92.7^{e}	26.40^{b}	25.65^{c}
LSD (5%)	0.8		0.54	
CV (%)	1.4		3.2	

Mean values in column and row with similar letter(s) have non-significant difference at P<0.05. LSD (5%) = least significant difference at P<0.05

Table 3: Interaction effect of root type and root treatment on germination percentage and speed of germination in seeds of secondary umbels of carrot

Seedling Vigour Index: The analysis of variance revealed that only the NPS fertilizer had significant (P<0.05) effect on vogour index I and II (Table 4).

The carrot plants which received 150 and 125 kg ha^{-1} blended NPS fertilizer had shown the highest (82.84 and 82.76) seedling vigor index I, respectively. While the lowest (75.90) seedling vigor index I was obtained from the plant that did not received fertilizer. However, seedling vigour index I at 100kg blended NPS fertilizer application had non-significant difference from 75kg blended NPS fertilizer ha^{-1}. Similarly, the highest (8.893) vigor index II was obtained from plant that received 150kg blended NPS fertilizer ha^{-1}, whereas the lowest (7.643) vigour index II was obtained from the control fertilizer. The result shows that there is gradual increase in seedling vigor index I with increased rates of blended NPS fertilizer. Thus increasing blended NPS fertilizer further from 0 to 75,100, 125 and 150kg blended NPS ha^{-1} increased the vigor index I by about 2.94%, 3%, 2.81% and 0.12%, respectively (Table 4).

Seed vigour [31] is considered a particular problem in carrots because of significant variation in performance of seed lots over a range of field conditions [32]. It is also generally considered that within a seed lot, seeds with a greater seed weight have greater storage reserves and thereby having increased seed vigor [33]. In the current finding the highest vigour index was obtained from the plant that received higher fertilizer rate which might be due to the quality of seeds that have greater seed weight obtained from the plant that received high rate of nutrient resulted in high germination percentage and good growth performance of seedlings, since quality seed issues good germination and vigorous growth. Powell reported that seeds with a greater seed weight have greater storage reserves and thereby having increased seed vigour which is almost similar with the finding of the current study [33].

Treatments		
Blended NPS fertilizer (kg ha^{-1})	vigor index I	vigor index II
0	75.90^{b}	7.643^{c}
75	78.13^{ab}	8.174^{abc}
100	80.50^{ab}	7.856^{bc}
125	82.76^{a}	8.652^{ab}
150	82.84^{a}	8.893^{a}
LSD (5%)	5.322	0.897
CV (%)	11.6	19

Mean values in column and row with similar letter(s) have non-significant difference at P<0.05, LSD (5%) = least significant difference at P<0.05, N=Nitrogen, P=Phosphorus, S=Sulphur

Table 4: Effect of blended NPS fertilizer on vigor index of Haramaya I carrot variety

Conclusion

The field experiment was conducted to assess the effect of blended NPS fertilizer, root type and root treatment on quality of Haramaya I carrot variety seed. The statistical results revealed that most of the parameters considered were significantly (P<0.05)

affected by the main effect of blended NPS fertilizer and root type. Besides, the interaction effect of root type and root treatment was significant ($P<0.05$) on germination and speed of germination in seeds of secondary umbels. Thus the highest (1.82g thousand seed weight of primary umbels, 95.88% seed germination, 25.58 speed of germination and 82.84 vigor index I) were observed from 150kg blended NPS fertilizer ha^{-1} application. Moreover, the highest (95.2% seed germination and 28.6 speed of germination in seeds from secondary umbels) were recorded due to cut root treated with ash and Mancozeb, respectively. In conclusion, the results of this study have indicated that the use of higher blended NPS fertilizer with cut root is the realistic approach to address the problem of low quality of carrot seed yield. In general, use of 150 kg blended NPS ha^{-1} with cut root and Mancozeb treatment produced high quality of Haramaya I carrot variety seed.

Conflict of the Interests

The authors have not declared any conflict of interest.

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