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Effect of calcium nitrate foliar application on mineral nutrient uptake and yield of chilli (*Capsicum annum.L*)

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ABSTRACT
The present study was carried out in kharif season of 2016 on mineral nutrient uptake and yield of chilli (Capsicum annum. L) at Agadi village, Dharwad, Karnataka, India .The plants were treated with 1.0 and 1.5 per cent calcium nitrate at different growth stages (45, 60 and 75 DAT) and the experiment consist of randomized block design with three replications and twelve treatments. The plant samples collected at 75, 105 and 140 DAT were air dried, oven dried to get constant weight then grinded and stored in butter paper bags for nutrient uptake analysis. The result showed that uptake of calcium and magnesium were significantly influenced by the foliar application of calcium nitrate. Highest uptake of calcium and magnesium were noticed due to three foliar applications of calcium nitrate at 1.5 per cent this was followed by treatments with one foliar spray given on 45th and 60th DAT at same concentration. The highest dry fruit yield (21.76 q ha $^{-1}$) was recorded by 1.5 per cent three foliar sprays closely followed by one foliar spray (21.38 q ha^{-1}) and differed significantly from all other treatments. Control which did not receive foliar spray of calcium nitrate recorded lowest dry fruit yield (12.76 q ha^{-1}). 1.5 per cent concentration is more superior in improving the yield of chillies over 1.0 per cent concentration.
Key words: Chilli, Calcium nitrate, Yield

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INTRODUCTION

Chilli is a long duration crop with 180 to 210 days as it is a indeterminate crop requires timely manuring particularly at grand growth (60-75 DAT) and fruit development(90-105 DAT) stages. The usual practice of soil application of nutrients results inconsiderable losses because of fixation, leaching, runoff etc. Hence, applied nutrients through soil at transplanting are not available to chilli plants during grand growth period/ fruit development stages. These results in reduced yield and quality of chillies. To supplement the immediate requirement of nutrients at specific growth stages, foliar application appears to be very effective. In this context, supply of nutrients through designed foliar spray of specialty at certain growth stages appears to be highly beneficial. Intensive agriculture, cultivation of high yielding varieties and extensive use of chemical fertilizers in unbalance manner have created deficiency of certain major plant nutrients in the soil. Use of Calcium nitrate is popular in agronomic situations where a readily soluble source of nitrate and calcium is needed. Nitrate moves freely with soil moisture and can be immediately taken up by plant roots. Unlike other common nitrogenous fertilizers, Ca(NO3)2 application does not acidify soils. Broadcasting of Ca(NO3)2 have risk of ammonia volatilization losses. Applications of Ca(NO3)2 also provides supplemental Ca for plant nutrition. Some soils may contain considerable amounts of Ca, but it may not be sufficiently soluble to meet plant demands. Since Ca is not mobile in the plant, it is important to apply Ca just in time at critical growth stages. Soil application of Ca(NO3)2 lead to considerable losses of nitrate nitrogen through leaching and Ca gets strongly adsorbed on clay complex leading to low availability to plant roots. Hence, foliar application of Ca(NO3)2 is a good option to enhance its timely and sufficient availability to pants.

MATERIAL AND METHODS

A field experiment was conducted in the farmer's field at Agadi village in Dharwad district, during kharif, 2016 on a Vertisol. The soil of the experimental field was clay in texture, with pH 7.30 and EC of 0.26 dSm^{-1}. The organic carbon, free lime, available nitrogen, phosphorus, potassium, sulphur, exchangeable calcium and magnesium contents were 6.90g kg^{-1}, 2.56 per cent, 180.65 kg ha^{-1}, 16.85 kg ha^{-1}, 282.24 kg ha^{-1}, 20.25 kg ha^{-1} and 14.50 (c mol (p^{+}) kg^{-1}) and 5.50 (c mol (p^{+}) kg^{-1}), respectively. The experiment was laid out in randomized complete block design with twelve treatments and three replications. Treatments include 1.0 and 1.5 per cent concentration of calcium nitrate sprayed on 45, 60 and 75th day after transplanting in combination. One month old chilli (Cv.Dyavnur) seedlings were transplanted at 75 cm x 75 cm spacing. Recommended NPK fertilizers (100:50:50 kg ha^{-1}) were applied in the form of urea, diammonium phosphate and muriate of potash respectively and FYM was applied at 25 t ha^{-1}. Nitrogen was applied into two split doses, basal dose of 50 per cent at the time of transplanting and remaining half dose at 45 days after transplanting. The fertilizers were applied in ring method and mixed with soil. The concentrations of calcium nitrate foliar solutions were fixed
based on their pH value in water. One and 1.5 per cent solutions of calcium nitrate had pH of 7.29 and 6.93 respectively, while still higher concentrations recorded marked acidic values. Hence, to avoid adverse effect of acidic pH on plants, 1.0 and 1.5 per cent were chosen.

RESULTS

Uptake of nitrogen

At 75 DAT, treatment (T9) that received two foliar sprays of 1.5 per cent Ca(NO3)2 recorded significantly highest uptake over all other treatments, which was on par with treatments T10 and T4.Irrespective of concentrations, treatments (T4 and T9) that received two foliar sprays of Ca(NO3)2 recorded significantly higher uptake of nitrogen than treatments that received single spray of Ca(NO3)2. At 105 DAT, the treatment (T10) that received three foliar sprays of 1.5 per cent Ca(NO3)2 recorded significantly highest uptake of nitrogen over all the treatments.

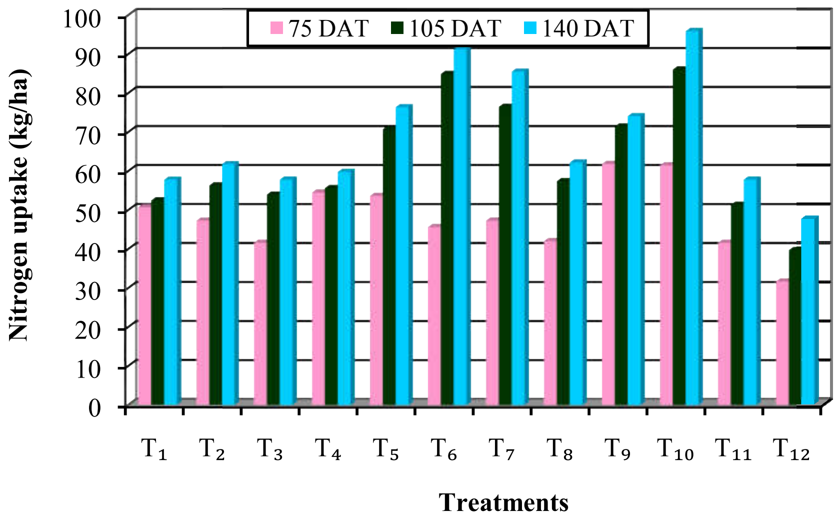

Fig. 1: Effect of foliar spray of calcium nitrate on uptake of nitrogen at 75, 105 and 140 DAT bychilli (cv. Dyavnur)

Except T6 that received two sprays of Ca(NO3)2. Treatment T11 that received 50 ppm NAA spray at peak flowering stage (60 DAT) recorded higher N uptake and differed significantly from control (T12) which recorded lowest uptake of N. At 140 DAT, significant difference existed with regard to nitrogen uptake by both plants and fruit samples. Highest nitrogen uptake was observed in treatment T10 that received three sprays of 1.5 per cent Ca(NO3)2 which was on par with treatment T6 that received one foliar spray of Ca(NO3)2 at the same concentration. Critical observation of the data revealed that, all the treatments that received foliar spray of Ca(NO3)2 at 1.5 per cent recorded higher nitrogen uptake than their corresponding treatments that received foliar spray at 1.0 per cent. Lastly control (T12) recorded lowest nitrogen uptake at all the three growth stages and differed significantly from all other treatments.

Uptake of Phosphorus

At 75 DAT, uptake of phosphorus uptake was significantly influenced by the foliar spray of Ca(NO3)2 (Fig.2). Highest phosphorus uptake was noticed in treatment (T9) that received two foliar sprays of 1.5 per cent Ca(NO3)2 one each at 45thand 60th DAT which differed significantly from all the treatments. Lowest was recorded in control (T12) that received only water spray which was on par with treatments T3 and T8.

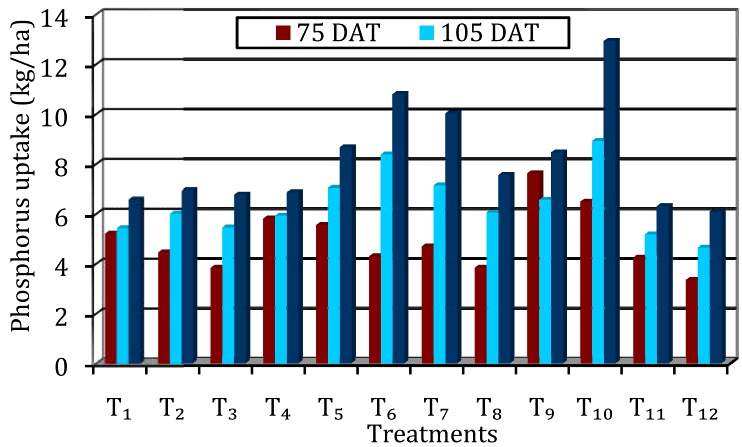

Fig. 2: Effect of foliar spray of calcium nitrate on uptake of phosphorus at 75, 105 and 140 DAT chilli (cv. Dyavnur)

At 105 and 140 DAT, treatment (T10) that received three foliar applications at 1.5 per cent Ca(NO3)2 concentration recorded significantly highest phosphorus uptake over all other treatments except that received foliar spray of 1.5 per cent Ca(NO3)2 at 45th DAT. Lowest was recorded in control that received only water spray which was on par with the treatment T11.

Uptake of Potassium

Fig.3 indicated that treatments differed significantly with regard to K-uptake at all the three stages. At 75 DAT, treatment (T_9) that received two foliar sprays of $Ca(NO_3)_2$ recorded highest uptake and differed significantly from all other treatments. At 105 DAT, treatment that received three sprays of $Ca(NO_3)_2$ at 1.5 per cent concentration recorded highest K uptake and differed significantly from all other treatments. This was followed by treatments (T_6) that received foliar spray at 1.5 per cent level on 45 DAT. At 140 DAT, treatment T10 that received three foliars spray of 1.5 per cent $Ca(NO_3)_2$ recorded significantly highest potassium uptake over all other treatments. Lowest value was recorded in control T_{12} that received only water spray which differed significantly from all other treatments at all the three stages of the crop.

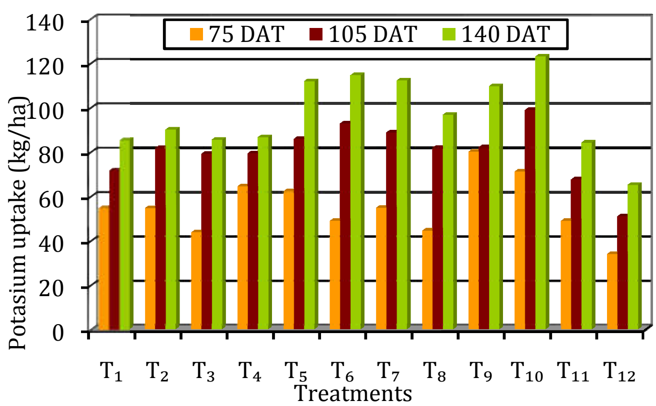

Fig. 3: Effect of foliar spray of calcium nitrate on uptake of potassium at 75, 105 and 140 DAT by chilli (cv. Dyavnur)

Uptake of calcium

Fig.4. elucidated that, treatments differed significantly with regard to calcium uptake at all the three stages. At 75 DAT, treatment (T9) that received two foliar sprays of 1.5 per cent Ca(NO3)2 recorded significantly highest uptake over all other treatments and at 105 DAT treatment (T10) that received three foliar sprays of 1.5 per cent Ca(NO3)2 recorded highest uptake of calcium over all other treatments except treatments (T6) that received foliar application of Ca(NO3)2 at 1.5 per cent on DAT. At 140 DAT, fruit samples of all the treatments recorded slightly higher calcium uptake compared to plant uptake. Significant difference existed with regard to calcium

uptake by both plant and fruit samples. Highest calcium uptake was observed in treatment that received three sprays of1.5 per cent Ca(NO3)2 which was on par with treatment T6 that received one foliar spray of Ca(NO3)2 on 45 DAT, but differed significantly from rest of the treatments. Control(T12) recorded lowest calcium uptake and differed significantly from all other treatments.

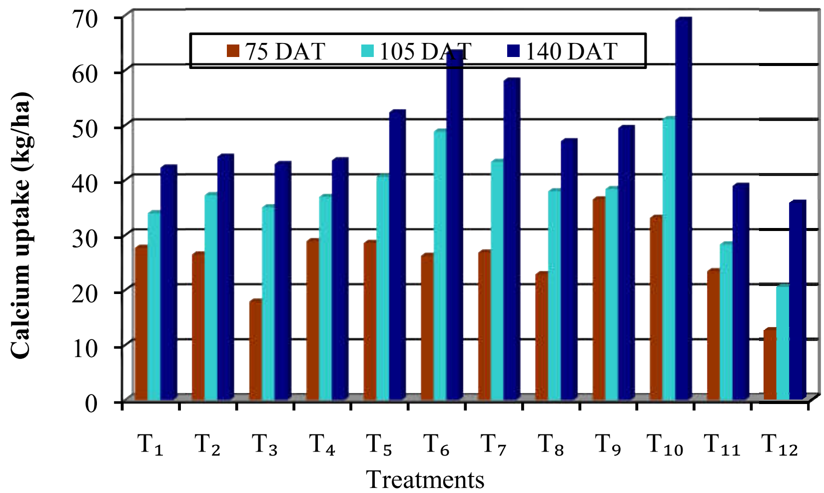

Fig. 4: Effect of foliar spray of calcium nitrate on the uptake of calcium at 75, 105 and 140 DAT by chilli (cv. Dyavnur)

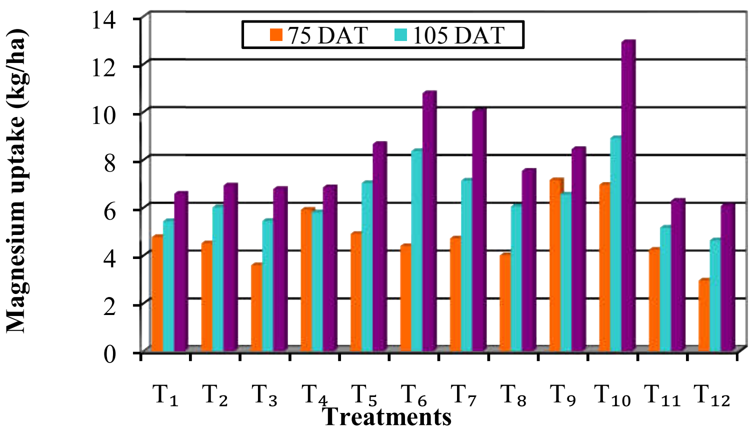

Fig. 5: Effect of foliar spray of calcium nitrate on the uptake of magnesium at 75, 105 and 140 DAT by chilli (cv. Dyavnur)

Uptake of Magnesium

At 75 DAT, treatment (T9) that received two foliar sprays of 1.5 per cent Ca(NO3)2 recorded highest Mg uptake and differed significantly from all other treatments except T10 . Lowest was recorded in control that received water spray and differed significantly from all other treatments. At 105 DAT, treatments (T10) that received three foliar sprays of 1.5 per cent Ca(NO3)2 recorded highest Mg uptake which was on par with treatment (T6) that received one foliar spray of Ca(NO3)2 at the same concentrations but differed significantly from rest of the treatments. At 140 DAT, fruit samples of all the treatments recorded slightly higher Mguptake than plant uptake. Significant difference existed between treatments with regard to Mg uptake by both plant and fruit samples. Highest Mg uptake was observed in treatment (T10) that received three sprays of 1.5 per cent Ca(NO3)2 which differed significantly from all other treatments. Control (T12) recorded lowest Mg uptake and differed significantly from all other treatments except treatment (T11) which received foliar spray of NAA.

Yield

Foliar application of $Ca(NO_3)_2$ recorded highest fruit yield in T_{10} closely followed by treatment (T_6) that received 1.5 per cent foliar spray and treatment (T_7) that received 1.5 per centfoliar spray . All the three treatments were on par with each other.

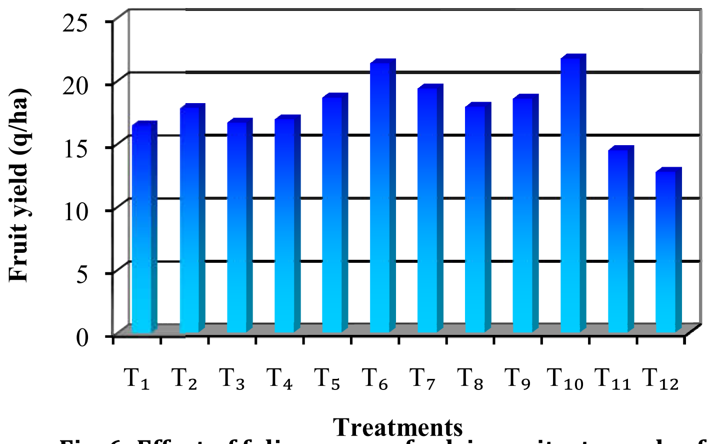

Fig. 6: Effect of foliar spray of calcium nitrate on dry fruit yield of chilli (cv. Dyavnur)

Comparison among the treatments (T_1 to T_5) receiving foliar spray of 1.0 per cent $Ca(NO_3)_2$, it was observed that, non-significant difference existed among the treatments however, treatment (T_5) that received three sprays of 1.0 per cent $Ca(NO_3)_2$ recorded highest dry fruit yield closely followed by treatment (T_2) that received one spray at 60th DAT. Treatment that received foliar spray of 50 ppm NAA at 60th DAT recorded higher fruit yield which was on par with treatments T_1 , T_2 , T_3 , T_4 , T_5, T_8 and T_9 . Comparison between the treatments that received 1.0 and 1.5 per cent foliar spray of $Ca(NO_3)_2$, it was noticed that, treatments that received 1.5 per cent foliar spray recorded numerically higher fruit yield than treatments that received 1.0 per cent foliar spray. Finally, control (T_{12}) that received water spray recorded lowest dry fruit yield which was on par with treatment T_{11} that received 50 ppm NAA foliar spray.

DISCUSSIONS

Nitrogen uptake

At 75 DAT highest uptake was recorded in treatment that received two foliar sprays of 1.5 per cent of Ca(NO3)2 followed by treatment that received two sprays of 1.0 per cent Ca(NO3)2. Which may be due to nitrogen concentration was mainly due to complete absorption and assimilation of calcium and nitrogen supplied on 45th and 60th DAT. But with advancement in plant growth there was increase in N uptake and highest nitrogen uptake was recorded in the treatment (T6). This was due to higher production of biomass coupled with ascorbic acid synthesis in fruits which demand more nitrogen supply because of the presence of the increased activity of ascorbic acid oxidase enzyme. Significantly lowest nitrogen uptake was noticed in control. This is obvious because of the absence of foliar spray of Ca(NO3)2.

Uptake of phosphorus
Similar to nitrogen uptake, phosphorus uptake was also significantly influenced by foliar spray of calcium nitrate (Fig.2). It was observed that, treatments that received foliar spray of 1.5 per cent Ca(NO3)2 recorded higher phosphorus uptake than treatments that received 1.0 per cent Ca(NO3)2. This may be due the nitrate nitrogen in foliar spray and direct absorption of this nitrogen by plant canopy stimulated P uptake from soil by plant roots because of synergistic relationship between N and P. Kolay [4] mentioned that, greater supply of nitrogen to plants stimulates P uptake by plants. Three foliar sprays of Ca(NO3)2 irrespective of concentration recorded higher uptake. This might be due to adequate supply of calcium and nitrogen through foliar spray which closely match with growth stages of plant. Further high concentrations of nitrogen (15.5 %) and the absorbed nitrogen by crop canopy enhanced cell division leading to more number of branches, leaves and flowers which lead to increased dry matter yield consequently there was enhanced P uptake. Similar findings were reported by Peyvast *et al.*[6] and Easterwood [1]. Treatment that received three foliar sprays of water (control) recorded lowest phosphorus uptake at all the three stages.

Uptake of potassium
From these results it can be highlighted that, higher concentration of calcium nitrate enhances physiological processes which lead to increased photosynthesis and translocation of nutrients from source to sink that caused increased dry matter production that lead to higher uptake of K. Similar results were obtained by Shafeek *et al*. [7]. It might be due to the synergetic effect of N on K which lead to increased K uptake by plant roots from soil. Fruit samples of different treatments recorded more K uptake than corresponding N and P contents. High K content in fruits was attributed to greater uptake of K from soil and its translocation to developing fruits as it plays a vital role in colour development.

Uptake of calcium
Foliar spray of Ca(NO3)2 significantly influenced the calcium uptake (Fig. 4). The highest uptake was recorded in treatment (T9) DAT which received two foliar sprays of 1.5 per cent Ca(NO3)2 followed by T4.This was mainly due to high dry matter yield recorded in this treatment compared to other treatments. But with advancement in plant growth, highest calcium uptake was recorded in the treatment that received three sprays of Ca(NO3)2 at 1.5 per cent due to higher production of dry matter with high concentration of Ca and N given through foliar spray of Ca(NO3)2 because of rapid cell elongation, cell division and more number of leaves which resulted in more vegetative and reproductive growth. At 140 DAT, fruit samples of all the treatments recorded slightly higher calcium uptake compared to plant uptake it might be due to translocation of nutrients from source to sink. Similar observations were reported by Das [2] and Shafeek *et al*. [7]. Irrespective of concentration, three foliar sprays recorded more calcium uptake and it might be due to increased calcium availability given through foliar spray (18.8 % Ca) leading to enhanced Ca uptake. The observations on Ca uptake closely agree with the findings of Luis *et al.* [5] who stated that, calcium plays a key role in biomass production because of its role in cell division. Finally, control recorded lowest uptake of calcium because it received only water spray at all the stages and their might be dilution effect on Ca content in plant.

Uptake of magnesium
Foliar application of Ca(NO3)2 had significant effect on the magnesium uptake 75, 105 and 140 DAT. Highest uptake at 75 DAT was recorded in the treatment (T9) that received two sprays of 1.5 per cent Ca(NO3)2 and for 105 and 140 DAT three sprays at same concentration (Fig. 5). This might be due to high dry matter production at 75 DAT. But with progress in growth and its indeterminate nature has resulted in greater dry matter yield because of vegetative growth stimulated through Ca(NO3)2 foliar spray. Calcium enhances nitrate nitrogen uptake [2] and nitrogen has synergistic relation with magnesium which may have resulted in higher uptake of magnesium from soil. However, lowest Mg uptake was recorded in control that received only water spray. This was because of low dry matter at all the three stages because of the absence of Ca and N otherwise supplied through foliar sprays of Ca(NO3)2.

Yield
The highest fruit yield (21.76 q ha-1) was noticed in treatment that received three foliar spray of 1.5 per cent Ca(NO3)2 and on par with treatment that received 1.5 per cent one foliar sprays. This might be due to favorable effects of Ca and N on yield components due to better uptake of Ca and N, their efficient translocation from source to sink increased the yield and role of Ca in providing strength to the terminal axes which lead to reduced flower dropping and increased fruiting synergized by 18 per cent Ca present in Ca(NO3)2. This has resulted in increased fruit yield [4] and [3].

CONCLUSION

Three foliar sprays of 1.5 per cent Ca(NO3)2 one each at 45th ,60th and 75th day after transplanting significantly improved the uptake of major and secondary nutrients and yield of chilli over NAA foliar spray and control. Three foliar sprays of Ca(NO3)2 are more effective than one and two sprays. 1.5 per cent concentration is more superior over 1.0 per cent concentration.

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