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Effect of Different Levels of Potassium and Boron on Growth,Yield and Quality of Carrot (*Daucus carota* cv. New Kuroda) in Nawalparasi, Nepal

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Abstract:- The yield and quality of carrot is limited due to the imbalance application of macro and micronutrients. The experiment was conducted at Horticulture farm of Kawasoti, Nawalparasi to assess the effect of different levels of potassium and boron on growth, yield and quality of carrots, during the period from 20th November, 2019 to 5th March, 2020. The experiment was laid out in RCBD design allocating 12 treatments and 3 replications. The treatment comprised of three different levels of potassium (i.e. 0, 50 and 100 kg/ha) and four different levels of boron (i.e. 0, 1.1, 2.2 and 3.3 kg/ha). The variety 'New Kuroda' was used in the experiment. The result of present study indicated the significant effect of different treatments on growth, yield and quality of carrot. The maximum plant height (51.67 cm), number of leaves (11.55) , root length (19.37 cm), root diameter (4.81 cm), fresh weight of leaves (81.11 gm) , fresh weight of roots (207.66 gm) and yield per plot (11.10 kg) was observed with the application of Potassium @ 100 kg/ha and boron @ 3.3 kg/ha. Besides, maximum value of quality parameters like TSS (11.50 ˚B), carotene content (6.367 mg/100 gm) and ascorbic acid content (3.720 mg/100 gm) was also observed with increase in levels of potassium and boron, whereas the minimum value for all the parameters were observed from control treatments. Considering these positive and beneficial effects of optimum levels of potassium and boron, it can be concluded that the application of potassium @ 100 kg/ha and boron @ 3.3 kg/ha was found beneficial for carrot production. Therefore, based on the present findings of the study, combined application of micronutrients along with major nutrients was found better for the optimum yield and quality carrot production in Nawalparasi.

Keywords:- *Carrot, boron, potassium, quality, micronutrients*

I. INTRODUCTION

Carrot (*Daucus carota* L.) is one of the most popular root crops, recognized worldwide for its nutritional and economic value. In worldwide, the majority of vegetable production takes place in Asian countries, with Nepal being the sixth leading producer of fresh vegetables following China, India, Vietnam, Philippines, and Myanmar in 2016 (FAO, 2016).The vegetable farming is increasingly gaining its importance in Nepal (Ghimire et al., 2018). In such, the diverse agro-climatic conditions of Nepal have provided unlimited scope for growing both seasonal and off-season vegetables including carrots (Bhattarai et al., 2017). The consumption of carrot isincreasing progressively due to its recognition as an important source of natural antioxidants having anticancer properties, anti-diabetic, anti-hypertensive, hepato-protective and wound healing properties. Furthermore, it is an important source of income and an effective means of poverty reduction in some part of Nepal (HRD, 2015).

Carrot is becoming an important commercial crop of Nepalese farmers. Due to its nutritive and economic value, it has been realized that the crop needs to be improved in order to exploit them to its maximum potentiality.Although carrots are known as medium feeders, they still require a fertile soil, allowing for normal growth of plants.According to Kadar (2008) carrot is a potassium demanding plant and requires regular supply of potassium during their growth period. Potassium is essential for root development, photosynthesis and for starch formation. It plays an important role in stomatal guard cells opening and closing, thus protects the plant from extremities. Thus, helps actively in disease response mechanism of carrot. Ivanov (2001) also discussed the role of potassium in maintaining soil fertility and emphasized the necessity of continuous use of potassium fertilizer for carrot production.

Besides, micronutrients play a very important role in vital processes of plant. They increase the chlorophyll content of leaves, improve photosynthesis which intensify the assimilating activity of the whole plants (Tripathi et al., 2015). The micronutrients act as catalyst and enhance the chemical composition of fruits and are also vital for the physiological activities within the plant (Abo Hamad et al.,2014).They are the key elements which stimulates the uptake of other primary and secondary nutrients when applied in optimal concentration because of their interaction effect like boron associated with uptake of potassium, zinc associated with uptake of phosphorus and iron associated with uptake of copper in plants. Boron is necessary for cell division, cell wall formation, protein synthesis, ATP formation, pollination, seed production and translocation of sugar and carbohydrates during fruiting stages (Siddiky et al., 2007).

As the fruit develops, it becomes larger sink for K thereby diminishing K levels in the leaves that are needed for continued plant growth and different physiological processes. In such, B has a major influence on plasma membrane of plant cells and ion transport system that helps in amendment of K, Ca and Mg levels in plant. Due to these overlapping roles played by K and B in plant physiology, the effects of these two plant nutrients on plant development are considered significant. Both K and B serve as buffers and are necessary for the maintenance of conducting tissues. Plant growth was restrained by the excess application of B whereas, K reduced the inhibitory effect of excess K on plant growth. Thus, the addition of K to the growing media can be beneficial in alleviating plant growth reduction and mineral imbalances caused by excess B (Samet et al., 2015).

The amount of fertilizers applied should give the best production, ensure nutrient availability to the crop and minimize the waste over the growth period of crop. The farmers of Nepal uses fertilizer in order to maximize profits without correctly adjusting the balance between nutrients applied. Similarly, Agriculture Development Strategy (2015-2034) has also highlighted the minimum use of fertilizers as the major reason for low productivity and commercialization. It also stated that the majority of Nepalese farmers are small and marginal, characterized by low purchasing power of costly fertilizers. Also, micronutrients are given less priority in case of crop production due to which yield and quality remains retarded though sufficient amount of macronutrients are supplied.In contrast to N, potassium application has been neglected by majority of farmers in our country resulting in continual depletion of soil K (Lal et al.,2007). However, the farmers are unaware about the proper management practices and complete fertilizer use in vegetable production due to which they are not achieving satisfactory yield (Gurung et al., 2016).

II. MATERIAL AND METHODS

The experiment was carried out during the winter season from 20 November, 2019 to 5 March, 2020 in the vegetable farm of Shahid Smriti Secondary School, Kawasoti, Nawalpur. It is situated at 170 m above the sea level and comes under tropical region. It lies between 27˚38’24’’ N latitude and 84˚6’56’’E longitude geographically.

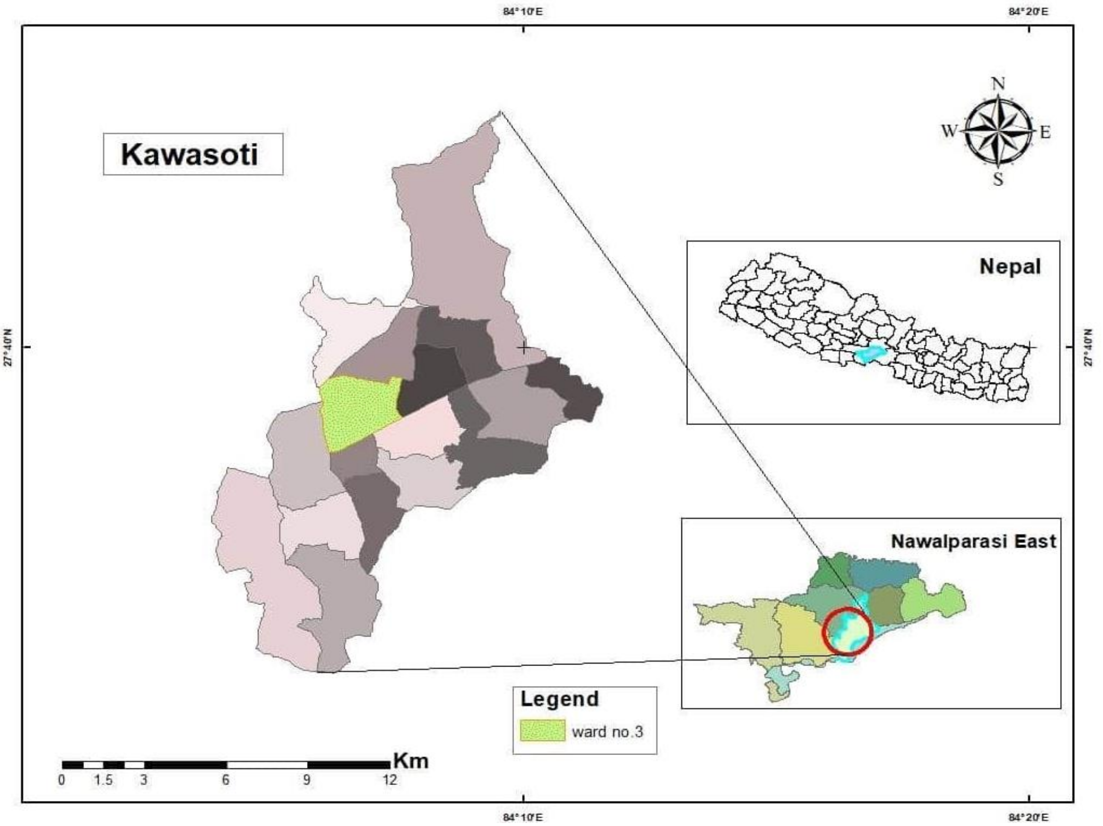

Fig. 1: Geographical map showing experimental site

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A. Climate and soil type

The soil condition of experimental site was truly marginal with limited amount of nutrients. The soil type was predominantly clayey type or slightly clayey loam type. The soil sample was taken 10 days before the study period. The soil test was carried out at BGTL Soil Laboratory, Pokhara and the information provided from the soil analysis are presented as;

Parameters	Unit	Readings	Status
PH	/	6.2	Acidic
Organic matter	%	2.05	Medium
Density	gm/cm^3	1.55	High
Porosity	%	40	Medium
Total Nitrogen	%	0.11	Medium
Available P	Ppm	104.1	Medium
Available K	Ppm	54.88	Medium
Zn	mg/kg	1.19	Medium
Fe	mg/kg	232	High
Mn	mg/kg	26	Medium
Cu	mg/kg	1.36	Low
B	mg/kg	0.40	Low

Table 1: Analysis report of soil samples from the experimental plot at Kawasoti, Nawalparasi before field experiment

Source: BGTL Soil Laboratory, Kaski

B. Experimental design

The experiment was carried out following Randomized Complete Block Design (RCBD) with three replications. The different three levels of potassium dose comprising with four levels of boron formed 12 different treatments. The treatments in each replication were allocated randomly. Thus, there were 36 different unit plots each of 3m × 1m in the experiment However, the distance between plots and the blocks were kept at 0.5m and 1 m respectively. The two factors or fertilization levels used in the experiment was presented below:

Factor A: Different levels of Potassium

- 0 kg/ha potassium (K_0)
- 50 kg/ha potassium (K_{50})
- 100 kg/ha potassium (K_{100})

Factor B: Different levels of Boron

- 0 kg/ha borax i.e. 0 kg/ha boron (B_0)
- 10 kg/ha borax i.e. 1.1 kg/ha boron (B_1)
- 20 kg/ha borax i.e. 2.2 kg/ha boron (B_2)
- 30 kg/ha borax i.e. 3.3 kg/ha boron (B_3)

C. Treatment details

Treatments	Treatment Combinations	Symbols
T1	100:50:0 kg/ha NPK + 0 kg/ha B (control)	K_0B_0
T2	100:50:0 kg/ha NPK + 1.1 kg/ha B	K_0B_1
T3	100:50:0 kg/ha NPK + 2.2 kg/ha B	K_0B_2
T4	100:50:0 kg/ha NPK + 3.3 kg/ha B	K_0B_3
T5	100:50:50 kg/ha NPK + 0 kg/ha B	$K_{50}B_0$
T6	100:50:50 kg/ha NPK + 1.1 kg/ha B	$K_{50}B_1$
T7	100:50:50 kg/ha NPK + 2.2 kg/ha B	$K_{50}B_2$
T8	100:50:50 kg/ha NPK + 3.3 kg/ha B	$K_{50}B_3$
T9	100:50:100 kg/ha NPK + 0 kg/ha B	$K_{100}B_0$
T10	100:50:100 kg/ha NPK + 1.1 kg/ha B	$K_{100}B_1$
T11	100:50:100 kg/ha NPK + 2.2 kg/ha B	$K_{100}B_2$
T12	100:50:100 kg/ha NPK + 3.3 kg/ha B	$K_{100}B_3$

Table 2: Treatment combinations used in the experiment at Kawasoti, Nawalparasi in 2019/20

Note: Nitrogen and Phosphorus fertilizer dose were applied in constant doses of 100 kg/ha and 50 kg/ha respectively.

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D. Field layout

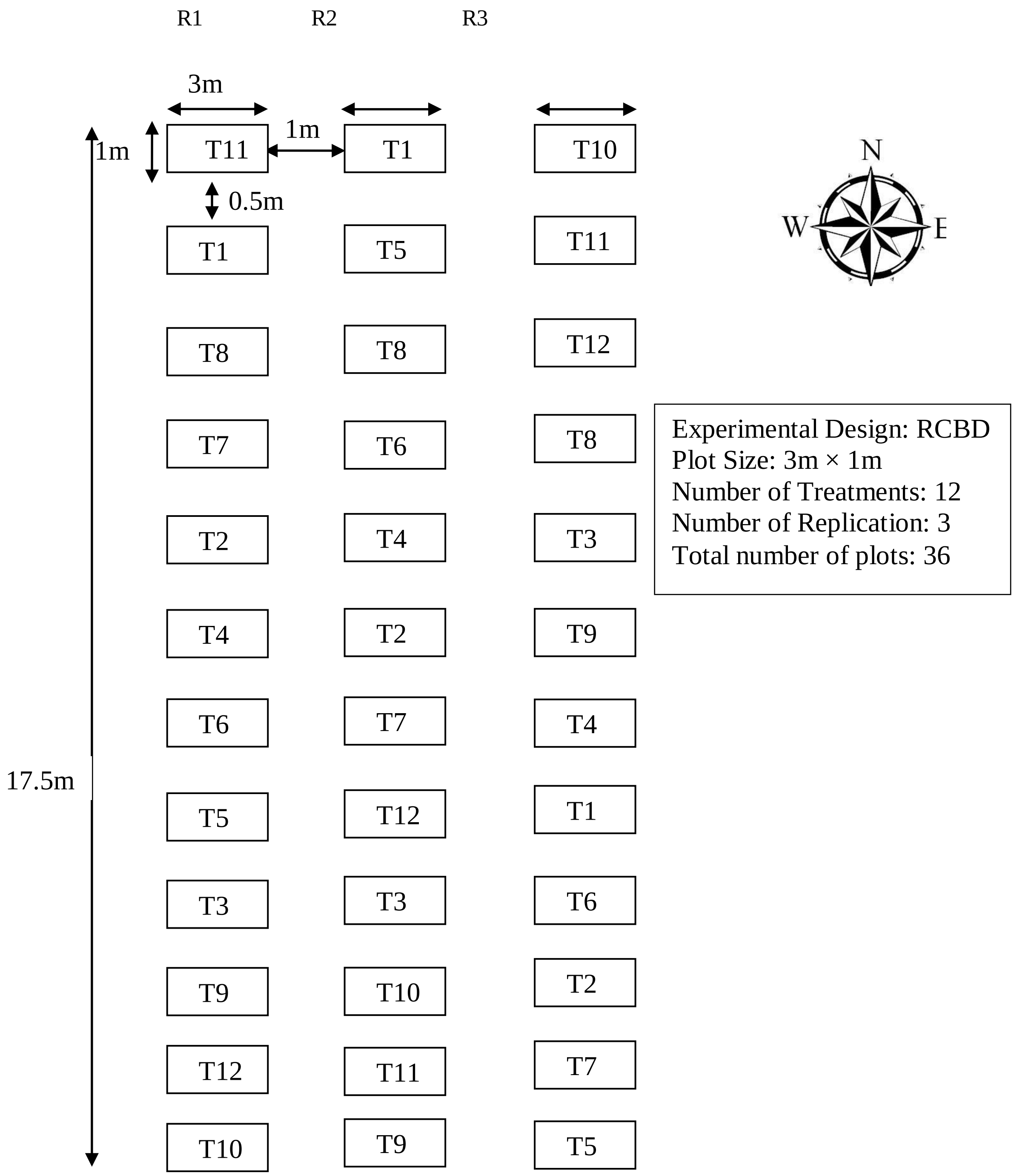

Fig. 2: Field layout of the experiment

The individual plot was of 3m × 1m dimension maintaining row to row and plant to plant distance of 30 cm and 10 cm respectively. The distance between plots in each block was 0.5 m while the distance between blocks was maintained as 1 m.

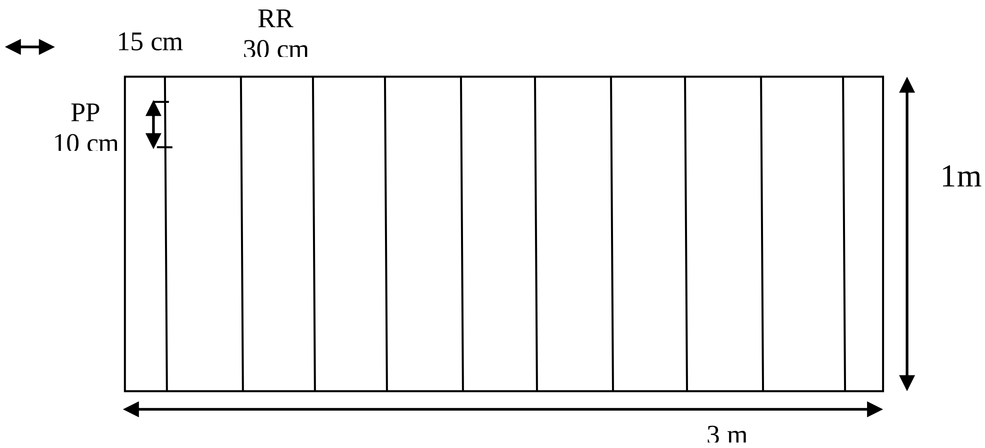

Fig. 3: Layout of a single plot

E. Statistical analysis

The data obtained for different parameters were statistically analyzed to observe the significant difference among the treatments by using Rand R-Studio computer package program. The mean square value was calculated and analysis of variance was performed. And, the significance of difference among the treatment means were estimated by Least Significant Difference (LSD) at 5% level of significance. However, Excel, Minitab and SPSS was also used to analyze co-relation and regression among different parameters.

III. RESULT AND DISCUSSION

A. Growth Parameters

The different levels of potassium and boron treatment used in the experiment showed highly significant effect on all the growth parameters. The maximum plant height (36.62 cm, 47.27 cm and 51.67 cm) was recorded in treatment T12 receiving 100 kg/ha potassium and 3.3 kg/ha boron and minimum (23.84 cm, 32.44 cm and 36.44 cm) was recorded from T1 (control) at 45 DAS, 75 DAS and at harvest respectively. Also, the number of leaves at 45 DAS, 75 DAS and at harvest were maximum (9.33, 11.55 and 10.0 respectively) for the treatment T12 and minimum leaves number (4.11, 6.96 and 5.22 respectively) were recorded from control treatments.It might be due to the functioning of boron in number of growth processes like development of meristematic tissue, protein synthesis and translocation of sugars.The result obtained from the study was similar with the findings of Tohamy et al. (2011) who reported that the highest plant height was obtained from the higher level of potassium and boron application.

Treatments	Plant height (cm)			Number of leaves		
	45 DAS	75 DAS	At harvest	45 DAS	75 DAS	At harvest
K_0B_0	23.84^{f}	32.44^{g}	36.44^{h}	4.11^{i}	6.96^{f}	5.22^{f}
K_0B_1	23.62^{f}	35.11^{fg}	39.78^{g}	4.67^{hi}	7.20^{ef}	5.64^{ef}
K_0B_2	27.02^{e}	36.90^{ef}	41.94^{efg}	5.22^{gh}	7.51^{def}	5.77^{ef}
K_0B_3	28.86^{de}	39.02^{def}	41.86^{fg}	5.67^{fg}	7.93^{def}	5.55^{f}
$K_{50}B_0$	27.23^{e}	39.06^{def}	41.58^{fg}	5.67^{fg}	7.71^{def}	5.44^{f}
$K_{50}B_1$	24.17^{f}	40.33^{cde}	42.70^{def}	6.33^{ef}	7.95^{def}	6.11^{def}
$K_{50}B_2$	27.63^{e}	42.62^{bcd}	44.32^{cde}	6.67^{de}	8.45^{cdef}	7.22^{bcd}
$K_{50}B_3$	34.44^{ab}	43.85^{abc}	45.53^{c}	7.45^{cd}	8.78^{bcde}	7.55^{cd}
$K_{100}B_0$	30.96^{cd}	41.18^{bcd}	45.07^{cd}	7.67^{bc}	9.00^{bcd}	6.89^{cde}
$K_{100}B_1$	32.39^{bc}	44.23^{abc}	45.97^{bc}	8.33^{b}	10.00^{abc}	8.33^{b}
$K_{100}B_2$	34.39^{ab}	44.72^{ab}	48.14^{b}	8.11^{bc}	10.33^{ab}	8.22^{b}
$K_{100}B_3$	36.72^{a}	47.27^{a}	51.67^{a}	9.33^{a}	11.55^{a}	10.00^{a}
Mean	29.27	40.56	43.75	6.60	8.61	6.83
SEM	1.44	2.40	1.43	0.48	1.0	1.0
$LSD_{0.05}$	2.43**	4.04**	2.42**	0.83**	1.70**	1.30**
CV %	4.93	5.92	3.28	7.49	11.75	11.34

Table 3: Effect of different levels of potassium and boron on growth parameters of carrot

Means with same letter within column do not differ significantly at p= 0.05 by DMRT. *=Significant at 5% ($p \leq 0.05$), **=Significant at 1% ($p \leq 0.01$), ***=Significant at 0.1% ($p \leq 0.001$), NS- Non –significant, SEM- Standard error of mean, LSD-Least significant difference, CV- Coefficient of variance

B. Yield Parameters

Similarly, the highest root length, root diameter, fresh weight of leaves, fresh weight of roots, dry matter content of leaves and dry matter content of roots (i.e. 19.37cm, 4.81 cm, 81.11gm, 207.66gm, 14.42gm and 21.37 gm respectively) were observed from treatment T12 i.e. 100 kg/ha K and 3.3 kg/ha B which was superior among all the treatments whereas minimum value (i.e. 11.29 cm, 2.24cm, 40.29gm, 130.8gm, 6.53gm and 10.95 gm respectively) were recorded from the control. It is due to the fact that combination of optimum doses of both potassium and boron might have important role in creating favorable soil conditions and supplying sufficient nutrients for better growth and development.The results are in close agreement with those obtained by Alam (2008) who reported that potassium application catalyzes many enzymatic actions in photosynthesis, maintaining turgor pressure and minimizing water loss from the shoot and roots, resulting in higher fresh weight during harvesting.

The interaction effect of different levels of potassium and boron showed significant effect on yield per hectare. The result of the experiment is presented in Table 17. which revealed that the maximum yield per hectare (37.3 ton/ha) was observed from treatment T12 and followed by treatment T11. And the lowest yield per hectare (15.67 ton/ha) was obtained from the control plots. The findings of the study were in close proximity with the findings of Baloch et al. (2014) who also reported significant increase in yield of radish with increased fertilization of potassium.

Treatments	Root length	Root Diameter	Fresh wt. of leaves	Fresh wt. of roots	Dry wt. of leaves	Dry wt. of roots
K_0B_0	11.29^{h}	2.24^{f}	40.29^{h}	130.80^{h}	6.73^{f}	10.95^{h}
K_0B_1	11.78^{gh}	2.63^{ef}	42.17^{gh}	135.76^{gh}	6.53^{f}	12.93^{g}
K_0B_2	12.67^{fgh}	2.79^{ef}	46.39^{fg}	145.84^{fg}	7.01^{f}	14.30^{f}
K_0B_3	13.54^{efg}	3.07^{cde}	47.24^{fg}	155.29^{ef}	8.09^{e}	15.73^{e}
$K_{50}B_0$	12.46^{gh}	2.87^{e}	48.83^{ef}	158.97^{e}	8.38^{e}	16.21^{e}
$K_{50}B_1$	14.33^{def}	2.93^{de}	53.17^{de}	158.63^{e}	8.63^{e}	15.83^{e}
$K_{50}B_2$	15.17^{cde}	3.47^{bcd}	55.22^{d}	164.58^{de}	9.04^{e}	17.38^{d}
$K_{50}B_3$	15.89^{cd}	3.58^{bc}	57.83^{cd}	171.78^{cd}	10.55^{cd}	17.67^{cd}
$K_{100}B_0$	14.78^{de}	3.49^{bcd}	53.78^{de}	178.00^{c}	10.19^{d}	17.70^{d}
$K_{100}B_1$	16.89^{bc}	3.79^{b}	62.94^{c}	197.52^{ab}	11.48^{c}	18.64^{c}
$K_{100}B_2$	17.78^{ab}	4.54^{a}	72.02^{b}	196.43^{b}	12.62^{b}	19.90^{b}
$K_{100}B_3$	19.37^{a}	4.81^{a}	81.11^{a}	207.66^{a}	14.42^{a}	21.37^{a}
Mean	14.66	3.34	55.08	166.77	9.47	16.55
SEM	1.04	0.33	3.27	6.45	0.60	0.63
$LSD_{0.05}$	1.77**	0.57**	5.52**	10.87**	1.02**	1.06**
CV %	7.17	10.16	5.95	3.86	6.43	3.82

Table 4: Effect of different levels of potassium and boron on yield parameters of carrot

Means with same letter within column do not differ significantly at p= 0.05 by DMRT. *=Significant at 5% (p≤0.05), **=Significant at 1% (p≤0.01), ***=Significant at 0.1% (p≤ 0.001), NS- Non –significant, SEM- Standard error of mean, LSD- Least significant difference, CV- Coefficient of variance

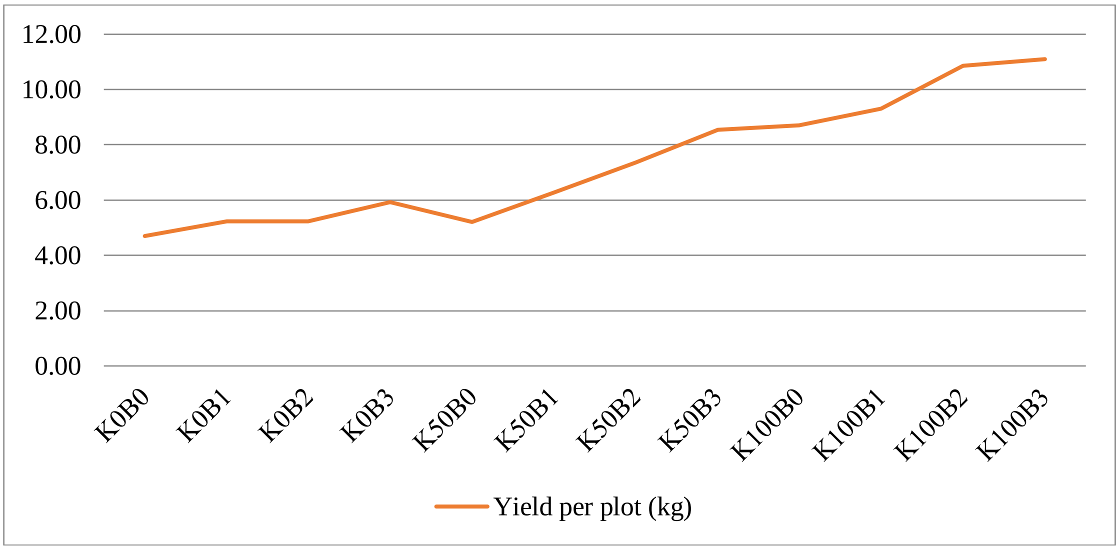

Fig 4: Graph showing yield of carrot in kg/ha

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C. Quality Parameters

The percentage of branched roots differed significantly with interaction effect of different levels of potassium and boron application. The maximum cracked and branched roots (3.33% and 8% respectively) was recorded in control treatments, while the minimum percentage (0.67% and 1.33%) was recorded from T11 i.e. potassium @ 100 kg/ha and B @ 2.2 kg/ha,followed by T12, T4, T8 and T7 respectively. This may be due to the higher protein synthesis and translocation of starch from shoot to storage parts as influenced by higher boron application. The result was in accordance with the findings of Patwary et al., 2015.

All the quality parameters of carrot such as TSS, carotene content and ascorbic acid content was significantly influenced due to increased application of potassium and boron. The highest TSS, carotene content and ascorbic acid content (i.e.11.50ºB, 6.36 mg/100gm and 3.720 mg/100gm respectively) was reported from T12 whereas minimum (i.e. 7.08ºB, 2.75 mg/100gm and 1.482 mg/100gm respectively) were reported from the control plots. Kumar et al. (2015) also reported similar findings in his experiment. The reason of enhanced TSS content could be due to the prominent role of potassium in translocation of sugars and soluble solids from leaves to the storage roots.The increment of the carotenes in carrot roots as a result of potassium and boron application may be due to photosynthetic activity by boron and enzymatic reaction triggered off by potassium and ultimately leading to carbohydrates transformation for carotene synthesis.

Treatments	Cracked roots (%)	Branched roots (%)	TSS content (ºB)	Carotene content (mg/100 gm)	Ascorbic acid content (mg/100 gm)
K_0B_0	3.33[a]	8.00[a]	7.08[g]	2.750[g]	1.491[g]
K_0B_1	2.67[ab]	6.67[ab]	7.39[g]	3.003[g]	1.482[g]
K_0B_2	1.00[bc]	6.67[ab]	8.23[f]	3.467[f]	1.555[fg]
K_0B_3	1.00[bc]	2.67[cd]	8.37[f]	3.58[f]	1.682[fg]
$K_{50}B_0$	2.67[ab]	4.00[bcd]	8.32[f]	3.910d[e]	1.86ef
$K_{50}B_1$	1.33[bc]	5.00[abc]	8.72[cef]	4.127[cde]	2.159[de]
$K_{50}B_2$	1.33[bc]	1.67[cd]	9.38[bcd]	4.387[c]	2.266[d]
$K_{50}B_3$	1.00[bc]	2.00[cd]	9.38[acd]	4.280[cd]	2.389[d]
$K_{100}B_0$	2.67[ab]	5.00[abc]	9.17[de]	4.003[de]	2.712[c]
$K_{100}B_1$	1.00[bc]	4.67[abcd]	9.83[c]	5.713[b]	3.155[b]
$K_{100}B_2$	0.67[c]	1.33[d]	10.66[b]	6.200[a]	3.453[ab]
$K_{100}B_3$	1.00[bc]	2.00[cd]	11.50[a]	6.367[a]	3.720[a]
Mean	1.63	4.13	9.00	4.310	2.320
SEM	1.0	2.03	0.31	0.17	0.17
$LSD_{0.05}$	1.70*	3.43*	0.55**	0.290**	0.317**
CV %	61.85	49.31	3.66	4.020	8.090

Table 5: Effect of different levels of potassium and boron on quality parameters of carrot

Means with same letter within column do not differ significantly at p= 0.05 by DMRT. *=Significant at 5% ($p \leq 0.05$), **=Significant at 1% ($p \leq 0.01$), ***=Significant at 0.1% ($p \leq 0.001$), NS- Non –significant, SEM- Standard error of mean, LSD- Least significant difference, CV- Coefficient of variance

IV. CONCLUSIONS

From this experiment, it was concluded that the efficient production of carrot was highly influenced by the judicial application of both macro and micro elements in appropriate amount. The application of recommended doses of macronutrients with the combination of micronutrients provided maximum satisfactory yield. However, the excess application of some nutrients revealed some antagonistic effect on plant growth and crop production. Soil health must also be considered while productivity and high economic return are of major concern. Thus, considering all these aspects of crop productivity and soil health for sustainable production, treatment T12 receiving potassium @ 100kg/ha and boron @ 3.3 kg/haisproved to be the best combination of treatment for the profitable and qualitative carrot production in Nawalparasi district of Nepal.

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