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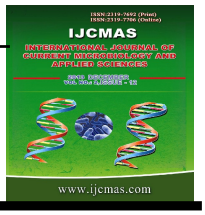

Original Research Article

Application of Nitrogen and Potassium efficiency on the growth and yield of chilli *Capsicum annuum* L.

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A B S T R A C T

A field experiment was conducted at the research farm of Botanical Garden, Department of Botany, Annamalai University, During November 2012 to March 2012 to study the effects of Nitrogen and Potassium on the growth and yield of capsicum. The treatments were 4 levels of N (0, 25, 50 & 75 kg ha^{-1} designated as N0 , N 25, N 50, & N75, respectively) and 3 levels of K (0, 30 & 60 kg ha^{-1} designated as k0, K30 & K60 , respectively). Plant height at first flowering and at first harvest, number of branches at first flowering number of fruits per plant increased significantly with increasing nitrogen doses up to 75 kg N ha^{-1}. However, plant height at final harvest and number of branches at first and final harvest increased significantly up to 75 kg N ha^{-1} (N_3 treatment). On the other hand plant height at first flowering and number of branches at first harvest increased significantly increasing levels of K up to the treatment K_1 (30 kg K ha^{-1}), whereas plant height and number of branches at final harvest and number fruits yield per plant enhanced significantly up to the treatment K_2 (60 kg K ha^{-1}). Considering the combined effect of nitrogen and potassium, the maximum plant height a final harvest were obtained from N_3 K_2 (75 kg N +60kgKha^{-1}). On the other hand, maximum number of fruits per plant was found in the treatment combination N_3 K_2 (75 kg N + 60 kg K ha-^{1}).

K e y w o r d s

Capsicum;
Nitrogen;
Potassium;
Plant height;
Fruits Yield.

Introduction

Chilli plants botanically referred to as genus *Capsicum* is the member of *Solananceae* family. It is the native to the Tropical South America and Brazil. The genus *Capsicum* consists of about 20species and only four species are under cultivation, out of which *C. pendulum* and *C. pubescens* are restricted to the South and Central America. The other two species such as *C. annuum* and *C. frutescens* are commonly cultivated throughout the world. *C. annuum* is the most commonly cultivated species and all green chilies in the market and most of the dry chilies belong to this species. *Chilli*, the fruit of *Capsicum annuum* L, is one of the most important commercial crops in India. With an annual production of 1.1

million tones, India is the largest producer of chili in the world (Khan and Raj, 2006). Owing to its high cash value and consumption rate the annual trade of chilli is approximately 17% of total spice trade in the world (Ahmed *et al*., 2000) and is about 33%in India However, the yield of chili in India is substantially low when the large area (930,000 hectares) of production is considered (Bharathi *et al*., 2004).*Chilli* (*Capsicum annuum* L.)This belongs to Solananceae, is known as a vegetable, and consumed both as fresh and dehydrated species (Bosland and Vostava, 2000). Pepper is good source of vitamins A, C, E, B1and B2, Potassium, phosphorus and calcium? Moreover, it is one of the valuable medicinal plants in pharmaceutical industries because of high amount of antioxidant, capsaicin and capsicum as main active substances. A large amount of herbicides, pesticides, and fertilizers is applied every year to achieve maximum productivity of chilli and to meet the growing demand, the use of chemical fertilizer in India has increased 170 times in last 50 years (FAO, 2010). This is a major environmental and health concern considering the deleterious impact of these chemical compounds on terrestrial and aquatic ecosystem *Nitrogen(N), Potassium*(*K)* are the primary nutrients that in excessive amounts pollute our lakes, streams, and wetlands. The largest natural source of nitrogen is the Earth's atmosphere, which is roughly 78% gaseous nitrogen, an inert and essentially biologically unavailable form of the element. Its biological unavailability is because the two nitrogen atoms form an extremely stable bond, which is not easily broken. Apart from human industrial processes that fix nitrogen gas to solid or liquid forms, the primary means of nitrogen fixation are through the high temperature and energy of lightning strikes and biological nitrogen fixation by bacteria. These processes produce nitrogen in three main forms, each of which is available to plants: nitrate, nitrite, and ammonium (Wiedenhoeft, (2006). *Nitrogen* enters the ecosystem in several chemical forms and also occurs in other dissolved or particulate forms, such as tissues of living and dead organisms. Nitrate, compound containing nitrogen, can exist in the atmosphere or as a dissolved gas in water, and at elevated levels can have harmful effects on humans and animals. Nitrates in water can cause severe illness in infants and domestic animals. *Potassium* is a soil exchangeable action and is actively absorbed by plant roots. *Potassium* is the primary osmolyte and ion involved in plant cell membrane dynamics, including the regulation of stomata and the maintenance of turgor and osmotic equilibrium. It also plays important roles in the activation and regulation of enzyme activity (Wiedenhoeft, 2006).

Common sources of excess nitrate reaching lakes and streams include septic chili like many vegetable crops, requires certain quantities of some elements, e.g. *N* and *K* for maintaining good yield levels. High yields of *Capsicum* have been obtained in the tropics mainly through the use of improved genotypes, fertilizers and good cultural practices (Saha *et al*., 1994). Inorganic fertilizers are relied upon to improve crop yields and maintain soil fertility. However, the wide use of these fertilizers is hampered by their high costs, and the highly Variables vegetables crops responses under small scale farming (Garts, 1970, Blackie, 1995 and Badiune and Delglo, 1995).This study was, therefore, conducted to investigate the effects of *Nitrogen* and *Potassium* fertilizers on yield and some growth

parameters of *Capsicum annuum* L. Fertilizer is one of the major factors of crop production. Among the factors, nitrogen is very much essential for good plant establishment and expected growth. Use of inorganic and organic fertilizer has amused a great significance in recent years in vegetables production, for two reasons. Firstly, the need for continued increase production and per hectare yield of vegetables requires the increase amount of nutrients. Secondly, the increase amount of a large number of experiments on inorganic fertilizer conducted in several countries reveal that inorganic fertilizer alone cannot sustain the productivity of soils under highly intensive cropping system. The productivity of pepper is highly responsive to N fertilizer. Tumdare *et al*., (2004) reported that nitrogen fertilizer increased fruit weight, yield and fruit number of chili peppers. Qawasmi *et al*., (1999) reported that increasing the rates of nitrogen applied in pepper plants increases the uptake of nitrogen by the plants and at the same time, stimulated the uptake of potassium and phosphorus through the synergistic effect of *nitrogen* on them. *Potassium* uptake also depends on plant factors, including Genetics and developmental stage (vegetative versus reproductive stages (Rengel *et al*., 2008). Optimum dose of fertilizer increase the pepper growth, development and maximize the yield of pepper. Further - more, in studies where several fertilizer *K* salts were evaluated, fruit quality improvements appeared to depend on *K* source. For instance, Jifon and Lester (2009) showed that when midto- late season soil or foliar *K* applications were made using KNO_3 there were little or no improvements in fruit marketable or human-nutritional quality attributes and in some instances, these attributes were actually inferior compared to fruit from control plots. Slow release fertilizer also holds great promise for the production of solanaceous vegetable such as eggplant and tomato. Therefore, the present investigation was undertaken to study the effect of *nitrogen* and *potassium* fertilizer on growth and yield of chilli and to find out the optimum dose of Fertilizer for successful growth and yield of Chilli plants.

Materials and Methods

Chilli Preparations

Chilli from var. Hybrid SITARA "*Capsicum annuum L."* was supplied Periyakulam, Tamil Nadu, India. Chilli seeds were surface sterilized with 0.05% sodium hypochlorite for 45min before sowing. The treated seeds including control were sown in sand beds in size m^2 in a shade net condition at Botanical Garden, Department of Botany, and Annamalai University, India.

The experiment was laid out in a Randomized Test (DMRT) Complete Block Design (RCBD) with three replications of each fertilizer treatment combinations. Fertilizer treatments consisted of 4 levels of N (0, 25, 50 and 175 *kg N* ha^{-1} designed a N0,N25,N50,& N75,respectively) and3levels of *K* (0,30,and 60 Kg kha^{-1} designated as k0 k30 and k60 respectively). There were 12 treatment combinations. The treatment combinations were follows:

N_0k_0 = control (without *N* and *K* application)
N_0k_{30} = 0 kg N ha^{-1}+ 30kg K ha^{-1}
N_0k_{60} = 0 kg N ha^{-1}+ 60kg K ha^{-1}
$N_{25}k_0$ = 25 kg N ha^{-1}+ 0kg K ha^{-1}
$N_{25}k_{30}$=25 kg N ha^{-1}+ 30kg K ha^{-1}
$N_{25}k_{60}$=25 kg N ha^{-1}+ 60kg K ha^{-1}

$N_{50}k_0$ = 50 kg N ha-$^{-1}$+ 0kg K ha^{-1}
$N_{50}k_{30}$ = 50 kg N ha-$^{-1}$+3 0kg K ha^{-1}
$N_{50}k_{60}$ = 50 kg N ha-$^{-1}$+6 0kg K ha^{-1}
N_{75} $k_{0\,=}$7 5 kg N ha-$^{-1}$+ 0kg K ha^{-1}
N_{75} $k3_{0\,=}$7 5 kg N ha-$^{-1}$+3 0kg K ha^{-1}
N_{75} $k6_{0\,=}$7 5 kg N ha-$^{-1}$+6 0kg K ha^{-1}

The land operation was completed on 27 November 2012.The remaining Urea was top dressed in two equal installments-at 20 days after transplanting (DAT) and 50 DAT respectively. Healthy and uniform sized 30 days old seedling were taken separately from the seed bed and were transplanted in the experimental field on 28Novmber 2012 minting a spacing of 55 cm and 27.5cm between the rows and plants separately. The seedlings were watered after transplanting. Shading was providing by piece of banana leaf sheath for five days to protect the seedling from the direct sunshine. When the seedlings were established, the soil around the base of each seedling was pulverized. Gaps filing, weeding, irrigation and pest management were done as per requirement.

Fruits were harvested at 8 days intervals during maturity to ripening stage. Harvesting was started from 6 March 2012 and completed by 29 March 2012. The collected data were statistically analyzed by using the ANOVA technique. The test of significance of all parameters was done. The Duncan's Multiple Range Test (DMRT) was used for this study. Benefits from applying different levels of nitrogen and potassium were compared. Net benefits of a treatment are the difference between the benefits due to and the cost of the treatment in question. Benefits are the product crop yields associated with a particular treatment and the price of the crop. Costs, on the other hand, comprise the costs of fertilizer treatments and their application.

Results and Discussion

The effect of different levels of Nitrogen and Potassium fertilizers on chilli yield and other growth parameters

Plant height at first flowering

Plant height at first flowering of *Capsicum* was significantly increased by increasing different levels of Nitrogen (Table.1).The highest plant height at first flowering (15.583cm) was found with 75kg N ha^{-1} which was statistically similar with that of 50 kg N ha^{-1} and the lowest plant height at first flowering (12.020cm) was observed in control treatment which was statistically similar to25 kg N ha^{-1}. It was that plant height flowering stage increased gradually with the increment of nitrogen dose. This could be due to higher availability of *N* and their uptake that progressively enhanced that plant height at first flowering. This result is supported by Aliyu and Yusuf. They stated that, greatest plant height, leaf numbers were obtained with 75kg *N* ha^{-1}.Plants reached 70-80%of their total height in the first 60 days growth, being tallest with the highest N rate. This was found by Chailloux *et al*., (1992).

There was a significant effect among the different levels of potassium in respect of plant height at first flowering (Table2). It plays an important role in the process of photosynthesis and food-production. It controls the enzymatic activities of the plant-body. Plant height at first flowering increased level of potassium. The highest plant height at first flowering (15.550cm) was observed with 60 kgha^{-1} and the lowest plant height at first flowering (13.216cm) was found in control treatment. The treatment combination of nitrogen and potassium had significant

effect on plant

Table.1 Effect of *Nitrogen* on Yield attributes of *Capsicum*

Treatment	Plant height at first flowering (cm)	Plant height at first harvest (cm)	Plant height at final harvest (cm)
N_0	12.020 ± 0.020	16.036±0.015	20.210±0.010
N_1	13.220 ± 0.020	17.253±0.011	21.510±0.026
N_2	14.490 ± 0.0100	18.130±0.010	22.846±0.025
N_3	15.583 ± 0.020	19.030±0.043	26.280±1.723
LSD $_{0.05}$	0.50	0.40	0.90
CV (%)	4.59	5.29	6.55

Figure in column, having same letters(S) do not differ significantly at 5% level
NS=Non significant,
N_0 = Control (without N), N_1=25Kg Nha^{-1}, N_2 =50 Kg Nha^{-1}, N_3=75 Kg N ha^{-1}

Table.2 Effect of *Potassium* on yield attributes of *Capsicum*

Treatment	Plant height at first flowering (cm)	Plant height at first harvest (cm)	Plant height at final harvest (cm)
K_0	13.216±0.05	15.210 ±0.010	18.530 ±0.010
K_1	14.560 ±0.010	16.376 ±0.015	19.626 ±0.015
K_2	15.550 ±0.010	17.416 ±0.015	20.86 ±0.015
LSD 0.05	0.59	NS	1.01
CV	4.59	5.69	6.50

K_0= control (without). K_1=30Kgha^{-1}, K_2= 60kgha^{-1}
Figure in column, having same letters (s) do not differ significantly at 5%level
NS = Non-significant

height at first flowering (Table 3). The highest plant height at first flowering (17.560cm) was found N^3K^2 treatment. The lowest plant height at flowering (12.016cm) was observed in control treatment (N_0K_0). These results showed that higher dose of potassium higher dose nitrogen were found by Sarma *et al*. They stated that plant height (22.25cm) increased significantly with 75:35:35kg NPK ha^{-1}.

Plant Height at First Harvest

With the increase of nitrogen level plant height at first harvesting stage of *Capsicum* was significantly increased (Table 1). The highest plant height at first harvesting stage (19.030cm) was found with 75kg N ha^{-1} which was statistically similar with that of 50 kg N ha^{-1} and the lowest plant height at first flowering (16.036cm) was observed in control. It was observed that that plant height at first harvesting gradually with the increment of nitrogen dose. This must be due to higher availability of n and their uptake that gradually enhance the plant height at first harvesting stage.

With the increase of potassium level plant height at first harvest stage of *Capsicum*

was not significantly increased (Table 2). The highest plant height at first harvesting stage (17.416cm) was found with 60kg N ha^{-1} which was statistically similar with that of 30 kg N ha^{-1} and the lowest plant height at first flowering (15.210cm) was observed in control. He stated potassium levels significantly increased hot pepper plant height, number of levels per plant up to 35kg k ha^{-1}. Combined treatment of nitrogen and potassium had significantly effect on plant height at first harvesting stage (Table3). The highest plant height at first harvesting stage (25.02cm) was found in N_3K_2 treatment. The lowest plant height at first harvesting stage (19.12cm) was observed in control treatment (N_0K_0).\

Plant Height at Final Harvest:

Plant height at final harvesting stage of capsicum was significantly increased by increasing different levels of Nitrogen (Table1).The highest plant height at final harvesting (26.280cm) was found with 75kg N ha^{-1} which was statistically similar with that of 50 kg N ha^{-1} and the lowest plant height at final harvesting (20.210cm) was observed in control. Plant height at final harvesting stage increased squinty with the augment of nitrogen dose. Because to higher availability of N and their uptake that gradually enhance the plant height at final harvesting stage. Therefore higher dose of nitrogen increased plant height (Pervez *et al*., 2004). With the increase of potassium level, plant height at final harvesting stage of *Capsicum* was not significantly increased (Table 2). Plant height at final harvesting stage increased with increasing level of potassium. The highest plant height at final harvesting stage (20.856cm) was observed with 60kg ha^{-1} and it was found that the lowest result (18.530cm) was identified in the control treatment of potassium fertilizer.

Plant height at final harvesting stage with combined treatment of nitrogen and potassium had significant effect (Table 3). The highest plant height at final harvesting stage (30.420 cm) was found in N_2 K_2 treatment. The lowest plant height final harvesting stage (25.166 cm) was observed in control treatment (N_0 P_0).

Number of fruits per Plant

The number of fruit per plant increased significantly with the increase of nitrogen level (Table 4). The highest number of fruits per plant (6.343) was found with 75 kg N ha^{-1} and the lowest number of fruits per plant (3.410) was found in control treatment. Number of fruits per plant increased gradually with the increase of nitrogen dose. These results are consistent with those reported by Bar *et al*., (2001), Magdatena (2003), Akanbi *et al*., (2007) who also reported that increasing the rate of nitrogen fertilizers increases the average fruit weight and volume of pepper. Application of 75 kg N in combination with 35 kg K ha^{-1} recorded the highest number of fruit per plants.

Number of fruit per plant increased with the increment of potassium of *capsicum* significantly (Table5). The highest number of fruit per plant (7.230) was observed with 60 kg K ha^{1} of Potassium fertilizer. It was found that the lowest number of fruit (5.310) per plant was identified in the control treatment. Fawzy et al., (2005) who showed that potassium fertilizer had a significant effect on the fresh weights of leaves and stems, early and total yield of sweet pepper plants. Adequate K nutrition has also been associated with increased yields, fruit size, increased soluble solids and ascorbic acid concentrations, improved fruit color, increased shelf life, and shipping quality of many horticultural

Table.3 Interaction effect *N* and *K* on yield attributes of *Capsicum*

Treatment	Plant height at first flowering (cm)	Plant height at first harvest (cm)	Plant height at final harvest (cm)
N_0k_0	12.016±0.015	19.110±0.010	25.166±0.015
N_0k_1	12.533±0.0152	20.376±0.015	26.270±0.010
N_0k_2	13.463±0.025	22.546±0.591	27.270±0.010
N_1k_0	12.646±0.251	21.756±0.020	27.143±I.436
N_1k_1	15.426±0.0152	22.680±0.010	27.666±1.105
N_1k_2	13.726±0.015	22.913±0.015	26.102±0.435
N_2k_0	14.616±0.066	23.670±0.100	27.226±2.033
N_2k_1	16.413±0.102	24.010±0.010	29.870±0.666
N_2k_2	16.590±0.010	24.210±0.010	29.433±2.046
N_3k_0	14.560±0.010	23.566±0.020	28.036±1.717
N_3k_1	17.316±0.015	24.643±0.015	30.420±0.718
N_3k_2	17.560±0.173	25.010±0.010	30.243±0.015
$LSD_{0.05}$	1.25	2.25	3.25
CV (%)	4.59	5.69	6.59

Figure in column, having same letters (s) do not differ significantly at 5%level
NS=Non significantly

Table.4 Effect of *Nitrogen* on Yield attributes of *Capsicum*

Treatment	Number of fruits /plant
N_0	3.410±0.010
N_1	4.210±0.010
N_2	5.650±0.010
N_3	6.343±0.015
$LSD_{0.05}$	0.51
CV%	7.44

Figure in column, having same letters (s) do not differ significantly at 5%level
NS=Non significantly; N_0 = Control (without N), N_1=25Kg Nha^{-1}, N_2 =50 Kg Nha^{-1}, N_3=75 Kg N ha^{-1}

Table 5: Effect of *Potassium* on Yield attributes of *Capsicum*

Treatment	Number of fruits /plant
K_0	5.310±0.010
K_1	6.090±0.010
K_2	7.230±0.010
$LSD_{0.05}$	0.41
CV%	8.55

Figure in column, having same letters (s) do not differ significantly at 5%level
NS=Non significantly
K_0 = Control (without K), K_1=30Kg Nha^{-1}, K_2 =60 Kg Kha^{-1},

Table.6 Interaction Effect *N* and *K* on Yield attributes of *Capsicum*

Treatment	Number of fruits /plant
N_0k_0	2.570±0.010
N_0k_1	3.240±0.010
N_0k_2	3.950±0.020
N_2k_0	4.590±0.010
N_1k_1	5.210±0.010
N_1k_2	6.120±0.010
N_2k_0	6.810±0.010
N_2k_1	7.443±0.020
N_2k_2	8.083±0.020
N_3k_0	7.933±0.030
N_3k_1	8.556±0.05
N_3k_2	9.240±0.010
$LSD_{0.05}$	1.10
CV (%)	7.24

Figure in column, having same letters (s) do not differ significantly at 5%level
NS=Non significantly

crops (Geraldson, 1985; Lester et al., 2005, 2006, 2007; Kanai et al., 2007). It is most connected with the quality of seeds and fruits. It is necessary for early ripening of crops. Its use improves the quality of fruits and vegetables and they can be stored for a longer period of time.

Combined treatment of nitrogen and potassium had significant effect (Table 6) on number of fruit per plant. Number of fruit per plant (9.249) was the highest in N_3 K_2 treatment. The lowest number of fruit per plant (2.570) was observed in control treatment (N_0 K_0). From these results it was stated that higher dose of nitrogen and potassium was influential nutrients for number of fruit per plant. According to Edward and Daniel (1992) if poultry manure was added in combination with chemical fertilizer, it supplemented all nutrients to crop, and increased the productivity of crop.

This study further confirms the role of Nitrogen and Potassium fertilizers in increasing growth and grain yield in Chilli from var. Hybrid SITARA production. From the result of the experiment, application rate of 75kgN/ha^{-1} + 60kgK/ha^{-1} may be recommended for increasing chilli yield particularly in the study area. However, application of 60kgN/ha^{-1} + 30kgK/ha^{-1} can also bring about increase in the yield of Chilli. This will greatly benefit farmers in area where supply of Nitrogen, Potassium, and fertilizer is low or in cases where farmers cannot afford the cost of high fertilizer input. The result showed that organic manures played an important and significant role in increasing yield of Chilli plants.

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