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RESEARCH ARTICLE

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

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Abstract

Information is scanty on the effect of different rate of blended NPS fertilizer, root type and root treatment on carrot seed production. Therefore, this study was conducted in 2017 to assess the effect of blended NPS fertilizer, root type and root treatments and to estimate the economic feasibility of treatments for higher seed yield of Haramaya I carrot variety. The experiment consisted of five levels of blended NPS fertilizer (0, 75, 100, 125 and 150 kg ha^{-1}), three levels of root treatments (Ash, Mancozeb and Distilled water) and two level of root type (whole and cut root). Randomized complete block design (RCBD) 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 NPS fertilizer, Root type and root treatment. The highest seed yield per hectare (1972kg) was recorded due to 150kg blended NPS. The interaction of root type with root treatments showed significant ($P< 0.05$) effect on number of primary umbels per plant and seed yield per hectare. The highest (1827 kg ha^{-1}) seed yield was obtained from the interaction effect of cut root with ash. The result of economic analysis showed that the maximum net benefit (2215979.64 Birr ha^{-1}) was obtained due to the application of 150 kg blended NPS with the combination of whole root and ash treatment. In conclusion, the result of the study showed that application of 150kg blended NPS fertilizer with whole root and ash treatment enhanced yield of carrot seed with acceptable economic benefit.

Keywords: Diameter; Parameters; Seed Yield; Umbel; Umbellets

Introduction

Carrot (*Daucus carota* L.) is produced in a wide range of agro-ecologies from the lowlands to the highlands of Ethiopia. It is grown from true seeds and its successful production is dependent upon a sustainable and satisfactory supply of high yielding seed [1]. However, the seed supply from the domestic production is not adequate, mainly due to low temperature (vernalization) requirement of carrot for seed production. Therefore, growers depend mainly on imported seeds that demand foreign currency and are of questionable sources with respect to germination and susceptibility to diseases. Carrot seed can be produced by either seed to seed or root to seed method [2].

In Ethiopia, the total production of carrot reached 14, 297.01 tons on 3,697.26 hectares of land (CSA, 2014/15) According to Getachew and Mohammed [4], 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 growing nature (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 yielding carrot seed in a reasonable price on a time are among the carrot production constraints in Ethiopia.

Haramaya I is the common name for the carrot (*Daucus carota* L.) variety with the original collection name AUA-108. The variety was developed through selection in the eastern highlands of Ethiopia and it was selected from 64 carrot genotypes collected from Haramaya woreda (district). The variety has deep orange root color. The released carrot variety was found to be superior in marketable and total root yields (52.65 totes per hectare) and the variety had also a margin of seed production potential amounting to 11.81% over the Nantes variety [5]. First, the variety (Haramaya I) was developed (produced) with the application of 100kg DAP and 100kg Urea fertilizer with no research based recommendation for newly released variety (Haramaya I) both for root and seed production. The production of high carrot seed yield is influenced by the amount of nutrient applied [6]. Different authors reported that 0 -110 and 50-100kg N and P_2O_5ha^{-1}, respectively, to be appropriate rates to produce maximum carrot seed yield [6,7].

Multiple steps are required to produce high seed yield of carrot. Thus, to determine the amount of nitrogen, phosphorus and sulfur nutrients for high carrot seed production is one among the steps [7]. Therefore, research has to be directed towards assessing the effect of these nutrients on seed yield of Haramaya I carrot variety. The amount of macro elements N and P_2O_5 ha^{-1} required for the seed production of this variety is not the only reason that forced to conduct research on fertilizer rates, but also the type of the fertilizer supplied in the country is changed to NPS. However, neither the amount of this fertilizer for each crop, including neither root production nor seed production of carrot is recommended.

During production of carrot by root to seed method, it is important to treat root by a protective fungicide effective against a wide range of fungal disease (Alternaria leaf blight and Black rot) [8]. However, the appropriate method of root type (using whole or cut root) as planting material at transplanting time for seed production of carrot and treatment has not yet been studied for the newly released variety (Haramaya I) [5]. Moreover, the interaction effect of blended NPS fertilizer, root type and treatment is not studied. This experiment, therefore, was initiated to assess the effect of blended NPS fertilizer, root type and root treatment on yield of Haramaya I carrot variety seeds, and to estimate the economic feasibility of the treatments for carrot seed production.

Materials and Methods

Description of experimental site

The experiment was conducted at 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 790mm. 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 [9].

Treatments and experimental design

The Field experiment was conducted using factorial combination of five blended NPS fertilizer (0, 75, 100, 125 and 150 kg NPSha), three root treatments (ash, distilled water Mankozeb fungicide) and two root types (whole and cut roots) using carrot variety Haramaya I. A total of 30 treatments in factorial arrangement (5x3x2) were laid out in randomized complete block design (RCBD) 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 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.

Experimental procedure and field management

The roots were grown on well prepared nursery and after 14 weeks of seed sowing, roots were harvested. Three days after harvesting, roots with average size of the variety were selected. The vegetative parts of the roots were cut 5cm 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 Mankozeb fungicide at 2g per liter of water for 5 minutes and roots these received ash treatment were coated with well sieved ash. The roots treated with distilled water were dipped in distilled water for 5 minutes. 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. 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. Weeding was practiced by hoeing and hand weeding four times throughout the experiment period. Harvesting of the umbels was started 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.

Data Collection

The data collection procedures and measurements were 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.

Cost benefit analysis

Partial budget analysis was employed for economic analysis of blended fertilizer application, root type and carrot root treatment. The economic analysis was based on the formula developed by CIMMYT [10] and given as follows

Gross average yield (kg ha^{-1}) (AvY)

is an average yield of each treatment

Adjusted yield (AjY)

is the average yield adjusted downward by 10% to reflect the difference between the experimental yield and yield of farmers. (Let us assume that farmers can only achieve 90% of the yield obtained in the experimental fields. Therefore, reduce average yield by 10% based on the formula developed by CIMMYT [10].

AjY = AvY- (AvY*0.1)

Gross field benefit (GFB)

It was computed by multiplying field/farm gate price that farmers receive for the crop when they sale it as adjusted yield.

GFB = AjY*field/farm gate price for the crop

Total cost

is the cost of fertilizers and other treatments for the experiment. The costs of other inputs and production practices such as labor cost for land preparation, planting, weeding, and harvesting were considered the same or considered as insignificant among treatments.

Net benefit (NB)

was calculated by subtracting the total costs from gross field benefits for each treatment.
NB = GFB – total cost

Marginal rate of return (MRR %)

was calculated by dividing change in net benefit by change in cost.

$$MRR = \frac{\Delta\, NB}{\Delta\, \mathrm{TC}}$$

Data Analysis

Data were subjected to Analysis of variance (ANOVA) as per the experimental designs for each experiment using Genstat (15th edition) software [11]. The significant differences among treatments were separated by using LSD (Least Significant Difference) at 5% level of significance. The statistical model used for analysis of data collected from the experimental field is given by:

$Yijkl=\mu+\alpha i+\gamma j+\theta k+\alpha\gamma\theta ijk+\beta+\varepsilon ijkl.$

where, Yijkl=the response variable, μ=overall mean; αi=Effect of factor A(NPS fertilizer), γj=Effect of factor B(root treatment), θk=Effect of factor C(root type) αγθijk=Interaction effect of the three factors (AxBxC), β=block, εijkl=Treatment error of factor A (NPS fertilizer),factor B (root treatment) and factor C (root type), interaction effect and replication as block l.

Results and Discussion

Effect of Blended NPS Fertilizer, Root type and treatment on Carrot Phenology

The analysis of variance revealed that blended NPS fertilizer and root type for planting had highly significant (P<0.01) effect on days to flowering and days to fruit set, but both main factors did not significantly affect days to bolting and duration to fruit set (Table 1).

Character				
NPS fertilizer kg ha^{-1}	**Days to bolting**	**Days to 50% flowering**	**Days to fruit set**	**Duration to fruit set**
0	57.06^{a}	60.33^{c}	87.94^{c}	27.61^{a}
75	57.33^{a}	60.83^{c}	90.22^{b}	29.33^{a}
100	58.17^{a}	62.61^{bc}	91.61^{b}	29.06^{a}
125	59.17^{a}	64.72^{ab}	95.83^{a}	31.28^{a}
150	61.00^{a}	68.44^{a}	97.17^{a}	28.72^{a}
LSD (5%)	4.70	3.87	2.2	4.00
Root Type				
Whole root	57.58	62.07	91.09	29.09
Cut root	59.51	64.71	94.02	29.31
LSD (5%)	2.97	2.45	1.39	2.58
Root Treatment				
Ash	61.13^{a}	63.83^{a}	94.33^{a}	30.60^{a}
Distilled water	58.50^{ab}	64.80^{a}	91.47^{b}	30.33^{a}
Mancozeb	56.00^{b}	62.00^{a}	91.87^{b}	26.67^{b}
LSD (5%)	3.63	3.00	1.7	3.16
CV (%)	12	9.2	3.6	20.9

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 and S=Sulphur

Table 1: Effect of blended NPS fertilizer, root type and root treatment on crop phenology of carrot

The root treatment had also significant (P<0.05) effect on days to bolting, days to fruit set and duration to fruit set, but it had nonsignificant effect on days to flowering. However, neither the two factors nor the three factors interactions influenced the phenology of Haramaya I carrot variety. The carrot plants which received 150 and 125kg blended NPS fertilizer had delayed days to 50% flowering and fruit set after planting without significant difference between them. Similarly the control and 75kg blended NPS applied had early days to flowering. Moreover, plants that did not receive fertilizer also had significantly early days to fruit set (Table 1). The application of 150 and 125 kg blended NPS fertilizer delayed about eight and nine days to attain days to 50% flowering and fruit set, respectively (Table 1). The results showed that the flowering and fruit set of Haramaya I carrot variety was more affected by the application of high rates of blended NPS fertilizer than the types of roots used for planting.

The application of phosphorus fertilizer enhances early growth, stimulates blooming, enhances bud set, aids in seed formation and hastens maturity [12]. The supply of sulfur to plants also enhances the earliness [13]. However, the application of nitrogen fertilizer enhances vegetative growth and delayed flowering and fruit set [6,14,15]. Therefore, delayed flowering and fruit set due to increasing rates of blended NPS might be due to the effect of the nitrogen that offset the effect of two (phosphorus and sulfur fertilizers) on crop flowering and fruit set. In agreement with the current study results, Nesa [16], Anjum and Amjad and Satyaveer, *et al.* [17,18] found the more number of days to flowering and fruit set from the application of highest rates of inorganic fertilizers (nitrogen, phosphorus, potassium and sulfur).

The whole roots used for planting had early flowering and fruit set, while, plants grown from cut root had delayed 50% flowering and fruit set. However, only about three days attained early flowering and fruit set due to the use of whole root (Table 1). Moreover, the ash treated roots had significantly delayed days to bolting (61.13), days to fruit set (94.33) and duration to fruit set (30.60) , however, both ash and Mancozeb treated roots had nonsignificant difference for duration to fruit set (Table 1). Treating of roots with ash increased days to bolting, days to fruit set and duration to fruit set by about 5 (9.16%), 3 (3.13%) and 4 (14.74%) days, respectively, than the minimum days required for bolting, fruit set and duration of fruit set by other root treatments. This may showed that either treating carrot roots with ash or Mancozeb might not have practical importance in terms of early bolting and fruit setting.

Growth Character and Umbel Traits

The two main factors viz., blended NPS fertilizer and root type had significant effect on plant height, number of primary umbels and number of secondary umbel/plant (Table 2). However, neither of the possible two and three factors interactions influenced umbel traits except root type interacted to influence significantly the number of primary umbels per plant (Table 2).

Blended NPS Fertilizer (kg ha^{-1})	Plant height (cm)	Number of primary umbel/plant	Number of secondary umbel/plant
0	112.7^{c}	10.22^{c}	13.94^{d}
75	119.4^{bc}	11.22^{c}	15.06^{c}
100	122.2^{ab}	12.50^{b}	16.83^{b}
125	122.2^{ab}	12.89^{b}	17.78^{b}
150	130.5^{a}	14.17^{a}	19.06^{a}
LSD (5%)	8.49	1.03	1.01
Root type			
Whole root	127.8	11.44	18.00
Cut root	117.8	12.96	15.07
LSD (5%)	5.37	0.65	0.642
CV (%)	10.4	12.7	9.2

Mean values in column of each character and treatment with similar letter(s) have no 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 blended NPS fertilizer, root type and root treatment on growth character and umbel traits

The carrot plants which received 150kg blended NPS fertilizer had shown tallest plant height with non-significant difference between 100 and 125kg blended NPS fertilizer. Similarly, the tallest (127.8cm) plant height was recorded due to planting the whole root as compared to cut root (Table 2). The results showed that the plant height of Haramaya I carrot variety was increased as the rates of blended NPS fertilizer increased. The increased plant height at the highest level of blended NPS fertilizer could be attributed to the increasing adequate supply of nitrogen, phosphorus and sulfur nutrients, which helped, in high vegetative growth and development. The result of this study agrees with the finding of Anjum and Amjad and Nesa, [17,16] who reported that increasing the rates of fertilizer increased the height of carrot plant. Similarly Rao and Maurya and Robin, *et al.* [19,20] also reported that higher rate of plant growth due to increased rate of nitrogen supply and N application promotes vegetative growth.

The carrot plants which received 150kg ha^{-1} bended NPS fertilizer had shown the highest number of primary and secondary umbel per plant. The control and application of 75kg blended NPS 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, and Satyaveer, *et al.* [16,18], who found large number of umbel traits from increased rates of inorganic fertilizer.

Similarly, the cut root used for planting had shown significantly higher number of primary umbel as compared to whole root. However, whole root used for planting had shown significantly higher number of secondary umbel (Table 2). The higher number of primary umbel produced from cut root might be due to the larger surface area produced by the root cut that lead to produce more number of branches in plants grown from cut root. Mostafezur also found that the carrot plants grown from cut root produced more number of umbels which is almost similar to the current study finding [21].

In the interaction of root type and root treatment, significantly the highest (18.60) number of primary umbels per plant was registered for plants grown from cut root treated with ash, whereas the lowest (14.27) number of primary umbels per plants was observed in plants grown from whole root treated with Mancozeb. However, number of primary umbels per plant in plants from cut root treated with ash had non-significant difference with Mancozeb and distilled water (Table 3). The interaction of cut root with root treatments to produce more number of primary umbels per plants than whole root treated with similar root treatments indicated that root cutting encourages development of more number of primary umbels.

	Root type	
Root treatment	Cut root	Whole root
Ash	18.60^{a}	15.00^{bc}
Mancozeb	17.73^{a}	14.27^{c}
Distilled water	17.67^{a}	15.93^{b}
LSD (5%)	1.11	
CV (%)	12.7	

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; CV (%) = Coefficient of variation in percent

Table 3: Interaction effect of root type and root treatment on number of primary umbel per plant of carrot

Seed yield and yield component

The application of blended NPS fertilizer had highly significant (P<0.01) effect on seed yield of primary and secondary umbels, seed yield per plant and per hectare and the root type had also significant effect on seed yield of secondary umbels (Table 4). The two main factors (root type and root treatment) as well as all possible combinations of the three main factors did not significantly influence seed yield per plant. However, the interaction of root type and root treatment had significant effect on seed yield per hectare (Table 5).

Treatment	Character			
Blended NPS 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	10.93^{d}	17.04^{d}	35.81^{e}	1592^{d}
75	12.90^{c}	18.09^{cd}	38.00^{d}	1692^{c}
100	13.78^{c}	19.31^{bc}	39.52^{c}	1753^{c}
125	15.04^{b}	20.46^{b}	41.93^{b}	1862^{b}
150	16.97^{a}	22.54^{a}	44.38^{a}	1972^{a}
LSD (5%)	1.135	1.505	1.457	65.6
Root type				
Whole root	13.73	18.96	39.75	1782.
Cut root	14.12	20.01	40.11	1766
LSD (5%)	0.72	0.952	0.92	41.5
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

Table 4: Effect of blended NPS fertilizer and root type on seed yield of carrot

	Root type	
Root treatment	Cut root	Whole root
Ash	1767^{ab}	1827^{a}
Mancozeb	1769^{ab}	1756^{ab}
Distilled water	1811^{a}	1716^{b}
LSD (5%)	71.9	
CV (%)	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.

Table 5: Interaction effect of root type and root treatment on seed yield per hectare of carrot

The carrot plants which received 150 blended NPS fertilizer had shown the highest (16.97g) seed yields of primary umbels, (22.54g) seed yields of secondary umbels, (44.38g) seed yield per plant and (1972 kg ha^{-1}) seed yield per hectare. The highest mean value of seed yield ha^{-1} obtained at 150 kg blended NPS was higher by 23.87% than the control. However, there was no significant difference between 75 kg and 100 kg NPS ha^{-1} application (Table 4). The result of current study showed as there was high potential of increase seed yield of carrot through increased application of blended NPS fertilizer. This might be due to the more number of primary and secondary umbels obtained through the increased rates of blended NPS fertilizer resulting in high seed yield of carrot. The result agrees with the finding of Satyaveer, *et al*. [18]; Amjad, *et al.* and Nesa [14,16], who reported higher seed yield of carrot under higher level of nitrogen, phosphorus, potassium and sulfur than application of lower level of fertilizer. Similarly, significantly the highest (20.01g) seed yield of secondary umbel was recorded from cut root. Compared with seed yield of secondary umbel obtained for whole root, seed yield of secondary umbel obtained at cut root was higher by about 5.53% (Table 4). In the current study finding, the highest seed yield of carrot produced from cut root might be due to the larger amount of umbels produced by the root cut than whole root that leads to production of more number of seeds in plants grown from cut root resulting more seed yield, which is in line with the earlier finding of [21], who found higher seed yield of carrot from the carrot plants grown from cut root. Similarly, Bose and Som found high seed yield from cut root [22].

From the interaction of root type and root treatment, significantly the highest (1827 and 1811 kg ha^{-1}) seed yield per hectare were obtained from whole root treated with ash and cut root treated with distilled water, respectively. However, seed yield per hectare from cut root treated with ash had non-significant difference with plants grown from cut roots treated with Mancozeb (Table 5). The highest seed yield obtained due to whole root treated with ash and cut root treated with distilled water might be that the root cutting and ash treatment encouraged branches and further higher yield in carrot plant.

Partial Budget Analysis

The highest net benefit (2207079.64 Birr ha^{-1}) with acceptable MRR was obtained at the combination of 150 kg ha^{-1} blended NPS fertilizer, whole root and ash, whereas the lowest net benefit (1743692.8 Birr ha-1) was obtained at the combination of 0kg blended NPS, whole root and ash applied (Table 6). This has resulted in net benefit advantage of birr 463386.8 and 310210.8 over the combination of 0kg NPS, whole root and ash. In conclusion the net benefit obtained by the use of newly released Haramaya I carrot variety with rates of 125-150 kg ha^{-1} blended NPS, and ash with either type of root were found to be greater than the benefit of applying blended NPS (75-100 kg ha^{-1}), Therefore, the net positive benefit obtained with application of 150 kg ha^{-1} blended NPS ha^{-1} + cut/whole root+ash to Haramaya I carrot variety are economically profitable (Table 7).

Treatment	TVC (Birr)	AVY Kg ha^{-1}	AdYkg ha^{-1}	GFB(Birr)	NB(Birr ha^{-1})	MRR (%)
CR+a+0	5000	1619.16	1457.244	1748692.8	1743692.8	
CR+a+0	5600	1622.71	1460.439	1752526.8	1746926.8	539
WR+a+75	7700	1730.27	1557.243	1868691.6	1860991.6	5431.66
WR+a+100	8100	1822.2	1639.98	1967976	1959876	24721.1
WR+a+125	8500	1909.63	1718.6697	2062403.64	2053903.64	23506.9
WR+a+150	8900	2051.83	1846.6497	2215979.64	2207079.64	38294

Where, CR: Cut Root; WR: Whole Root; A: Ash; TVC: Total Variable Cost; AVY: Average Yield; AdY: Adjusted Yield; GFB: Gross Field Benefit; NB: Net Benefit; MRR: Marginal Rate of Return in Percent

Table 6: Marginal analysis of carrot seed yield influenced by NPS fertilizer, root type & root treatment for none dominated Treatments

Treatments	TVC (Birr)	AVY Kg ha^{-1}	AdYkg ha^{-1}	GFB(Birr)	NB(Birr ha^{-1})	Dominance
WR+A+0	5000	1619.16	1457.244	1748692.8	1743692.8	ND
WR +M+0	5278	1572	1414.8	1697760	1692482	D
WR +DW+0	5560	1590.53	1431.4797	1717775.64	1712215.64	D
CR+A+0	5600	1622.71	1460.439	1752526.8	1746926.8	ND
CR+M+0	5878	1573.05	1415.745	1698894	1693016	D
CR+ DW +0	6160	1573.41	1416.0717	1699286.04	1693126.04	D
WR+ A +75	7700	1730.27	1557.243	1868691.6	1860991.6	ND
WR+ M +75	7978	1646.84	1482.156	1778587.2	1770609.2	D
WR+ A +100	8100	1822.2	1639.98	1967976	1959876	ND
WR+ DW +75	8260	1640.12	1476.1053	1771326.36	1763066.36	D
CR+ A +75	8300	1708.05	1537.245	1844694	1836394	D
WR+ M +100	8378	1667.71	1500.939	1801126.8	1792748.8	D
WR+ A +125	8500	1909.63	1718.6697	2062403.64	2053903.64	ND
CR+ M +75	8578	1782.2	1603.98	1924776	1916198	D
WR+ DW +100	8660	1705.67	1535.1003	1842120.36	1833460.36	D
CR+ A +100	8700	1756.77	1581.0903	1897308.36	1888608.36	D
WR+ M +125	8778	1894.25	1704.825	2045790	2037012	D
CR+ DW +75	8860	1643.6	1479.24	1775088	1766228	D
WR+ A +150	8900	2051.83	1846.6497	2215980	2207079.64	ND

Treatments	TVC (Birr)	AVY Kg ha^{-1}	AdYkg ha^{-1}	GFB(Birr)	NB(Birr ha^{-1})	Dominance
CR+ M +100	8978	1845.21	1660.689	1992826.8	1983848.8	D
WR+ DW +125	9060	1750.2	1575.18	1890216	1881156	D
CR+ A +125	9100	1847.73	1662.9597	1995551.64	1986451.64	D
WR+ M +150	9178	2000.27	1800.243	2160291.6	2151113.6	D
CR+ DW +100	9260	1723.27	1550.9403	1861128.36	1851868.36	D
CR+ M +125	9378	1906.08	1715.472	2058566.4	2049188.4	D
WR+ DW +150	9460	1895.33	1705.7997	2046959.64	2037499.64	D
CR+A+150	9500	1900.77	1710.6903	2052828.36	2043328.36	D
CR+DW+125	9660	1864.5	1678.05	2013660	2004000	D
CR+M+150	9778	1944.92	1750.428	2100513.6	2090735.6	D
CR+DW+150	10060	2040.33	1836.2997	2203559.64	2193499.64	D

where; RTY: Root Type; RT: Root Treatment; CR: Cut Root; WR: Whole Root; D: Dominated Treatment; ND: Non Dominated Treatment; WR: Whole Root; A: Ash; DW: Distilled Water; TVC: Total Variable Cost; AVY: Average Yield; AdY: Adjusted Yield; GFB: Gross Field Benefit; NB: Net Benefit

Table 7: Marginal analysis of carrot seed yield influenced by blended NPS fertilizer, Root type and Root treatment

Conclusion

The field experiment was conducted to assess the effect of blended NPS fertilizer, root type and root treatments and to estimate the economic feasibility of treatments for higher seed yield of Haramaya I carrot variety. 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 seed yield per hectare. Thus the application of 150kg blended NPS gave about 23.9% more seed yield per hectare compared to the untreated control. Moreover, the highest (1827kg ha^{-1}) seed yield per hectare obtained due to whole root treated with ash. In conclusion, the results of this study have indicated that the use of higher blended NPS fertilizer with whole root is the realistic approach to address the problem of low productivity of carrot seed yield. In general, use of 150kg blended NPS ha^{-1} with whole root and ash treatment produced high yield with the best economic benefit of profitability.

Conflict of the Interests

The authors have not declared any conflict of interest.

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