

Effect of Boron and Zinc on growth and yield attributes in early cauliflower (*Brassica oleracea* var. *botrytis* L.)

ABSTRACT

The present experiment was carried out with cauliflower with a view to study the effect of Boron and zinc on growth and yield in the early cauliflower having four levels of Boron as: 0, 1, 2, 3 kg ha⁻¹ and four level of Zn as: 0, 2.5, 5.0, 7.5 kg ha⁻¹ constituting sixteen treatments were applied in a Factorial Randomized Block Design with three replications during the year 2016 and 2017 respectively. The results of the experiment with applied boron and zinc had significant growth and yield in cauliflower. The highest curd depth (8.69 cm) and curd equatorial diameter (16.45 cm) was found with applied boron and zinc (2 kg ha⁻¹ + 2.5 kg ha⁻¹) respectively. While as, maximum net curd weight (368g) and marketable curd weight (485g) was found with sprayed boron and zinc (1 kg ha⁻¹ + 2.5 kg ha⁻¹) respectively. Another characters like, Maximum harvest index (63.58 %) and calculated yield (123.33 q ha⁻¹) was found when applied with boron and zinc (1 kg ha⁻¹ + 5 kg ha⁻¹) and (0 kg ha⁻¹ + 5 kg ha⁻¹) respectively. The other important traits like maximum curd compactness (34.34) and dry matter compactness (14.48) were found with application of boron (1 kg ha⁻¹) and zinc (2 kg ha⁻¹ + 5 kg ha⁻¹) respectively. Hence, on the basis of overall findings of the present investigation stated that the increasing concentration of micronutrients like boron and zinc which increases the vegetative growth as well as reproductive stage of cauliflower respectively.

Keywords: Boron, cauliflower, yield, quality, zinc.

Introduction

Cauliflower is one of the important cool season vegetable crop grown for its flavour, nutrition, delicious taste and more sensitive to soil and climatic requirements (Thakur *et al.* 2019) which is botanically known as *Brassica oleracea* var. *botrytis* L. having chromosome number 2n=18 comes under the family cruciferae.

Among many factors responsible for low productivity of cauliflower, inadequate and imbalanced nutrition occupy the top position causing nutrient deficiency, particularly of boron, which are more responsible for deteriorated soil health and yield stagnation (Yadav *et al.* 2015). Hence, soil application of micronutrients may not readily available to the plants. The foliar sprays could be beneficial to cover up the related deficiencies of these nutrients. Every micronutrient has specific role to play in the plant and its presence in optimum concentration is necessary for the plant to complete its life cycle, which ends with maturity and harvesting of the economic produce. Over the years, with intensive cultivation, Indian agriculture has moved from

an era of single element deficiency to more complex multiple nutrient deficiencies. This is true especially in the case of micronutrients. The widespread deficiency of micronutrients has increased with the introduction of high yielding varieties of crops which was known to remove higher amount of nutrients and adoption of modern agricultural technology such as multiple cropping system, irrigation, intensive use of high analysis fertilizers with concomitant decrease in recycling of crop residues and use of animal manures. Full benefits of applied nitrogen, phosphorus and potassium fertilizer can only be obtained provided the availability of micronutrients is adequately ensured. Among the micronutrients, occurrence of zinc (Zn) deficiency is quite common and widespread, followed by boron (B) in the soils of north Karnataka (Pulakeshi *et al.* 2012, Manoj kumar, 2011, Pujari, 2012 and Karajanagi, 2013).

Zinc is an indispensable micronutrient for proper plant growth and development. It plays an important role in different plant metabolic processes such as enzyme activity, development of cell wall, respiration, photosynthesis, chlorophyll formation and other biochemical functions. It is essential component of many enzymes such as carbonic anhydrase, alcohol dehydrogenase, superoxide dismutase and RNA polymerase etc and also involved in nitrogen metabolism. The deficiency of Zn in plants disrupts these processes resulting in reduced plant growth, yield and quality.

The magnitude of Zn deficiency varies widely with the soil types, while the rate of application varies with crops, soil type and climatic conditions. Zinc deficiency occurs commonly in coarse textured, calcareous or alkaline pH, low organic carbon and highly eroded soils. Zinc deficiency in Indian soils occurred in 46 per cent soils (Murthy *et al.*, 1999). In Zn deficient plants, middle leaves show development of golden yellow or orange colour in the interveinal portion. The young leaves remain small in size and often termed as “little leaf” or “rosetting”.

Boron is required for the translocation of sugars, root extension and growth of meristematic tissues, the pyrimidine biosynthetic pathway and the ATPase; it is also involved in translocation of sugars, synthesis of amino acid, protein and carbohydrate metabolism. Further, it plays a vital role in pollen enlargement, fertilization and flowering processes of plants. Boron deficiency affects development of terminal bud of shoots and growing root tips in plants, since it is immobile in plants. Therefore its deficiency, adversely affects the yield and quality of the

seeds and fruits. The effects on the yield can occur despite no deficiency symptoms are evident on the foliage. This physiological phenomenon is referred to as 'hidden hunger' which is the reason for B deficiency being an unsuspected enemy of crop production for a long time.

Boron deficiency is most widespread next to Zn causing heavy yield reduction in horticultural crops (Singh, 1999). Incidence of B deficiency is very high in the States of West Bengal, Bihar, Uttar Pradesh, Madhya Pradesh and Tamil Nadu. By and large, B deficiency is critical for crop productivity in highly calcareous, sandy, leached, lime applied acidic and laterite soils. According to All India Coordinated Research Project on Micronutrients (ICAR), B deficiency in Indian soils ranged from 0 to 68 per cent with a mean of 33 per cent (Shrotriya and Phillips, 2002).

Boron deficiency occurs in wide array of cruciferous crops such as cauliflower (brown heart), beetroot (heart rot), turnip (brown heart), and also groundnut (hollow heart). Cole crops including cauliflower require higher quantities of B for proper growth and development (Gupta, 1979). In cauliflower, boron deficiency first appears as water-soaked patches on the developing head of cauliflower which soon turn brown and may rot. The leaves curl down and become brittle. Blistering may occur on the petiole and along the midrib. The pith stem below the curd breaks down and develops the cracks which later on form an elongated cavity.

Material & Methods

Field experiment was performed to test the impact of zinc and boron on cauliflower production, yield and quality (*Brassica oleraceae* var. botrytis L.) in 2016 and 2017 at Noorsarai Horticulture College, i.e. in the southern part of Bihar. The study site's soil was coarse sandy loam with an estimated 903.5 mm annual rainfall having 4°C-44°C temperature spectrum and 30 to 95% relative humidity. The experiment was performed with three replications in a factorial Randomized Block configuration. Seedlings were transplanted into the main field twenty-five days ago, at spacing of approximately 60 cm. For three replications, the trial consisted of twelve treatments; each distributed arbitrarily according to the random number table process.

Table1.Description of the treatment are given below

| S.No. | Treatment | Details | S.No. | Treatment | Details |
|-------|-----------|---------|-------|-----------|---------|
|-------|-----------|---------|-------|-----------|---------|

| | | | | | |
|----|-------------------------------------------------|---------------------------------------------------|-----|--------------------------------------------------|---------------------------------------------------|
| 1. | T ₁ - B ₀ Zn ₀ | 0 kg ha ⁻¹ + 0 kg ha ⁻¹ | 9. | T ₉ - B ₂ Zn ₀ | 2.0 kg ha ⁻¹ + 0 kg ha ⁻¹ |
| 2. | T ₂ - B ₀ Zn ₁ | 0 kg ha ⁻¹ + 2.5 kg ha ⁻¹ | 10. | T ₁₀ - B ₂ Zn ₁ | 2.0 kg ha ⁻¹ + 2.5 kg ha ⁻¹ |
| 3. | T ₃ - B ₀ Zn ₂ | 0 kg ha ⁻¹ + 5.0 kg ha ⁻¹ | 11. | T ₁₁ - B ₂ Zn ₂ | 2.0 kg ha ⁻¹ + 5.0 kg ha ⁻¹ |
| 4. | T ₄ - B ₀ Zn ₃ | 0 kg ha ⁻¹ + 7.5 kg ha ⁻¹ | 12. | T ₁₂ - B ₂ Zn ₃ | 2.0 kg ha ⁻¹ + 7.5 kg ha ⁻¹ |
| 5. | T ₅ - B ₁ Zn ₀ | 1.0 kg ha ⁻¹ + 0 kg ha ⁻¹ | 13. | T ₁₃ - B ₃ Zn ₀ | 3.0 kg ha ⁻¹ + 0 kg ha ⁻¹ |
| 6. | T ₆ - B ₁ Zn ₁ | 1.0 kg ha ⁻¹ + 2.5 kg ha ⁻¹ | 14. | T ₁₄ - B ₃ Zn ₁ | 3.0 kg ha ⁻¹ + 2.5 kg ha ⁻¹ |
| 7. | T ₇ - B ₁ Zn ₂ | 1.0 kg ha ⁻¹ + 5.0 kg ha ⁻¹ | 15. | T ₁₅ - B ₃ Zn ₂ | 3.0 kg ha ⁻¹ + 5.0 kg ha ⁻¹ |
| 8. | T ₈ - B ₁ Zn ₃ | 1.0 kg ha ⁻¹ + 7.5 kg ha ⁻¹ | 16. | T ₁₆ - B ₃ Zn ₃ | 3.0 kg ha ⁻¹ + 7.5 kg ha ⁻¹ |

Soil Sampling and Laboratory Analysis

Samples of composite soil were taken before the cauliflower seedlings were transplanted from each block. The samples were air-dried and processed using 2 mm sieve. Testing was performed with nitrogen, phosphorus, potassium, boron, and zinc. Table 2 described the chemical properties of the soil in experimental map. General application of manures and fertilizers, distributed according to soil properties i.e. urea @ 260kg / ha, single super phosphate@ 178kg / ha and Potash Murate @133kg / ha.

Table 2: Chemical properties of the soil

| Soil parameter | Values | Status |
|-------------------------------------------------|-------------|--------|
| Soil pH (1 : 2.5) | 7.6 | |
| EC (dS/m) | 0.10 (dS/m) | |
| Organic carbon (%) | 0.61 % | Medium |
| Available N (kg/ha) | 181.88 Kg | Low |
| Available P ₂ O ₅ (kg/ha) | 34.93 kg/ha | Medium |
| Available K (kg/ha) | 138 kg/ha | Medium |
| Available S (ppm) | 18.2 ppm | Medium |
| Boron (ppm) | 0.60 ppm | Medium |
| Zinc (ppm) | 1.85 ppm | Medium |

Each bed's upper layer of 5 cm was combined with equivalent quantities of well-rotten FYM and sieved dirt. Seeds were sown 10 cm apart in sheets. Watering was performed by rose may daily. Weeding periodically rendered the raised beds tidy. Using two sprays of pesticides when appropriate held the seedlings safe. The data were taken from randomly selected five plants on various characteristics from each plot: plant height (cm), stem length (cm), amount of leaves per field, leaf area, Days to 50 percent curd Formation, Curd depth (Polar diameter)(cm), Curd compactness, gross curd weight (kg / field), net curd weight (g / plant), Marketable curd weight (g), Marketable curd yield (q / ha) and Dry matter c The data were taken from randomly

selected five plants from each plot on various characters viz., plant height (cm), stem length (cm), number of leaves per plant, leaf area, Days to 50 % curd Formation, Curd depth (Polar diameter)(cm), Curd compactness, gross weight of curd (kg/plant), net weight of curd (g/plant), Marketable curd weight (g), Marketable curd yield (q/ha), and Dry matter content of curd (%) and Harvest index (%).

Results

Growth parameters

Significant variation was observed for all the growth parameters except for stem length and days to 50% curd initiation. The plant height showed significant influenced at different levels of boron and zinc application. It was observed by random selection of five plants and presented in Table 3. The significantly superior plant height was observed in treatment T₇(68.25) which was statistically similar to T₆ (65.98) and T₈ (64.76). There was remarkable variation found in leaves per plant at harvest. The number of leaves per plant was observed highest in treatment T₁₁, T₆, T₇T₈ (21) which was significantly at par with all other treatment whereas control treatment represented the minimum number of leaves per plant (16). It is evident from the table that leaf area showed considerable amount of variation. The maximum leaf area was observed in treatment T₁₀ (697.11) followed by T₃ (696.99) and T₁₂ (657.13).

Yield components

A significant effect of micronutrient application was observed on yield components. The curd depth responded significantly to different micronutrients treatments (Table 1) and it increases as micronutrient was applied at varying rates. Maximum curd depth was recorded in treatment T₁₀ (8.69) and was statistically at par with treatment T₁₂ (8.57), T₆ (8.49). Among different sources of micronutrient, treatment T₁₀ proved its superiority over others as the maximum Curd equatorial diameter (16.45). The curd diameter was statistically at par with treatment T₉ (16.36) and T₁₁ (16.12). Net curd weight, varied significantly due to the application of different doses of boron and zinc treatments. Maximum net curd weight was observed highest in treatment T₆ (368) followed by treatment T₇ (358) and T₁₅ (350). On the other hand, control treatment-T₁ (234). A significant effect of micronutrient treatments on marketable curd weight was observed. It varied from 345g to 485g. Maximum marketable curd weight was observed highest in treatment T₆

(485). Marketable curd weight was statistically at par with the treatments T₁₅, T₃ and T₄. Lowest marketable curd weight was observed in treatments T₁.

Total dry matter and curd yield

Significant amount of variation was observed for total dry matter and curd yield due to different doses of boron and zinc. Harvest index was observed maximum in treatment T₇ (63.58) which was statistically at par with the treatments T₁₃ and T₅. Calculated yield was observed maximum in treatment T₃ (123.33) and minimum in treatment T₁ (86.37). Curd compactness varied from 29.36 to 34.34. Treatment T₅ (34.34) observed maximum curd compactness which was significantly at par with treatment T₁₀ (32.77) and T₁₄ (32.68). Dry Matter content in cauliflower varied significantly. It varied from 12.07 to 14.48 and was observed highest in treatment T₁₁ (14.48) whereas rest of the treatment was significantly at par.

Discussions

It was found that zinc and boron combinations play an active role in cauliflower vegetative growth. Because of their involvement in physiological processes and cellular functions inside plants, the beneficial impact of micronutrients on growth parameters and they also played an important role in enhancing plant growth via the biosynthesis of endogenous hormones responsible for promoting plant development. With the combined application of boron and zinc, the number of leaves per plant and leaf area increased significantly in growth, the parameters plant height. Applying foliar plant nutrients, especially boron and zinc, which play a major role in vigorous vegetative growth, may have beneficial effects by imparting deep green color to the leaf. These nutrients play an essential role in the formation of chlorophyll which has influenced cell division, meristematic tissue activity, cell expansion, and cell wall formation. It has stimulating and catalytic effects on metabolic processes which ultimately affect cauliflower's growth traits. These are in line with the Chowdhury and Sikder investigation (2017) study that micronutrients play vital roles in plant growth and production, which ultimately enhance flower yield and quality (Alloway and Brai 2008 & Khosa et al 2011).

Result indicates that foliar application of various levels of zinc and boron varies considerably. Owing to the application of micronutrient the curd diameter and curd weight increase significantly. It stimulated chlorophyll synthesis, increased physiological activities such as those that photosynthesize from leaves to curd for translocation of plant assimilates, and their

deposition in curd. Improvement in photosynthesis and other metabolic activity resulted in an increase in the various plant metabolites responsible for cell division and elongation. The higher curd yield may be due to the synergetic effect between boron and zinc applied to the plant. This can act as energy source for auxin synthesis. Chaudhari et al (2017) and Hasan et al 2018 have documented an improved photosynthetic reaction in the presence of zinc and boron.

Absolute dry matter and curd compactness of rise coupled with zinc and boron production at various stages. The primitive influence of B and Zn on the transfer of further carbohydrates, proteins along with their function in improving their translocation from the synthesis site to the storage organs. It helps to improve development by using adequate nitrogen and phosphorus amounts. The results above were in consonance with Chaudhari et al 2017 and Rene et al 2017.

Conclusion

There was significantly higher gross plant weight (kg), Curd diameter (cm), curd depth (cm), Net curd weight (kg) among different rates of B and Zn use. Treatment T₁₅ — B₃Zn₂ — (3.0 kg / ha + 5.0 kg / ha) found a maximum yield of 152.22 q / ha for T₁₁ — B₂ Zn₂- (2.0 kg / ha + 5.0 kg / ha) of 148.88 q / ha for calculated yield (q / ha). It can be concluded from the "Impact of application of boron and zinc supplements on growth, yielding characteristics and cauliflower quality" investigation.

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Table 3. Mean of growth and yield component of cauliflower

| Characters/ Treatment | Growth parameters | | | | | Yield components | | | | Total dry matter and curd yield | | | |
|--------------------------|-------------------|------------------|-------------------------|----------------------------------|-----------------------------|------------------|-------------------------------|---------------------|----------------------------|---------------------------------|---------------|------------------|----------------|
| | Plant height (cm) | Stem length (cm) | No. of leaves per plant | Leaf Size (L x B)cm ² | Days to 50% curd initiation | Curd depth (cm) | Curd equatorial diameter (cm) | Net curd weight (g) | Marketable curd weight (g) | Harvest Index % | i (q/Ha) | Curd Compactness | Dry Matter (%) |
| T1- B0 Zn0 | 49.13 | 13.78 | 16 | 468.66 | 113 | 6.33 | 11.42 | 234 | 345.5 | 51.10 | 86.37 | 30.52 | 13.87 |
| T2- B0 Zn1 | 53.68 | 16.44 | 17 | 539.10 | 109 | 7.80 | 12.75 | 320 | 451 | 57.32 | 112.75 | 30.65 | 12.07 |
| T3- B0 Zn2 | 56.01 | 16.98 | 19 | 616.88 | 102 | 7.23 | 13.54 | 325 | 480 | 55.85 | 123.33 | 30.02 | 13.23 |
| T4- B0 Zn3 | 52.26 | 16.58 | 20 | 590.51 | 105 | 7.57 | 13.54 | 320 | 480 | 54.71 | 120.00 | 30.16 | 12.35 |
| T5- B1 Zn0 | 49.74 | 13.22 | 17 | 592.99 | 105 | 8.11 | 13.15 | 310 | 420 | 59.16 | 105.00 | 34.34 | 12.92 |
| T6- B1 Zn1 | 65.27 | 14.72 | 21 | 615.45 | 108 | 8.49 | 14.15 | 368 | 485 | 62.04 | 121.25 | 32.51 | 13.56 |
| T7- B1 Zn2 | 67.53 | 16.62 | 21 | 643.36 | 108 | 8.43 | 15.07 | 358 | 455 | 63.58 | 113.75 | 29.36 | 13.48 |
| T8- B1 Zn3 | 67.47 | 16.28 | 21 | 580.80 | 104 | 8.19 | 15.00 | 345 | 462 | 60.96 | 115.50 | 29.74 | 13.30 |
| T9- B2 Zn0 | 59.47 | 16.27 | 16 | 607.78 | 103 | 8.22 | 16.36 | 305 | 445 | 55.63 | 111.25 | 32.77 | 14.30 |
| T10- B2 Zn1 | 60.53 | 17.77 | 19 | 697.11 | 100 | 8.69 | 16.45 | 310 | 475 | 54.02 | 118.75 | 32.39 | 14.48 |
| T11- B2 Zn2 | 60.33 | 17.87 | 21 | 652.12 | 100 | 8.42 | 16.12 | 327 | 460 | 58.47 | 115.00 | 31.79 | 13.98 |
| T12- B2 Zn3 | 66.04 | 17.52 | 20 | 657.13 | 98 | 8.57 | 16.00 | 335 | 455 | 60.62 | 113.75 | 31.35 | 12.13 |
| T13- B3 Zn0 | 49.83 | 16.57 | 19 | 580.89 | 102 | 7.20 | 15.89 | 340 | 435 | 63.32 | 108.75 | 32.45 | 11.83 |
| T14- B3 Zn1 | 60.56 | 17.12 | 19 | 630.46 | 102 | 7.76 | 15.80 | 335 | 460 | 59.60 | 115.00 | 32.68 | 12.29 |
| T15- B3 Zn2 | 60.91 | 16.28 | 19 | 653.59 | 99 | 7.67 | 15.33 | 350 | 480 | 60.42 | 120.00 | 32.23 | 12.98 |
| T16- B3 Zn3 | 53.51 | 15.39 | 18 | 590.38 | 99 | 7.11 | 15.33 | 335 | 450 | 61.13 | 112.50 | 31.5 | 12.45 |
| Mean | 58.26 | 16.21 | 18.93 | 607.32 | 103.56 | 7.86 | 14.74 | 326.06 | 452.40 | 58.62 | 113.30 | 31.52 | 13.07 |
| CD @ 5 % | 6.557 | NA | 1.979 | 55.23 | NA | 0.72 | 1.16 | 25.758 | 40.198 | 3.953 | 7.659 | 2.116 | 1.392 |
| CV | 7.091 | 5.929 | 6 | 5.45 | 5.557 | 5.43 | 4.69 | 4.284 | 3.745 | 4.216 | 4.586 | 4.006 | 6.354 |