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Effect of Nitrogen and Potassium Concentration on Different Growth Stage of Capsicum in Hydroponic Culture

M. REZAUL KARIM
Scientific Officer, Olericulture Division, Horticulture Research Centre (HRC), Bangladesh Agricultural Research Institute (BARI), Gazipur-1701
EFTEKHAR MAHMUD
Senior Scientific officer, Regional Horticulture Research Station (RHRS), BARI, Patuakhali-8602
H.E.M. KHAIRUL MAZED[1]
Scientific Officer, Regional Agricultural Research Station (RARS), BARI, Jamalpur-2000
M.M. RAHMAN TALUKDER
Principal Scientific Officer, Regional Agricultural Research Station, BARI, Barishal-8211
HASIB BIN SAIF
Scientific Officer, Planning & Evaluation Wing, BARI, Gazipur-1701

Abstract

An experiment was carried out in hydroponic net house at RHRS, BARI, Lebukhali, Patuakhali to find out the effect of nitrogen and potassium dose on vegetative and reproductive stage of capsicum (BARI Mistymarich 1). There were five nitrogen and potassium dose combined treatment (T_1= $N_{200}K_{300}$, T_2= $N_{220}K_{270}$, T_3= $N_{220}K_{330}$, T_4= $N_{180}K_{270}$, T_5= $N_{180}K_{330}$) at vegetative stage and while 5x5 of these treatment combinations a total of 25 treatment combinations were evaluated at reproductive stage. In the vegetative stage part T_2 ($N_{220}K_{270}$) performed better than other four treatment statistically significant for all growth parameter considered. In reproductive stage significant response was observed in terms of fruit weight, fruit number and yield per plant. T_3T_1($N_{220}K_{330}$, $N_{200}K_{300}$), T_2T_1($N_{220}K_{270}$, $N_{200}K_{300}$) and T_3T_3($N_{220}K_{330}$, $N_{220}K_{330}$) treatment combination performed statistically better in average fruit weight and yield per plant. But in terms of fruit per plant ($N_{220}K_{330}$, $N_{180}K_{330}$) and T_3T_5 ($N_{220}K_{330}$, $N_{180}K_{330}$) treatment combination showed better performance (9 fruit per plant).

Keywords: Hydroponic culture, Growth stage, Capsicum, Nitrogen, Potassium.

INTRODUCTION

Hydroponic crop production has significantly increased in recent years worldwide, as it allows a more efficient use of water and fertilizers, as well as a better control of climate and pest factors. Furthermore, hydroponic production increases crop quality and productivity, which results in higher competitiveness and economic incomes. In highly populated areas, hydroponics can provide locally grown high-value crops such as leafy vegetables or cut flowers. Besides economic benefits, hydroponics implies conservation of water, cogeneration of energy, income-producing employment for reducing the impact on welfare rolls and improving the quality of life. Among factors affecting hydroponic

[1] Corresponding author: hemkhairulmazed@gmail.com

production systems, the nutrient solution is considered to be one of the most important determining factors of crop yield and quality.

Application of nutrients may be performed according to analyses of a specific crop stage that may describe the consumption of the various typical nutrients of the particular crop or by means of analyses of the total plant needs quantitatively adjusted to the rate of growth and the amounts of water supplied. Thus, the composition and concentration of the nutrient solution are dependent on culture system, crop development stage, and environmental conditions (Coic, 1973; Steiner, 1973). The content of particular elements in leaves changes over leaf lifetime, and these changes are partially associated with phenology during the growing season (Bueno*et al.*, 2011) in association with organ ageing, which affects the mineral composition of plant organs (Thomas, 2013). The nutrient concentrations of vegetative parts therefore often decline sharply during the reproductive stage (Marschner, 2012), and 60 to 70% of the absorbed N, P, or K is accumulated in the fruits (Dumas, 1990), which account for 52 to 72% of the total plant dry biomass at this time (Peil and Galvez, 2005). In this context, the establishment of appropriate N/K ratios for the various stages of the crop is a fundamental factor for managing the production of capsicum in hydroponic (Hernández-Díaz*et al.*, 2009). Therefore, there is a need to find out the effect of N and K on growth and yield in order to propose models that can predict the behavior of growth rates in response to the supply of N in the vegetative stage and K in the reproductive age. The study was undertaken to fulfill following Objectives:

- To find out optimum nitrogen and potassium dose for vegetative stage of capsicum
- To find out optimum nitrogen and potassium dose for reproductive stage of capsicum

MATERIALS AND METHODS

Net house experiments were conducted to evaluate the effect of nitrogen and potassium dose on hydroponic Capsicum vegetative and reproductive growth. Experiments were conducted during winter 2017 at RHRS, BARI, Lebukhali, Patuakhali. There were mainly two experiments. 3” uPVC pipe were drilled 1 feet gap. Each set was made with six 10 feet pipe. 10 plant on one pipe. So, 60 plants in one set. Each set was automated with one submersible pump, one plastic reservoir and a timer. Each set was circulating after every 30 minutes for 50 seconds.

Vegetative stage experiment: This experiment was conducted with five treatments. The treatments were 4 levels of nitrogen and potassium combined set (T_2= $N_{220}K_{270}$, T_3= $N_{220}K_{330}$, T_4= $N_{180}K_{270}$, T_5= $N_{180}K_{330}$) and one Cooper (1979) standard (T_1= $N_{200}K_{300}$) composition. All other macro micro elements were as Cooper (1979) standard solution. The N and K concentrations in the nutrient solutions followed levels established for each treatment. The concentrations of the other nutrients for all treatments were those proposed by Cooper (1979). Stock solutions of 100x concentration were prepared for all the treatments. To avoid precipitation, three separate stock solutions were prepared. Stock A, Stock B and Stock C.

Reproductive stage experiment: The reproductive stage experiment was consisted of combined five vegetative stage treatments. At the time of 50% flowering 12 plants from each vegetative stage experiment were rearranged among the five treatments. So at reproductive stage experiment there was 25 treatment combinations.

The treatments were composed of five vegetative stage treatment and five reproductive stage treatments, a combination of 25 treatments. The experimental design was a complete randomized block in a 5 × 5 factorial combination scheme with three replications. Each of these 6 pipes had a total area of 60 ft^2, corresponding to a growing channel containing 10 plants. The nutrient solutions of each treatment were manually prepared in separate 100-L tanks. The data were analyzed using analysis of variance, and the means compared by Tukey's test ($P \leq 0.05$). The Statistical Analysis System STAR program was used to perform the data analysis.

Table 1: Cooper formulations for hydroponic.

Nutrient	ppm		Nutrient	ppm
N (Nitrogen)	200		Fe (Iron)	12
P (Phosphorus)	60		Cu (Cupper)	0.1
K (Potassium)	300		Zn (Zinc)	0.1
Ca (Calcium)	170		Mn (Manganese)	2.0
Mg (Magnesium)	50		B (Boron)	0.3
S (Sulphur)	68		Mo (Molibdenum)	0.2

Plant Material

Capsicum variety BARI Misty marich 1 seed were sown on November 22, 2017 in trays filled with coco dust. At the fourth true leaf stage, individual plants were transplanted into plastic pots filled with coco dust on 12 December 2017.

Variables Measured

Plant height was measured every two weeks.Plants were harvested and separated into roots, stems, and leaves 30 DAT and at harvest. Plant fraction samples were oven dried for 5 days at 70°C, and weights of fruits, stems, and leaves were measured for each plant harvest. Plant height (measured from the plastic pot to the top of the canopy) was measured every 15 days. Parameters measured were plant height, root length, number of leaves per plant, number of fruit per plant, individual fruit weight, yield per plant, dry matter content of fruit and plant part.

RESULTS AND DISCUSSION

First experiment: Effect of nitrogen and potassium dose on vegetative stage of capsicum.

Nitrogen significantly influenced all the growth parameter measured: plant height, leaf number, root length, root dry weight, shoot fresh weight, shoot dry weight, leaf fresh weight and leaf dry weight. The fastest plant growth rate was present in T_2 ($N_{220}K_{270}$) treatment followed by T_3= $N_{220}K_{330}$ treatment. Data is presented in Table 1. Leaf number at 25 DAT and 35 DAT in T_2 ($N_{220}K_{270}$) treatment significantly varied from all other treatments. Minimum number (9) of leaf was found in T_5 ($N_{180}K_{330}$) treatment at 35 DAT and 11.5 at 35 DAT. There were significant differences among the nitrogen and potassium dose treatments in terms of root length, root fresh weight and root dry weight. Longest root (13.17 cm) was obtained from T_2 ($N_{220}K_{270}$) treatment at 35 DAT followed by T_3= $N_{220}K_{330}$ treatment 9.47cm. Shortest root (11.5 cm) was found in T_5 ($N_{180}K_{330}$) treatment. At 35 DAT the fresh root weight and dry root weight of plants grown with T_2 ($N_{220}K_{270}$) treatment and T_3= $N_{220}K_{330}$ treatment gave higher root weight than other nitrogen and potassium dose treatment. The result was same for leaf fresh weight and leaf dry weight. In terms of shoot fresh weight and shoot dry weight there was no significant difference among the nitrogen and potassium dose treatments. Though highest shoot fresh weight and shoot dry weight was given by T_2 ($N_{220}K_{270}$) treatment. Increasing nitrogen rate in nutrient solution has positive interaction among plant root shoot ratio, plant height, leaf number and leaf dry weight. T_2 ($N_{220}K_{270}$) treatment and T_3= $N_{220}K_{330}$ treatment with higher nitrogen dose 220 ppm gave significant higher root shoot ratio than all other treatment at vegetative stage T_4 ($N_{180}K_{270}$), T_1($N_{200}K_{300}$) and T_5($N_{180}K_{330}$) treatment.

The present experiment demonstrated that increasing the nitrogen concentration in the nutrient solution increases the biomass of the plant (Table 1), which may be attributed to the increased N concentration in the leaf, which in turn results in an increase in photosynthetic capacity, as noted by Chechin and De Fátima-Fumis (2004). The photosynthetic capacity of the leaves is related to the nitrogen content (Mengel and Kirkby, 2001; Osaki *et al.*, 2001), mainly because the thylakoids (which account for 24% in spinach leaves) and proteins of the Calvin cycle account for the majority of the N in the leaf. Positive relationships between N content and RuBisCO (this enzyme represents 20-30% of total foliar N) and chlorophylls have been reported (Makino *et al.*, 2003; Heuvelink and Dorais, 2005; Bloomfield *et al.*, 2014). Therefore, N fertilization facilitates further incorporation of CO_2 (Wang *et al.*, 2012) through RuBisCO, since this enzyme is most required in order to maintain high photo-synthetic rates (Engels *et al.*, 2012).

Second Experiment, effect of nitrogen and potassium dose on Reproductive stage of capsicum.

This experiment starts after 45 DAT. The plant growth rate was highest at the beginning of reproductive stage but at the later stage the growth rate reduces drastically, mainly at 75 to harvest 85 DAT it was minimal. This behavior may occur because the crop was producing fruits, which account for 52 to 72% of the total dry matter of the plant, as indicated by Peil and Galvez (2005), and additionally, leaves started the senescence process. At the time of harvest longest plant was obtained from T_2T_1 ($N_{220}K_{270}$, $N_{200}K_{300}$) 39.22cm followed by T_3T_1 ($N_{220}K_{330}$, $N_{200}K_{300}$) and T_3T_2($N_{220}K_{330}$, $N_{220}K_{270}$). The largest fruit was obtained from T_3T_1 ($N_{220}K_{330}$, $N_{200}K_{300}$) treatment combination 61.33 g which was statistically similar with T_3T_3 ($N_{220}K_{330}$, $N_{220}K_{330}$) and T_2T_1($N_{220}K_{270}$, $N_{200}K_{300}$) treatment combination. Smallest fruit was obtained from T_5T_5 ($N_{180}K_{270}$, $N_{180}K_{270}$) 18.33g. Highest number of fruit per plant was occurred in T_3T_5 ($N_{220}K_{330}$, $N_{180}K_{330}$) and T_4T_5 ($N_{220}K_{330}$, $N_{180}K_{330}$) 9 fruit per plant. Lowest number of fruit per plant was occurred in T_4T_4 ($N_{180}K_{270}$, $N_{180}K_{270}$) treatment combination. Yield per plant significantly differ among the 25 treatment combination. Highest yield per plant was obtained from T_3T_1 ($N_{220}K_{330}$, $N_{200}K_{300}$) treatment combination (433.33 g per plant) which was statistically similar with T_2T_1 ($N_{220}K_{270}$, $N_{200}K_{300}$) and T_2T_3($N_{220}K_{270}$, $N_{220}K_{330}$). There was no statistically significant difference among the 25 treatment combination in terms of fruit dry matter percentage and shoot dry matter percentage.

Table 2: Nitrogen and potassium dose effect on plant height, leaf number, root length, root, stem, leaf, and total plant dry weight of capsicum plants grown in hydroponic culture at vegetative stage.

Sl. no.	Treatments ppm	Plant height at 25 DAT (cm)	Plant height at 35 DAT (cm)	Plant height at 45 DAT (cm)	Leaf no. at 25 DAT	Leaf no. at 35 DAT	Root length at 35DAT (cm)
T_1	$N_{200}K_{300}$	15.00	18.17	20.00	9.83	14.17	9.67
T_2	$N_{220}K_{270}$	17.25	20.42	26.33	10.50	14.50	13.17
T_3	$N_{220}K_{330}$	17.83	19.58	24.33	10.33	13.17	11.50
T_4	$N_{180}K_{270}$	14.08	19.17	19.00	9.50	11.83	8.17
T_5	$N_{180}K_{330}$	14.58	17.50	19.33	9.00	11.50	9.00
CV%		6.51	9.04	8.46	6.69	7.86	6.86
LSD		1.86	2.94	3.35	-	1.86	1.28
Level of Sig		**	Ns	**	ns	*	***

Table 2 continued

Sl. no.	Treatments ppm	Root fresh weight at 35DAT (g)	Root dry weight at 35DAT (g)	Leaf fresh weight at 35DAT (g)	Leaf dry weight at 35DAT (g)	Shoot fresh weight at 35DAT (g)	Shoot dry weight at 35DAT (g)
T_1	$N_{200}K_{300}$	7.80	0.70	7.04	1.22	2.36	0.583
T_2	$N_{220}K_{270}$	11.57	1.06	8.43	1.52	3.19	0.50
T_3	$N_{220}K_{330}$	9.47	0.93	6.72	1.18	2.93	0.47
T_4	$N_{180}K_{270}$	7.03	0.72	6.35	1.14	2.04	0.33
T_5	$N_{180}K_{330}$	4.17	0.54	5.50	0.96	1.98	0.31
CV%		12.62	11.55	8.37	8.44	9.71	26.85
LSD		1.86	0.16	1.03	0.18	0.441	-
Level of Sig		**	**	*	**	**	ns

DAT= Days after transplanting

Table 3: Nitrogen and potassium dose effect on growth and yield parameter measured of capsicum plants grown in hydroponic culture at reproductive stage.

Vegetative	Reproductive	Treatment combination	Plant height at 60 DAT cm	Plant height at 75 DAT cm	Plant height at Harvest cm	Average fruit weight g
$N_{200}K_{300}$	$N_{200}K_{300}$	T_1T_1	20.66	29.00	29.89	37.00
$N_{200}K_{300}$	$N_{220}K_{270}$	T_1T_2	20.00	30.33	31.44	28.00
$N_{200}K_{300}$	$N_{220}K_{330}$	T_1T_3	20.67	27.66	29.55	33.33
$N_{200}K_{300}$	$N_{180}K_{270}$	T_1T_4	21.17	25.89	27.11	35.33
$N_{200}K_{300}$	$N_{180}K_{330}$	T_1T_5	21.00	26.00	27.11	27.33
$N_{220}K_{270}$	$N_{200}K_{300}$	T_2T_1	28.33	38.89	39.22	49.33
$N_{220}K_{270}$	$N_{220}K_{270}$	T_2T_2	24.00	31.00	31.33	31.33
$N_{220}K_{270}$	$N_{220}K_{330}$	T_2T_3	25.33	32.33	33.22	49.67
$N_{220}K_{270}$	$N_{180}K_{270}$	T_2T_4	27.22	35.00	36.00	38.67
$N_{220}K_{270}$	$N_{180}K_{330}$	T_2T_5	21.55	31.33	32.44	29.00
$N_{220}K_{330}$	$N_{200}K_{300}$	T_3T_1	24.89	34.22	35.11	61.33
$N_{220}K_{330}$	$N_{220}K_{270}$	T_3T_2	25.11	34.11	35.55	40.67
$N_{220}K_{330}$	$N_{220}K_{330}$	T_3T_3	24.44	30.22	31.67	51.33
$N_{220}K_{330}$	$N_{180}K_{270}$	T_3T_4	24.11	28.44	29.67	30.00
$N_{220}K_{330}$	$N_{180}K_{330}$	T_3T_5	27.00	33.00	33.55	38.00
$N_{180}K_{270}$	$N_{200}K_{300}$	T_4T_1	22.44	31.67	32.33	27.33
$N_{180}K_{270}$	$N_{220}K_{270}$	T_4T_2	25.22	33.11	35.11	26.33
$N_{180}K_{270}$	$N_{220}K_{330}$	T_4T_3	24.66	28.67	31.00	26.00
$N_{180}K_{270}$	$N_{180}K_{270}$	T_4T_4	22.55	26.55	29.11	26.00
$N_{180}K_{270}$	$N_{180}K_{330}$	T_4T_5	24.11	28.66	29.11	21.33
$N_{180}K_{330}$	$N_{200}K_{300}$	T_5T_1	24.22	29.67	30.55	21.67
$N_{180}K_{330}$	$N_{220}K_{270}$	T_5T_2	23.66	32.33	33.67	23.33
$N_{180}K_{330}$	$N_{220}K_{330}$	T_5T_3	22.78	28.66	32.00	31.00
$N_{180}K_{330}$	$N_{180}K_{270}$	T_5T_4	21.78	28.77	30.33	25.00
$N_{180}K_{330}$	$N_{180}K_{330}$	T_5T_5	23.33	29.89	32	18.33
CV%			8.66	7.56	6.84	13.47
LSD			6.46	7.31	6.9	14.07
Level of significance			**	**	**	**

Table 3 continued

Vegetative	Reproductive	Treatment combination	No. of Fruit/plant	Yield/plant g	Fruit dry matter %	Shoot dry matter %
$N_{200}K_{300}$	$N_{200}K_{300}$	T_1T_1	5.33	196.00	9.56	14.33
$N_{200}K_{300}$	$N_{220}K_{270}$	T_1T_2	5.33	150.33	8.77	13.89
$N_{200}K_{300}$	$N_{220}K_{330}$	T_1T_3	4.33	144.33	11.11	17.5
$N_{200}K_{300}$	$N_{180}K_{270}$	T_1T_4	4.33	154.33	10.61	18.33
$N_{200}K_{300}$	$N_{180}K_{330}$	T_1T_5	5.33	144.67	12.48	17.77

$N_{220}K_{270}$	$N_{200}K_{300}$	T_2T_1	7.67	381.67	9.07	17.75
$N_{220}K_{270}$	$N_{220}K_{270}$	T_2T_2	4.33	134.00	10.76	22.45
$N_{220}K_{270}$	$N_{220}K_{330}$	T_2T_3	8.00	398.33	9.26	14.94
$N_{220}K_{270}$	$N_{180}K_{270}$	T_2T_4	5.67	216.67	10.72	17.24
$N_{220}K_{270}$	$N_{180}K_{330}$	T_2T_5	5.67	166.67	13.64	17.69
$N_{220}K_{330}$	$N_{200}K_{300}$	T_3T_1	7.00	433.33	9.38	14.42
$N_{220}K_{330}$	$N_{220}K_{270}$	T_3T_2	6.00	243.67	8.04	16.77
$N_{220}K_{330}$	$N_{220}K_{330}$	T_3T_3	7.33	377.33	9.56	15.48
$N_{220}K_{330}$	$N_{180}K_{270}$	T_3T_4	6.33	189.00	11.64	18.51
$N_{220}K_{330}$	$N_{180}K_{330}$	T_3T_5	9.00	340.67	9.36	16.04
$N_{180}K_{270}$	$N_{200}K_{300}$	T_4T_1	7.67	208.33	8.06	14.85
$N_{180}K_{270}$	$N_{220}K_{270}$	T_4T_2	4.67	122.67	13.98	23.13
$N_{180}K_{270}$	$N_{220}K_{330}$	T_4T_3	8.00	209.67	12.07	15.30
$N_{180}K_{270}$	$N_{180}K_{270}$	T_4T_4	4.00	129.67	9.85	16.21
$N_{180}K_{270}$	$N_{180}K_{330}$	T_4T_5	9.00	191.00	10.92	11.55
$N_{180}K_{330}$	$N_{200}K_{300}$	T_5T_1	8.00	176.33	8.29	14.54
$N_{180}K_{330}$	$N_{220}K_{270}$	T_5T_2	6.33	149.33	11.42	21.37
$N_{180}K_{330}$	$N_{220}K_{330}$	T_5T_3	8.00	247.33	10.42	16.66
$N_{180}K_{330}$	$N_{180}K_{270}$	T_5T_4	6.33	158.33	8.71	15.00
$N_{180}K_{330}$	$N_{180}K_{330}$	T_5T_5	5.00	74.33	16.70	19.39
CV%			14.44	21.58	22.1	25
LSD			2.89	145.57	-	-
Level of significance			**	**	ns	ns

CONCLUSION:

In hydroponic cultivation for capsicum at vegetative stage growth 220 ppm nitrogen and 270 ppm potassium may be used. For reproductive stage 200 ppm nitrogen and 330 ppm potassium may be used in the nutrient solution. In the later stage of plant reproductive stage there was a temperature rise above 30^{o}C. So, next year this experiment has to repeat with early planting to avoid high temperature.

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