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Performance of Mulches and Micronutrients on Ratooning Yield of Broccoli (*Brassica oleracea* L var. *italica Plenck*)

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Abstract

The Field experiment was conducted to find out the response of mulches and micronutrients on growth and yield of broccoli with an objective to estimate production economics. The experiment was laid out in split-plot design with three main plots (mulches), nine sub plots (micronutrients) and twenty-seven interaction treatments (mulches x micro nutrients) and each treatment was replicated thrice. The results revealed that mulches and micronutrients as well as their interaction significantly affected sprout production and yield of broccoli. Remarkable increase in sprout number (5.59), maximum sprout weight (62.89g) and highest sprout yield (5.59 t/ha) were observed where plants were grown under paddy straw mulch @7 t. ha^{-1} and treated with Zn-1% + Bo1-0.5% (M_1mn_6).

Key words: *Brassica oleracea var. italica*, Mulching, Paddy straw mulch, Micronutrients, Zinc and Boron, Sprout yield, Foliar application

Broccoli (*Brassica oleracea var. italica*) is an important Cole crop belonging to the family Brassicaceae and is valued for its rich antioxidant content, including phenolics, vitamins, glucosinolates, minerals, and folates. Balanced plant nutrition is essential for achieving higher yield and quality Saha *et al.* [10], and proper fertilizer application is a prerequisite for improved yield and head quality Brahma *et al.* [1]. Among micronutrients, zinc and boron play key roles in broccoli production. Zinc promotes auxin synthesis and chlorophyll formation, enhancing photosynthesis and plant growth [16], while its deficiency leads to small, poorly developed heads. Boron facilitates translocation of photosynthates from leaves to the developing head, increasing head weight and yield [6]; deficiency results in browning and hollow heart, reducing market acceptability.

Water is another critical factor influencing crop growth and development. In rainfed areas, inadequate rainfall during the rabi season constrains vegetable cultivation Prasad *et al.* [7] Adoption of water conservation practices such as mulching can help mitigate moisture stress, and the use of low-cost, eco-friendly materials like paddy straw and water hyacinth offers an economical solution.

Ratooning in broccoli (*Brassica oleracea var. italica*) is a postharvest practice in which the primary head is harvested while the plant remains in the field to produce secondary side shoots from axillary buds [2], [9]. Removal of the apical head reduces apical dominance and stimulates lateral shoot growth, enabling repeated harvests of tender sprouts Taiz *et al.* [14]. Appropriate harvesting techniques, supplemental nitrogen, adequate irrigation, and effective pest management enhance regrowth and shoot development [4]. Sprouting and calabrese types generally exhibit better ratooning potential than single-head hybrids [8]. This practice can extend the harvest period by several weeks, increase total yield, and reduce replanting costs while maintaining desirable quality [15]. Ratooning is particularly advantageous under mild climatic conditions and intensive production systems, offering a resource-efficient and economically viable approach to sustainable broccoli production.

MATERIALS AND METHODS

The field experiment was conducted at the Horticultural Farm, Institute of Agriculture, Visva-Bharati University. The experimental field was situated in semi-arid, sub-humid zone of West Bengal (23° 42′ N latitude and 87° 40′ 30″ E longitude), India. The soil of the experiment was sandy loam with pH of 5.8-6.1 having low organic matter (0.63%). The experiment was laid out in split plot design with three main plots (mulches), nine sub plots (micronutrients) and twenty-seven interaction (mulches x micro nutrients) treatments, each plot having an area of 6meters(2mx3m). According to the experimental design plots were prepared by ploughing followed by harrowing. Well prepared plots were manured with FYM @ 20 t. ha^{-1} and fertilized with recommended dose of N: P: K @ 100:80:100 kg/ha, respectively, in the form of urea, super phosphate (SSP), muriate of potash (MoP). The full dose of P and K and half of N was applied as basal and the remaining amount of N was top-

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dressed 30 days after transplanting (DAT). Seedlings were transplanted at 60cm x 40 cm spacing and mulches were applied uniformly after establishment of seedlings. Measured quantity of life saving irrigation was applied to each plot uniformly. Foliar application of micro nutrients carried at 30 and 45 DAT and other recommended package of practices were followed. After harvesting of the main head sprout growth and yield attributes viz., number of sprouts, sprout weight was recorded and accordingly sprout yield was calculated.

RESULTS AND DISCUSSION

Number of sprouts

Analyzed data as indicated in (Fig 1) shown remarkable improvement in number of sprouts with application of mulches of different types. Among applied mulches, paddy straw mulch @ 7 t. ha^{-1} produced superior results with maximum number of sprouts (4.88) over similar quantity of various kind of mulch (i.e. M_2-water hyacinth mulch@7 t. ha^{-1}). However, minimum number of sprouts (3.65) was observed where the plots devoid of mulching (M_3- No mulch).

The progressive performance of applied micronutrients resulted to increase in number of sprouts and it was maximum (4.76) with application of highest level of zinc and boron each (1%) (i.e. mn_9). Application of mn_8 (4.45), mn_6 (4.38) and mn_7 (4.35) produced statically similar number of sprouts. Whereas, lowest number of sprouts (3.50) produced form the plants devoid of any micronutrient application (mn_1).

Interaction between mulches and micro nutrients remarkably influenced the number of sprouts per plant as observed from the pooled analysis. The maximum value (5.59) was noted with applied paddy straw mulch @ 7 t. ha^{-1} along with foliar application of Zn-1% + Bo-0.5% (M_1mn_6). However, lowest (3.10) in this regard was observed in plots with absence of any mulch and micro nutrient application (M_3mn_1).

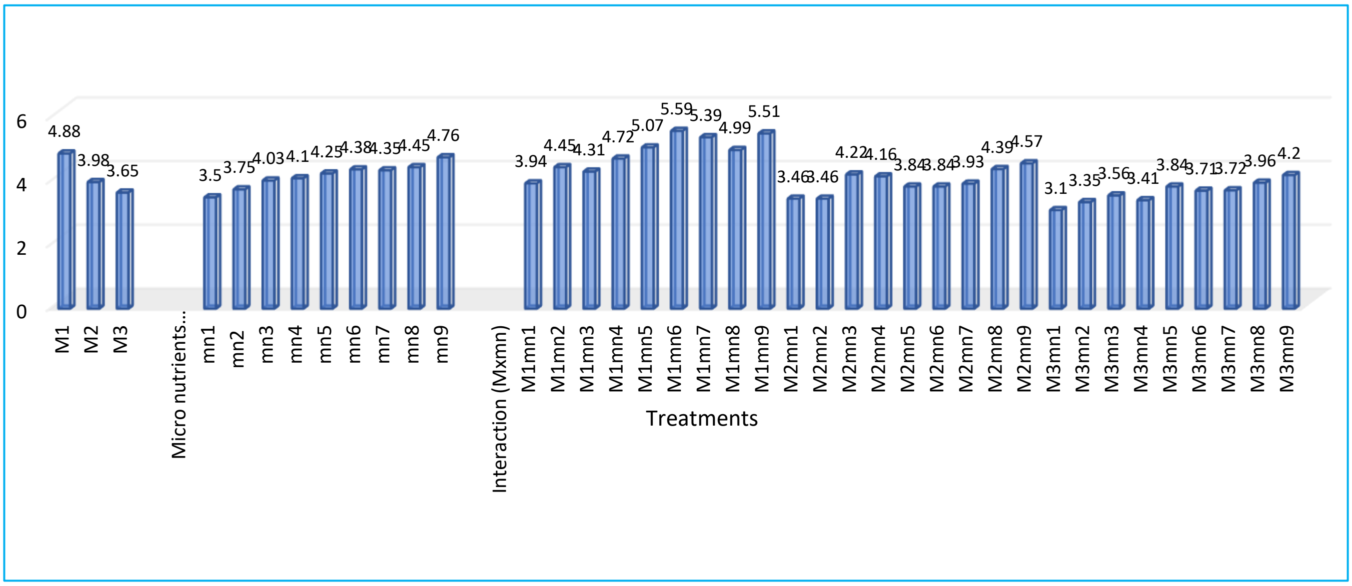


Fig 1 Performance of mulches and micronutrients on ratooned sprout number of Broccoli

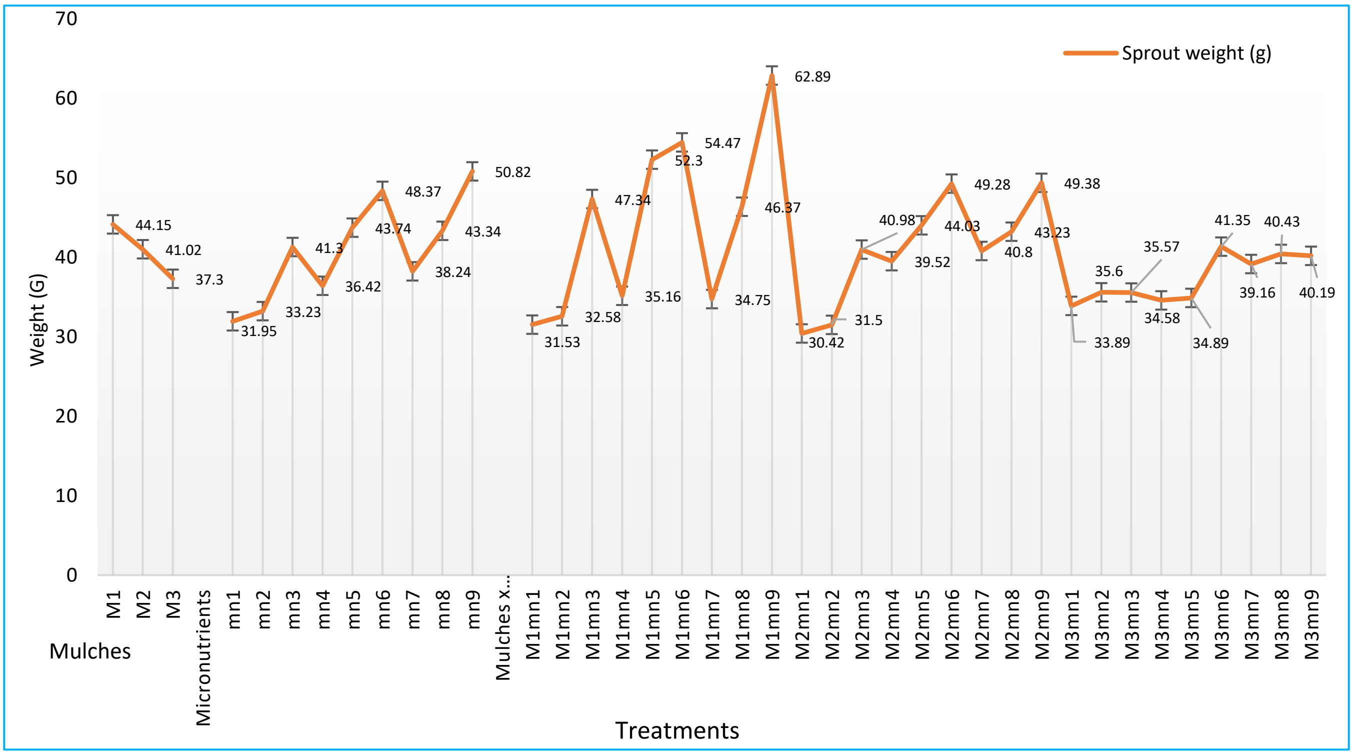
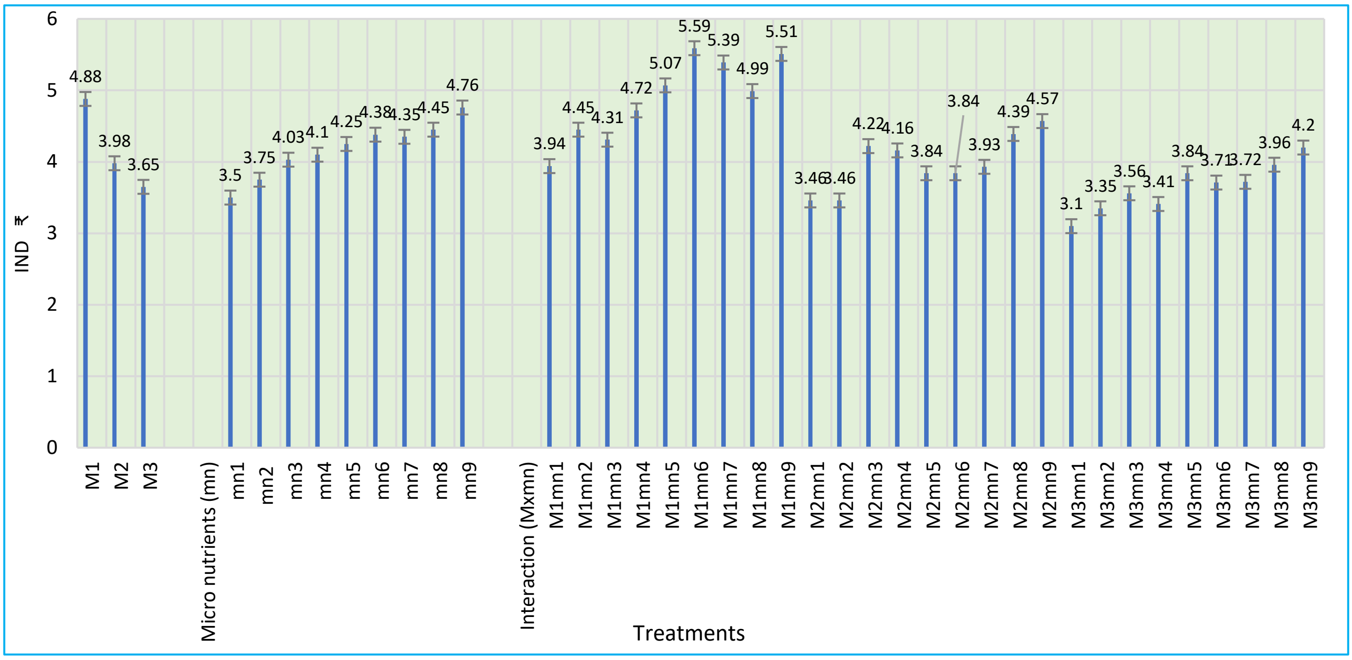


Fig 2 Effect of mulches and micro nutrients on ratooned sprout weight (g) of broccoli



M_1 - Paddy straw mulch (PM)-7 t. ha^{-1} M_2 - Water hyacinth mulch (WHM)-7 t. ha^{-1} M_3 - No mulch (NM).

mn_1- Zn $_0$(0.00 %)+ B_0 (0.00 %) ,mn_2 - Zn $_1$ (0.5 %) + B_0(0.00 %) ,mn_3- Zn $_2$ (1 %) +B_0(0.00 %) ,mn_4- Zn $_0$ (0.00 %)+B_1 (0.5 %),mn_5- Zn $_1$ (0.5 %) + B_1 (0.5 %),mn_6- Zn $_2$ (1 %) + B_1 (0.5 %),mn_7- Zn $_0$(0.00 %)+B_2 (1 %),mn_8- Zn $_1$ (0.5 %) + B_2(1 %) ,mn_9- Zn $_2$ (1 %) + B_2 (1 %).

M_1mn_1- PM +Zn $_0$(0.00 %)+ B_0 (0.00 %),M_1mn_2 – PM +Zn $_1$ (0.5 %) + B_0(0.00 %) , M_1mn_3- PM +Zn $_2$ (1 %) +B_0(0.00 %) , M1mn4- PM +Zn $_0$ (0.00 %)+B_1 (0.5 %), M_1mn_5- PM+ Zn $_1$ (0.5 %) + B_1 (0.5 %), M_1mn_6- PM +Zn $_2$ (1 %) + B_1 (0.5 %), M_1mn_7- PM+ Zn $_0$(0.00 %)+B_2 (1 %), M_1mn_8- PM+ Zn $_1$ (0.5 %) + B_2(1 %) , M_1mn_9- PM +Zn $_2$ (1 %) + Bo_2 (1 %). M_2mn_1- WHM +Zn $_0$(0.00 %)+ B_0 (0.00 %) , M_2mn_2 - WHM+ Zn $_1$ (0.5 %) + B_0(0.00 %) , M_2mn_3- WHM +Zn $_2$ (1 %) +B_0(0.00 %) , M_2mn_4- WHM +Zn $_0$ (0.00 %)+B_1 (0.5 %), M_2mn_5- Zn $_1$ (0.5 %) + B_1 (0.5 %), M_2mn_6- Zn $_2$ (1 %) + B_1 (0.5 %), M_2mn_7- Zn $_0$(0.00 %)+B_2 (1 %), M_2mn_8- Zn $_1$ (0.5 %) + B_2(1 %) , M_2mn_9- WHM +Zn $_2$ (1 %) + B_2 (1 %). M_3mn_1- NM +Zn $_0$(0.00 %)+ B_0 (0.00 %) , M_3mn_2– NM +Zn $_1$ (0.5 %) + B_0(0.00 %) , M_3mn_3- NM +Zn $_2$ (1 %) +B_0(0.00 %) , M_3mn_4- NM +Zn $_0$ (0.00 %)+B_1 (0.5 %), M_3mn_5- NM+Zn $_1$ (0.5 %) + B_1 (0.5 %), M_3mn_6- NM +Zn $_2$ (1 %) + B_1 (0.5 %), M_3mn_7- NM +Zn $_0$(0.00 %)+B_2 (1 %), M_3mn_8- NM +Zn $_1$ (0.5 %) + B_2(1 %) , M_3mn_9- NM+ Zn $_2$ (1 %) + B_2 (1 %).

Fig 3 Performance of mulches and micronutrients on ratooned sprout yield t/ha of Broccoli

Fig 4 Paddy straw mulch @ 7 t. ha^{-1} along with foliar application of Zn-1% + Bo-0.5%

Sprout weight (g)

It was observed that mulching had remarkable effect on sprout weight (g). Highest sprout weight (44.15g) was observed from the plots mulched with paddy straw mulch applied @ 7 t. ha^{-1} (M_1) followed by (41.02g) water hyacinth mulch@ 7 t. ha^1. Whereas, lowest (37.30g) in this aspect was observed under no mulch condition (M_3). It was clear that highest level of Zn and B (i.e.1% each) (mn_9) excreted remarkably highest sprout weight (50.82g). There was no statistical difference recorded with applied micro nutrients mn_6 (48.37g), mn_5 (43.74g) and mn_8 (43.34g) though, these were significantly superior over control condition (mn_1). However, reduction in sprout weight up to 31.95g was observed in plants with non-application micronutrients (mn_1). Interaction between mulch and micronutrients improved sprout weight over sole application, significantly highest sprout weight (62.89g) noticed in the treatment M_1mn_9 (Paddy straw mulch @ 7 t. ha^{-1} and Zn-1% + Bo-1%). Treatments viz., M_1mn_6, M_1mn_5 and M_2mn_9 were statistically at par with each other. However, lowest value (30.42g) in this regard was observed with application of water hyacinth mulch @ 7 t. ha^{-1} along with sole application of boron (i.e.M_2mn_2).

Sprout yield (t/ha)

Paddy straw mulch @ 7 t. ha^{-1} (M_1) remarkably enhanced the sprout yield per plot up to 4.88 t/ha over similar quantity of water hyacinth mulch and un-mulched control. Whereas, lowest (3.65 t/ha) in this regard observed under no mulch condition (M_3). Among applied micro nutrients, highest level of zinc and boron (i.e.1% each) (mn_9) remarkably increased the sprout yield per plot (4.76 t/ha) and it was at par with mn_8 (4.45 t/ha). Whereas, application of treatments like mn_6 and mn_7 produced statically similar sprout yield per plot, though, it was significant with respect to non-application (mn_1). However, plants devoid of micronutrients i.e. Zn and B (each 0%) produced lowest sprout yield (3.5 t/ha). Interaction between mulches and micronutrients as mentioned in and (Fig 3) remarkably increased the sprout yield per plot and it was maximum (5.59

t/ha) where plants grown under paddy straw mulch @ 7 t. ha^{-1} along with treatment of Zn_2-1% + Bo_1-0.5% (M_1mn_6). Treatments M_1mn_9 (5.51 t/ha), M_1mn_7 (5.39 t/ha) were produced statistically similar sprout yield and at par with each other. However, the lowest value (3.1 t/ha) in this regard was observed in plants grown without application of any mulch and micro nutrients (M_3mn_1).

Application of mulch influenced number of sprouts, sprout weight, sprout yield per plant and sprout yield per plot remarkably in comparison with non-application of mulch. Beneficial effect of paddy straw mulch in comparison with water hyacinth mulch was more conspicuous through analyzed data. Better conservation of soil moisture apart from other benefits usually derived from mulching resulted better vegetative growth which might have supported these secondary yield contributing characters.

On other hand, application of micronutrients through foliar spray remarkably influenced number of sprouts, sprout weight, sprout yield per plant and sprout yield per plot, respectively. Auxin induced apical dominance before harvesting of heads which prevented the development of sprouts [11]. After harvesting of heads, dormant axillary buds (sprouts) started growing actively which is known as sprouting of broccoli [3]. Moreover, Zn being precursor of auxin had increased the auxin level with its (Zn) increased concentration in plant body due to foliar application inducing more apical dominance. This not only improved development of heads as observed in previous discussion but also had probable negative effect on development of dormant axillary buds (sprouts) which was resumed after harvesting of head (apical meristematic part). Thereafter, higher concentration of auxin might have helped development of more number of sprouts with increased weight and yield. Moreover, sufficient availability of boron due to foliar application might have improved sprouting and their weight and yield as a whole due to its positive role on production and translocation of photosynthates from source (leaf) to sink (sprouts).

Interaction between paddy straw mulch along with foliar application of Zn (1%) + B (1%) (M_1mn_9) also revealed its favorable effect on the said traits. Whereas, plants grown without mulches and foliar application of zinc and boron notably decreased the number of sprout and sprout yield per plant which was ultimately reflected in reduced sprout yield per plot. Moreover, the present results are in conformity with result of findings of Moniruzzaman *et al.* [5], Sing *et al.* [12], Thapa *et al.* [17] in broccoli and Suganiya and Kumuthini [13] in ratooned brinjal crop.

The positive response of the plants in this field trial showed the beneficial effect of applied treatments consisting of mulches and micro nutrients over non-application. Beneficial effects of micro nutrients and mulching were already evident for different yield attributes especially in head weight, number of sprouts per plant and sprout yield per plot which might have positively contributed to head yield per plot, head yield per hectare.

CONCLUSION

From the aforementioned study it could be concluded that application of paddy straw mulch @ 7 t ha^{-1} significantly enhanced sprout number, weight, and yield in broccoli. Foliar application of zinc and boron (1% each) further improved these parameters. The combined application of paddy straw mulch with Zn and B proved most effective in maximizing productivity of ratoon broccoli, making it a viable and sustainable production strategy.

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