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Impact of Foliar Feeding of Boron Supplements on Growth, Yield Contributing Characters and Quality of Cauliflower

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ABSTRACT: During *rabi* 2018-19 a field investigation was conducted on cauliflower (*Brassica oleracea* var. *botrytis*) cv. Pusa Snowball K-1 at the experimental farm of Department of Soil Science, COA, CSK HPKV, Palampur consisting of twelve treatments each replicated thrice in a randomized block design with an aim to evaluate the efficiency of four boron sources *viz.*, borax, boric acid, boron metalosate and boron calcium metalosate and two methods of application i.e. soil and foliar. All treatments received recommended dose of fertilizers (120:60:75 kg/ha N:P_2O_5:K_2O) and FYM @ 20 t/ha uniformly except farmers' practice where FYM @ 25 t/ha was applied along with 50 per cent of recommended dose of fertilizers. Soil application of boron @ 2 kg/ha through borax and foliar spray at three levels i.e. half (0.017 %), recommended (0.034 %) and 1.5 times of recommended dose (0.051 %) with three boron sources *viz.*, boric acid, boron metalosate and boron calcium metalosate were tested. The growth, yield contributing characters and quality of cauliflower were significantly affected by different boron treatments. The foliar application of boron @ 0.051 per cent through boron calcium metalosate along with recommended dose of fertilizers and FYM recorded less number of days to curd initiation (85), marketable curd maturity (100), significantly tall plants (52.8 cm), more number of leaves per plant (22), curd diameter (29.9 cm), curd depth (11.4 cm), equatorial length (16.8 cm), curd size index (191 cm^2), curd solidity (67.0 g/cm) and the total soluble solids (8.9 ˚Brix). However, in case of the stalk length of cauliflower non significant effect of different boron treatments was recorded.

Keywords: Foliar feeding, boron supplements, cauliflower.

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INTRODUCTION

Cauliflower, *Brassica oleracea* var. *botrytis* L. (2n=18) one of extensively grown winter vegetable crop of crucifereae family has registered a pride place in the country owing to its flavour, nutrition and delicious taste. The edible portion called curd constitutes roughly 45 per cent of the entire plant (Rai and Yadav, 2005). Cauliflower is a good nutrient source in human diet owing to its reasonable price, consumer's preference and of course year-round availability.

During 2017-18, cauliflower was grown in 453 thousand hectares area having a total production of 8668 thousand MT in India (Anonymous, 2017) whereas in Himachal Pradesh the area and production was 5.31 thousand hectares and 124.33 thousand MT, respectively during 2016-17 (Anonymous, 2016). Among many factors responsible for low productivity of cauliflower, inadequate and imbalanced nutrition occupy the top position causing nutrient deficiency, particularly of boron, responsible for deteriorated soil health and yield stagnation.

Boron has emerged as the third most deficient nutrient in Indian soils after zinc and sulphur and the latest figures showing 23.2 per cent deficiency level (Shukla and Behera, 2017).

Boron plays crucial role in flowering and fertilization, curd quality, yield and seed yield of cauliflower as the crop is highly sensitive to boron deficiency. Moreover, boron is involved in several physiological processes *viz.*, calcium metabolism, auxin synthesis, sugar metabolism, translocation of solutes and protein synthesis. The enzymatic activities directly responsible for potassium uptake are drastically hampered when boron supply is inadequate. Agricultural intensification coupled with addition of boron free inputs and also inadequate organic matter additions have further increased boron deficiency in soils. The range between boron deficiency and toxicity is very narrow and it demands careful calibration of boron doses.

In order to arrest the boron deficiency, two options are available i.e. soil and foliar feeding through number of commercial sources namely borax, boric acid, granubor, solubor etc.

The recent introduction of metalosate products in India *viz.,* boron metalosate (5% B) and boron calcium metalosate (5% B and 13% Ca) were evaluated for their foliar efficiency against the standard sources. These products are 100 per cent water soluble, non toxic and exclusively designed for foliar feeding. The peculiarity of metalosate is that the minerals are chelated with amino acids. The metalosates are quickly absorbed, translocated and metabolized by plants similar to natural amino acids to chelate the minerals (Dickinson and O'Brien, 2008).

Foliar feeding of boron has advantages (i) it can address the deficiency problem owing to weather conditions and (ii) the risk of deficiency during later growth period is minimized. Therefore, considering the significance of boron in cauliflower production, its optimum rate and method of application, the present study on "Impact of foliar feeding of boron supplements on growth, yield contributing characters and quality of cauliflower" was undertaken during *rabi* 2018-19.

MATERIALS AND METHODS

A field trial was conducted during *rabi* 2018-19 on cauliflower cv. Pusa Snowball K-1 at the experimental farm of CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur situated at 32°6' N latitude and 76°3' E longitude at an altitude of about 1290 m above mean sea level. The study area lies in the Palam valley (district Kangra) representing mid hills sub humid agro-climatic conditions of Himachal Pradesh. Taxonomically, the soils of the experimental site fall under order Alfisol and sub-group Typic Hapludalf. The rocks like slates, phyllites, quartzites, schists and gneisses are responsible for the formation of such soils. The soil of the experimental site was acidic in reaction with pH 5.26, silty clay loam in texture and the content of available nitrogen, phosphorus, potassium and boron was 248 kg/ha, 21.8 kg/ha, 174 kg/ha and 0.31 mg/kg, respectively. The organic carbon content at initiation of the experiment was 7.08 g/kg. The experiment was laid out in Randomized Block Design (RBD) consisted of twelve treatments; each allocated randomly according to the random table and replicated thrice. The treatments comprised of T_1: zero B, T_2: Soil B (Borax), T_3: 0.017% B (Boric acid), T_4: 0.034% B (Boric acid), T_5: 0.051% B (Boric acid), T_6: 0.017% B (B Metalosate), T_7: 0.034% B (B Metalosate), T_8: 0.051% B (B Metalosate), T_9: 0.017% B (B + Ca Metalosate), T_{10}: 0.034% B (B + Ca Metalosate), T_{11}: 0.051% B (B+Ca Metalosate) and T_{12}: Farmers' practice (FYM @ 25 t/ha + 50% NPK of RDF). The recommended dose of fertilizers (RDF) and FYM @ 20 t/ha (Fresh weight basis) were incorporated in all the treatments except farmers' practice (T_{12}).

Boron was applied by two methods i.e. soil application of B @ 2.0 kg/ha through borax (T_2) at transplanting and foliar feeding (T_3- T_{11}) with three supplements *viz*., Boric Acid (BA), Boron Metalosate (BM) and boron calcium metalosate (BCaM). Boron was applied at half, recommended and 1.5 times of the recommended rate through boric acid from treatment T_3 to T_5, respectively. Boron metalosate (T_6-T_8) and boron calcium metalosate (T_9-T_{11}) were also applied in the similar manner as boric acid. The foliar application of B was done at 45 and 65 days after transplanting (DAT).

The cauliflower seedlings were transplanted in October, 2018 at 60 × 45 cm apart. The recommended dose of fertilizers for cauliflower was 120:60: 75 kg/ha N: P_2O_5: K_2O. FYM was added uniformly at recommended rate i.e. 20 t/ha (fresh weight basis) in all plots except farmers' practice (T_{12}) where it was incorporated at the rate of 25 t/ha along with half of the recommended dose of fertilizers. At the time of transplanting half dose of N and K, full dose of P along with FYM were applied in soil. 1/4th dose of N was applied one month after transplanting and remaining 1/4th dose of N and half of K was applied during curd initiation. In farmers' practice, half of recommended dose of fertilizers was also applied in the same manner. As per treatments, boron was supplied to cauliflower via four supplements i.e. borax, boric acid, boron metalosate and boron calcium metalosate. Urea, single super phosphate and muriate of potash were the sources of N, P and K, respectively. Irrigation and other intercultural operations were followed as per the recommended package of practices. Five plants were randomly selected to record observations for various growth, yield contributing characters and quality parameters of cauliflower which consisted of curd initiation, marketable curd maturity, stalk length, number of leaves, plant height, curd depth, equatorial length, curd size index, curd diameter, curd solidity, total soluble solids and curd colour. The statistical analysis of data generated was done by using analysis of variance for randomized block design for the interpretation of results as given by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

A. Growth Parameters

Curd Initiation. The curd initiation was significantly affected by different boron treatments (Fig. 1). Less number of days to curd initiation (85 days) were recorded when B @ 0.051 per cent was applied through boron calcium metalosate (T_{11}) along with recommended dose of NPK and FYM which was statistically at par with the treatments consisted of foliar feeding of B @ 0.034 and 0.051 per cent through boron calcium metalosate (T_{10}) and boron metalosate (T_8), respectively. The treatments comparison revealed that in case of recommended doses of boron through different supplements, days to curd initiation were statistically at par where boron was applied through boron calcium metalosate (T_{10}) and boron metalosate (T_7) at their recommended rates as foliar spray however, equal number of days to curd initiation (92) were registered in case of soil application of borax (T_2) and foliar spray of boric acid (T_4).

Marketable Curd Maturity. A significant effect of boron treatments on marketable curd maturity was observed (Fig. 1).

It varied from minimum of 100 days in treatment where foliar application of B at 1.5 times of the recommended was done (0.051%) through boron calcium metalosate (T_{11}) to the maximum of 118 days under the treatment where farmers' practice (T_{12}) was adopted. Moreover, the marketable curd maturity followed similar trend as curd initiation.

Plant Height. The variable rates of boron application through different sources registered significant impact on plant height. The plant height increased when boron doses were increased from half to 1.5 times of the recommended rate in case of foliar application (Fig. 2). However, among treatments comprised of recommended doses of boron, both the methods of B application (soil and foliar) behaved statistically alike with respect to plant height of cauliflower except the treatment where boron calcium metalosate was the source. Generally, the tallest plants (52.8 cm) were recorded in the treatment which received B @ 0.051 per cent through boron calcium metalosate (T_{11}) as foliar spray and was statistically at par with boron metalosate (T_8) at the same rate.

Stalk Length. The stalk length of cauliflower did not show any significant effect irrespective of boron treatments. However, the maximum stalk length of 4.7 cm was noted when foliar feeding of B at its super optimal rate (0.051 %) was done through boron calcium metalosate (T_{11}).

Number of Leaves. The number of leaves per plant were significantly influenced by different boron treatments (Fig. 2). The minimum number of leaves per plant (15) were recorded under farmers' practice (T_{12}) whereas the maximum number of leaves (22) were found in the treatment which received foliar feeding of B at super optimal rate (0.051%) through boron calcium metalosate (T_{11}) conjointly with recommended dose of fertilizers and FYM.

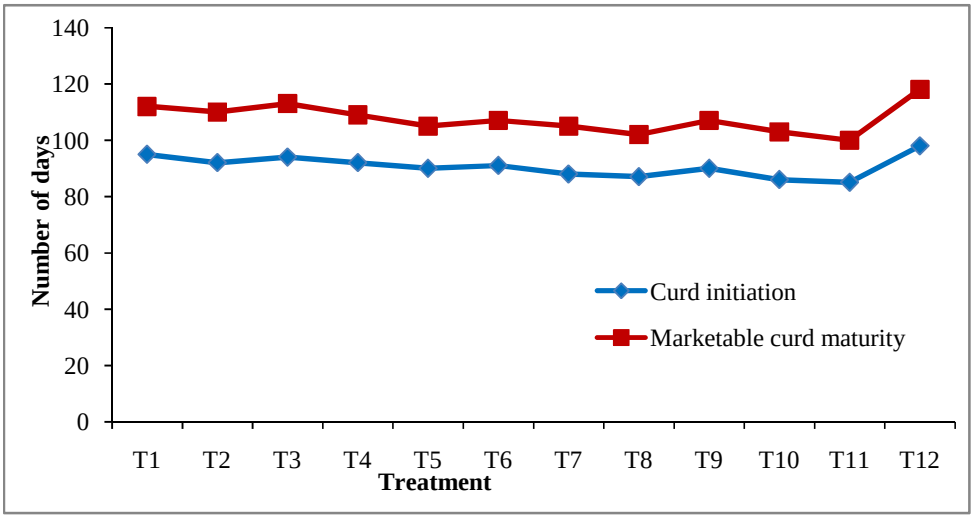

Fig. 1. Effect of foliar spray of B on number of days to curd initiation and marketable curd maturity of cauliflower.

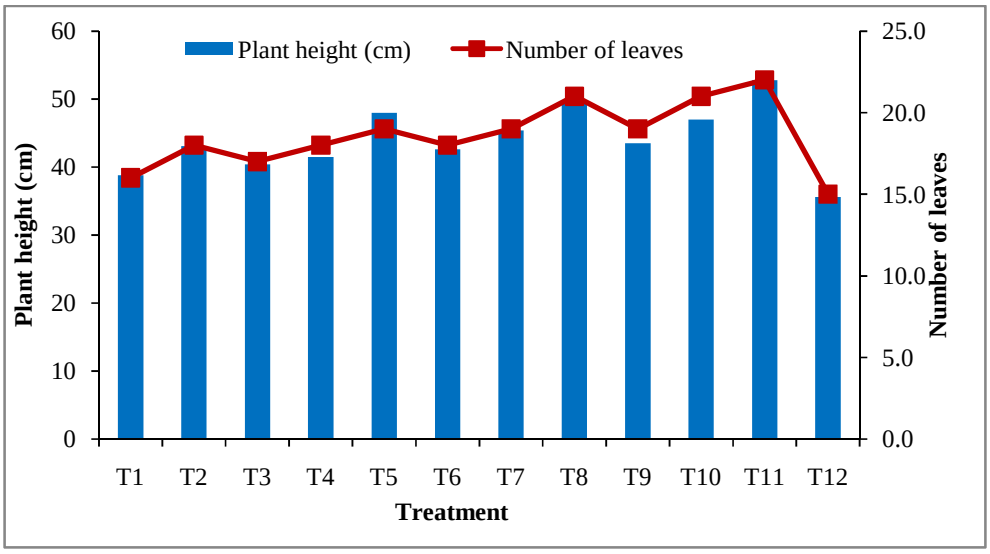

Fig. 2. Effect of foliar spray of B on plant height and number of leaves of cauliflower.

Also, the number of leaves recorded in the latter treatment (T_{11}) was statistically at par with the treatments supplied with foliar spray of B at same rate (0.051%) as well as at recommended rate (0.034%) through boron metalosate (T_8) and boron calcium metalosate (T_{10}), respectively suggesting that both the sources at same rates were equally effective in increasing the number of leaves. In case of the treatments receiving B at recommended rates either through soil as borax (T_2) or foliar spray through boric acid (T_4) recorded equal number of leaves (18) however, foliar feeding through boron calcium metalosate (T_{10}) at its recommended rate resulted in maximum number of leaves (21).

The application of boron enhanced its availability to the plants which accelerate the growth of meristematic tissues and cell division. B also has an important role in increasing the permeability of cell membrane which led to better transportation of sugars and carbohydrates. The complimentary effect of addition of calcium through boron calcium metalosate also improved the growth parameters of cauliflower as calcium enhanced the uptake of N and micronutrients *viz*., Fe, Mn, Zn, Cu and B. In relation to this study equivalent results were also reported by Deepika and Pitagi (2015) in radish, Kumar and Khare (2015) in cabbage, Thapa *et al.*, (2016) in broccoli, Anonymous (2017), Hassan *et al.*, (2018) and Moklikar *et al.*, (2018) in cauliflower crop.

B. Yield Contributing Characters

Curd Diameter. Among different sources of boron, boron calcium metalosate proved its superiority over others as the maximum curd diameter (29.9 cm) was recorded when B @ 0.051 per cent (1.5 times of the recommended) was applied as foliar spray through boron calcium metalosate (T_{11}) in combination with 100 per cent NPK and FYM (Fig. 3). However, the curd diameter was statistically at par where boron metalosate (T_8) was the source at same rate. In case of treatments comprising of recommended doses of boron, both the methods i.e. soil and foliar application behaved statistically alike in relation to curd diameter except the treatment where foliar spray of boron through boron calcium metalosate (T_{10}) was done. The curd diameter was observed to be 6.6 cm more when B @ 0.051 per cent through boron calcium metalosate (T_{11}) was applied as foliar spray in comparison with the treatment receiving sole application of NPK (T_1).

Curd Depth. The curd depth of cauliflower responded significantly to different boron treatments (Fig. 3) and the curd depth increased when boron was applied through different sources at varying rates. At recommended rate, maximum curd depth was recorded with foliar spray of B at recommended rate through boron calcium metalosate (T_{10}) and was statistically at par with soil application through borax as well as foliar feeding through boric acid (T_4) at the same rate. Further, the foliar application of B at super optimal rate (0.051 %) through boron calcium metalosate (T_{11}) recorded the maximum curd depth (11.4 cm) and was statistically at par when boron metalosate (T_8) was the source at the same rate as well as boron calcium metalosate (T_{10}) at the recommended rate (0.034 %) suggesting that both the sources were equally effective in influencing the curd depth.

Equatorial Length. A significant effect of different boron treatments was recorded on the equatorial length of cauliflower curd. It was maximum (16.8 cm) when B @ 0.051 per cent through boron calcium metalosate (T_{11}) was applied along with recommended dose of NPK and FYM (Fig. 3). The equatorial length was statistically similar when foliar feeding of boron at the same rate through boron metalosate (T_8) was done, therefore at super optimal rate both metalosates were equally good. However, the equatorial length in the treatments comprised of recommended doses of boron followed similar trend as curd depth of cauliflower.

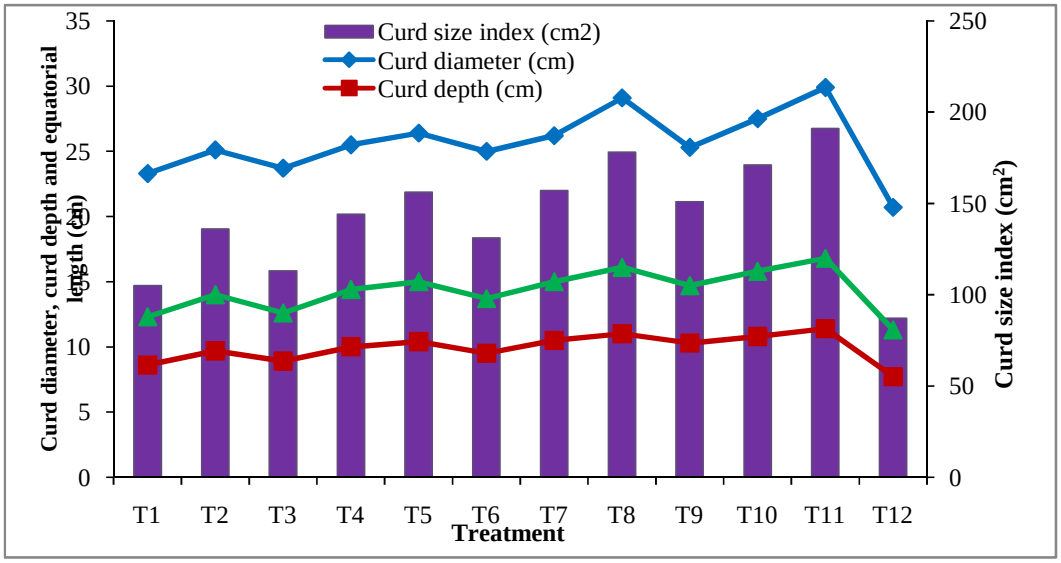

Fig. 3. Effect of foliar spray of B on yield contributing characters of cauliflower.

Curd Size Index. The foliar application of boron at 1.5 times of the recommended rate i.e. 0.051 per cent through boron calcium metalosate (T_{11}) recorded the maximum curd size index (191 cm^2) which was statistically at par with foliar feeding of boron through boron metalosate (T_8) at the same rate (Fig. 3). The curd size index also followed similar trend as curd depth in case of the treatments where recommended doses of boron were applied irrespective of source and method.

The enhancement in yield contributing characters was noted with the increasing doses of boron from half to 1.5 times of the recommended rate which might have increased the cell division and cell elongation and influenced tissue formation and ultimately the vegetative growth of plant. Our findings are in agreement with the earlier results of Singh *et al.*, (2011) and Chaudhari *et al.*, (2017) for cauliflower.

C. Quality Parameters

Curd Solidity. Cauliflower cv. Pusa Snowball K-1 responded well to different boron treatments and a significant effect on curd solidity was recorded (Fig. 4). The curd solidity was maximum (67.0 g/cm) when cauliflower was supplied with B at super optimal rate (0.051%) through boron calcium metalosate (T_{11}) as foliar spray conjointly with recommended dose of fertilizers and FYM and was significantly superior over all other treatments. Among the treatments consisting of recommended doses of boron applied either through soil or foliar application, curd solidity was recorded to be statistically at par in treatments receiving B through borax (T_2) and boric acid (T_4). Therefore, either soil application of borax or foliar feeding of boric acid had same impact on curd solidity at same rate.

Total Soluble Solids. A significant improvement in the TSS content of fresh cauliflower curds was recorded with the application of boron through different sources. The maximum TSS content was recorded in the treatment which received foliar feeding of B @ 0.051 per cent through boron calcium metalosate (T_{11}) and was at par with the treatment where B was applied at 0.051 per cent through boron metalosate (T_8) and boric acid (T_5) and at 0.034 per cent through boron calcium metalosate (T_{10}) and boron metalosate (T_7) as foliar spray (Fig. 4). So super optimal dose through either source as well as at recommended rates were equally effective in improving the TSS. However, at recommended doses of boron, both the methods of application (soil and foliar) behaved statistically alike in increasing the TSS irrespective of supplements *viz*., borax, boric acid, boron metalosate and boron calcium metalosate. The increased TSS with the foliar feeding of metalosates is a good sign of improved cauliflower quality.

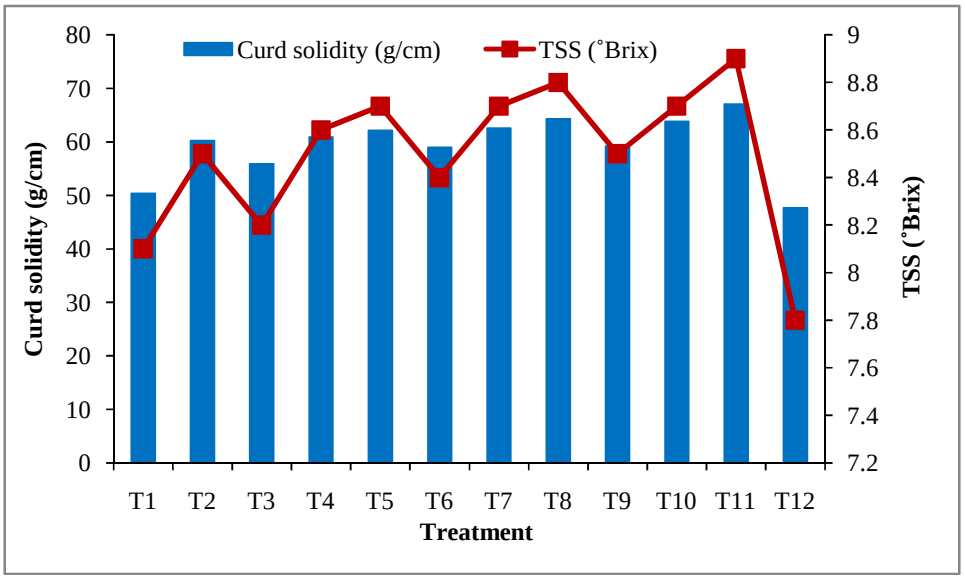

Fig. 4. Effect of foliar spray of B on curd solidity and total soluble solids of cauliflower.

Boron played an important role in translocation of sugars and carbohydrates from site of synthesis to the site of storage i.e. from leaves to curds which might have resulted in the improvement in TSS content with B application through different supplements. The results match with the earlier findings of Thapa *et al.*, (2016), Singh *et al.*, (2018) and Pankaj *et al.*, (2018) in broccoli; and Moklikar *et al.*, (2018) in cauliflower.

Curd Colour. The cauliflower curds were visually examined and it was observed that the boron treatments did not have a marked influence on the curd colour. Generally, cauliflower cv. Pusa Snowball K-1 exhibits snow white curds but in this experiment the curds were off white in colour which might be due to variations in temperature during the cropping season.

CONCLUSION

It can be concluded from the investigation entitled "Impact of foliar feeding of boron supplements on growth, yield contributing characters and quality of cauliflower" that foliar feeding of boron at 1.5 times of the recommended rate (0.051 %) through boron calcium metalosate along with recommended dose of fertilizers and FYM enhanced growth, yield contributing characters and quality parameters of cauliflower followed by foliar spray of boron at the same rate through boron metalosate. As metalosate products were evaluated on different crops under variable climatic situations of the country through AICRP on "Micro and Secondary Nutrients and Pollutant Elements in Soils and Plants", the preliminary results are encouraging in terms of improved growth and quality parameters of cauliflower.

FUTURE THRUST AREAS

The superiority of metalosate products needs to be evaluated across diversified climatic situations and crops.

The cost constraint require addressal at FCO level and for that detailed investigations are needed for different crops and climatic situations to match the conventional sources of nutrients comparable with the metalosate products.

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