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ORIGINAL ARTICLE

Effect of molybdenum and boron on the growth and yield of Broccoli (*Brassica oleracea var. itallica)* under citrus *(Citrus limetta)* based Agroforestry system

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ABSTRACT
Nutrient management is one of the main practices to get a higher productivity and quality production of a crop.It's very important to manage nutrient availability under agroforestry system for better crop production. An experiment was conductedin this regard to study the effect of different doses of Molybdenum (Mo) and Boron (B) on the growth and yield of Broccoli (Brassica oleracea var. italica) c.v. Green comet under Citrus (Citruslimetta) based Agroforestry system in Rabi season of year 2019-20. The experiment was carried out in a Randomized block design consisting of ten treatments with three replications using NPK (recommended dose) and variable dose of Molybdenum and Boron. The seedlings were sown in a row to row at a distance of 30cm and plant to plant at a distance of 45 cm. Results obtained during the course of experimentation shows significant impact of different doses of Mo and B on growth and yield of Broccoli. The treatments T_7 (100% NPK + 1kg/ha Molybdenum + 10kg Borax) has showed maximum yield (148 q/ha) as best for overall growth, yield and while the minimum yield (53 q/ha) was reported on T_0 (Control). Significant effect of different doses of molybdenum and boron along with NPK on yield attributing characters was found. Also interactive effect of molybdenum and boron in plant height, number of leaf, leaf length, girth of stem, diameter of florets and broccoli yield was found significantly different.
Keywords*:Agroforestry, Broccoli, Molybdenum, Boron, Growth and Yield etc.*

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INTRODUCTION

Agroforestry is a system of land use where woody perennials are used on the same land-management unit as annual agricultural crops with the aim of obtaining greater outputs on a sustained basis. Agroforestry has traditionally been a way of life and livelihood in many parts of India for centuries and even now being popularizing. Agroforestry, like the multifunctional agriculture, has the objective of promoting economically, socially and environmentally sustainable rural development [19]. It provides opportunities to increase the value of total production through marketing of multiple products from a given unit of land [3, 4]. It offers many advantages such as crop and livestock protection, soil and stream conservation and protection, diversification of agricultural revenues through the production of timer and non-timber forest products, promotion of biodiversity, landscape enhancement and carbon sequestration [1, 2, 5]. In India, just as there is a great diversity in climate similarly there exists a large number of agroforestry systems of various forms and types [6]. The accurate assessment of area under different agroforestry systems is quite difficult. A large number of researchers and agencies are continuously engaged to work out the accurate assessment of area under Agroforestry Systems. The current area under agroforestry in India is estimated as 25.31 million hectares or 8.2 percent of the total reporting geographical area of the country by Dhyani *et al.,* [7]; Dagar *et al*. [6]. Agroforestry plays a better role in increasing agriculture productivity by nutrient recycling, reducing the soil erosion and improving soil fertility and enhancing farm income compared with conventional crop production [12-14]. Furthermore,

it has promising potential for reducing deforestation while increasing food fodder and fuel wood production [2]. Agroforestry continues to play an integral role in enlightening the competitive position of the agricultural sector. The main issue for optimizing production in agroforestry systems is rational utilization of resource by maximizing positive interactions and minimizing negative ones [15-17, 39, 26, 27]].

Broccoli is an edible green plant in the cabbage family whose large flowering head is eaten as a vegetable. Broccoli is a member of *Cruciferae* its botanical name is *Brassica oleracea var.italica***.** The word *broccoli* comes from the Italian plural of *broccolo*, which means "the flowering crest of a cabbage", and is the diminutive form of *brocco*, meaning "small nail" or "sprout". Broccoli is often boiled or steamed but may be eaten raw. Broccoli has large flower heads, usually green in colour, arranged in a tree-like structure branching out from a thick, edible stalk. The mass of flower heads is surrounded by leaves. Broccoli resembles cauliflower, which is a different cultivar group of the same species. It is classified into two types, heading and sprouting. The cultivation of broccoli was initially restricted to hill areas of Jammu and Kashmir, Himachal Pradesh and Uttar Pradesh but now successfully grown under North Indian plain condition. The nutritive value of broccoli per 100g is moisture 89.3g, energy 141kj, carbohydrates 6.64g, sugar 1.7g, dietary fibre 2.6g, fat 0.37g, protein 2.82g, vitamin A 9000IU, calcium 47mg, iron 0.73mg, phosphorous 66mg, thiamine 0.071mg, riboflavin 0.117mg, niacin 0.639mg, vitamin C 89.2mg.

Nutrient management is one of the main practices to get a higher productivity and quality production of a crop.It's very important to manage nutrient availability under agroforestry system for better crop production. Broccoli being a cole crop is heavy feeder to plant nutrients. This micronutrient deficiency causes many anatomical physiological and biological disorders [33] that affected curd distortion in shape, size, bitter in taste and less productive which adversely affects the market value. It is reported that Boron (Bo) helps in increasing the growth and yield of the crops as it helps in cell wall development, cell division, cell extension and pollen tube growth [28, 19-24, 38]. While, Molybdenum (Mo) helps in N^2 fixation because it is a part of metaprotein nitrogenase [10, 17, 18, 25]. It is also an essential micronutrient in symbiotic nitrogen fixation. The present study was aimed to increase the yield and growth of broccoli with application of Molybdenum and Boron.

MATERIAL AND METHODS

Presentinvestigation entitled "The effect of Molydenum and Boron on growth and Yield of Broccoli *(Brassica oleracea var. italica)* under Citrus *(Citrus limenta)* based on Agroforestry System" was conducted from October 2019 to Feb 2020. The experiment was laid out in a Randomized Block Design with 10 Treatments and 3 Replications in Prayagraj agro climatic condition at the experimental field in Research Farm of College of Forestry, Sam Higginbottom University of Agriculture, Technology and Science, Prayagraj.The experimental site at elevation of 98m above sea level at 28.87^0 N latitude and 81.15^0 E longitude. The research area has a sub-tropical climate with extremes of summer and winter. During the summer season, the temperature reaches upto 46-48□, while during winter season, especially in the month of November and January temperature drops down to as low as 1-2□. The average rainfall in this area is around 882mm.The site selected for this experiment was uniform and well levelled. In order to study the physical and chemical properties of the soil sampling technique before sowing. The soil selected for experiment was medium black with good drainage. The land was prepared in usual manner by ploughing, crushing and was brought to the fine tilth.

Molybdenum and Boron were studied with the recommended doses of Fertilizer(NPK) laid out under Randomized Block Design. Soil of experimental field was sandy loam to clay loam having a soil pH of 7.2 and comes under sub-tropical climate prevailing in the south-east part of U.P. with both the extremes in temperature, i.e. the winter and the summer. In cold winters, the temperature sometimes is as low as 32°F in December – January and very hot summer with temperature reaching up to 115°F in the months of May and June. During winter, frosts and during summer, hot scorching winds are also not uncommon. The average rainfall is around 1013.4mm with maximum concentration during July to September months with occasional showers in winters. Recommended doses of fertilizers i.e. 100kg N, 80kg P and 80kg K per hectare were applied in the form of Urea, DAP and KCl. The doses were applied half before transplant and after 40 days of transplanting. The result was recorded in respected of the vegetative growth of Broccoli (plant height, number of leaves, leaf length, girth of stem, diameter of florets and yield).

RESULTS AND DISCUSSION

Effect of Molybdenum and Boron on vegetative growth of Broccoli.

Theeffect on increase of plant height of broccoli growth and development at all stages over control. The various treatments the maximum plant height at 20, 40 and 60 days after transplanting (DAT) was

21.27cm, 34.30cm and 50.47cm observed in treatment T_7(100% NPK + 1kg/ha Molybdenum+ 10kg Borax) and the minimum was recorded in T_0 Control.Similarly, the number of leaves were counted maximum underT_7(100% NPK + 1kg/ha Molybdenum+ 10kg Borax)on broccoli growth and development at all stages over control. The various treatments were recorded the maximum number of leaves at 20, 40 and 60 days after transplanting (DAT) was 4.83, 11.68 and 22.16 observed in treatment and the minimum was in T_0 Control. Likewise, significant differences in leaf length were counted maximum underT_7(100% NPK + 1kg/ha Molybdenum+ 10kg Borax) on broccoli growth and development at all stages over control. The various treatments were recorded the maximum leaf length at 20, 40 and 60 days after transplanting (DAT) was 10.33 cm, 16.01 cm and 28.35cm observed in treatment and the minimum was in T_0 Control. In all cases of vegetative growth, it was clearly observed that the combination of molybdenum and boron was better as compared to their soil application along with NPK.

Table 1: Effect of Molybdenum and Boron on vegetative growth of Broccoli.

TREATMENTS	Plant height (cm)			Number of leaves			Leaf Length (cm)		
	20 DAT	40 DAT	60 DAT	20 DAT	40 DAT	60 DAT	20 DAT	40 DAT	60 DAT
T_0– Control	14.63	26.67	40.97	4.16	11.17	21.35	6.43	10.04	20.48
T_1 -100% NPK	16.60	29.63	44.00	4.25	11.28	21.45	7.90	11.55	21.55
T_2 -100% NPK +05kg/ha Borax	17.60	31.30	44.37	4.37	11.32	21.56	8.28	12.29	22.76
T_3 -100% NPK + 10kg/ha Borax	18.33	32.73	45.93	4.48	11.48	21.65	8.49	12.35	23.35
T_4 -100% NPK + 15kg/ha Borax	18.83	33.33	45.60	4.57	11.52	21.71	8.63	13.80	25.57
T_5 -100% NPK + 20kg/ha Borax	19.30	33.67	45.73	4.62	11.44	21.82	8.65	13.54	25.40
T_6 -100% NPK + 0.5kg/ha Molybdenum + 10kg Borax	20.13	34.10	46.53	4.71	11.52	21.88	8.81	13.26	26.71
T_7 -100% NPK + 1kg/ha Molybdenum + 10kg Borax	21.27	34.30	50.47	4.83	11.68	22.16	10.33	16.01	28.35
T_8 -100% NPK +1.5kg/ha Molybdenum + 10kg Borax	20.90	33.90	49.33	4.77	11.56	21.93	9.58	15.61	27.17
T_9 -100% NPK +2kg/ha Molybdenum + 10kg Borax	20.20	33.83	46.40	4.66	11.49	21.84	9.28	15.57	25.93
C.D	1.061	1.182	2.813	0.024	0.02	0.025	0.091	1.015	1.644
S.E(m)	0.354	0.395	0.94	0.008	0.007	0.008	0.231	0.339	0.549

Effect of Molybdenum and Boron on quality of Broccoli florets:

The girth of stem and diameter of florets was measured by the tape. It was seen that the average girth of stem and the diameter of the florets were significantly influenced by different treatment combinations. The treatment T_7 (100% NPK + 1kg/ha Molybdenum + 10kg Borax) has the maximum girth stem with 6.15cm and followed by T_8 (100% NPK +1kg/ha Molybdenum + 10kg Borax) with 6.09cm whereas the minimum girth of stem was observed in treatment T_0 (control) with 4.55cm. The application of Molybdenum and Boron with 100% NPK caused a significant increase in girth of stem, which shows that Molybdenum and boron has the positive effect on girth of stem of Broccoli. The average diameter of florets significantly influenced by the different treatments of Molybdenum and Boron, the maximum diameter of florets was recorded in T_7 (19.17 cm) which was at par with T_6 and T_8. On the other hand, the minimum diameter of florets was found in treatment T_0(control) with12.52cm. The results showed that the effect of molybdenum and boron was significant. Similarly results have been reported by [12-14, 18, 34-37].

Table 2: Effect of Molybdenum and Boron on quality of Broccoli florets.

TREATMENTS	Girth of stem (cm)		Diameter of Florets(cm)
	At harvest		At harvest
T_0– Control	4.55		12.52
T_1 -100% NPK	4.75		15.81
T_2 -100% NPK +05kg/ha Borax	4.94		16.07
T_3 -100% NPK + 10kg/ha Borax	5.05		17.06
T_4 -100% NPK + 15kg/ha Borax	5.14		17.23
T_5 -100% NPK + 20kg/ha Borax	5.57		17.56
T_6 -100% NPK + 0.5kg/ha Molybdenum + 10kg Borax	5.90		17.85
T_7 -100% NPK + 1kg/ha Molybdenum + 10kg Borax	6.15		19.17
T_8 -100% NPK +1.5kg/ha Molybdenum + 10kg Borax	6.09		18.55
T_9 -100% NPK +2kg/ha Molybdenum + 10kg Borax	5.05		18.46
C.D	0.18		0.832
S.E(m)	0.06		0.278

Effect of Molybdenum and Boron on yield of Broccoli:

The head weight was measured with digital weighing machine. It was observed that the average head yield was effectively improved due to the application of Molybdenum and Boron. Application of Molybdenum and Boron along with NPK caused a significant increase in head yield of Broccoli which proved that the Molybdenum and Boron has a positive effect on head development. Yield data presented in table.3 that the maximum yield per plant (0.99kg) was recorded in T_7 (100% NPK + 1kg/ha Molybdenum + 10kg Borax) while the minimum was found in Control (0.35kg). The maximum yield per plot was observed in T_7 receiving 100% NPK+1kg/ha Molybdenum + 10kg Borax with (5.92kg). The results show that the effect of Molybdenum and Boron was significant. Subsequently, as a result the maximum yield (5.92 kg/plot or 148 q/ha), when planted at 30 x 30cm spacing was observed in T_7 (100% NPK + 1kg/ha Molybdenum + 10kg Borax) and the minimum was recorded in T_0. Higher vegetative growth in the treated crops produced more photosynthetic metabolites that lead to the improvement of quality of broccoli heads. Similar findings of higher yield with application of Molybdenum, Boron, Zinc and other micronutrients in broccoli, carrot and tomato also stated by [20, 21, 22, 37].

Table 3: Effect of Molybdenum and Boron on yield of Broccoli.

TREATMENTS	Yield Per plant (kg)		Yield Per plot (kg)		Yield Per hectare (q)
T_0 - Control	0.35		2.12		53.00
T_1 -100% NPK	0.59		3.52		88.00
T_2 -100% NPK +05kg/ha Borax	0.64		3.82		95.50
T_3 -100% NPK + 10kg/ha Borax	0.73		4.40		110.00
T_4 -100% NPK + 15kg/ha Borax	0.79		4.74		118.50
T_5 -100% NPK + 20kg/ha Borax	0.87		5.22		132.00
T_6 -100% NPK + 0.5kg/ha Molybdenum + 10kg Borax	0.91		5.48		137.00
T_7 -100% NPK + 1kg/ha Molybdenum + 10kg Borax	0.99		5.92		148.00
T_8 -100% NPK +1.5kg/ha Molybdenum + 10kg Borax	0.93		5.64		141.00
T_9 -100% NPK +2kg/ha Molybdenum + 10kg Borax	0.88		5.28		132.00
C.D	0.026		0.174		4.742
S.E(m)	0.009		0.058		1.584

CONCLUSION

Agroforestry is being popularizing for providing benefits for farmers and rural people, leading to the generation of employment and revenue; food and nutritional security; meeting the other basic human needs on the sustainable basis and cushioning farmers from the harshness of climate change. Agroforestry creates more integrated, diverse opportunities for sustainable land use systems to increase the country's forest and tree cover to the 33%.On the basis of the results attempted from present investigation conducted during 2019-20, it is concluded that Broccoli can be well grown under agroforestry. Results also shows that treatment T_7 i.e.100% NPK + 1kg/ha Molybdenum + 10kg Borax was found to be the best treatment for growth, yield (148.00 q/ha) has the most appropriate dose for the good growth, better yield and quality production. These findings are based on one-year research so further trial is needed for the same.

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