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Impact of foliar application of different micronutrients morpho-physiological and yield traits of Broccoli (*Brassica oleracea* var. *italica*) F1 hybrid Shishir

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Abstract
Broccoli, one of the cool climate vegetables, is highly resistant to low temperatures and can be grown easily in areas with temperate climates. Nutrient management such as fertilization with nitrogen and micronutrients is an important practice to increase the yield and quality of broccoli. Therefore, the present study, "Impact of foliar application of different micronutrients morpho-physiological and yield traits of Broccoli (*Brassica oleracea* var. italica) F1 hybrid Shishir," was carried out. for two consecutive years 2018-19 and 2019-20 during the *Rabi* season in polyhouse conditions at the Department of Plant Physiology, Agricultural Biochemistry, Medicinal and Aromatic Plants, College of Agriculture, Raipur, Chhattisgarh. The experiment was carried out following the Randomized Block Design with six replications and hybrid Shishir F_1 was used as planting material. The treatment consisted of different concentration and combination of micronutrient *viz*., boron (B) and molybdenum (Mo) along with basal dose of fertilizers (RDF). During the study various phenological, morpho-physiological, yield and yield attributing traits were recorded and results showed that application of micronutrients significantly improve the growth, physiology, yield and yield-contributing traits of broccoli. The most promotive results were obtained with a combined application of B and Mo at 1.0% followed by B and Mo at 1.25% with 100% RDF. On the other hand, the highest SCMR values were recorded with the foliar application of B and Mo at 1.25% followed by B and Mo at 1.0% with 100% RDF; whereas yield-contributing traits and final curd yield were found highest with B and Mo at 0.75% in combination with basal dose of N, P and K at 100%.In conclusion, the identified concentrations of micronutrients could be used for the improvement of growth, physiology and yield of broccoli crop.

Keywords: Broccoli, micronutrients, boron, molybdenum, phenology, morpho-physiological, yield and yield attributing traits

1. Introduction
Broccoli (*Brassica oleracea* var. italica) is a well-known cole crop and is one of the most nutritious edible green plants of Brassicaceae family, whose large flowering head is edible. It has 14 times more beta-carotene than cultivated cabbage and under exploited crop in India (Sharma, 2000) [18]. With the recent advancement of horticulture, it is mostly cultivated in hilly states of India like Himachal Pradesh, Uttar Pradesh, Jammu and Kashmir, Nilgiri Hills and Northern plains of India. Broccoli is considered as a valuable vegetable due to presence of vitamins, antioxidants, glucosinolates and other anti-carcinogenic compounds (Parente *et al*., 2013) [15]. Its florets also showed some amount of omega-3 fatty acids which help to control bad cholesterols. Thus, broccoli market value is becoming very high, especially in super markets, big hotels and restaurant etc.
Successful production of broccoli includes many factors of which application of micronutrients such as B and Mo is most important. Molybdenum (Mo) is an essential micronutrient for plants as it directly related to metabolic function of nitrogen in the plant through nitrate reductase enzyme that reduces the nitrate to nitrite (Bambara *et al*. 2010) [1]. Molybdenum stimulates nodulation and biological nitrogen fixation, thus improving the plant growth (Elkhatib, 2009) [5]. Molybdenum increases cauliflower yield and ascorbic acid content (Hunashikatti *et al*. 2000) [7]. The deficiency generally occurs in crops when grown in very acidic soils or on very well drained alkaline soils. The deficiency symptoms include chlorosis, leaves may turn white particularly along leaf margins, leaf become cupped, wither and eventually die. The growing point of plant also collapses (Ningawale *et al*. 2016) [13].
Similarly, boron is an element that vegetables and other plants need in trace amounts and affecting growth and yield of cole crops (Yaziciand Korkmaz, 2020) [23].

Moniruzzaman *et al*. (2007) [12] determined that boron fertilization in addition to nitrogen fertilization increased plant height, number of leaves per plant, leaf size, main head weight, and yield in broccoli. Similarly, Saha *et al*. (2010) [17] found that foliar applications of boron also increase the yield of the main head in broccoli. In addition, it has been determined that 1.0 kg ha^{-1} additional boron application may be suitable for high yield in broccoli. If the correct fertilization is not made in soils especially poor in boron since the nutrient uptake of broccoli is high yield and quality losses can occur (Hussain *et al*., 2012) [6]. For this reason, the importance of balanced fertilization is revealed once again to increase yield and plant growth quality (Korkmaz *et al*., 2021) [10]. Even though micronutrients are required in small quantities, are very much essential for good crop growth and achieving profitable yield. On the other hand, most of the agricultural soils of the world are reported to be inadequate in one or more of the essential nutrients to render healthy plant. This situation supports the view that approximately 60%of the world's arable land is not suitable for crop production due to a lack of some important plant nutrients (Bukvić *et al*., 2003) [2]. Among the many factors responsible for low productivity of broccoli, inadequate and imbalanced nutrient supply occupies the first position, particularly of boron, and molybdenum. The rate of fertilizer application has increased than earlier in crop production whereas; application of micronutrients has largely been neglected and deficiency of micronutrients is more prevalent in Indian soils. Another reason is over mining of soil nutrient by plants which causes most of the micronutrients run short in supply to the crops and appearance of disorders, resulting in low yields.

Decreasing yield trend and the deteriorated quality and curd production in India especially in Chhattisgarh is commonly observed. Although broccoli is a high-value vegetable crop in the world, there is a lack of research to show the effects of boron and molybdenum on broccoli, especially in field conditions. Therefore, rational and optimum use of micronutrient coupled with recommended fertilizers would be beneficial for increasing curd yield per unit area in broccoli. Keeping in view these facts and considering above all the perspective, the present investigation was carried out to assess the effect of different micronutrients on phenology, morpho-physiological, yield and yield-attributing traits of broccoli under polyhouse conditions.

2. Material and Methods

The whole study was conducted for two consecutive years 2018-19 and 2019-20 during the *Rabi* season. The experiment was carried out in polyhouse conditions at the Department of Plant Physiology, Agricultural Biochemistry, Medicinal and Aromatic Plants, College of Agriculture, Raipur, Chhattisgarh. The Research Site is located at 21.235 Nlatitude, 81.70 E longitude, and 289.01±11 m above sea level. The planting materials for experiment work was consisted of broccoli hybrid Shishir F_1.The experiment was carried out following the Randomized Block Design with six replications. The sowing was done by dibbling method on 29thNovember 2019 during first year and on 8th October 2020 during second year of experimentation. The seedlings were irrigated at regular interval and need based plant protection measures were taken up as and when necessary. The seedlings were ready for transplanting within three weeks.

The recommended dosage of fertilizers was given though drip method (N, P and K); whereas micronutrients were applied as foliar spray two times i.e., at 20 and 40 days after transplanting (prior to flowering stage). The different treatments, i.e., T_0-control−Recommended Dose of Fertilizers (RDF), T_2- RDF + (Mo +B at 0.25%), T_3- RDF + (Mo +B at 0.25%), T_4-RDF + (Mo +B at 0.25%), T_5-RDF + (Mo +B at 0.25%) were applied. The morphological observations were recorded at 20 days, 40 days and at harvesting stage after transplanting (DAT).

The morpho-phenological traits like days to first curd initiation, days to 50% curd maturity, days to maturity, plant height, number of leaves, plant spread were recorded. The phenological traits were recorded when crop appeared to respective stage; whereas morphological traits were recorded at 20 days, 40 days after transplanting. Similarly, physiological traits such as leaf area $plant^{-1}$, and SPAD chlorophyll meter readings (SCMR) were recorded at 40 and 60 and at harvesting stage. The yield contributing such as weight of curd with and without guard leaves, fresh and dry weight of plant, and final curd yield was recorded at harvest. The significance of variation was estimated using the methods as suggested by Panse and Sukhatme (1985) for randomized block design.

3. Results and discussion

3.1. Effect of different micronutrients (B and Mo) on phenological Parameters of broccoli

The data on phenological traits *viz*., days to first curd formation, days to 50% curd maturity and days to total curd maturity were recorded and significant differences were observed during both the seasons. The obtained results revealed that days to first curd formation ranged from 64.00 to 70.00 days with a mean of 67.71 days during the first year and from 68.34 to 73.33 days with a mean of 70.99 days during the second year. Similarly, days to 50% curd maturity varied from 84.00 to 87.67 days with a mean of 85.11 days; whereas from 81.67 to 86.00 days with a mean of 84.49 days during first and second year respectively. The results obtained on days to full curd maturity further revealed a variation from 87.00 to 93.67 days with a mean of 89.77 days during first year and from 86.65 to 94.00 days with a mean of 89.10 days during second year respectively. The mean performance revealed that the application of micronutrients (B and Mo) significantly results in earliness flowering and maturity in broccoli. The most promotive results were recorded when plants were treated with a combined application of B and Mo at 1.0% in combination with 100% RDF (T_4) followed by B and Mo at 1.25% with 100% RDF (T_5) during both the seasons compared to rest of treatments and control.

Crop duration is inter-actively determined by genotype x environment (Dingkuhn and Asch 1999) [4]. The experimental results showed that day to first curd initiation, days have taken to 50% curd maturity, days to maturity significantly reduced due to application of both micronutrients (boron and molybdenum) when applied in combinations along with basal dose of N, P, and K. similar to these results, the reports from Sitapara *et al*. (2011) [20]; Kumar *et al*. (2012) [11]; Singh *et al*. (2018) [19] also observed similar pattern of earliness in maturity. This might be due to the positive role played by regulating micronutrients in the balanced absorption of nutrients might improve physiological activities, which resulted in the endogenous growth hormone synthesis responsible for early curd formation in plants.

The present result is in agreement with the findings of Kumar *et al*. (2012) [11].

3.2. Effect of different micronutrients (B and Mo) on morphological traits of broccoli

The mean performances revealed that plant height significantly ranged from 13.13 to 17.07 cm with a mean of 15.03 cm during the first season; whereas from 11.93 to 16.23 cm with a mean of 14.19 cm during the second season at 20 DAT. The range of variation was from 30.53 to 34.33 cm with a mean of 32.26 cm and from 31.63 to 35.83 with a mean of 33.83 cm during first and second season respectively. Furthermore, plant height was also recorded at harvest and found to varied from 42.80 to 48.73 cm with a mean of 46.78 cm during first season; whereas from 42.40 to 46.62 cm with a mean of 45.10 cm during the second season.

The data recorded on the number of leaves revealed significant differences at all the growth stages (20, 40 DAT, and at harvest). During the first season, the number of leaves varied from 3.67 to 6.32 with a mean of 5.16 at 20 DAT, from 11.00 to 14.00 with a mean of 12.56 at 40 DAT, and from 11.50 to 16.74 with a mean of 14.18 at harvest. Similarly, during the second season, the number of leaves varied from 4.00 to 6.35 with a mean of 5.23 at 20 DAT, from 10.67 to 14.34 with a mean of 12.89 at 40 DAT, and from 12.34 to 17.33 with a mean of 13.92 at harvest. It was observed from the results that application of micronutrients (B and Mo) along with RDF in any combination enhanced the number of leaves in broccoli plants. However, most superior results were obtained with the foliar application of B and Mo at 1.0% followed by B and Mo at 0.75% in combination with RDF compared to control during both the seasons at all the growth stages.

The data on plant spread showed that plant spread significantly varied from 19.77 to 24.07 cm with a mean of 21.62 cm in the first year; while from 19.56 to 22.81 cm with a mean of 21.43 cm during the second year at 20 DAT. At 40 DAT, plant spread ranged from 32.60 to 36.17 cm with a mean of 34.65 cm during the first season; whereas from 33.60 to 36.09 cm with a mean of 34.67 cm during the second season. At the harvesting stage, plant spread was found to vary from 39.33 to 45.57 cm with a mean of 42.48 cm and from 38.14 to 44.65 cm with a mean of 41.50 cm during the first and second seasons. The mean performance showed that foliar spray of B and Mo at 1.0% in combination with RDF at 100% (T_4) results in maximum plant spread followed by foliar spray of B and Mo at 0.75% in combination with RDF at 100% (T3) at all the growth stages (20, 40 DAT and at harvest) during both the years compared to control.

It was observed from the results that foliar application of both micronutrients (B and Mo) significantly promotes growth and development and enhances morphological traits. Along with this, it is also evident from the results that as the concentration of micronutrients increases, plant height and number of leaves were also increases correspondingly. The promotive effect of boron and molybdenum on morphological traits was also reported by Patel *et al*. (2017) [16], Singh *et al*. (2018) [19], Jakhar *et al*. (2018) [9], Chowdhury and Sikder (2019) [3], and Tudu *et al*. (2020) [22] in broccoli.

The improvement in morphological traits might be due to the positive effect of boron and molybdenum which enhanced photosynthetic activity, and efficient assimilation of photosynthetic products and resulted in rapid cell division and cell elongation in the growing portions of the plant ultimately causing an increased plant height. In addition, adequate boron improves phosphorus and potassium uptake maintaining the proper function and structure of the cell membrane. Similarly, Pandey *et al*. (2020) [14] stated that boron is essential for the structural integrity of the cell wall in plants. It helps with sugar or energy translocation into growing parts of the plant; thus, it affects carbon and nitrogen metabolism and increases plant height. Boron is taken into consideration as important for actively growing plant parts, particularly for root tips, new leaves, and bud development. On the other hand, it was also noticed that excess application of micronutrients leads to a negative impact on the number of leaves and these results follow the findings of Islam *et al*. (2015) [8].

3.3. Effect of different micronutrients (B and Mo) on physiological traits of broccoli

The SCMR values were recorded at 20, 40 DAT and at harvesting stage and data revealed significant differences at all the growth stages. During the first season, the SCMR values varied from 31.33 to 42.30 with a mean of 38.00, from 41.73 to 48.83 with a mean of 12.56, from 31.20 to 36.12 with a mean of 34.00 at 20, 40 DAT and at harvesting stage respectively. Similarly, during second season, SCMR values ranged from 33.51 to 41.37 with a mean of 38.15 at 20 DAT, from 44.53 to 49.89 with a mean of 46.97 at 40 DAT, and from 30.20 to 35.40 with a mean of 32.95 at harvest. The mean performance further showed that the foliar application of B and Mo at 1.25% in combination with 100% RDF (T_5) results in the highest SCMR values followed by treatment with B and Mo at 1.0% with 100% RDF (T_4) compared to all rest of treatments and control at all growth stages.

The data on leaf area were recorded and significant differences were observed. During the first year, the leaf area ranged from 472.20 to 598.42 cm^2 with a mean of 551.06 cm^2 at 20 DAT, from 1051.10 to 1480.18 cm^2 with a mean of 1252.17 cm^2 at 40 DAT, and from 990.79 to 1598.34 cm^2 with mean of 1301.67 cm^2 at harvesting stage. Likewise. during the second season, the range of variation was from 498.21 to 675.12 cm^2 with a mean of 593.11 cm^2 at 20 DAT, from 1110.4 to 1568.17 cm^2 with mean of 1358.69 cm^2 at 40 DAT and from 1078.31 to 1652.47 cm^2 with mean of 1359.36 cm^2 at harvest. From the result, it was observed that the maximum leaf area was recorded with a combined application of B and Mo at 1.0% along with 100% RDF (T4) followed by B and Mo at 1.25% along with 100% RDF (T5) at all growth stages compared to control.

Chlorophyll is one of the most important chloroplastic components for photosynthesis because it harvests light energy and produces reducing powers. The present study showed that foliar application of micronutrients (B and Mo) enhances the micronutrient SPAD values. The above results were following the finding of Jakhar *et al*. (2018) [9], and Chowdhury and Sikder (2019) [3] in broccoli crops. Molybdenum (Mo) is an essential micronutrient for higher plants and plays an important role in the photosynthetic process because of its key involvement in the chlorophyll biosynthesis pathway, chloroplast configuration and ultrastructure (Yu and Wuhan, 2005) [24]. In addition, previous studies reported that Mo deficiency results in yellowing and etiolating leaves inhibition of chlorophyll biosynthesis (Sun *et al*., 2009) [21], and abnormal changes in the chloroplast ultrastructure and configuration (Yu and Wuhan, 2005) [24].

Similarly, the observed results indicated that foliar application of both boron and molybdenum enhanced the leaf area when given at any concentration. Similar to these results, the findings from previous researchers such as Singh *et al*. (2018) [19], Tudu *et al*. (2020) [22], and Jakhar *et al*. (2018) [9] were also in agreement.

This increase in leaf area (leaf length and width) might be due to the involvement of boron and molybdenum in cell division and meristematic growth of the tissue. On the other hand, the use of adequate Mo improves plant health and growth. In cauliflower, Mo deficiency appears symptoms in younger leaf tissues with the characteristic loss of proper lamina development, leathery leaves, and meristem necrosis, and plants become stunted. Furthermore, increased leaf area might be due to the stimulating influence of boron enhancing the rate of absorption of N, P and K, and other nutrients. The nitrogen in turn promotes quick growth and is helpful to attain maximum vegetative growth including plant height, leaf growth, and plant spread (Moniruzzaman *et al*. 2007) [12].

3.3. Effect of different micronutrients (B and Mo) on yield-contributing traits of broccoli

The plant's fresh and dry weights were recorded and result revealed significant differences. During the first season, fresh weight of the plant ranged from 1132.24 to 1370.92 g with an average fresh weight of 1263.89 g. During the second season, the fresh weight of the plant varied from 1252.11 g to 1416.83 g with a mean of 1359.91 g. Likewise, the dry weight of the plant ranged from 108.14 to 147.04 g with a mean of 132.95 during first season, whereas it ranged from 114.94 to 138.65 g with an average of 129.95 g during the second season. It was observed that during both the seasons fresh and dry weights of plant's were found highest when plants were treated with a combined application of B and Mo at 0.75% along with RDF at 100% (T_3) followed by treatment with B and Mo at 1.0% + RDF at 100% (T4) compared to control.

The data on curd diameter were recorded and found to varied significantly from 13.33 cm to 15.20 cm with an average diameter of 14.23 cm, whereas from 13.23 cm to 14.70 cm with an average diameter of 13.99 cm during first and second seasons respectively. In both seasons, the highest curd weight was recorded due to a combined application of B and Mo at 0.75% along with a basal dose of N, P, and K in combination (T_3), followed by T_4 (B and Mo at 1.0% + 100% RDF) compared to control. The per se performance revealed that curd weight without leaves varied from 263.33 to 382.00 g with a mean of 337.63 g during the first year; whereas from 303.33 to 466.87 g with a mean of 370.16 g during the second year. It was observed that the application of micronutrients (B and Mo) significantly increased the curd weight of broccoli. The maximum curd weight without leaves was recorded with a combined application of B and Mo at 0.75% in combination with 100% RDF (T3) followed by B and Mo at 1.0% with 100% RDF (T4) during both seasons compared to the rest of treatments and control.

The data on the final curd yield of plant^{-1} was recorded and it varied from 263.38 to 382.00 g, with an average curd yield of 333.68 g during first season; whereas from 329.47 to 466.87 g with a mean of 382.28 g during second season. The maximum curd yield was noticed under a combined application of B and Mo at 0.75% as a foliar spray in addition to a basal dose of N, P, and K at 100% (T3), followed by B and Mo at 0.75% in combination with RDF at 100% (T3) compared to the control and rest of the treatments. It is concluded from the mean data that the collective application of B and Mo to the broccoli plants significantly enhanced the fresh/dry weights, curd diameter, curd weight and final curd yield and this fact is consistent with the results of Islam *et al*. (2015) [8], Ningawale *et al*. (2016) [13], Taheri *et al*. (2020), Tudu *et al*. (2020) [22] and Kaymak and Kazdal (2022) in broccoli.

In addition, various researchers reported that the yield of broccoli is affected by cultivars, nitrogen doses, seedling age, planting time, and plant density (Yaralı *et al*., 2007; Hussain *et al*., 2012) [6]. Boron plays an important role in many biochemical processes in plants, like carbohydrate metabolism and the transport of sugar through membranes, tissue development, and cell division (Kumar *et al*. 2010) [11]. Collectively it resulted in rapid cell division and cell elongation in the growing portions of the plant ultimate caused an increased in fresh/dry weight of broccoli. Pizetta *et al*. (2005), in their studies with broccoli, cabbage, and cauliflower, obtained positive results in growth, development, and yield due to the increase in boron dose, thus showing the positive relationship between boron application and the increase in yield of Brassicaceae species.

The better efficacy of the combined application of boron and molybdenum might also be due to the better availability of soil nutrients, which facilitate good vegetative growth and reflect head diameter (Saha *et al*., 2010; Singh *et al*., 2017) [17]. Application of B and Mo might be attributed to their role in increasing the rate and efficiency of metabolic activities, resulting in high assimilation of proteins and carbohydrates, enhancing the translocation of carbohydrates from the site of their synthesis to the storage tissue, which in turn helps in improved nutrient absorption by plants, resulting in higher yields.

Table 1: The effect of micronutrients (boron and molybdenum) on phenology of broccoli cultivar SHISHIR F1 HYBRID in Rabi season during year 2018-19 and 2019-20

Treatments	Days to first curd formation			Days to 50% curd maturity			Days to curd maturity		
	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
T_0 (Control)	70.00	73.33	71.67	87.67	86.00	86.84	93.67	94.00	93.84
T_1RDF + (Mo + B 0.25%)	68.33	70.62	69.48	85.06	84.78	84.92	91.30	91.00	91.15
T_2RDF + (Mo + B 0.50%)	67.93	71.33	69.63	84.91	85.16	85.04	89.00	87.66	88.33
T_3 RDF + (Mo + B 0.75%)	68.33	72.00	70.17	84.66	85.31	84.99	89.31	87.67	88.49
T_4 RDF + (Mo + B 1.0%)	64.00	68.34	66.17	84.00	81.67	82.84	87.00	86.65	86.83
T_5 RDF + (Mo + B 1.25%)	67.67	70.31	68.99	84.34	84.00	84.17	88.33	87.64	87.99
C.V.	2.73	3.76	1.77	1.07	0.74	0.80	1.48	1.12	1.10
SE(m)	1.06	1.51	0.70	0.53	0.36	0.39	0.73	0.55	0.54
C.D.	3.39	3.06	2.24	1.68	1.15	1.26	2.32	1.77	1.69

Table 2: The effect of micronutrients (boron and molybdenum) on plant height of broccoli cultivar SHISHIR F1 HYBRID in Rabi season during year 2018-19 and 2019-20

Treatments	Plant height(cm) at 20 DAT			Plant height (cm) at 40 DAT			At harvest stage		
	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
T_0 (Control)	13.13	11.93	12.53	30.60	31.63	31.12	42.80	42.40	42.60
T_1RDF + (Mo + B 0.25%)	14.70	13.33	14.02	30.53	32.13	31.33	45.43	45.20	45.32
T_2RDF + (Mo + B 0.50%)	15.10	14.73	14.92	32.63	34.87	33.75	48.42	45.48	46.95
T_3 RDF + (Mo + B 0.75%)	15.12	14.97	15.05	33.23	35.47	34.35	48.50	46.10	47.30
T_4 RDF + (Mo + B 1.0%)	17.07	16.23	16.65	34.33	35.83	35.08	48.73	46.62	47.68
T_5 RDF + (Mo + B 1.25%)	15.08	13.95	14.52	32.24	33.07	32.66	46.77	44.80	45.79
C.V.	2.53	6.17	3.23	3.76	3.53	2.93	3.86	2.41	2.14
SE(m)	0.22	0.51	0.27	0.7	0.69	0.56	1.04	0.69	0.57
C.D.	0.70	1.61	0.87	2.24	2.2	1.78	3.33	2.19	1.82

Table 3: The effect of micronutrients (boron and molybdenum) on number of leaves of broccoli cultivar SHISHIR F1 HYBRID in Rabi season during year 2018-19 and 2019-20

Treatments	Number of leaves at 20 DAT			Number of leaves at 40 DAT			Number of leaves at harvest		
	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
T_0 (Control)	3.67	4.00	3.84	11.00	10.67	10.84	11.50	12.34	11.92
T_1RDF + (Mo + B 0.25%)	5.33	5.00	5.17	11.33	12.00	11.67	12.67	13.17	12.92
T_2RDF + (Mo + B 0.50%)	6.00	5.00	5.50	12.00	12.67	12.34	13.65	13.32	13.49
T_3 RDF + (Mo + B 0.75%)	5.65	5.67	5.66	13.67	13.33	13.50	15.52	14.00	14.76
T_4 RDF + (Mo + B 1.0%)	6.32	6.35	6.34	14.00	16.34	15.17	16.74	17.33	17.04
T_5 RDF + (Mo + B 1.25%)	4.00	5.33	4.67	13.34	12.32	12.83	15.00	13.37	14.19
C.V.	11.74	7.55	11.07	8.40	4.75	6.45	3.46	6.61	4.21
SE(m)	0.38	0.23	0.33	0.61	0.34	0.47	0.31	0.60	0.38
C.D.	1.21	0.73	1.06	1.95	1.10	1.50	0.99	1.92	1.20

Table 4: The effect of micronutrients (boron and molybdenum) on plant spread (cm^2) of broccoli cultivar SHISHIR F1 HYBRID in Rabi season during year 2018-19 and 2019-20

Treatments	Plant spread (cm^2) at 20 DAT			Plant spread (cm^2) at 40 DAT			Plant spread (cm^2) at harvest		
	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
T_0 (Control)	19.77	19.56	19.67	32.60	33.60	33.10	39.33	38.14	38.74
T_1RDF + (Mo + B 0.25%)	20.83	20.78	20.81	33.63	33.72	33.68	41.70	39.83	40.77
T_2RDF + (Mo + B 0.50%)	20.93	21.77	21.35	35.12	34.19	34.66	40.80	40.95	40.88
T_3 RDF + (Mo + B 0.75%)	22.37	22.18	22.28	35.27	35.34	35.31	44.83	43.03	43.93
T_4 RDF + (Mo + B 1.0%)	24.07	22.81	23.44	36.17	36.09	36.13	45.57	44.65	45.11
T_5 RDF + (Mo + B 1.25%)	21.73	21.46	21.60	35.11	35.09	35.10	42.67	42.37	42.52
C.V.	4.71	4.02	4.07	3.00	1.65	1.68	2.45	2.06	1.90
SE(m)	0.59	0.50	0.51	0.60	0.33	0.34	0.60	0.49	0.46
C.D.	1.88	1.59	1.61	1.93	1.06	1.08	1.92	1.57	1.47

Table 5: The effect of micronutrients (boron and molybdenum) on SPAD of broccoli cultivar SHISHIR F1 HYBRID in Rabi season during year 2018-19 and 2019-20

Treatments	SPAD at 20 DAT			SPAD at 40 DAT			SPAD at harvest		
	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
T_0 (Control)	31.33	33.51	32.42	41.73	44.53	43.13	31.20	30.21	30.71
T_1RDF + (Mo + B 0.25%)	36.80	37.34	37.07	44.57	46.13	45.35	32.48	30.20	31.34
T_2RDF + (Mo + B 0.50%)	37.57	38.51	38.04	47.57	45.54	46.56	33.17	33.80	33.49
T_3 RDF + (Mo + B 0.75%)	39.97	38.44	39.21	48.33	47.52	47.93	35.48	32.83	34.16
T_4 RDF + (Mo + B 1.0%)	40.00	39.73	39.87	47.97	48.19	48.08	35.53	35.24	35.39
T_5 RDF + (Mo + B 1.25%)	42.30	41.37	41.84	48.83	49.89	49.36	36.12	35.40	35.76
C.V.	4.13	3.31	2.82	4.71	5.08	5.28	0.91	3.81	0.91
SE(m)	0.91	0.74	0.62	0.97	1.08	1.11	0.18	0.73	0.18
C.D.	2.89	2.37	1.99	3.11	3.45	3.53	0.57	2.31	0.56

Table 6: The effect of micronutrients (boron and molybdenum) on leaf area of broccoli cultivar SHISHIR F1 HYBRID in Rabi season during year 2018-19 and 2019-20

Treatments	Leaf area (cm^2) at 20 DAT			Leaf area (cm^2) at 40 DAT			Leaf area (cm^2) at harvest		
	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
T_0(Control)	472.20	498.21	485.21	1051.10	1110.40	1080.75	990.79	1078.31	1034.55
T_1RDF + (Mo + B 0.25%)	551.14	575.65	563.40	1152.14	1294.25	1223.20	1193.13	1270.61	1231.87
T_2RDF + (Mo + B 0.50%)	559.10	593.34	576.22	1213.16	1200.13	1206.65	1206.15	1152.47	1179.31
T_3 RDF + (Mo + B 0.75%)	554.16	597.14	575.65	1290.00	1371.20	1330.60	1369.20	1492.18	1430.69

T_4 RDF + (Mo + B 1.0%)	598.42	675.12	636.77	1480.18	1568.17	1524.18	1598.34	1652.47	1625.41
T_5 RDF + (Mo + B 1.25%)	571.31	619.22	595.27	1326.41	1488.00	1407.21	1452.42	1510.14	1481.28
C.V.	5.24	2.34	3.30	3.22	2.38	1.42	2.42	3.45	2.04
SE(m)	16.68	8.00	10.91	23.26	18.43	10.64	18.15	27.09	15.65
C.D.	53.24	25.52	34.81	74.23	58.82	33.95	57.92	86.46	49.96

Table 7: The effect of micronutrients (boron and molybdenum) on fresh weight, dry weight and final curd yield with and without leaves of broccoli cultivar SHISHIR F1 HYBRID in Rabi season during year 2018-19 and 2019-20

Treatments	Fresh weight of plant (g)			Dry weight of plant (g)			Final curd yield (g)		
	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
T_0(Control)	1,132.24	1,252.11	1,192.18	108.14	114.94	111.54	263.38	329.47	296.40
T_1RDF + (Mo + B 0.25%)	1,140.55	1,320.31	1,230.43	124.36	126.13	125.25	326.67	326.69	326.67
T_2RDF + (Mo + B 0.50%)	1280.57	1,394.51	1337.54	139.88	135.05	134.03	303.33	370.00	303.33
T_3 RDF + (Mo + B 0.75%)	1,370.92	1,416.83	1,393.88	147.04	138.65	141.05	382.00	466.87	424.43
T_4 RDF + (Mo + B 1.0%)	1,330.71	1,397.11	1,363.91	140.51	136.73	138.62	368.29	405.66	387.83
T_5 RDF + (Mo + B 1.25%)	1,328.33	1,378.59	1,353.46	137.74	128.18	138.20	356.70	303.33	384.17
C.V.	3.41	3.27	1.91	2.66	1.72	1.41	5.39	8.15	4.63
SE(m)	24.86	25.71	14.49	2.04	1.29	1.07	10.38	17.60	9.45
C.D.	79.34	82.06	46.26	6.52	4.13	3.41	33.14	56.18	30.17

Table 8: The effect of micronutrients (boron and molybdenum) on curd diameter, curd weight with and without leaves of broccoli cultivar SHISHIR F1 HYBRID in Rabi season during year 2018-19 and 2019-20

Treatments	Curd diameter (cm^2)			Curd weight without Leaves (g)		
	2018-19	2019-20	Pooled	2018-19	2019-20	Pooled
T_0 (Control)	13.33	13.23	13.28	263.33	329.47	296.40
T_1RDF + (Mo + B 0.25%)	13.90	13.83	13.87	326.67	303.94	315.31
T_2RDF + (Mo + B 0.50%)	13.90	13.63	13.77	327.12	405.67	366.40
T_3 RDF + (Mo + B 0.75%)	15.20	14.70	14.95	382.00	466.87	424.44
T_4 RDF + (Mo + B 1.0%)	15.17	14.30	14.74	370.00	411.66	390.83
T_5 RDF + (Mo + B 1.25%)	13.87	14.27	14.07	356.67	303.33	330.00
C.V.	2.575	3.376	1.4	2.683	8.239	5.06
SE(m)	0.21	0.27	0.11	5.17	17.79	10.34
C.D.	0.67	0.87	0.36	16.50	56.77	32.99

4. Summary and Conclusion

An investigation to find out the potential role of boron and molybdenum on phenological morpho-physiologicaltraits was carried for two consecutive seasons. The findings revealed that the application of micronutrients (B and Mo) results in significant earliness in crop phenology as well as growth and development of broccoli. Also, physiology of plants was also improved due to application of micronutrients. Among the applied different concentration of micronutrients either individually or in combination, the most promotive results were obtained when plants were supplied with a combined application of B and Mo at 1.0% in combination with 100% RDF followed by B and Mo at 1.25% with 100% RDF. However, the highest SCMR values were recorded with the foliar application of B and Mo at 1.25% in combination with 100% RDF followed by B and Mo at 1.0% with 100% RDF compared to control during both the seasons. On the other hand, the yield-contributing traits and final curd yield were found highest B and Mo at 0.75% in combination with basal dose of N, P and K at 100%. In conclusion, the identified concentrations of micronutrients could be used for the improvement of growth, physiology and yield of broccoli crop.

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