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Effect of planting density of carrot (*Daucus carota* L) and fertilizer level on chemical properties of soil

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Abstract
The present investigation, "Studies on planting density and fertilizer levels on seed production of temperate carrot (*Daucus carota* L.)'' was carried out at Vegetable Research Station, Kalpa, of Regional Horticultural Research & Training Station and Krishi Vigyan Kendra, Kinnaur (HP), Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan, H.P. from April to October 2015. The experiment was laid out in Randomized Block Design (Factorial) in the field. The treatment combinations comprised of four planting densities (D) *viz.*, D_1 (45×15 cm), D_2 (45×30 cm), D_3 (30×30 cm) and D_4 (30×15 cm), four fertilizer levels (F) *viz.*, F_1 (75% RD NPK), F_2 (100% RD NPK), F_3 (125% RD NPK) and F_4 (150 % RD NPK). Non-significant differences of planting density, fertilizer levels as well as interaction were observed on electrical conductivity and pH. On the other hand, available NPK status was influenced only by fertilizer levels. Maximum electrical conductivity (0.250 dSm^{-1}), pH (6.80), nitrogen (369.33 kg ha^{-1}), phosphorus (30.40 kg ha^{-1}) and potassium (147.71 kg ha^{-1}) and minimum electrical conductivity (0.197dSm^{-1}), pH (6.43), nitrogen (329.66 kg ha^{-1}), phosphorus (23.61 kg ha^{-1}) and potassium (136.47 kg ha^{-1}) were recorded in F_4D_2 (150 % RD NPK & 45×30 cm) and F_1D_3 (75 % RD NPK & 30×30 cm), respectively.

Keywords: planting density, fertilizer level, nitrogen, phosphorus and potassium

Introduction
Carrot (*Daucus carota* L.) is a cross pollinated root vegetable belonging to family Umbelliferae and has got diploid chromosome number of 2n=2x=18. It is grown during spring, summer and autumn in temperate climate and during winter in tropical and subtropical climates. It is native to Afghanistan (Rubatzky and Yamaguchi, 1999) [9]. It is a good source of vitamin A, thiamin, protein, calcium, riboflavin and vitamin C. Its root is valued as food mainly for high carotene content, β-carotene, having high vitamin A activity (Biesalski, 1997) [2] which constitutes 60 to 90 per cent of carrot carotenoids (Simon and Wolff, 1987) [10].
Carrot is an annual or biennial herb, with an erect to much branched stem, 30-120 cm high arising from a thick, fleshy tap root, 5-30 cm long. Usually the stem elongates and produces rough hispid branches during the second year. The edible portion of carrot is actually an enlarged fleshy taproot. It consists of phloem or cortex and core or xylem. Most of the world's carrot production occurs in temperate countries. In India it is cultivated mainly in the states of Punjab, Haryana, Uttar Pradesh, Assam, Karnataka, and Andhra Pradesh. European carrots have a special significance in Himachal Pradesh where breeding and seed production is mainly conducted for entire country.
In India, the crop occupies an area of 40.9 thousand hectares with a production of 1144.54 million metric tonnes (Anonymous, 2013) [1]. By increasing the plant density the contribution of primary umbels to seed yield is expected to increase. Earlier researchers have reported higher seed yield and better quality in terms of germination and 1000 seed weight from primary umbels. In some experiments contribution of primary umbels has been reported up to 90 per cent of total seed yield.

Material and Methods
An experiment on the effect of planting density on seed production of temperate carrot (*Daucus carota* L.) was carried out at Vegetable Research Station, Kalpa, of Regional Horticultural Research & Training Station and Krishi Vigyan Kendra, Kinnaur (HP), Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan, H.P.

The field was thoroughly ploughed by tractor followed by planking 15 days prior to actual date of transplanting. Stones, pebbles and residues of previous crop were removed manually. Field was leveled and sufficient provision for drainage was made. The full recommended doses of P_2O_5 and K_2O along with half dose of N in the form of single super phosphate, muriate of potash and urea, respectively were applied as per treatment at the time of transplanting.

Carrot cultivar 'Early Nantes' was chosen for the present study. It is a temperate variety (European), 12-15 cm long, cylindrical, orange flesh with self-coloured core. The stecklings were planted on flat beds in plot size of 1.8 m × 1.5 m. Stecklings were prepared from medium sized roots stored in trenches during October-November 2014. Openings were made with a spade slightly deeper than the length of the stecklings. After transplanting, the field was immediately irrigated.

The experiment was laid in a Randomized Block Design (Factorial) with four different spacing viz. 45×15 cm (D_1), 45×30 cm (D_2), 30×30 cm (D_3) and 30×15 cm (D_4) and four level of fertilizer viz. 75% RD of NPK (F_1-75% RD NPK includes 23 g urea, 51g SSP and 13 g MOP), 100% RD of NPK (F_2-100% RD NPK includes 30 g urea, 68 g SSP and 17g MOP), 125% RD of NPK (F_3-125% RD NPK includes 38 g urea, 85 g SSP and 21g MOP) and150% RD of NPK (F_4-150% RD NPK includes 45g urea, 102 g SSP and 26g MOP). Nitrogen was given in 2 split doses *viz.* replanting of stecklings and at the time of flowering.

Result and Discussion

The data contained in Table 1 & 2 indicated that effect of planting density and interaction between different planting density and level of fertilizer was non-significant on soil electrical conductivity, pH, nitrogen, phosphorus and potassium. Among different planting densities (Table 2), maximum soil electrical conductivity (0.239 dSm^{-1}), pH (6.75), nitrogen (354.91), phosphorus (28.08) and potassium (143.91) was observed with the 45×30 cm (D_2) and minimum with 30×15 cm (D_3).

Like the effect of individual factors, of planting density and fertilizer level (F × D) was also non-significant effects (Table 1) on soil electrical conductivity, pH, nitrogen, phosphorus and potassium. Maximum electrical conductivity (0.250 dSm^{-1}), pH (6.80), nitrogen (369.33 kg ha^{-1}), phosphorus (30.40 kg ha^{-1}) and potassium (147.71 kg ha^{-1}) and minimum electrical conductivity (0.197dSm^{-1}), pH (6.43), nitrogen (329.66 kg ha^{-1}), phosphorus (23.61 kg ha^{-1}) and potassium (136.47 kg ha^{-1}) were recorded in F_4D_2 (150 % RD NPK & 45×30 cm) and F_1D_3 (75 % RD NPK & 30×30 cm), respectively. Further interaction of nitrogen, phosphorus and potassium has been reported to have synergistic effect on availability of nitrogen in soil. Tripathi *et al*. (2009) [12] has also reported that availability of nitrogen increased with the increasing levels of NPK fertilizer in coriander. Similarly, Khanday *et al.* (2012) [3] has also reported significant increase in the availability of nitrogen in soil with increase in the fertilizer dose in garden pea. The results are in conformity with Kumar *et al.* (2005) [5] who found significant increase in the availability of nitrogen in soil with increase in the fertilizer NPK dose in rajmah.

The application of fertilizer doses (Table 3) had also exhibited non-significant effect on soil electrical conductivity and pH. However, maximum soil electrical conductivity (0.239 dSm^{-1}) and pH (6.71) were observed with the 150% RD NPK (F_4).This report is in agreement with Kumar *et al*. (2014) [4] and Majumdar *et al*. (1998) [6, 7], who also reported non-significant effect on soil electrical conductivity in carrot and non significant effect on soil pH in garlic, respectively.

Application of varying fertilizer doses (Table 3) exhibited significant effect on available nitrogen, phosphorus and potassium. Significant higher available nitrogen (359.00 kg ha^{-1}), phosphorus (29.40 kg ha^{-1}) and potassium (146.09 kg ha^{-1}) were observed with the 150% RD NPK (F_4) was at par with F_3 (125 % RD NPK) and minimum available nitrogen, phosphorus and potassium were observed with 75% RD NPK (F_1). The increase in available phosphorous status of the soil with increasing levels of these fertilizer nutrients may be due to lower utilization of phosphorus, by the crop, at higher levels of applied phosphorus, resulted in higher build up of soil phosphorus. Another reason for higher P status of soil could be due to adequate supply of phosphorus through fertilizer. Similar results has also been reported by Kumar *et al*. (2014) [4] in carrot and Khanday *et al.* (2012) [3] in garden pea. Also, increasing fertilizer levels showed a significant increase in the amount of available K content in the soil after crop harvest. This could possibly be attributed to direct K addition in available K pool of soil (Tandon and Sekhon, 1988) [11]. Similar results were also reported by Rao and Swamy (1984) [8] in turmeric and Khanday *et al.* (2012) [3] in garden pea.

Table 1: Effect of interaction between different planting density and level of fertilizer application on electrical conductivity, pH, available nitrogen, phosphorus and potassium of soil

Spacing	Fertilizer	Electrical conductivity (dS m^{-1})	Soil pH	Nitrogen (kg ha^{-1})	Phosphorus (kg ha^{-1})	Potassium (kg ha^{-1})
45×15cm	75% RD NPK	0.210	6.53	332.66	23.79	139.29
45×30cm	75% RD NPK	0.240	6.70	333.33	24.07	139.84
30×30cm	75% RD NPK	0.197	6.43	329.66	23.61	136.47
30×15cm	75% RD NPK	0.203	6.49	330.66	23.74	137.66
45×15cm	100% RD NPK	0.223	6.62	350.66	27.88	142.79
45×30cm	100% RD NPK	0.227	6.76	353.00	28.18	143.47
30×30cm	100% RD NPK	0.203	6.53	342.33	26.77	140.23
30×15cm	100% RD NPK	0.223	6.56	344.00	27.33	141.11
45×15cm	125% RD NPK	0.227	6.60	360.66	28.56	144.17
45×30cm	125% RD NPK	0.240	6.73	364.00	29.78	144.65
30×30cm	125% RD NPK	0.213	6.53	352.33	26.96	143.37
30×15cm	125% RD NPK	0.217	6.76	353.00	27.94	143.81
45×15cm	150% RD NPK	0.237	6.76	364.00	30.30	146.07
45×30cm	150% RD NPK	0.250	6.80	369.33	30.40	147.71
30×30cm	150% RD NPK	0.240	6.70	350.66	28.27	145.13
30×15cm	150% RD NPK	0.230	6.60	352.00	28.61	145.44
$CD_{0.05}$		NS	NS	NS	NS	NS

Table 2: Effect of planting density on electrical conductivity, pH, available nitrogen, phosphorus and potassium of soil

Treatments	Electrical conductivity (dS m^{-1})	Soil pH	Nitrogen (kg ha^{-1})	Phosphorus (kg ha^{-1})	Potassium (kg ha^{-1})
45×15 cm	0.224	6.63	352.00	27.66	143.08
45×30 cm	0.239	6.75	354.91	28.08	143.91
30×15 cm	0.213	6.55	343.75	26.40	141.30
30×30 cm	0.218	6.60	344.91	26.91	142.00
$CD_{0.05}$	NS	NS	NS	NS	NS

Table 3: Effect of fertilizer levels application on electrical conductivity, pH, available nitrogen, phosphorus and potassium of soil

Treatments	Electrical conductivity (dS m^{-1})	Soil pH	Nitrogen (kg ha^{-1})	Phosphorus (kg ha^{-1})	Potassium (kg ha^{-1})
75 % RD NPK	0.213	6.53	331.58	23.80	138.31
100% RD NPK	0.219	6.62	347.50	27.54	141.90
125% RD NPK	0.224	6.65	357.50	28.31	144.00
150% RD NPK	0.239	6.71	359.00	29.40	146.09
$CD_{0.05}$	NS	NS	10.07	1.34	2.01

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