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Effect of INM Practices on Performance of Early Cauliflower Var. *Sabour agrim* and Soil Nutrient Status

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ABSTRACT

Field trial were conducted at 10 farmers field by Krishi Vigyan Kendra Katihar during the year 2018 and 2019 to assess the effect of INM practices on performance of early Cauliflower var. *Sabour agrim* as well as their residual effects on soil properties. The treatments comprised with RDF and RDF + 20 t/ha FYM + 20 kg/ha Borex with sodium molybdate @ 2 kg/ha alone and in combination. The control treatment (NPK @ 180: 40: 20 kg/ha) was also followed by farmers. There were quadratic responses in growth and yield attributes of early cauliflower by application of boron and molybdenum with RDF in combination of FYM. Significant linear positive correlations between curd yield and growth attributes were found. Among the various treatments, the combined application of borax 20 kg/ha and sodium molybdate 2 kg/ha as soil application in combination of recommended dose of NPK @ 120: 60:60 kg/ha (T_3) gave the maximum height of the plant, length of leaf, width of leaf, total weight of plant, width of curd, average weight of curd, curd yield, economics. Positive correlation was obtained between soil nutrient and curd yield.

***Key words*:** INM, Cauliflower var. *Sabour agrim*, Growth attributes, Yield, Economics, Soil nutrient status

Cauliflower (*Brassica oleracea* L. var. *botrytis*) is an important vegetable crop throughout the world, native to temperate Mediterranean region belonging to crucifer family. It is regarded as indispensable group of food as it contains vitamin A (51 IU), vitamin C (56 mg), riboflavin (0.10 mg), thiamin (0.04 mg), nicotinic acid (1.0 mg), calcium (33mg), phosphorus (57 mg), potassium (138 mg), moisture (90.8 g), carbohydrates (4.0 g), protein (2.6 g), fat (0.4 g), fiber (1.2 g) and iron (1.5 mg) per 100 g of edible portion of cauliflower [1]. Moreover, it has medicinal value and has been found effective in inhibition of carcinogenesis as it contains high concentration of glucothiocyanate and indol-3-Carbinol with anti-inflammatory properties [2]. This crop has an important economic value at farmer point of view but it's more economic whenever transplanted in early in comparison to timely sown.

It requires balanced and sufficient supply of nutrients for better growth and higher yield. The concept of integrated nutrient management has emerged as important tool for maintaining soil fertility and crop productivity. The concept of integrated nutrient management requires optimum use of organic, inorganic and bio-sources of plant nutrients. In an integrated manner to each cropping system and farming situation in it's ecological, social and economic possibility. Integrated use of fertilizer, manure and biofertilizers improve soil fertility and crop growth. They are also reported to have an effective role in improving disease resistance in the crop by producing antibacterial and anti-fungal compounds and also produce growth regulators [3]. INM refers to integration of organic, inorganic and biological components to increase crop productivity and maintenance of soil fertility for future use. This is all done without any deleterious effect on the physico-chemical and biological properties of the soil on a long-term basis [4]. The conjoint application of organic and inorganic fertilizers with micronutrient significantly increased yield and weight in cauliflower over control [5]. Integrated applications having judicious combination of mineral fertilizer with organic and biological sources of nutrients are not only complimentary but also synergistic as organic inputs have beneficial effects [6]. Therefore, INM was applied to make cauliflower cultivation sustainable and to improve soil productivity and fertility. The combined effect of organic, inorganic fertilizer with micronutrients at varying doses was observed on growth, yield, concentration of nutrients and quality of cauliflower. Therefore, studies were done to enhance growth and yield of cauliflower by employing INM.

Cauliflower is a heavy feeder and it requires large amount of macronutrients as well as micronutrient for better development of curd and its quality. In addition to checking the various diseases and physiological disorders, the use of chemical fertilizers is one of the well-known constrain for maximization of crop yield through their proper utilization. The

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application of optimum dose of nitrogenous, phosphatic and potassic fertilizers along with some micro-nutrient *viz*, boron and molybdenum are also essential for higher production, better quality and control of nutritional disorders in cauliflower. Plant grown on micro-nutrient deficient soils can exhibit a similar reduction in plant growth and yield as macro- nutrients. Cauliflower has a high micro-nutrients requirement, particularly boron and molybdenum. Boron is very important for growth and development of cauliflower and is involved in cell division and hence helps in root elongation and shoot growth. It is associated with several physiological processes such as calcium metabolism, auxin synthesis, sugar metabolism translocation of solutes and protein synthesis. Boron plays an essential role in the development and growth of cell in the plant meristem. Since it is not readily translocated from old to actively growing tissues, the first visual deficiency symptoms are cessation of terminal bud growth, leaves are curled, lathery and less in number followed by the death of young leaves. Boron deficiency symptoms appear at the initial stage as water-soaked areas developed in the center of the curd and in advanced stage the stem becomes hollow with the cavity surrounded by water-soaked tissues. Later curd change to rusting brown, bitter in taste and become rotten. Mehrotra and Mishra [7] reported that the curd formation was delayed, which turned dirty pale to brown in colour due to deficiency of boron in cauliflower.

Molybdenum is also very essential micro-nutrient for the better growth and development. It is an essential component of major enzyme nitrate reductase in the plant. It occurs in envelops of chloroplast in leaves. Cauliflower responds severely to the deficiency of molybdenum and the damage may be considerable. Young cauliflower plant deficient in molybdenum becomes chlorotic and may turn white particularly along the leaf margins. They also become cupped and wither, eventually. The leaf dies and the growing point also collapses. In older plants the lamina of the newly formed leaves is irregular in shape frequently consisting of only a large bare midrib and hence the common name "whiptail; originated. In a field experiment, the application of molybdenum (80 or 160 g ha^{-1}) increased cauliflower yield by 7-8% over the control [8]. Keeping these facts in view, the present investigation was planned to generate scientific information on influence of boron and molybdenum on growth yield and quality parameter of cauliflower.

MATERIALS AND METHODS

The experiment was conducted at Farmers field of Katihar district by Krishi Vigyan Kendra, Katihar, (Bihar Agricultural University Sabour, Bhagalpur) during two consecutive years of 2018-19 and 2019-20. The trial was done to assess the effect of INM practices on performance of early Cauliflower Var. *Sabour agrim* as well as their residual effects on soil properties. It lies between Latitude 25'N to 26'N, Longitude 87' to 88'E with an altitude of 20 m above MSL. The climate is sub-tropical and humid having mean maximum and minimum temperature between 46°C and 4°C, respectively and the average annual rainfall of the district is about 1298 mm. The experimental soils are non-calcareous light gray flood plain belongs to the Alluvial Tract (Agro ecological zone-II) lies between three major rivers Mahananda, Kosi and Ganga. The physio-chemical properties of experimental soil have been presented in (Table 1). These study included with cauliflower with Sabour agrim cultivar with the following treatments T_1-Farmers Practice (180:40:20: N:P:K), T_2-120:60:60 : N:P:K + 20 t/ha FYM and T_3- 120:60:60 : N:P:K + 20 t/ha FYM + Borax @ 20 kg ha^{-1} + Sodium molybdate 2 kg ha^{-1}. The experiment was laid out in RBD with ten replications. The unit plot size was 4.0 m × 2.5 m. The land was prepared in early June and fertilizers were applied as per recommendation. All the fertilizers were applied as per treatments dose in each individual plot during the final land preparation including FYM and mixed thoroughly in the soil. Remaining 2/3 of urea was applied at two split doses at 30 days and 45 days after transplanting as top dressing before earthling was done. The micronutrients i.e., boron and molybdenum were applied as soil application alone or in combination or as a foliar spray at 20 and 40 days after transplanting as per treatment. In order to keep the field free from weeds, two hands weeding followed by hoeing were done manually 30 days and 45 days of transplanting. The seed of cauliflower variety *Sabour agrim* was selected for sowing in well prepared raised bed by opening the miniature furrows at 5 cm distance. One month old healthy seedlings were lifted carefully and transplanting was done on flat beds at the distance of 60 × 45 cm. After transplanting the seedling, a light irrigation was done. In all, 5 irrigations were given during the crop period.

The treatments comprised with foliar application of boron @ 100 ppm and molybdenum @ 50 ppm with the levels of borax @ 20 kg/ha and sodium molybdate @ 2 kg/ha. The control treatment (NPK @ 180: 40: 40 kg/ha) was also done by farmers. Boron was applied in the form of borax and molybdenum through sodium molybdate. The observation related to growth attributes and yield components of individual plant parameters were recorded from randomly selected plants in each plot. The evaluated traits were plant height, 50% curd initiation days, 50% curd maturity days, curd maturity duration, marketable curd length, diameter, yield and economics of farmers.

The soil samples were collected from different farmer field before start the experiment and after final harvest the crop and at each sampling site, soil samples were collected from top soil and finding are presented in table-1. The soil texture of the area varies from sandy loam to sandy clay with non-calcareous light gray flood plain belong to alluvial tract. At each sampling point four cores (5.0 cm diameter) were randomly taken within one meter at each other to a depth of 15 cm. About 500 g composite soil samples were obtained after combining at each point. A total of 75% composite soil samples were air dried and pass through 2mm sieve. Organic carbon content was determined by the Walkley and Black [9] method. Available nitrogen was determined by the alkaline $KMNO_4$ method [10], and available phosphorous [11] and available potash were determined Flamphotometrically method [12]. The pH and ECe were measured in soil suspension (1:2.5) using electrode [13]. The average values of all parameters were statistically analyzed to find out the level of significance using MSTAT-C package programme. The means differences were compared by Dancan's New Multiple Range Test (DMRT) at 5% level of significance.

RESULTS AND DISCUSSION

Effect of INM on growth parameters of cauliflower

Plant height

The observation regarding the height of plant influenced by the application of boron and molybdenum along with FYM and recommended dose of fertilizers on cauliflower reveled that treatment T_3: 120:60:60 : N:P:K + 20 t/ha FYM + Borax @ 20 kg ha^{-1} + Sodium molybdate 2 kg ha^{-1} has highest 58.75 cm plant height, whereas in farmers practices it was minimum 52.48 cm (Table 2, Fig 1). It is clear from the presented data, that the micronutrients played significant role in directly affecting the plant height. The result may pertain to adding organic manures to soil in combination with inorganic fertilizers and micronutrients boron and molybdenum which increases the availability of nutrients considerably result in positive effect on plant height [14].

Table 1 Physico-chemical properties of experimental soil

Treatments	pH (1:2.5)		Bulk density (g/cm)		Particle density (g/cm)		ECe (dSm^{-1})		O.C. (%)		Available nutrients (kg ha^{-1})					
											N		P		K	
	I	F	I	F	I	F	I	F	I	F	I	F	I	F	I	F
T_1	6.17	6.15	1.28	1.31	2.24	2.28	0.18	0.18	0.68	0.65	329	278	36	33	259	255
T_2	6.12	6.24	1.28	1.27	2.25	2.24	0.20	0.20	0.67	0.67	316	318	32	35	256	268
T_3	6.12	6.35	1.29	1.24	2.25	2.21	0.21	0.23	0.67	0.68	324	340	35	38	260	275
CD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	0.02	Ns	0.01	1.27	1.25	0.82	0.14	1.08	1.35

*I- Average report of initial soil samples F- Average report of soil after plant harvest

Table 2 Effect of different treatments on growth attributes of cauliflower

Treatments	Plant height (cm)	Root length (cm)	Root diameter (cm)	Root density (cm)	No of leaves	Leaf area (cm^2)	Plant spread (cm)
T_1	52.48	20.17	0.62	0.46	17.02	410	26.82
T_2	56.18	20.46	0.85	0.54	19.38	512	32.08
T_3	58.75	21.03	0.98	0.62	21.14	586	35.17
CD (p=0.05)	0.4	NS	0.47	0.03	0.04	2.08	0.2

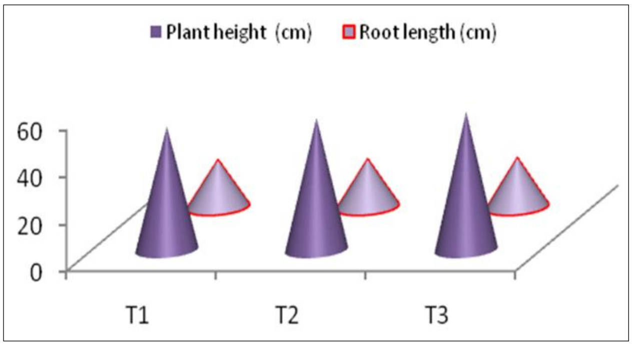

Fig 1 Effect of different treatment on plant and root length (cm)

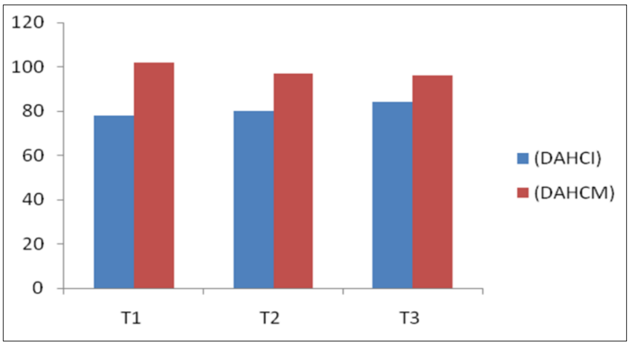

Fig 2 Effect of different treatment on curd initiation and maturity days of cauliflower

Number of leaves

The data presented in (Table 2), clearly indicated that the micronutrients along with organic and inorganic fertilizers played significant role in directly affecting the number of leaves per plant. The maximum number of leaves per plant was recorded statistically significant with T_3 which was recorded 21.14 leaves. The minimum number of leaves per plant (17.02) was noticed with farmers practices. Micronutrients along with organic fertilizers played a significant role and directly affecting the number of leaves per plant.

Plant spread

Plant Spread showed significant difference with treatments. Maximum plant spread (35.17 cm) was also recorded with treatment T_3 (120:60:60 : N:P:K + 20 t/ha FYM + Borax @ 20 kg ha^{-1} + Sodium molybdate 2 kg ha^{-1}) which was statistically significant with other treatments [15]. The plant spread may be due to supply of balanced available macro and micro nutrient from the soil comparatively less retention in the roots and more translocation to aerial portion for synthesis of protoplasmic proteins and other metabolites enabling expansion of photosynthetic area, hence plant spread.

Leaf area

Integrated uses of recommended dose of fertilizers along with farm yard manure and micronutrients showed significant differences in leaf area which was statistically significant with other treatment combinations. This might be possible due to numerous humic acid contained in FYM along with micronutrients, which enhances the growth of leaves.

Effect of INM on root growth parameters of cauliflower

Maximum root length, diameter and density of cauliflower were observed with T_3 where recommended dose of fertilizers is applied along with FYM and micronutrients B and Mo. These may be attributed to improved soil physico-chemical properties and better availability of nutrient which promote root properties of cauliflower [16].

Effect of INM on yield parameters of cauliflower

Curd initiation and maturity

Cauliflower of treatment T_1 (control) had taken 78 days with the shortest period for 50% curd initiation but curd maturity was longer (102 days) with lesser curd diameter. However, in T_3 96 days required for the 50% maturity of the curd with more curd diameter (14.85 cm). It was possible due to treatment Borax @ 20 kg ha^{-1} + Sodium molybdate 2 kg ha^{-1} applied with RDF and FYM, has resulted curd maturity take shortest time 14 days in comparison to other treatments. It is possible due to balance availability of nutrients required for them.

Curd length

Significance differences in curd depth, an indicator of curd size was observed in response to different treatment combinations. Average curd depth was found maximum (11.87 cm) in T_3 (120:60:60 : N:P:K + 20 t/ha FYM + Borax @ 20 kg ha^{-1} + Sodium molybdate 2 kg ha^{-1}) and lowest curd depth (10.4 cm) was found in T_1. The result may be attributed to beneficial role of FYM improving soil physical, chemical and biological properties which in turn help in better nutrient availability to plants resulting in better development of the curd.

Curd diameter

The average curd diameter influenced by the treatment T_3 (20:60:60 : N:P:K + 20 t/ha FYM + Borax @ 20 kg ha^{-1} + Sodium molybdate 2 kg ha^{-1}) had the highest significant difference (14.85 cm) among other treatment combinations and had lowest curd diameter (13.27 cm) in T_1 (farmers practices) [15]. This might be possible due to increasing chlorophyll content and maximum photosynthetic activity in plant.

Average curd weight

Curd weight was found to have increased under the influence of recommended dose of fertilizers along with organic sources farm yard manure and micronutrients. The average curd weight was found maximum (345.27 g) in T_3 in comparison with other treatments. This is possible due to added supply of nutrients and proliferous root system enabling better absorption of water and nutrient along with the physical environment [17].

Marketable curd weight

The fresh weight of curd was also influenced significantly due to applied treatments. The observation regarding the marketable weight of curd again treatment T_3 has recorded highest 127.78 qt ha^{-1}, whereas lowest weight was under control 110.37 $qtha^{-1}$ (Table 3). The increase in marketable yield might be due to particularly the function of boron, which resulted into the precipitation of excess cation, buffer action, maintenance of conducting tissues, which ultimately helped in absorption of nitrogen. However, molybdenum activates a physiological process by stimulating factor in the metabolism and growth of the plant. The finding is in accordance with the study carried out by the Ghosh and Hasan [18] in cauliflower. Mohanata *et al.* [19] also found highest curd yield in vermicompost integrated treatments. The role of vermicompost to increase in yield can be attributed to the balanced C:N ratio and enhanced availability of essential plant nutrients throughout the growing season, hence increased rate and efficiency of metabolic activities resulting in high assimilation of metabolites. The beneficial effects of added organic matter in improving soil physical, chemical and biological properties is well known which in turns helps in better nutrient absorption by plants resulting in better yield.

Effects of integrated nutrient management on residual soil properties

Soil pH and ECe

Integrated nutrient management has no significant effect on soil pH over a period of work. However, application of organic, inorganic nutrients with micronutrients in soil was found to increase the soil pH closer to neutrality but apply only inorganic fertilizer reduces the soil pH. The trend found that application of inorganic fertilizer to make the soil acidic while integrating organic and inorganic fertilizer helps to balance the acidity of soil [20] under integrated application of organic and inorganic fertilizers. This may be attributed to the buffering capacity of the organic manures, which resists change in pH values, however, addition of organic manures tends to increase the pH value and leads to neutrality.

Table 3 Effect of different treatments on yield attributes and yields of cauliflower

Treatments	Days after 50% curd initiation (DAHCI)	Days after 50% curd maturity (DAHCM)	Curd maturity duration (CMD)	Curd length (cm)	Curd diameter (cm)	Marketable curd weight (g)	Yield of marketable curd (qt ha^{-1})
T_1	78	102	15	10.52	13.27	298.52	110.37
T_2	80	97	14	11.46	14.17	328.18	121.48
T_3	84	96	14	11.87	14.85	345.27	127.78
CD (p=0.05)	1.6	0.5	NS	0.9	0.07	21	1.06

Organic matter

Integrated supply of organic and inorganic fertilizers with micronutrients increases the soil organic matter than that of application of sole inorganic fertilizer. Soil having the treatment T_3 (120:60:60 :: N:P:K + 20 t/ha FYM + Borax @ 20 kg ha^{-1} + Sodium molybdate 2 kg ha^{-1}) had highest soil organic matter percentage (0.68) after harvest while T_1 (180:40:20 :: N:P:K) had the lower percentage (0.65). Higher amount of organic matter in the soil receiving integrated supply of chemical fertilizer and FYM with micronutrients might be attributed to the application bulk volume of FYM on equivalent basis. Organic residues of plant and animal waste are the parent materials of organic matter and humus, which make up the nutrient supplies of microorganisms and plant root [20].

Bulk density

It is clear from the data presented in (Table 3) that no significant difference found in soil bulk density in respective treatments applied in plots. However, farm yard manure treated plots along with boron and molybdenum were found to have lower bulk density in comparison to inorganic fertilizer treated plots. T_3- 120:60:60 : N:P:K + 20 t/ha FYM + Borax @ 20 kg ha^{-1} + Sodium molybdate 2 kg ha^{-1} showed the lowest value and T_1- (180:40:20 : N:P:K) showed the highest value of soil bulk density. The lower value of soil bulk density in integrated treatments might be attributed to the higher proportion of soil organic matter [20].

Particle density

Non significant effect were found on particle density between the different treatment. However, FYM treatments were found to have lower particle density, while treatment having only inorganic fertilizer had higher particle density. Integration of organic fertilizers along with inorganic fertilizers have decreased the particle density to the greater extent because of addition of soil organic matter [21].

Infiltration rate

The treatments were insignificant for infiltration rate. However, fym treated treatments had higher infiltration rate, while, treatment having only inorganic fertilizer had lower infiltration rate. T_3- 120:60:60 : N:P:K + 20 t/ha FYM + Borax @ 20 kg ha^{-1} + Sodium molybdate 2 kg ha^{-1} had highest infiltration rate and T_1- (180:40:20 :: N:P:K) and T_2-1 20:60:60 :: N:P:K + 20 t/ha FYM had lowest infiltration rate. The result may be attributed to integration of organic manures which are bulky source of nutrients having high organic matter contained in it. Highest infiltration rate (0.522 mm/sec) was obtained from FYM whereas the lowest was obtained from control plot [22].

Available nitrogen

The average data of two consecutive year for the available nitrogen in soil, pre sowing and after harvesting of the crop. It clearly shows significance differences among different treatment combinations. However, FYM treated were found to increase the available nitrogen. The increased available nitrogen may be attributed to slow release of the mineral nutrients while the low available nitrogen might be attributed to the loss of the mineral nutrients or due to efficient utilization of mineralized nitrogen in short growing period [15].

Available phosphorus

The highest available P (38 kg ha^{-1}) was recorded under treatment T_3- 120:60:60 : N:P:K + 20 t/ha FYM + Borax @ 20 kg ha^{-1} + Sodium molybdate 2 kg ha^{-1} and lowest (33 kg ha^{-1}) with T_1 (180:40:20 : N:P:K). Addition of organic manure like FYM along with inorganic fertilizer had a beneficial effect in increasing the phosphate availability [23]. The increase in available P might have resulted by the solubilization of insoluble P due to application of organic manure having high P solubilization efficiency. Addition of organic manure like FYM with inorganic fertilizer had a beneficial effect in increasing the phosphate availability thus reducing phosphorus accumulation in soil [15]. Decrease in phosphorus content in INM treatments could be due to the efficient utilization of phosphorus by the plant.

Available potash

Pooled analysis of data revealed that the effect of different treatments was significant and highest potassium 275 kg ha^{-1} was recorded under T_3 and lowest 255 kg ha^{-1} in T_1. The beneficial effect of FYM on available K may be ascribed to the direct potassium addition to the potassium pool of the soil besides the reduction in potassium fixation and its release due to interaction of organic matter with clay particles. The beneficial effects of integration of organic manures + chemical fertilizers along with micronutrients in promoting inherent fertility status of soil [24] in cauliflower. Significantly higher amount of available potassium through application of biofertilizer with FYM in conjunction with inorganic fertilizers in cauliflower [25].

Table 4 Effect of different treatments on economics of cauliflower

Treatments	Cost of cultivation (Rs/ha)	Gross income (Rs/ha)	Net Income (Rs/ha)	B:C ratio
T_1	88500	386296	297796	4.36
T_2	89600	425185	335585	4.75
T_3	91300	447222	355922	4.90
CD (p=0.05)	102.08	87.36	92.74	ND

Gross income

Data on economics presented in (Table 4) revealed that gross income in different treatments varied from Rs. 447222.00 to Rs. 386296.00. The maximum gross income per hectare was witnessed in T_3 and the minimum in T_1 which indicated that transplanting of cauliflower after summer with T_3- 120:60:60 : N:P:K + 20 t/ha FYM + Borax @ 20 kg ha^{-1} + Sodium molybdate 2 kg ha^{-1} proved most profitable in respect of quality and quantity of the crop in comparison to the other treatments. It was also observed that net income per hectare with different treatments was varied significant positively.

CONCLUSION

Thus, it is concluded that the increased plant height, number of leaves, plant spread, leaf area, curd length, curd diameter, curd weight and marketable curd yield of cauliflower was the highest at Borax @ 20 kg/ha with sodium molybdenum 2 kg ha^{-1} with FYM and RDF. Similarly, root length, root diameter and root density were found better in FYM treatments. The residual soil properties such as pH, bulk density, particle density, infiltration rate, total nitrogen and available phosphorus were found better under integration of FYM. The experiment showed a significant correlation between boron and molybdenum uptake by plants. Similarly, significant correlation between plant boron with molybdenum uptake and vice versa was also observed. Synergistic interaction could be obtained by applying boron and molybdenum within soil and plant system. It can be recommended that borax 20 kg ha^{-1} and sodium molybdate 2 kg ha^{-1} as soil application in combination of recommended dose of NPK @ 120: 60:60 kg/ha (T_3) is effective in increasing the growth, yield and quality of cauliflower.

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