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Effect of Blended NPSZn Fertilizer and Variety on Yield and Yield Component of Carrot (*Daucus carota* L.) Seed at Hossana, Southern Ethiopia

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Abstract

There is no much Information on the effect of newly introduced blended NPSZn fertilizer on carrot seed production .Therefore, this study was conducted in 2019 to assess the effect of blended NPSZn fertilizer on locally used carrot varieties and to evaluate carrot varieties on seed yield of carrot at Hossana, southern Ethiopia. The experiment consisted of five levels of blended NPSZn fertilizer (0, 100, 125, 150 and 175 kg ha^{-1}) and three carrot varieties (*Haramaya I*, *Nantes* and *royal Chantenay*). Randomized complete block design in factorial arrangement with three replications was used. The analysis showed that almost all parameters were significantly ($P< 0.05$) affected by the main effect of blended NPSZn fertilizer. The crop phenology also showed significant ($P< 0.05$) differences among the varieties. The highest (17.97, 23.54 and 45.38 g) seed yield from primary, secondary umbels and total yield were obtained from the carrot plant that received 175 kg ha^{-1} NPSZn fertilizer, respectively. Likewise, the highest seed yield per hectare (1973 kg ha^{-1}) was recorded from the application of 175 kg blended NPSZn fertilizer, which could be recommend for carrot seed producers in the study area and similar environments.

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Introduction

Carrot (*Daucus carota* L.) 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). It is grown from true seeds and its successful production is dependent upon a sustainable and satisfactory supply of high quality seed (Copeland and McDonald, 2001). However, the seed supply from the domestic production is not adequate, mainly due to low temperature (vernalization) requirement of carrot for seed production as well due to limited production packages in use. Therefore, growers depend mainly on imported seeds that demand foreign currency and are of questionable sources with respect to germination and successive growth .

In Ethiopia, the total production of carrot reached 14, 297.01 tons on 3,697.26 hectares of land (CSA, 2016). According to Getachew and Mohammed (2012), until the release of *Haramaya I* in 2014, by Haramaya University, there was no improved variety developed for the country, mainly due to the crop's vernalization requirement for seed production which is difficult under tropical countries like Ethiopia. In tropics, the production of carrot seed is difficult because of the prevailing high temperatures throughout the year. Therefore, both the absence of improved variety that fits to the country's agro-ecologies (hot climate) and the availability of high quality seed of carrot are among the carrot production constraints in Ethiopia.

The production of high carrot seed yield is influenced by the amount of nutrient applied (Salo, 1996) and varieties (Robert 2021). Different authors reported that about 110 and 50-100kg N and $P_2O_5 ha^{-1}$, respectively, to be appropriate rates to produce carrot seed (Salo, 1996; Hart and Bulter, 2003).Vegetable production is high in Hadiya zone, Hossana. However, the production of vegetable crops both in Hadiya Zone and other parts of the country is limited by inappropriate application of fertilizers and lack of improved varieties though the popular carrot variety under production in Ethiopia particularly in Hadiya Zone for root production is Nantes. The amount of macro elements N and P_2O_5 ha^{-1} required for the seed production of these varieties is not the only reason to conduct research on fertilizer rates, but also the type of the fertilizer supplied in the country is changed from DAP to NPS/NPSZn and NPSB. However, the amount of this fertilizer for each crop, including seed production of carrot is not recommended. Therefore, both the improved carrot variety and optimal fertilizer recommendation that fits to the agro-ecology in the study area necessitated to undertake this study with the objectives to assess the effect of blended NPSZn fertilizer and to evaluate carrot varieties on seed yield of carrot at Hossana, southern Ethiopia.

Materials and methods

Description of 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 short rainy season is from late February to early April. The average annual rainfall is 1250mm. The average annual minimum and maximum temperature are 14°C and 28°C, respectively.

Treatments and experimental design

The Field experiment was conducted using factorial combination of five blended NPSZn fertilizer (0, 100, 125, 150 and 175kgNPSzn/ha) and three carrot Varieties (*Hramaya I, Nantes, and Royal Chantenay*). A total of 15 treatments in factorial arrangement were laid out in randomized complete block design with three replications. The treatments were assigned randomly to each plot consisting of four rows of 3 m length each row accommodating 10 plants. Plants were spaced 30cm apart and the spacing between rows was 75 cm. 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 on both sides. The whole rates of blended NPSzn fertilizer was applied once

during planting while 100kg/ha Urea fertilizer was applied uniformly in two splits, half rates during root transplanting and the remaining half applied after 5 weeks of the first Urea fertilizer application.

Experimental procedure and field management

Roots of the three varieties were grown on well prepared nursery and after 15 weeks of seed sowing, they were harvested. Three days after harvesting, roots with average size of the variety were selected. The vegetative parts of the roots were cut 5 cm above intact point and 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 subsequent irrigation water applications were applied at interval of 4 days, keeping in view the establishment and growth of plants as well as weather conditions. Weeding was practiced by hoeing and hand weeding three times throughout the experiment period. Harvesting of the umbels was started as they turned to dark brown color. The umbels were kept for 2 days under sun and seeds were collected by hand threshing. The seeds were then dried, cleaned very carefully, weighed, and finally stored in paper bags.

Data Collection

The data collection procedures and measurements we re presented below.

Days to bolting

it was registered from the date of planting to when 50% of the plants produce visible flower buds in the four central rows.

Days to flowering

The number of days from the date of transplanting to when 50% of the plants in the central rows open flowers on the primary umbel.

Days to fruit set

The number of days from the date of transplanting to when 50% of the plants in the central rows set fruit on the primary umbel.

Duration to fruit set

The number of days from the date of 50% flowering to the date when 50% of the plants in the central rows set fruit on the primary umbel.

Plant height (cm)

Was measured when the first umbel turned to brown. The height was measured from the ground level to the tip of the tallest seed-stalk and the average height of the five plants was calculated for statistical data analysis.

Number of primary umbels per plant

All primary umbels produced by plant in the net plot were counted at harvesting time divided by the number of plants harvested and the average was considered as the number of primary umbels per plant.

Number of secondary umbels per plant

All secondary umbels produced by plants in net plot were counted at harvesting time and the number of secondary umbels per plant was obtained by dividing the number of total secondary umbels by the total number of plants at harvest in the central rows or net plot.

Seed yield of primary umbels (g)

The primary umbel produced by five randomly taken plants from the central rows was detached by pruning shear. All sample primary umbels were threshed after drying in the sun for 3 days and divided by the number of umbels.

Seed yield of secondary umbels (g)

The secondary umbels produced by five randomly taken plants from the central rows were detached, threshed after drying for 3 days and divided by the number of secondary umbels.

Seed yield per plant (g)

All umbels produced by plants in the net plot was detached at time of harvesting, kept for 3 days in the

sun, threshed, weighed and divided by the number of plants harvested.

Seed yield per hectare (kg)

All umbels produced by plants in the net plot was detached at a time of harvesting, kept for 3 days in the sun, threshed , weighed by the analytical balance in gram and yield of seed per hectare was calculated from seed yield per plot for each plot.

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 5% level of significance.

Results and discussions

Days to flowering and fruit set

The analysis of variance revealed that blended NPSZn fertilizer had significant (P<0.05) effect on days to flowering and days to fruit set, but it did not significantly affect days to bolting and duration to fruit set (Table1). The varieties also had shown significant (P<0.05) differences in days to bolting, days to fruit set and duration to fruit set, but it had no significant effect on days to flowering. However, their interactions didn't influence the phenology of the carrot varieties.

Table 1. Effect of blended NPSZn fertilizer and varieties on crop phenology of carrot.

NPSZn fertilizer	Character			
kg ha^{-1}	Days to bolting	Days to 50% flowering	Days to fruit set	Duration to fruit set
0	58.06^{a}	61.33^{c}	88.94^{c}	28.61^{a}
100	58.33^{a}	61.83^{c}	91.22^{b}	30.33^{a}
125	59.17^{a}	63.61^{bc}	92.61^{b}	30.06^{a}
150	60.17^{a}	65.72^{ab}	96.83^{a}	32.28^{a}
175	62.00^{a}	69.44^{a}	98.17^{a}	29.72^{a}
LSD (5%)	NS	3.87	2.2	4.00
Varieties				
Haramaya I	62.00^{a}	64.83^{a}	93.47^{a}	29.50^{a}
Nantes	59.40^{ab}	65.80^{a}	90.33^{b}	29.23^{a}
Royal Chantenay	57.00^{b}	63.00^{a}	91.87^{b}	27.57^{b}
LSD (5%)	3.63	NS	1.7	3.16
CV (%)	12	9.2	3.6	20.9

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; CV (%) = Coefficient of variation in percent, N=Nitrogen, NS: non-significant different, P=Phosphorus and S=Sulphur, Zn: zinc.

The carrot plants which received 150 and 175 kg ha^{-1}blended NPSZn fertilizer had delayed days to 50% flowering by four and eight days and fruit set after by eight and ten days, respectively, compared to plants that didn't receive NPSZn (Table 1).

The application of phosphorus fertilizer enhances early growth, stimulates blooming, enhances bud set, aids in seed formation and hastens maturity (Brady and Weil, 2002). The supply of sulfur to plants also enhances the earliness (Naeem and MacRitchie, 2003). However, the application of nitrogen fertilizer enhances vegetative growth and delayed flowering and fruit set (Salo 1996; Amjad et al., 2005; Bilekudari *et al.,* 2005). Therefore, delayed flowering and fruit set due to increasing rates of blended NPSZn might be due to the effect of the nitrogen that offset the effect of three (phosphorus, sulfur and Zinc fertilizers) on crop flowering and fruit set. In agreement with the current study results, Nesa,

(2007), Anjum and Amjad (2001) and Satyaveer *et al.*(1994) found more number of days to flowering and fruit set from the application of highest rates of inorganic fertilizers (nitrogen, phosphorus, potassium and sulfur).

The *Haramaya I* carrot variety had significantly delayed days to bolting (62), days to fruit set (93.47) and duration to fruit set (29.5); however, *Nantes* did not have significant difference *from Haramaya I* for the days to 50% bolting and duration to fruit set (Table 1). *Haramaya I* carrot variety had increased days to bolting, days to fruit set and duration to fruit set by about 5, 3 and 2 days, respectively, than the minimum days required for bolting, fruit set and duration of fruit set by another two varieties.

Table 2. Effect of blended NPSZn fertilizer on growth character and umbel traits.

Blended NPS fertilizer (kg ha^{-1})	Plant height (cm)	Number of primary umbel/plant	Number of secondary umbel/plant
0	111.6^{c}	9.12^{c}	12.94^{d}
100	118.3^{bc}	10.12^{c}	14.06^{c}
125	121.1^{ab}	11.40^{b}	17.83^{b}
150	121.1^{ab}	11.79^{b}	18.78^{b}
175	129.4^{a}	13.07^{a}	20.06^{a}
LSD (5%)	8.49	1.03	1.01
CV (%)	10.4	12.7	9.2

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; CV (%) = Coefficient of variation in percent, N=Nitrogen, P=Phosphorus and S=Sulphur, Zn: zinc.

Growth character and umbel traits

The main factor blended NPSZn fertilizer had significant ((P<0.05) effect on plant height, number of primary umbels and number of secondary umbel/plant (Table 2). However, neither the varieties nor the two factors interactions influenced umbel traits (Table 2). The carrot plants which received 150 kg blended NPSZn fertilizer had shown tallest plant height with non-significant difference between 125 and 150 kg blended NPSZn fertilizer.

The results showed that the plant height of carrot varieties was increased as the rates of blended NPSZn fertilizer increased. The increased plant height at the highest level of blended NPSZn fertilizer could be attributed to the increasing adequate supply of nitrogen, phosphorus and sulfur and Zinc nutrients, which helped, in high vegetative growth and development. The result of this study agrees with the finding of Anjum and Amjad (2001) and Nesa (2007), who reported that increasing the rates of fertilizer increased the height of carrot plant. Similarly Rao and Maurya (1998) and Robin *et al.* (2001) also reported that higher rate of plant growth due to increased rate of nitrogen supply from larger rates of blended NPSZn which promotes vegetative growth.

The carrot plants which received 175kg ha^{-1} bended NPSZn fertilizer had shown the highest number of primary and secondary umbels per plant.

The control and application of 100 kg blended NPSZn had shown lower number of primary umbel without significant difference between the two treatments (Table 2). It could be concluded that highest doses of fertilizer might encouraged vegetative growth and branching in carrot plant as result of its vital role on photosynthetic activity in carrot plant. These results agree with the finding of Nesa, (2007) and Satyaveer *et al.* (1994), who found large number of umbel traits from increased rates of inorganic fertilizer.

Seed yield and yield component

The application of blended NPSZn fertilizer had significant (P<0.05) effect on seed yield of primary and secondary umbels, seed yield per plant and per

hectare. However, the variety,as well as,the interaction effect of the two factors did not significantly influence seed yield of primary and secondary umbels, seed yield per plant and seed yield per hectare. (Table 3).The carrot plants which received 175 blended NPSZn fertilizer had shown the highest (17.97 g) seed yields of primary umbels, (23.54 g) seed yields of secondary umbels, (45.38 g) seed yield per plant and (1973 kg ha^{-1}) seed yield per hectare. The highest mean value of seed yield ha^{-1} obtained at 175 kg blended NPSZn was higher by 23.3 % than the control. However, there was no significant difference between 100 kg and 125 kg NPSZn ha^{-1} application (Table 3).

Table 3. Effect of blended NPSZn fertilizer on seed yield of carrot.

Treatment	Character			
Blended NPSZn fertilizer (kg ha^{-1})	Seed yield of primary umbels (g)	Seed yield of secondary umbels (g)	Seed yield per plant (g)	Seed yield per hectare (kg)
0	11.93^{d}	18.04^{d}	36.81^{e}	1593^{d}
100	13.90^{c}	19.09^{cd}	39.00^{d}	1693^{c}
125	14.78^{c}	20.31^{bc}	40.52^{c}	1754^{c}
150	16.04^{b}	21.46^{b}	42.93^{b}	1863^{b}
175	17.97^{a}	23.54^{a}	45.38^{a}	1973^{a}
LSD (5%)	1.135	1.505	1.457	65.6
CV (%)	12.2	11.6	5.5	5.5

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; CV (%) = Coefficient of variation in percent, N=Nitrogen, P=Phosphorus and S=Sulphur, Zn: zinc.

The result of current study showed as there was high potential of increase seed yield of carrot through increased application of blended NPSZn fertilizer. This might be due to the more number of primary and secondary umbels obtained through the increased rates of blended NPSZn fertilizer resulting in high seed yield of carrot. The result agrees with the finding of Satyaveer *et al.* (1994); Amjad *et al.* (2005) and Nesa (2007), who reported higher seed yield of carrot under higher level of nitrogen, phosphorus, potassium and sulfur than application of lower level of fertilizer.

However, there was no interaction effect of the two factors. The highest (1973 kg ha^{-1}) seed yield of carrot was obtained from the carrot plants which received 175 blended NPSZn fertilizers. Thus, the application of 175 kg blended NPSZn gave about 23.3% more seed yield per hectare compared to control. In conclusion, the results of this study have indicated that the use of higher blended NPSZn fertilizer is the realistic approach to address the problem of low productivity of carrot seed yield. In general, use of higher rates blended NPSZn ha^{-1} produced high seed yield of carrot varieties.

Conclusion

The field experiment was conducted to assess the effect of blended NPSZn fertilizer and to evaluate the adaptable and high seed yielding varieties of carrot to increase production and productivity of the crop .The statistical results revealed that most of the parameters considered were significantly (P<0.05) affected by the main effect of blended NPSZn fertilizer and the crop phenology of carrot was also significantly (P<0.05) affected by varieties of carrot. This indicates the need to assess further higher rates as well as economic analysis to establish optimal rates of fertilizer for carrot seed production in the study area.

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