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Effect of Blended NPSZn fertilizer and Variety on quality of Carrot (*Daucus Carota* L.) Seed at Hossana, Southern 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 and a lack of improved varieties resulting in low yield and low quality of carrot seed. Therefore, this study was conducted in 2019 to assess the effect of blended NPSZn fertilizer and to evaluate high seed-yielding carrot varieties at Hossana, southern Ethiopia. The field experiment consisted of five levels of blended NPSZn (0, 100, 125,150 and 175 kg ha^{-1}) fertilizer and three Carrot Varieties (*Hramaya I, Nantes and Royal Chantenay*). A complete randomized design with four replications was used for the laboratory experiment, whereas a randomized complete block design in factorial arrangement with three replications was used for the field experiment. The result of the analysis revealed that the main factors (blended NPSZn fertilizer and varieties) had a highly significant ($P<0.01$) effect on seed purity, thousand seed weight, seed germination, speed of seed germination and seedling vigor index.The highest(1.72 g and 1.55 g) thousand seed weight from primary and secondary umbel's seed, respectively, germination of seed (94.88%), speed of germination(24.58%), vigor index I (81.83) and vigor index II (7.8) were obtained from the application of 175 kg ha^{-1} blended NPSZn fertilizer. The variety *Haramaya I* had shown a significantly higher speed of germination as compared to *Nantes* and *Royal Chantenay*. In conclusion, the result of the study showed that application of 175 kg blended nitrogen, phosphorus, sulphur and Zinc (NPSZn) ha^{-1} fertilizer with *Haramaya I* carrot variety enhanced the quality of carrot seed.

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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 (Salunkhe and Kadam, 1998). 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 (Yawalker, 1992) and some important medicinal values (Simon, 1992; Sadhu 1993; Hart and Butler, 2003).

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) (Rubatzky, 1999 and Dawit *et al.* 2004). 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 *Haramaya I* (Wassu *et al.*, 2015). *Haramaya I* carrot variety has no 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 spenton purchasing 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 in obtaininga high yield. Similarly, therefore, for *Haramaya I* carrot variety, the use of high-quality and genetically pure seeds is critical to increasing the productivity of the crops (Wassu *et al.*, 2015). To save the foreign currency and to increase carrot production in the country, a timely supply of quality seeds should be ensured(Lemma *et al.*, 1994). The production of quality seed depends on the application of the best possible agronomic practices in addition to the genetic potential of the variety. This is because the seed production agronomic practices (fertilizer rates, evaluating the performance of quality seed yielding variety... etc.) depends on the variety, and the environment where it grow. In carrot, other than agronomic practices, the seed quality has variations depending on the umbels where the seeds are collected (Rubatzky, 1999; Hampton. 1999).

The production of high-quality seeds is influenced by the amount of nutrients applied (Salo, 1996). Large nitrate concentration in soil tends to improve shoot: root ratio (Raynal, 1994). 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 (Warncke, 1996). Carrots require adequate available phosphorus for satisfactory growth. The deficiency of phosphorus causes a reduction in yield, with a concomitant increase in dry matter, sugar and carotene contents of carrot root (Rao and Maurya,1998).

Different authors reported that 0 -110 and 50-100kg N and P_2O_5 ha^{-1}, respectively, are appropriate rates to produce maximum carrot seed yield with the required quality (Salo, 1996; Hart and Butler, 2003). The blended NPSZn fertilizers are in use to substitute the earlier DAP fertilizers in Ethiopia (CSA, 2017). However, the rates of fertilizer to be applied and High seed-yielding carrot variety have not yet been studied). Moreover, the interaction effect of blended NPSZn fertilizer and variety is not studied. Therefore, it was felt necessary to conduct research to determine the amount of blended NPSZn fertilizer and its interaction effect with variety on the seed quality of carrot. This experiment, therefore, was initiated to assess the effect of blended NPSZn fertilizer and variety on the quality of carrot seeds.

Materials and methods

Description of the experimental site

The study was carried out at Hadiya Zone, Hossana, Southern Ethiopia, which is situated between 7°35'N latitude, 37°30'E longitude and 2134 meter above sea-

level. The rainfall of the area is characterized by bimodal distribution pattern and the main rainy season is between June and end of September and the short rainy season is from late February to early April. The average annual rainfall is 1250mm. The average annual minimum and maximum temperatures are 14°C and 28°C, respectively.

Treatments and experimental design

The field experiment was conducted using (5×3) factorial combination of five blended NPSZn fertilizer (0, 100, 125, 150 and 175 kg NPSZn/ha) and three Carrot Varieties (*HramayaI*, *Nantes* and *Royal Chanteny*). The DAP fertilizer is substituted by NPSZn blended fertilizer. Urea at 100 kg ha^{-1} was applied for all treatments.

A total of 15 treatments in factorial arrangement (5×3) were laid out in a randomized complete block design (RCBD) with three replications in the field experiment. The treatments were assigned randomly to each plot consisting of four rows of 3 m length, each row accommodating 10 plants. Plants were spaced 30 cm apart and the spacing between rows was 75 cm. A distance of 1 and 1.5 m 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 was3 m × 3 m (9 m^2) with 3 m ×1.5 m (4.5 m^2) net plot size. The whole rates of NPSZn fertilizer were applied once during planting while the 100kg/ha Urea fertilizer was applied in two splits, half rates during root transplanting and the remaining half were applied after 6 weeks of the first Urea fertilizer application.However, for laboratory experiments (seed quality test), a total of 15 treatments (5×3) in completed randomized design (CRD) with four replications were used.

Experimental procedure

The experimental land was opened with a power tiller followed by repeated ploughing and cross ploughing. Then the clods were broken into small pieces and the land was leveled. Thus the land was prepared for a good tilth. During land preparation, weeds and stables of the previous crops were collected and removed from the field. The roots were grown in a 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 the intact point and removed. The roots 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 30 cm between the rows and plants, respectively.

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

The umbels were harvested at different dates by pruning shear as they turned to dark brown color. The umbels were kept for 2 days under the 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 representative samples were taken to determine 1000 seed weight and to carry out germination and vigor tests.

Datacollection

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

Seed quality test

The seed quality test or analysis was carried out in the 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 (2008) rules for seed quality test.

Physical quality: 40 g 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 mixing the sample seeds of each treatment, 40 g out of the total seed samples from each treatment was taken as a working sample. This working sample was divided into four equal parts (10 g each), in which the seed physical quality test was conducted. Each partition of the seed samples (10 g of four replicates) was considered a replication. The working sample was separated into pure seed, other seeds and inert matter by keeping on a purity work board with the help of a spatula (ISTA, 2008). 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 weights 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 the high constant temperature oven method, which was carried out in four replications independently drawing 10g working samples from each treatment, which was weighed with a sensitive electronic balance. The sample was beatinga temperature of 130° C for one hour. The seed samples were kept in the oven for drying when they reached the required temperature. At the end of the drying period, the container was transferred into the desiccators, the desiccators were closed and the sample was 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

M_1 =weight of the empty container with its lid.

M_2= weight of the container with its cover and seed before drying.

M_3= 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 physical seed 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 a germination box (13 x 18 cm) lined with two layers of filter paper or blotter paper. The sample was kept in a seed germinator at 20° C temperature. The first count was done on 7th day after placing of seeds in the germination box and the final count was done on 14th day. Seedlings were evaluated as normal, abnormal seedlings, hard, fresh and dead seeds according to ISTA manual. The result of the germination test was calculated as a percentage for each portion of quality parameters in each replication. The quality of the sample seeds was expressed as a percentage of number of normal seedlings (ISTA, 2008).

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

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, 1993). Normal seedlings were counted and removed from the germination box each day, and the speed of germination (GS) was calculated (Maguire, 1962) as follows:

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

Seedling vigor

Shoot and root length of seedlings (mm): were determined by measuring the average shoot and root length of 10 randomly taken seedlings in millimeters

after completion of the 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 the 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 (Fiala, 1987). The shoot and root lengths were registered separately and the total seedling length was 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 (AOSA, 2002). 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 (1973). 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 Index 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 were recorded daily until no further emergence. The field emergence index was calculated by dividing the number of seedlings that emerged on each day with the number of days in which they emerged (Yang *et al.*, 2005).

$$\text{Emergence index} = \frac{\text{Number of seedlings emerged}}{\text{Days of first count}} + \ldots + \frac{\text{Number of seedling emerged at final count}}{\text{Days of final count}}$$

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

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

Seed health testing

The seed sample was studied for the association of different fungal and bacterial seed-borne pathogens. The seed-borne pathogens were tested by using the agar plate method (for internal pathogens).

The seeds were treated with a 5% sodium hypo-chlorite (NaOCl) solution for five minutes. Ten seeds were placed at equal distances on Petri dishes which were 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. The percentage of seed infection by each pathogen was calculated as:

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

Data analysis

Data were subjected to Analysis of Variance (ANOVA) as per the experimental designs for each experiment using Genstat (15th edition) software (Genstat, 2012). The significant differences among treatments were separated by using LSD (Least Significant Difference) at a 5% level of significance.

Results and discussion

Seed purity

The analysis of variance revealed that the two main factors (NPSZn) had significant ($P<0.05$) effect on the physical purity of carrot seeds (Table 1). The carrot plants which received 175 and 150 kg ha^{-1} blended NPSZn fertilizer showed the highest (95.21% and

94.42%) seed purity with a non-significant difference, respectively, whereas the lowest was obtained from varieties that did not receive fertilizer. However, plants that received 100 and 125 kg ha^{1} blen ded NPSZn had a non-significant difference inthe physical purity of the seed (Table 1). In the current study, the high physical quality of the seed was observed from the plant that received higher rates of blended NPSZn fertilizer 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.

Table 1. Effect of blended NPSZn fertilizer on physical purity and thousand seeds weight of carrot varieties.

Treatment	Character		
NPSZn (kg/ha)	Physical purity of seed (%)	1000 seeds weight from primary (g)	1000 seeds weight from secondary umbels (g)
0	91.42^{c}	1.25^{e}	1.21^{e}
100	92.54^{b}	1.41^{d}	1.30^{d}
125	93.38^{b}	1.49^{c}	1.36^{c}
150	94.42^{a}	1.61^{b}	1.47^{b}
175	95.21^{a}	1.72^{a}	1.55^{a}
LSD (5%)	0.91	0.07	0.06
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,Zn: Zinc.

Thousand seed weight

The carrot plants which received 175 kg blended NPSZn fertilizer had shown the highest thousand seed weight of primary umbel (1.72 g) and secondary umbel (1.55g), respectively. Similarly, plants that did not receive fertilizer had shown the lowest thousand seed weights of primary and secondary umbels, respectively (Table 1). Thousand seed weight increased as blended NPSZn rate increased, indicating the positive effect of blended NPSZn fertilizer on thousand seed weight of carrot varieties. Thus increasing blended NPSZn fertilizer further from 0 - 100, 100-125,125-150 and 150-175 kg blended NPSZn ha^{-1}increased the thousand seed weight of primary umbels by about 12.8%, 5.6%, 8% and 6.8% respectively and higher by 7.4%, 7.8% 8% and 5.4%,for secondary umbels ,respectively. This might be due to the larger seed size in primary and secondary umbels produced from high blended NPSZn fertilizer that led to a 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.* (1992) and Khangi *et al.* (1996), who reported an increase in 1000 seed weight with increasing seed size.

Speed and percentage of germination (%)

The two main factors (blended NPSZn fertilizer and verities) had a highly significant (P<0.01) effect on the percentage of germination and speed of germination on carrot seed. The highest percentage of germination (94.88%) of seed was observed from 175kg blended NPSZn fertilizer ha^{-1} application and it was higher by 4% than control (0 kg NPSZn fertilizer)(Table 2). Moreover, significantly the highest (95.6%) germination in seeds of primary umbels was registered from the plant that received 175 kg followed by 150 kg blended NPSZn fertilizer (95.21%). However, germination of seed obtained from primary umbels that did not receive fertilizer had a non-significant difference with the plant that received 100 kg ha^{-1} blended NPSZn fertilizer. Moreover, the plant that received 150 ha^{-1} kg NPSZn fertilizer had a non-significant difference fromthe plant that received 175 kg ha^{-1} blended NPSZn fertilizer on germination of seed obtained from

primary umbel (Table 2).The carrot plants which received 175 kg ha^{-1} blended NPSZn fertilizer showed the highest (93.71%) germination of seeds of secondary umbel, speed of germination (24.58), speed of germination of seeds in primary umbels (23.21) and speed of germination ofseeds in secondary umbels (26.96). However, speed of germination and speed of germination of seeds from the primary umbel of plants that did not receive fertilizer had a non-significant difference with a plant that received 100 kg ha^{-1} blended NPSZn fertilizer (Table 2). At each level of blended NPSZn fertilizer, there was an increase in the 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 the earlier finding of (Rodet *et al.,* 1992), who reported that superior umbels usually produce seeds with higher germination vigor.

Table 2. Effect of blended NPSZn fertilizer and variety on percentage and speed of germination of carrot seeds.

Treatment	Seed germination (%)			Speed of germination of seeds		
NPSZn(kg ha^{-1})	Mean	Primary umbels	Secondary umbels	Mean	Primary umbels	Secondary umbel
0	91.17^{d}	94.04^{c}	90.58^{e}	21.04^{d}	20.38^{d}	23.62^{e}
100	92.25^{c}	94.5b^{c}	91.25^{d}	21.71^{d}	20.88^{d}	24.42^{d}
125	92.83^{bc}	94.62^{b}	92.00^{c}	22.62^{c}	22175^{c}	25.38^{c}
150	93.50^{b}	95.21^{a}	92.79^{b}	23.62^{b}	22.38^{b}	26.2 ^{b}
175	94.88^{a}	95.46^{a}	93.71^{a}	24.58^{a}	23.21^{a}	26.96^{a}
LSD (5%)	0.732	0.46	0.59	0.68	0.55	0.49
Varieties						
Haramaya I	92.92^{a}	94.88^{a}	91.95^{a}	23.32^{a}	22.02^{a}	25.02^{b}
Nantes	92.90^{a}	94.80^{a}	91.83^{b}	22.45^{b}	21.6^{ab}	25.02^{b}
Royal Chantenay	92.95^{a}	94.62^{a}	92.46^{a}	22.37^{b}	21.52^{b}	24.82^{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 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,Zn: zinc.

The variety *Haramaya I* had shown a significantly hig her speed of germination as compared to *Nantes* and *Royal Chantenay*. However, germination of seeds from secondary umbel at*Haramaya I* variety had no significance with *Royal Chantenay* Variety. The speed of germination of seed obtained from the *Haramaya I* variety was wider by about 4% and 3.6% than *Royal Chantenay* and *Nantes* carrot varieties, respectively (Table 2).

The current study finding the percentage of germination and seed of germination for seeds obtained from plant that received higher rates of fertilizer might be d ue to larger-sized and weighty seeds obtained. Many authors (Ahmad, 1997; Humpton and Takrony, 1995) recorded significantly higher germination percentages and the seed of germination for the seed that had large size and weighty seeds from primary and secondary umbels which is almost similar to the current study finding.

Seedling vigour *index*

The analysis of variance revealed that only the NPSZn fertilizer had a significant (P<0.05) effect on vogour index I and II (Table 3).The carrot plants which received 175 and 150 kg ha^{-1} blended NPSZn fertilizer had shown the highest (81.83 and 81.75) seedling vigor index I, respectively. While the lowest (74.80) seedling vigor index I was obtained from the plant that did not receive fertilizer. However, seedling vigour index I at 125 kg blended NPSZn fertilizer application had a non-significant difference from 100 kg blended NPSZn fertilizer ha^{-1}. Similarly, the highest (7.89) vigor index II was obtained from a plant that received 175 kg blended NPSZn fertilizer ha^{-1}., whereas the lowest (6.64) vigour index II was obtained from the control fertilizer.

Table 3. Effect of blended NPSZn fertilizer on vigor index of carrot varieties.

Treatments		
NPSZn fertilizer (kg ha^{-1})	vigor index I	vigor index II
0	74.8 ^{b}	6.64^{c}
100	77.13^{ab}	7.17^{abc}
125	79.51^{ab}	6.85^{bc}
150	81.75^{a}	7.65^{ab}
175	81.83^{a}	7.89 ^{a}
LSD (5%)	5.322	0.897
CV (%)	11.6	19

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

The result shows that there is a gradual increase in seedling vigor index I with increased rates of blended NPSZn fertilizer.Seed vigour (ISTA, 1996) is considered a particular problem in carrots because of significant variation in the performance of seed lots over a range of field conditions (Jacobsohn and Globerson, 1980). 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 (Powell, 1988). In the current finding, the highest vigor index was obtained from the plant that received a higher fertilizer rate which might be due to the quality of seeds that have greater seed weight obtained from the plant that received a high rate of nutrients, resulting in high germination percentage and good growth performance of seedlings, since quality seed issues good germination and vigorous growth.Powell (1988) reported that seeds with a greater seed weight have greater storage reserves and thereby have increased seed vigor, which is almost similar with the finding of the current study.

Conclusion

The statistical results revealed that most of the parameters considered were significantly (P<0.05) affected by the main effect of blended NPSZn fertilizer. Thus The highest (1.72 g and 1.55 g) thousand seed weight from primary and secondary umbel's seed, respectively, germination of seed (94.88%), speed of germination (24.58%), vigor index I (81.83) and vigor index II (7.89) were obtained from the application of 175 kg blended NPSZn fertilizer. The variety *HaramayaI* had shown a significantly higher speed of seed germination as compared to *Nantes* and *Royal Chantenay varieties*. In conclusion, the results of this study have indicated that the use of higher blended NPSZn fertilizer with *Haramaya I* carrot varieties is the realistic approach to address the problem of low-quality of carrot seed yield. In general, use of 175 kg blended NPSZn ha^{-1} with *Haramaya I* variety produced high-quality carrot seed.

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