

Potassium and micronutrients interact to affect carrot (*Daucus carota*) productivity and economics.

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Article Info

Received: 25-04-2025 Revised: 09-05-2025 Accepted: 11-05-2025 Published: 21-05-2025

Abstract

The carrot, or *Daucus carota* L., is a biennial root vegetable that is usually farmed as an annual crop in tropical regions. It is believed to be a native of the Mediterranean area (Peirce, 1987). Although the tap root is the most often consumed component, carrot leaves are also tasty. Pickled fragile roots, salads, and preserves are common uses for it. It is consumed both fresh and cooked in pea curries. "Gajar Halwa" is a delicious delicacy made with carrots. Sometimes carrot juice, which is high in carotene, is used as a food colouring. Black carrots are used to make "kanji," a drink that is considered a delicious appetiser. Carrots are the greatest source of carotene, a precursor to vitamin A, which is the primary reason they are as highly prized as food (Zeb and Mahmood 2004).

Introduction

Carrots need a balanced application of fertilisers, especially potassium and micronutrients, since they are a root crop. All root crops react well to liberal potassium treatments, and potassium is necessary for photosynthesis, cell growth, protein synthesis, sugar transport, nitrogen and carbon metabolism (Inam et al. 2011). It is also necessary for better-quality carrots. Because muriate of potash (MOP) is mobile in plants, it helps balance cations and anions in the cytoplasm and controls the osmotic pressure within the cell, making it a popular source of potassium (Hu et al. 2016). One plant that needs potassium is carrots (Kadar 2008). Therefore, administering potassium may be beneficial for increasing carrot yield. One of the micronutrients that is also required in trace levels for plant development is zinc. Zinc increases the amount of chlorophyll in leaves and enhances photosynthesis, both of which increase the plant's overall capacity for assimilation (Tripathi et al. 2015). Plants that are severely dwarfed, have older leaves that may die, and have young leaves that become white are all signs of a zinc deficiency. Therefore, the experiment was designed to investigate how different potassium and micronutrient formulations affect carrot performance.

The experiment was carried out at Sri Karan Narendra Agriculture University, Jobner, Jaipur (26°05' N and 75°20' E), Rajasthan, during the winter (rabi) season of 2018–19. This area is in Rajasthan's agroclimatic zone IIIA (Semi-Eastern Plains). Four potassium dosages (K0, Control; K1, 50 kg; K2, 100 kg; and K3, 150 kg) and four micronutrient formulations (M0, Control; M1, FeSO₄ @0.5%; M2, Borax @0.5%; and M3, ZnSO₄@0.5%), each duplicated three times, were used in this factorial randomised block design (F-RBD). At the time of seeding, potassium (MOP-muriate of potash) was added to the soil, and 45 days later, micronutrient formulations were sprayed on the leaf. To get better outcomes, all cultural practices were followed and the row and plant spacing was maintained at 30 cm × 10 cm. The average root weight (g), root diameter (cm), shoot:root ratio, root core diameter (cm), edible root length (cm), and root yield (q/ha) of carrots were all manually recorded. Following crop harvest, net returns (₹/ha) and the B:C ratio of crop output were calculated for each treatment combination.

Statistical analysis: As recommended by Panse and Sukhatme (1985), the analysis of variance (ANOVA) approach was used to statistically analyse the experiment's data.

The root yield and B:C ratio were calculated as:

$$\text{Root yield (q/ha)} = [\text{Root yield (kg/plot)} \times 10,000 / \text{Net area of plot (m}^2\text{)}] \times 100$$

$$\text{B:C ratio} = \text{Net return (₹)} / \text{Total cost of cultivation (₹)}$$

Carrot root production, yield characteristics, and economics were all greatly impacted by the application of MOP and micronutrient formulations to the soil (Table 1). The average root weight (189.3 g), root diameter (3.7 cm), shoot:root ratio (0.5), edible root length (23.7 cm), root yield (28.3 t/ha), net returns (₹205161/ha), and B:C ratio (2.7) were found to be better in the treatment soil application

of potassium @150 kg/ha than in the other treatments, but they remained statistically comparable to soil application of potassium @100 kg/ha in terms of yield parameters and economics. When potassium was applied at a rate of 150 kg/ha, the average root weight, root diameter, edible root length, shoot:root ratio, root yield, and net returns were found to be (34.0 and 22.3%), (23.2 and 10.4%), (18.6 and 8.8%), (23.8 and 8.3%), (31.1 and 19.8%), and (42.3 and 26.4%). A large portion of the movement of photo-assimilates from the foliage to the roots may be caused by the increased photosynthetic activity that follows the application of potassium to the soil (Haque et al. 2019). This could account for the increased values of yield, yield parameters, and economics under the given treatments. Potassium is moved from older tissues to the plant's growth regions, the roots and leaves, where it takes up a very intermediate position. The transfer of sugar and other carbohydrates from the leaves to the roots results in increases in the production of sugar and roots. These findings are consistent with those of Thapa et al. (2023) for carrots and Amin et al. (2023) for radish. Comparing the foliar application of ZnSO₄ @0.5% to other treatments, the carrot crop showed a significant response in terms of average root weight (182.8 g), root diameter (3.7 cm), shoot:root ratio (0.5), edible root length (24.2 cm), root yield (27.8 t/ha), net returns (₹202576/ha), and B:C ratio (2.7). When ZnSO₄ @0.5% was applied topically, the average root weight, root diameter, edible root length, shoot:root ratio, root yield, net returns, and B:C ratio increased by 23.2, 22.2, 18.2, 27.9, 23.4, 34.4, and 33.2% compared to the control. The improved growth parameter values under ZnSO₄ @0.5% may be the consequence of zinc sulphate rapidly increasing nutrient absorption in the carrot's organs and tissues, which reduced nutritional inadequacies. Zinc enhanced the activity of several enzymes needed for plant cell division and the control of the K:Ca ratio. Zinc's critical function in raising agricultural productivity may be the cause of improved yield, yield characteristics, and economic performance (Alam et al. 2021). Better locations for photosynthesis and the redirection of photosynthates toward roots were made possible by the increased development of foliage. Ahamad et al. (2023) showed similar results for carrots. The overall improvement of production, yield metrics, and carrot economics were shown to be significantly impacted by the interaction between potassium and micronutrients (Fig. 1 and 2, Table 2). Treatment combination K3M3 (Potassium @150 kg/ha with ZnSO₄ @0.05%) showed significantly higher average root weight (209.56 g), root yield (31.4 t/ha), net returns (₹235918/ha), and B:C ratio (3.03) than the other treatment combinations, with the exception of potassium @100 kg/ha along with ZnSO₄ @0.05% (K2M3). The availability of sufficient amounts of plant nutrients in sufficient form throughout the crop's growth period, particularly during critical growth periods, may also be responsible for the beneficial effects of potassium and micronutrients on carrot root yield. This leads to improved uptake, increased plant vigour, and higher yield parameters.

The average root weight (189.3 g), root diameter (3.7 cm), shoot:root ratio (0.5), edible root length (23.7 cm), root yield (28.3 t/ha), and net returns were all considerably improved by the application of MOP @150 kg/ha.

Table 1 Effect of potassium and micronutrient formulations on root yield, yield parameters and economics of carrot

Treatment	Average root weight (g)	Root diameter (cm)	Core diameter (cm)	Edible root length (cm)	Shoot: root ratio	Root yield (t/ha)	Net returns (₹/ha)	Benefit: cost ratio
<i>Potassium level</i>								
K ₀ (Control)	141.3	3.0	1.0	20.0	0.42	21.6	144130	2.0
K ₁ (K ₂ O 50 kg/ha)	154.8	3.4	1.2	21.8	0.48	23.6	162273	2.2
K ₂ (K ₂ O 100 kg/ha)	183.0	3.6	1.4	23.2	0.52	27.9	203525	2.6
K ₃ (K ₂ O 150 kg/ha)	189.3	3.7	1.5	23.7	0.54	28.3	205161	2.7
SEm±	2.8	0.08	0.03	0.48	0.01	4.1	4263	0.05
CD (P=0.05)	8.0	0.24	0.09	1.39	0.03	11.9	12309	0.16
<i>Micronutrient formulation</i>								
M ₀ (Control)	148.3	3.0	1.2	20.4	0.43	22.5	150676	2.0
M ₁ (Fe ₂ SO ₄ @0.5%)	171.4	3.6	1.3	22.6	0.47	26.0	185325	2.5
M ₂ (Borax @0.5%)	165.9	3.4	1.3	21.5	0.51	25.2	173513	2.3
M ₃ (ZnSO ₄ @0.5%)	182.8	3.7	1.3	24.2	0.55	27.8	202576	2.7
SEm±	2.8	0.08	0.03	0.5	0.01	4.1	4263	0.05
CD (P=0.05)	8.0	0.24	NS	1.4	0.03	11.9	12309	0.16

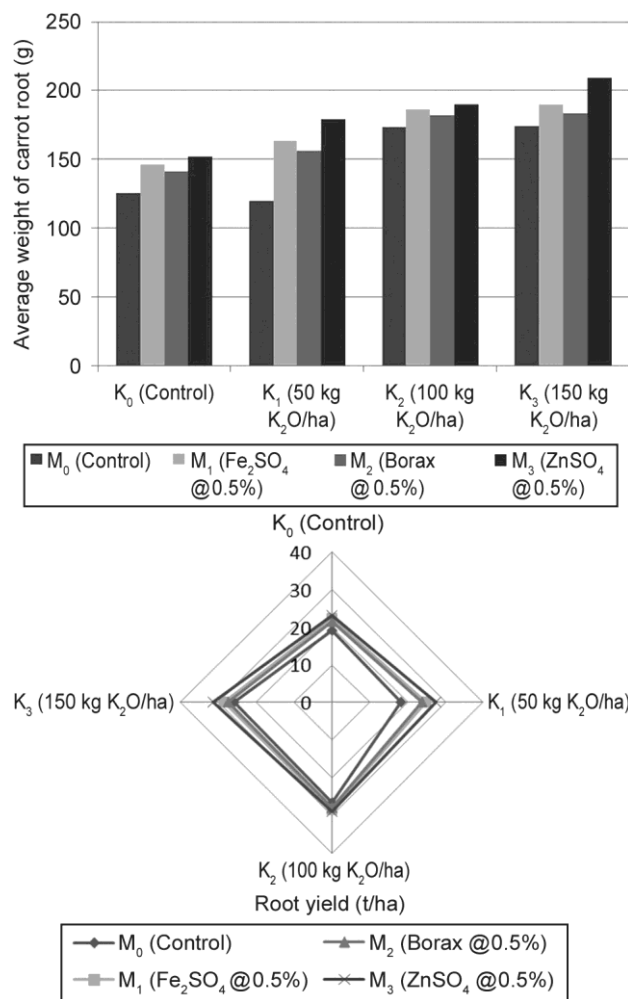


Fig. 1 Interactive effect of potassium and micronutrients on average weight of carrot root.

Fig. 2 Interactive effect of potassium and micronutrients on root yield.

Table 2 Interactive effect of potassium and micronutrients on net returns (₹/ha) and Benefit cost ratio of carrot

Treatment	K ₀	K ₁	K ₂	K ₃
<i>Net returns (₹/ha)</i>				
M ₀ (Control)	120730	109860	189600	182514
M ₁ (Fe ₂ SO ₄ @0.5%)	151351	175297	208769	205881
M ₂ (Borax @0.5%)	143788	164283	201648	196333
M ₃ (ZnSO ₄ @0.5%)	160650	199653	214082	235918
SEm±				8525
CD (P=0.05)				24619
<i>B:C ratio</i>				
M ₀ (Control)	1.7	1.5	2.5	2.4
M ₁ (Fe ₂ SO ₄ @0.5%)	2.1	2.4	2.7	2.6
M ₂ (Borax @0.5%)	2.0	2.2	2.6	2.5
M ₃ (ZnSO ₄ @0.5%)	2.2	2.7	2.8	3.0
SEm±				0.1

CD ($P=0.05$)

0.3

K₀, Control; K₁, 50 kg K₂O/ha; K₂, 100 kg K₂O/ha; K₃, 150 kg K₂O/ha.

(₹205161/ha) and the carrot's benefit cost ratio (2.7). ZnSO₄ @0.5% performed the best among the micronutrient formulations in terms of yield, yield characteristics, and economics. In comparison to the other treatment combinations, the combined application of MOP @150 kg/ha with foliar spray of ZnSO₄ @0.5% was found to significantly increase root yield, net returns, and B:C ratio (313.90 q/ha, ₹235918/ha, and 3.03), respectively. However, it remained statically comparable to K2M3 (MOP @100 kg/ha with foliage spray of ZnSO₄ @0.5%). Therefore, for carrot-growing regions in Rajasthan's semi-arid region, soil application of potassium @100 kg/ha and foliar treatment of ZnSO₄ @0.5% (K2M3) are recommended.

SUMMARY

Reduced carrot root production is mostly caused by deficiencies and inadequate nutrient administration. A balanced supply of nutrients is essential for achieving the best root output under certain agroclimatic conditions. Carrot production may increase with proper nutrition management, including micronutrients and potassium. The experiment was carried out at Sri Karan Narendra Agriculture University in Jobner, Jaipur, Rajasthan, to investigate the impact of different potassium and micronutrient formulations on carrot performance. The yield qualities, yield, and economics of carrots were shown to be important. The average root weight (189.3 g), root diameter (3.7 cm), shoot:root ratio (0.5), edible root length (23.7 cm), root yield (28.3 t/ha), net returns (₹205161/ha), and B:C ratio (2.7) of carrots were all considerably increased by applying potassium (MOP) @150 kg/ha to the soil. Among the micronutrient formulations, foliar application of ZnSO₄ @0.5% showed substantially greater average root weight (182.8 g), root diameter (3.7 cm), shoot:root ratio (0.5), edible root length (24.2 cm), root yield (27.8 t/ha), net returns (₹202576/ha), and B:C ratio (2.7). The average root weight (209.6 g), root production (31.4 t/ha), net returns (₹2,35,918/ha), and B:C ratio (3.03) were all considerably improved by soil application of potassium (MOP) @150 kg/ha and ZnSO₄ @0.5%, according to the interaction results.

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