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Effect of straw mulch and foliar application of boron on growth and yield of broccoli (*Brassica oleracea* var. italica)

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Abstract
Field investigation was carried out to study the effect of straw mulch and foliar application of boron on growth and yield of broccoli (*Brassica oleracea* var. italica) experiment was carried out in Split plot design consisting of fourteen treatments which included rice straw mulch application along with different levels of boron foliar application replicated three times. From the investigation it can be concluded that application of straw mulch along with foliar application of 0.75% B/ha and resulted in highest productivity and profitability in terms of broccoli growth and yield parameter.

Keywords: INM, Plant Parameters, Broccoli Crop, *Broccoli oleracea*

Introduction

Broccoli (*Brassica oleracae* var. italica) belongs to the family crucifereae. Crucifereae is a member of cole crop group. The broccoli originated in the mediterranean region. (Gray, 1982) [28]. Broccoli is dicotyledonous biennial herbaceous for seed production and considered as annual when harvest for fresh consumption (Yamaguchi, 1983) [45]. The area under cauliflower and broccoli is about 1.38 million hectares in the world with an annual production of about 24.18 million tonnes. In India, cauliflower and broccoli are grown over an area of 0.43 million hectares with annual production of 8.57 million tonnes (Anonymous, 2020) [21]. In India, it is generally grown in hilly areas of Himachal Pradesh, Jammu and Kashmir, Nilgiri Hills, Uttar Pradesh and Northern plains.

It is one of the most nutritious crops containing vitamin A, vitamin B, vitamin C and minerals like Ca, P and Fe (Acharya *et al.*, 2015) [19]. Its nutritional value consists of energy (34 Kcal), carbohydrate (6.64 g), fat (0.37 g), protein (2.82 g) and water (89.3 g) per 100 g raw broccoli. Hence nowadays, broccoli attracted more attention due to its multifarious use and great nutritional value. It has also a rich source of sulforaphane compound which is associated with reducing the risk of cancer. (Yoldas *et al.*, 2008) [46].

Mulching in vegetable crops has been found most effective means for the *in situ* conservation of soil moisture. Mulching represents a common intensifying element in cultivation technology of many vegetable crop, including broccoli. (Jasim and Al-Timmen, 2014) [29]. Different types of mulch (rice straw, black plastic, fresh weed biomass) reduces the weed population, moderates soil temperature and improves the microbial activity of the soil by improving the environment around the root zone (Dong *et al.*, 2009) [27]. Mulches can effectively minimize soil erosion and nutrient loss. Rice straw is weed-free organic mulch that is readily available in the summer and fall after rice crops have been harvested. Previously considered a waste item, rice straw helps reduce weeds and increase soil moisture when used on its own or as a base layer for mulch (Saha and Ghosh, 2013) [41]. Being a carbon-rich biomass, straw mulch contain carbon (40%-45%), nitrogen (0.6%-1%), phosphorus (0.45%-2%), potassium (14%-23%), and microelements, which are necessary for crop growth (Wang *et al.*, 2020) [44]. Rice straw is lightweight, so it is best used in a place that will not get heavy winds when used without heavier mulch as a top layer. In addition straw mulch will reduce weeds, conserve soil moisture and is also likely to lower the surface soil temperature (Kumar *et al.*, 2015) [31]. Straw mulch also enhance the soil biotic activity of earthworms (Lal, 2000) [35].

Straw mulch is having additional advantage over poly mulch, as it improve the soil health by enriching the soil organic carbon which is the main source of energy for soil microorganisms.

The carbon of the microbial biomass are the most used attributes in studies on the biological indicators of the soil, and microbial biomass is the most active living part of the soil organic matter, formed mainly by fungi and bacteria. Straw mulching enhances the microbial population in the rhizosphere as soil microbes are a diverse group of microorganisms that are multifunctional and involved in many important ecosystem processes, including biogeo-chemical cycling (Zhang *et al*., 2015) [2] and soil aggregation (Rilling and Mummey, 2006) [40]. Since last two decades, people are taking interest to improve soil quality throughout the world. They recognises the fragility of natural resource for development of soil health (Kumari *et al*, 2018) [34].

Boron (B) is an essential micronutrient which is required for growth and development of the plant and is directly and indirectly involved in many plant metabolic functions. Its essentiality in plant was reported by Warrington (1923) [43]. It is a constituent of cell membrane and is essential for cell division. Boran forms ester bonds between apiose residues of rhamnogalacturonan II (RGII) monomers, thus contributing to the cell wall's architecture and function and also forms *cis*-diol complex compounds with glycoproteins and glycolipids from the plasma membrane, thus maintaining its structure (Chormova and Fry, 2016) [24]. Boron promotes flowering, pollination, IAA and carbohydrate metabolism seed set and translocation of sugar. In plants B is required in the structure of cell wall **(**O'Neil *et al*., 2004) [37].

Inadequate boron supply causes numerous biochemical, physiological, and anatomic changes; therefore, it is extremely difficult to distinguish with certainty the primary and secondary effects of the deprivation (Dell and Huang, 1997) [25]. Interruption of cell division in the apical meristem is the most prominent effect that results in a reduction and even cessation of root growth. Boron deficiency decreases male fertility by reducing microsporogenesis germination, and elongation of the pollen tube (Cheng and Rerkasem, 1993) [23]. After fertilization, the nutrition disorder affects embryogenesis, resulting in seed deterioration or the formation of incomplete or damaged embryos (Rerkasem *et al*., 2019) [39].

Following green revolution period, with the induction of high yielding crop cultivars and use of high analysis chemical fertilizers, soils are showing a rapid decline in their ability to supply the essential micronutrients in required quantities (Bhupenchandra *et al*, 2020) [22]. Boron deficiency has been realized as the second most important micronutrients constraint in crops after that of zinc (Zn) on global scale (Ahmad *et al*., 2012) [20]. In India, around 33% soils are deficient in boron (Shukla and Behera, 2012) [42]. An estimated annual B requirement of 3.9 thousand tonnes by 2025 is an indication of its emergence as a major limiting nutrient to obtain optimum yield of many crops (Murthy, 2006) [36]. The deficiency of boron was found to be severe in the soils of Punjab with an average 12.1% of soil sample were found to deficit in available boron (Dhaliwal *et al*., 2020) [26].

Materials and Methods

The field experiment work of the present investigation entitled "Effect of straw mulch and foliar application of boron on growth and yield of broccoli (*Brassica oleracea*" was carried out in the Rabi season of 2021–2022 at the Students' Vegetable Research Farm, Khalsa College, Amritsar. Punjab is the province where Amritsar is located in northwest India. Amritsar is situated at a mean elevation of 229 metres above mean sea level, at latitude 31°63' North and longitude 74°86' East. The experiment's split plot design consisted of two main plot treatments (mulch and with mulch and seven sub plot each of which had a different boron level and was repeated three times. "Palm samridhi" was the cultivar utilised in the experiment, and it was planted in ridges 45cm apart, 45cm apart. Before preparing the seed bed, FYM was applied. The soil type in the field was sandy loam, and the NPK levels are provided as 100, 80, and 100 kg ha^{-1}. The three fertilisers were combined before application, and they were spread in the middle of ridges where the broccoli would later be sown. The first quarter of the nitrogen dose was broadcast applied during the second irrigation, the final quarter was applied after the first irrigation, and the other half was applied at the time of planting. 30 days after planting, the earthwork was finished (DAP). At 30 DAS and 50 DAS, vermiwash was sprayed. During the period of the earthing, weeding was done to get rid of the weeds.

Result and discussion Plant height (cm)

Plant height is an index of growth and development representing the infrastructural build up. Plant height was recorded periodically at 30, 60 and at harvesting. The perusal of data regarding the plant height of the broccoli crop presented in the Table 4.4 showed that plant height increased with the advancement of crop stages up to maturity. At 30 DAT plant height of (24.76 cm) in M1 was non-significantly higher than the M2. The percent increase in plant height at 60 DAT in M1 over M2 was 2.09 percent and it was significantly higher. At harvesting highest plant height was recorded at M1 which was significantly different from M2. The percent increase in the plant height at harvesting in M1 over M2 was 2.99 percent. This might be due to the fact that straw mulch has helped in improving the soil's physical and chemical characteristics in the broccoli rhizosphere and enhancing microclimate (Char *et al.*, 2020) [3].

While observing the effect of boron level on the plant height of broccoli crop, the perusal of data presented in Table 4.4 showed that the highest plant height was recorded in T4 (0.75% borax) up to 30 DAT and it was affected non-significantly due to different boron treatments.

The effect of boron treatment at 60DAT was significant, the plant height of the broccoli ranged from 41.70 (T1) to 47.98 cm (T4). The maximum plant height at 60 DAT was observed in treatment receiving 0.75% borax (47.98 cm), while the lowest was observed in T1 (41.70 cm).

At harvest, a similar trend was observed in plant height as noticed at 60 DAT. At harvest, the plant height of broccoli ranged from 55.56 cm (control) to 64.12 cm (T4). The maximum plant height at harvest was observed in treatment receiving 0.75% borax (64.12 cm) which was found to be at par with T5 (62.28 cm), while the lowest was observed in control (55.56 cm). The increase in plant height with the application of boron might be due to its involvement in the synthesis of the cell wall and maintaining its structure. These results are in line with the finding of Singh *et al.* (2022), Sourabh *et al.* (2021) and Kumar *et al.* (2021) [4, 5].

The interaction effect was non-significant

Number of leaves per plant

The number of leaves per plant is an important index of plant growth and development. Although the number of leaves per plant is controlled genetically it may be markedly modified by agronomic manipulations. The application of mulch showed a significant difference in the number of leaves per plant as shown in Table 4.5. The mean values are given in the table represented that the number of leaves per plant in M1 was significantly higher over M2 treatment at 60DAT and at harvest. The percent increase in the plant height at 60DAT and at harvesting in M1 over M2 was 4.76 and 9.15 percent, respectively. Whereas, at 30 DAT it was observed to be non-significant. The position effect of mulch on the number of leave per plant may be through increased nutrient content, improving the microclimate (temperature and moisture) regime of the soil, as well as by increasing the photosynthetic attributes and pigment content which would have encouraged the formation of a greater number of leaves (Zhang *et al.*, 2015) [2] and (Kosterna, 2014) [1].

A perusal of data in Table 4.5 further revealed that the average number of leaves per plant of all the treatments at harvest was higher as compared to the number of leaves per plant at 60 DAT. The number of leaves per plant at 30 DAT was not influenced significantly by the application of boron, while a significant response of boron was observed in the number of leaves per plant at 60 DAT. The maximum number of leaves per plant recorded was 17.87 and 23.89 in T4 at 60DAT and at harvesting, respectively. While the minimum number of leaves per plant was registered as 13.65 and 18.15 in control (T1) at 60DAT and at harvest, respectively. This might be due to its role in membrane metabolism and function. The results are similar to the findings of Farag *et al.* (2022) [6].

Interaction was non-significant

Table 1: Effect of straw mulch and foliar application of boron on plant height of broccoli

Symbol	Treatment	Plant heigh (cm)		
		30 DAT	60 DAT	At harvesting
Straw Mulching				
M1	With Mulch	24.76	46.11	63.37
M2	Without Mulch	23.02	44.23	59.68
	CD(P=0.05)	NS	1.05	1.5
Boron Level				
T1	Control	22.37	41.70	55.56
T2	0.25% Borax	23.04	43.55	58.47
T3	0.5% Borax	23.66	43.61	59.01
T4	0.75% Borax	24.64	47.98	64.12
T5	1.00% Borax	24.59	47.83	62.28
T6	1.25% Borax	24.01	45.99	59.5
T7	1.50% Borax	24.02	45.56	58.92
	CD (p=0.05)	NS	1.73	2.5
	Interaction	NS	NS	NS

Leaf area index

LAI is a measure of leafiness per unit ground area and indicates the extent of photosynthetic activities of the plant. It is the most important indicator of the size of the assimilatory system to maximize the harvest of the incident solar radiation. Leaf area affects the interception and utilization of solar radiation by crop canopies, consequently dry matter accumulation and ultimately the crop yield

The data on the leaf area index of crop growth as affected by mulch and boron levels are presented in Table 4.6. Significant variation in the LAI was observed due to mulch at harvest of crop growth. A higher LAI value (2.62) was developed in M1 (with mulch) while a lower LAI value (2.43) was recorded in plots receiving no mulch (M2). The increased LAI could be attributed to the favorable aeration-moisture regime conditions and higher soil biological activity as compared to no mulch (Akhtar *et al.*, 2018) [7].

At harvest boron application, 0.75% borax recorded a maximum leaf area index (2.98) which was significantly superior over all other treatments of boron except at 1% borax where it was at par with T5 (2.82). The increase in the leaf area index might be due to the application of borax that accounts for the synthesis of the cell wall, as well as the transport of ions, metabolites, and hormones. The result are line with findings of Banker *et al.* (2022) [8].

The interaction of mulch and boron level was found non-significant.

Table 2: Effect of straw mulch and foliar application of boron on the number of leaves per plant of broccoli

Symbol	Treatment	Number of leaves		
		30 DAT	60 DAT	At harvesting
Straw Mulching				
M1	With Mulch	6.63	17.65	23.83
M2	Without Mulch	6.61	15.76	19.88
	CD(P=0.05)	NS	0.47	1.27
Boron Levels				
T1	Control	6.58	13.65	18.15
T2	0.25%Borax	6.67	14.42	19.47
T3	0.5% Borax	6.51	15.92	20.52
T4	0.75%Borax	6.69	17.87	23.89
T5	1.00%Borax	6.63	17.67	23.46
T6	1.25%Borax	6.68	16.96	22.06
P7	1.50%Borax	6.6	16.70	21.88
	CD(p=0.05)	NS	0.69	1.27
	Interaction	NS	NS	NS

Table 3: Effect of straw mulch and foliar application of boron on growth and yield of broccoli on leaf area index

Symbol	Treatment	Leaf area index
Straw Mulching		
M1	With Mulch	2.62
M2	Without Mulch	2.43
	CD(P=0.05)	0.14
Boron Level		
T1	Control	2.04
T2	0.25% Borax	2.38
T3	0.5% Borax	2.49
T4	0.75%Borax	2.98
T5	1.00%Borax	2.82
T6	1.25%Borax	2.55
T7	1.50%Borax	2.46
	CD(p=0.05)	0.3
	Interaction	NS

Stem girth (cm)

The data on stem girth at different stages of crop growth as influenced by straw mulch and boron application is presented in Table 4.7. Significant variation in stem girth was observed due to mulching. M1 showed a higher stem girth (5.44 cm) while a lower stem girth (4.80cm) was obtained without mulch (M2) at harvest. The increase in the plant spread may be due to the favorable conditions in mulched plots through enhanced nutrients availability and ensuring good soil physical conditions (Gharbat *et al.*, 2016) [9].

Boron application also had a significant influence on stem girth. Maximum stem girth (5.55 cm) was observed in T4 and was found to be at par with T5 (5.52 cm). While minimum stem girth (4.55 cm) was obtained in T1. An increase in stem girth might be due to the role of boron in cell wall formation and influenced membrane metabolism. Then result conformity with the findings of Lakiang *et al.* (2021) [10].

Average curd weight (g)

Data pertaining to average curd weight as affected by mulch and boron application are presented in Table 4.8 showed that the mulch had a significant effect on average curd weight per hectare having higher average curd weight (254.15g) when the crop was grown with mulch (M1), whereas lower weight (247.02g) was observed when the crop was grown without mulch (M2). This might be due to the increase in biomass attributing characteristics like plant height (Table no. 4.4), no of leaves per plant (Table no. 4.5), and leaf area index (Table no. 4.6). The results are in line with findings of Zhang *et al.* (2015) [2].

An examination of data presented in table 4.8 further revealed that borax 0.75% result in the higher average curd weight (267.40g) over the control (235.73g). Among the growth attributes, the positive association of crop growth concerning plant height, leaf area index, and the number of leaves per plant might be the reason for increased average curd weight. In addition, the enhanced leaf area index might have helped for better exposure of leaves to the sunlight thus increasing the photosynthetic area further accounting for average curd weight. These results are closely related to Masarirambi *et al* (2013) [11] Interaction was non-significant

Table 4: Effect of straw mulch and foliar application of boron on stem girth of broccoli

Symbol	Treatment	Stem girth (cm)
Straw Mulching		
M1	With Mulch	5.44
M2	Without Mulch	4.8
	CD (*p*=0.05)	0.32
Boron level		
T1	Control	4.55
T2	0.25% Borax	4.79
T3	0.5% Borax	4.93
T4	0.75% Borax	5.55
T5	1.00% Borax	5.52
T6	1.25% Borax	5.32
T7	1.50% Borax	5.21
	CD (*p*=0.05)	0.17
	Interaction	NS

Head yield (q ha^{-1})

Head yield is an important component of the yield parameters. Data on the head yield of broccoli as affected by mulch (Table 4.8) showed that the head yield of broccoli was found significantly higher in M1 (168.95 q ha^{-1}) over M2 (165.28 q ha^{-1}). The higher head yield obtained under mulch may be through increased nutrient content, improving the microclimate (temperature and moisture) regime of the soil, as well as by increasing the photosynthetic attributes and pigment content which would have encouraged the formation of a greater head yield. A similar type of results have already been reported by Tiwari *et al.* (2003) [13] and Tumuhairwe and Gumbs (1983) [12].

The different boron treatments showed a significant variation in the head yield of broccoli during the study period (Table 4.8). The highest head yield was noticed in T4 (176.34 q ha^{-1}) which was at par with T5 (174.61 q ha^{-1}) and the lowest being in control T1 (155.33 q ha^{-1}). It might due to season that boron had a critical role in crop growth, involving photosynthesis processes, and biochemical and physiological activities and thus their importance in achieving higher yield. These results confirm the findings of Islam *et al.* (2015) [14] and Choudhury *et al.* (2022) [15]. The interaction of zinc and land configuration was found non-significant.

Dry matter accumulation (DMA)

Dry matter accumulation (DMA) is the most important parameter to observe the effect of different treatments on the metabolic efficiency of the plant which is a direct indicator of plant health and vigor. It is also a good indicator of photosynthetic activity. The data was recorded and presented in table 4.8. The data on the dry matter accumulation revealed that the mulch had a significant effect on dry matter accumulation. The results show that treatment M1 (28.32kg ha^{-1}) produced significantly more dry matter in comparison to the M2 treatment (26.98kg ha^{-1}). This might be due to better hydrothermal conditions in the soil and improved soil physical and chemical properties. Dhar *et al.* (2014) [16] and Fracchiolla *et al.* (2020) [17] also observed such type of results. The highest dry matter accumulation due to higher in boron level was registered in T4 (29.84 kg ha^{-1}) which was at par with T5 (29.51kg ha^{-1}) but significantly superior to all other treatments. The increase in DMA in broccoli with the increasing level of boron application might be due to higher levels of boron resulting in more uptake of nutrients, which caused better metabolization of synthesized carbohydrates into amino acids and protein which in turn stimulated the cell division and cell elongation and thus allowed the plant to grow faster, which expressed morphologically an increase in various metabolic processes in presence of abundant supply of nutrients which ultimately resulted in increased vegetative growth. Similar results were observed by Islam *et al.* (2015) [14] and Al- Bayativ (2019) [18]. The interaction effects among various treatments were non- significant.

Table 5: Effect of straw mulch and foliar application of boron on yield parameter of broccoli

Symbol	Treatment	Average curd weight (g)	Head yield (q ha^{-1})	Dry matter accumulation (kg ha^{-1})
Straw Mulching				
M1	With Mulch	254.15	168.95	28.32
M2	without Mulch	247.02	165.28	26.98
	CD (*p*=0.05)	3.0	2.18	0.47
Boron level				
T1	Control	235.73	155.33	24.17
T2	0.25% Borax	241.62	161.62	26.63
T3	0.5% Borax	245.98	163.63	27.24
T4	0.75% Borax	267.40	176.34	29.84
T5	1.00% Borax	264.38	174.61	29.51
T6	1.25% Borax	256.54	170.39	28.25
T7	1.50% Borax	253.75	167.89	27.95
	CD (*p*=0.05)	5.3	3.7	0.7
	Interaction	NS	NS	NS

Conclusion

The findings of this field study entitled "Effect of straw mulch and foliar application of boron on growth and yield of broccoli (*Brassica oleracea* var. italica)" may lead to the conclusion that by using straw mulch along with application of boron @ 0.75%, better yields and larger returns can be achieved. Hence farmer are advised to make combine use of organic mulch and foliar boron application

References

1. Kosterna E. The yield and quality of broccoli grown under flat covers with soil mulching. Plant, Soil and Environment. 2014;60(5):228-233.
2. Zhang X, Qian Y, Cao C. Effects of straw mulching on maize photosynthetic characteristics and rhizosphere soil micro-ecological environment. Chilean Journal of

Agricultural Research. 2015;75(4):481-487.
3. Char G, Singh TK, Singh S, Pusam P. Effect of Bio-fertilizers and mulching on growth and broccoli under protected condition. Chemical Science. Review and Letters; c2020.
4. Sourabh S, Tripathy P, Sahu GS, Dash SK, Nayak RK, Sahu P, *et al*. Effect of lime, micronutrient and spraying schedule on growth and yield of broccoli variety Palma samridhi. Journal of Crop and Weed. 2021;15(3):32-38.
5. Kumar S, Kumar M, Kumar R, Sharma SK. Effect of boron and molybdenum on growth and yield on cauliflower (*Brassica oleracea var*, botrytis *L*) CV. Snowball-16 at different stage. The Pharma Innovation. 2021;10:1732-1734.
6. Farag AA, Abdrabbo MAA, Maharik ZY, El-Morshedy RM. Growth and yield of cauliflower as affected by boron spray and in- row plant spacing. Plant Achieves. 2022;22(1):425-430.
7. Akhtar K, Wang W, Ren G, Khan A, Feng Y, Yang G. Changes in soil enzymes, soil properties, and maize crop productivity under wheat straw mulching in Guanzhong, China. Soil and Tillage Research. 2017;182: 94-102.
8. Banker PN, Dr. Pavhane SB, Dr. Tambe TB. Effect of levels of nitrogen and boron and zinc on growth of broccoli (*Brassica oleracea* L. var. Italcia) Cv. Phule Ganesh. The Pharma Innovation. 2022;11:1362-1365.
9. Ghurbat HM, Taha ZS, Teli Ja. Effect of mulching and organic Fertilizer on growth, yield and Quality of Broccoli (*Brassica oleracea* var. Italica). Journal of Zankoy Sulaimani. 2016;18:207-212.
10. Lakiang HHK, Kharsahnoh W, Murma S. Effect of moybdenum and boron on the growth and yield of Broccoli (*Brassica oleracea* var. Italica) under citrus based agroforestry system. Advances in Bioresearch. 2021;12:135-140.
11. Masarirambi MT, Madzebele ME, Wahome PK, Oseni TO. Effects of white plastic and sawdust mulch on savoy baby cabbage (*Brassica oleracea* var. bullata) growth, yield and soil moisture conservation in summer in Swaziland, American-Eurasian Journal of Agricultural &Environment Science. 2013;13(2):261-268.
12. Tumuhairwe JK, Gumbs FA. Effect of mulches and irrigation on the production of cabbage (*Brassica oleracea*) in the dry season. Tropical agriculture. 1983;60:122-127.
13. Tiwari KN, Singh A, Mal PK. Effect of drip irrigation on yield of cabbage (Brassica oleracea L. var capitata) under mulch and non-mulch conditions. Agriculture and water management; c2003.
14. Islam MM, Majumdar F, Sultana T, Islam MS, Nizam R. Growth and yield potential of broccoli in response to organic manures and mulching. International Journal of Business, Social and Scientific Research. 2014;2:68-73.
15. Chaudhury R, Sarangthem I, Singh AH, Devi N, Singh N. Studies on the yield of broccoli (*Brassica oleracea* var. italica) as influenced by boron application in acid soil. The Pharma Innovation. 2022;11:595-601.
16. Dhar D, Datta A, Basak N, Paul N, Badole S, Thomas T. Residual effect of crop residues on growth, yield attributes and soil properties of wheat under rice-wheat cropping system. Indian Journal of Agriculture Resourse. 2014;48(5):373-78.
17. Fracchiolla M, Renna M, D'Imperio M, Lasorella C, Santamria P, Cazzato E. Living mulch and organic fertilization to improve weed management, yield and quality of broccoli Raba in organic farming. Plants. 2020;9(2):1-11.
18. Al-Bayati HJM. Growth and yield of cauliflower as affected by boron and fertilizer type. International Journal of Agriculture Statistic Science. 2019;15(2):595:599.
19. Acharya U, Thapa S, Sharma N. Study on the growth, yield and soil nutrient status of broccoli under organic nutrient management. International Journal of Current Research. 2015;7(2):13029-13032.
20. Ahmad W, Zia MH, Malhi SS, Niaz A, Ullah S. Boron Deficiency in soils and crops. A review of Crop plant, 2012, 65-97.
21. Anonymous. Horticultural Statistics at a Glance. Ministry of Agriculture & Farmers Welfare GoI, New Delhi; c2020.
22. Bhupenchandra I, Basumatary A, Datta S, Singh LS, Bora SS, Devi SH, *et al*. Micronutrient content in plant, its uptake and crop yield in cauliflower-cowpea-okra cropping sequence as impacted by graded level of boron fertilization. Communication in soil science and plant analysis, 2020;51(14):1870-1887.
23. Cheng C, Rerkasem B. Effect of boron on pollen viability in wheat. Plant Soil. 1993;155:313-315.
24. Chormova D, Fry SC. Boron bridging of rhamnogalacturonan-II is promoted *in vitro* by vitro by cationic chaperones including polyhistidine and wall glycoproteins. New Phytol. 2016;209(1):241-251.
25. Dell B, Huang L. Physiological response of plants to low boron. Plant Soil. 1997;193:103-120.
26. Dhaliwal SS, Shukla AA, Sharma V, Behera SK. Atlas on Status of micronutrients in soil of punjab publisher Department of soil science PAU Ludhiana; c2020.
27. Dong H, Li W, Tang W, Zhang D. Early plastic mulching increases stand establishment and lint yield of cotton in saline fields. Field Crops Research. 2009;111(3):269-275.
28. Gray AR. Taxonomy and evolution of broccoli (Brassica oleracea var Italica). Economic botany. 1982;36(4):397-410.
29. Jasim AH, Al-Timmen WMA. The effect of mulch and fertilizer on broccoli (Brassica oleracea L. var ltalica) oxidants and antioxidants. Net journal of agricultural science. 2014;2(4):124:130.
30. Kumar A, Parmar DK, Suri VK. Effect of boron fertilizers and organic manure on autumn cauliflower in western Himalayas. Annals of Horticulture. 2002;5(1):17-24.
31. Kumar J, Phookan DB, Lal N, Kumar H, Sinha K, Hazarika M. Effect of organic manures and bio-fertilizers on nutritional quality of cabbage (*Brassica oleracea* var. capitata). Journal of Eco-friendly Agriculture. 2015;10(2):114-119.
32. Kumar S, Charudhury DR, Kumar S. Effect of FYM, molybdenum on growth yield and yield attributing characters of cauliflower (*Brassica oleracea* var. Italica) cv. Pusa snow ball K-1 Annals of horticulture. 2002;5:53-57.
33. Raj Kumar Saroj, Sanjay Kumar, Shatrunjay Yadav. Effect of bio-fertilizers with chemical fertilizers on growth, yield, and quality of cauliflower (*Brassica oleracea* var. *botrytis*). Int. J Hortic Food Sci. 2022;4(1):26-31.
34. Kumari K, Prasad J, Solanki Is, Chaudhary R. Long-term effect of crop residues incorporation on yield and soil

physical properties under rice-wheat cropping system in calcareous soil. Journal of soil science and plant nutrition. 2018;18(1):27-40.
35. Lal R. Mulching effects on soil physical quality of an alfisol in western Nigeria. Land Degradation and Development. 2000;11(4):383-392.
36. Murthy IYLN. Boron studies in major oilseed crops. Indian journal of fertilisers, 2006;1(11):11-20.
37. O'Neill MA, Ishii T, Albersheim P, Darvill AG. Rhamnogalacturonan II structure and function of a borate cross-linked cell wall pectic polysaccharide. Annual Review of Plant Biology. 2004;55:109-139.
38. Prasad R. Crop Nutrition-Principles and Practices, New Vishal Publication New Delhi, 2007, 272.
39. Rerkasem B, Lordkaew S, Yimayam N, Jamjod S. Evaluating boron efficiency in heat tolerant wheat germplasm. International Journal of Agricultural Biology. 2019;21(2):385-390.
40. Rilling MC, Mummey DL. Mycorrhizas and soill structure. New phytol. 2006;171(1):41-53.
41. Saha R, Ghosh PK. soil organic carbon stock, moisture availability and crop yield as influenced by residue management and tillage practices in maize- mustard cropping system under hill agro-ecosystem. National Academy Science Letters. 2013;5:461:468.
42. Shukla AK, Behera SK. Micronutrient fertilizers and higher productivity. Indian Journal of Plant Nutrition. 2012;8(4):100-117.
43. Warington K. The effect of boric acid and borax on the broad bean and certain other plants. Annals of Botany. 1923;37(148):629-672.
44. Wang XL, Yang ZL, Liu X. The composition characteristics of different crop straw types and their multivariate analysis and comparison. Waste Management. 2020;110:87-97.
45. Yamaguchi M. World vegetables principles, production and nutritive values, AVI publishing company, INC Westport, Connection, USA; c1983. p. 405.
46. Yoldas F, Ceylan S, Yagmur B, Mordogan N. Effects of nitrogen fertilizer on yield, quality and nutrient content in broccoli. Journal of Plant Nutrition. 2008;31(7):1333-1343.