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Broccoli quality and nutrient uptake response to integrated nitrogen management and mulching

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Abstract

The importance of the efficient use of integrated fertilizers is also popular among the farmers to obtain higher nutritive and quality product. In an integrated agricultural technique, integrated nitrogen management gives the better way to solve various problems with regards to sustainability, enhance quality, economic and yield as well as efficiently maintain good soil productivity. Broccoli is one of the most essential crops among crucifer group vegetables and it is a significant source of nutrition and antioxidants, i.e., carotenoids sulphur-containing compounds viz., Sulforaphane, Glucoraphane and Glucosinolate etc. Research experiments were laid to find out the effect of poultry manure, vermicompost, FYM and cowdung with distant mulching in broccoli and conducted out in FRBD at the experimental at Lovely professional university in Punjab, in 2022-23. Integrated nitrogen management with mulching enhances the activity of various macro nutrients. Result showed that the nutrient uptake of broccoli were observed to be superior in the treatment N₅M₂ where 50% nitrogen through Urea + 50% nitrogen through Poultry manure were applied along with black polythene mulch. Head yield of broccoli was positively correlated with several nutrients uptake. Integration of nitrogen (organic sources) and Urea (inorganic sources) under different mulch treatment enhances nutrient uptake quality of broccoli and also maintains the healthy soil fertility.

Keywords: *Brassica oleracea* var. *italic*, mulch, nitrogen, nutrient uptake, quality

1. Introduction

Broccoli is an important Mediterranean region-originated Cole crop, scientifically known as *Brassica oleracea* var. *italica*. It is known as Hari Gobi in India. The broccoli's curd and tender stems are the central edible part; the large flower head is green, emerging from a thick edible stalk, usually consumed raw in the form of salad or cooked, stir-fried, etc. Broccoli is a significant source of nutrition and antioxidants, i.e., carotenoids and vitamins, as well as flavonol, hydroxycinnamic acids and sulphur-containing compounds viz., Sulforaphane, glucoraphane and Glucosinolate according to Baenas *et al.* (2017) [3], which helps in mitigating the risk of cancer. Broccoli is the richest source of organosulfur compounds like isothiocyanates and dithiolethiones, which enhance the activity of enzymes in detoxifying carcinogenic pathogens and other foreign compounds by Pankaj *et al.* (2017) [8]. Broccoli has the highest medicinal as well as nutritional value. In 2021, worldwide production of broccoli was recorded at 27.9 million tonnes, with India and China accounting for 69.4% of the world's total production. Broccoli is considered a commercial crop in India, as reported by Ebert *et al.* (2022) [5]. In India, it is cultivated on 4.4 lakh hectares of land, 32% of the overall area under broccoli cultivation worldwide, compared to 13.8 Lakh worldwide. About 27.6% of the area is covered by Punjab Anonymous *et al.* (2016) [1].

For successful crop growth and development, balanced fertilization is essential for improving the nutrient usage efficiency of plants and retaining soil productivity (Aouass *et al.*, 2022) [2]. It is widely known that imbalanced nutrient availability not only leads to low and poor-quality output but may also lead to mitigation of soil nutrient stores, nutrition scarcity, soil degradation and diseases; a specific balance among the various nutrients along with mulching techniques resulted in improving fertilizer usage efficiency.

Macro and micronutrients play essential roles in plant buildup along with broccoli's development, production and even composition of many nutrients and enzymes. The uptake of nutrients mostly starts three weeks before crop harvesting. Using organic manure as a nitrogen source improves macro-nutrient uptake by plants and enhances the availability of other micronutrients.

Mulching practices are another important intercultural operation that regulates soil temperature and moisture and can boost the efficiency of nutrients by influencing the activities of soil microorganisms (Zhao *et al.*, 2023) [14].

2. Methods and Materials

2.1 Experimental site: The present work was performed in the *Rabi* season of 2022-23 at the Horticulture research farm of LPU, Punjab, India. Experimental site is situated at 31.33°N 75.30°E at 226 m MSL. The weather pattern of the experiment location comes under a sub-tropical region in the central plane region of Punjab with rainfall of 613 mm. The study was laid out in FRBD with 3 replications with six different sources of nitrogen (Urea, Poultry manure, vermicompost, cow dung and FYM) and control *viz.*, N₀ (0% N), N₁ (100 percent nitrogen with Urea, N₂ (50% nitrogen by Urea + 50% nitrogen through Cow dung), N₃ (50% nitrogen through Urea + 50% nitrogen via FYM), N₄ (50% nitrogen by Urea + 50% nitrogen through Vermicompost), N₅ (50% nitrogen by Urea + 50% nitrogen by Poultry manure) and 3 types of mulches treatments *viz.*, M₀ (Control) M₁ (Paddy straw mulch) M₂ (Black Polythene mulch). All the cultural practices were followed per recommendations for the broccoli crop—forty-five-day-old seedlings of broccoli var. Palam Samridhi was transplanted in the experimental field at a spacing of 0.60×0.45 cm in both years. Five healthy samples were randomly selected for observation from each treatment for chemical analysis using standardized methodologies.

2.2 Sampling the soil

Soil sample (0-15 cm depth) was collected from various locations during the field preparation before layout to assess the initial nutrient status of the soil. The samples were keenly dried, crushed, a 2mm sieve used and safely stored in poly bags for chemical analysis. Moisture (%) from broccoli head estimated by given formula

$$\text{Moisture content (\%)} = \frac{\text{Wet weight} - \text{Dry weight}}{\text{Wet weight}} \times 100$$

Dry weight of broccoli head estimated by using hot air oven at temperature 70°(158°F) for 6 hour. Nitrogen uptake by the plant was determined using the Kjeldahl method. For the other elements, 1-2 g of sample was taken into a silica receptacle and dry-ashed at 500 °C (4-5 hours) in a muffle furnace until ashing was complete. The ash was dissolved in hydrochloric acids and nitric and evaporated in water immersion. The residue was washed in a 100-mL volumetric flask with tepid distilled water. Using an ICP emission spectrophotometer, the nutrients N, P, K, Mg and Ca were identified. The recorded data underwent statistical analysis employing OP STAT software CCS HAU, Hisar. The statistical significance was assessed using the F value at a 5% significance level, and the critical difference was established at the same significance level of 5%.

3. Results

3.1 Quality parameters

The data analysis (Table 1), observed that maximum dry matter (09.88%) was recorded in the treatment combination N₅M₂,

which was statistically at par with the treatment N₃M₁ (9.36%) respectively. However, dry matter (9.26) was recorded under the treatment N₂M₁, Whereas the minimum dry matter was observed under the treatment N₀M₁ (5.26). The maximum increase in the Moisture % was observed in treatment N₅M₂ (91.65%), followed by treatment N₄M₂ (86.87%), while the minimum moisture content was observed in treatment N₀M₀ (control), i.e. (70.53%).

3.2 Uptake of nutrients by broccoli plant

The statistically analyzed pool data of two-year experiments (Table 1) revealed that different levels of integrated nitrogen management along with mulch brought out a superior response in the uptake of nutrients of broccoli. One of the crucial elements and macro-nutrients i.e. Nitrogen, Phosphorus and Potassium were essential for various processes such as growth, fruiting, and resistance in plants. The maximum nitrogen uptake (1.041 mg/plant) was recorded under treatment N₅M₂ significantly, followed by treatment N₃M₂ (1.038 mg/plant) and treatment N₁M₂ (1.033 mg/plant). The minimum amount of nitrogen uptake (0.961 mg/plant) was observed from treatment N₁M₁. In terms of Phosphorus content, the highest phosphorus uptake (0.168 mg/plant) was found in treatment N₄M₁, which was statistically at par with treatment N₅M₂ (0.164 mg/plant) and treatment N₂M₂ (0.161 mg/plant). The least phosphorus uptake was observed under treatment N₂M₀ (0.111 mg/plant). The maximum amount of potassium uptake was recorded under treatment N₃M₂ (0.841 mg/plant), which was statistically at par with the treatment N₅M₁ (0.837 mg/plant) and treatment N₂M₁ (0.835 mg/plant). The plant recorded a minimum amount of potassium uptake under treatment N₂M₀ (0.771 mg/plant). The highest calcium uptake (104.3 mg/plant) was observed in treatment N₄M₁, followed by treatment N₂M₁ (101.4 mg/plant), whereas the least uptake of calcium was noted under treatment N₅M₂ (86.0 mg/plant). The data in Table 2 showed that the different levels of integrated nitrogen management and mulching material brought out significant responses for magnesium uptake by broccoli plants. The maximum amount of magnesium uptake was obtained from treatment N₂M₁ (88.4 mg/plant), followed by N₄M₁ (87.9 mg/plant), which was closely associated with treatment N₁M₂ (87.2 mg/plant). The minimum amount of magnesium uptake was observed from treatment N₄M₂ (81.1 mg/plant).

4. Discussion

4.1 Quality attributes influence by integrated nitrogen and mulching effect on broccoli.

The high dry matter weight (%) and moisture content (%) could be due to the more vegetative growth within the plant may be increased dry matter weight. Organic fertilizer improves leaf growth, which boosts photosynthesis and acquires more photosynthesized compounds, increasing the dry matter content in plants, similar to the finding reported by (Singh *et al.*, 2018) [13].

4.2 Uptake of nutrients by broccoli plant

The increase in uptake nitrogen content in plants by a combination of manure and fertilizers apply as 50% nitrogen by Urea + 50% nitrogen through Poultry manure along with black polythene mulch make a favourable soil environment that enhances uptake of nitrogen which ultimately increase the higher amount in broccoli plant. The results are in the line with findings of Ragusa *et al.* (2017) [9] and Choudhary *et al.* (2012) while Poultry manure is one of the enriching suppliers of nitrogen and trace elements for better crop production reported

by Sahito *et al.* (2018) [11]. The increase in uptake phosphorus content in plants by a combination of 50 percent nitrogen by Urea with 50 percent nitrogen through Vermicompost along with paddy straw mulch might be attributed to higher mineralization of native soil phosphorous by decreasing ability of soil nutrient to fix phosphorus and enhance its availability via liberation of organic acid. The organic material works as a preventive covering on sesquioxide, which mitigates the phosphate fixation capacity of soil and thus enhances the phosphorus status in plants. A similar data has also been recorded by Rosen *et al.* (2014) [10], where the Vermicompost comprises various enzymes and hormones along with macro and micronutrients (Meena *et al.* 2017). The increase in uptake potassium content in plants by a combination of (50% nitrogen with Urea and 50% nitrogen by FYM) and black polythene mulch. This could be due to the roles of potassium activation of the enzyme, stomata opening and closing, with Mg + improving the efficiency of photosynthesis, enhancing the growth of plants and inhibiting the detrimental effect of salinity stress. While the FYM increases the water holding capacity along with improved soil structure. It helps to increase nutrient availability, especially micronutrients (Chowdhury *et al.*, 2017) [4]. The higher amount of Ca uptake observed by the integrated sources, i.e., (50% nitrogen through Urea + 50% nitrogen by Vermicompost) with paddy straw mulch might be due to the mineralisation of

nutrients in the soil which accelerated the more root pressure flow to sufficient amounts of water-soluble Ca to the broccoli plant. Calcium also works in forming new plant tissue, such as meristematic tissue and young leaves and often exhibits degraded growth from improper cell wall formation. It also accelerates certain enzymes and sends signals that coordinate specific cellular activities. Similar observation was also recorded by Padamwar and Dakore (2010) [7]. The application of organic nitrogen fertilizer vermicompost resulted in a notable high in the nutritional content of both leaves and heads of broccoli. The depletion of nutrients from manure under paddy straw mulch was a slow process, which made the availability of essential nutrients during the growth till the maturity of broccoli. The study was reported by Hossain *et al.* (2020) [6]. Magnesium is one of the crucial components of plants for various enzymatic activities, such as photosynthesis and respiration. It is enhanced by the integration of 50% nitrogen by Urea + 50% nitrogen by Vermicompost with paddy straw mulch, which might be due to the mineralization of macronutrients leading to the succeeding uptake of magnesium. Mg is necessary to produce cytochrome, which increases photosystem activation and energy transfer from PS-I and PS-II. The relative rate of plant growth has been positively impacted by the increase in magnesium content in plants. The results mentioned above are consistent with those of Talat *et al.* (2014) [13].

Table 1: Quality parameter and Macro and micronutrient uptake by plant (mg/plant) influence by integrated nitrogen management and mulching.

Treatments		Quality parameter		Macro nutrient				
		Moisture percentage (%)	Dry weight of broccoli (%)	Nitrogen mg/plant	Phosphorus mg/plant	Potassium mg/plant	Calcium mg/plant	Magnesium mg/plant
		Mean	Mean	Mean	Mean	Mean	Mean	Mean
N ₀ M ₀	0% N	70.53	6.65	1.009	0.139	0.788	90.1	82.6
N ₀ M ₁	0% N + Paddy Straw mulch	78.37	5.26	0.983	0.121	0.811	92.1	83.7
N ₀ M ₂	0% N + Black Polythene mulch	83.52	5.37	1.021	0.151	0.818	96.1	81.8
N ₁ M ₀	100% N + Without Mulch	81.27	7.87	0.971	0.114	0.781	88.4	85.1
N ₁ M ₁	100% N Urea + Paddy Straw mulch	82.64	8.97	0.961	0.128	0.796	91.3	84.1
N ₁ M ₂	100% N + Black Polythene mulch	78.35	7.87	1.033	0.158	0.829	97.3	87.2
N ₂ M ₀	50% N Urea+50% N Cow Dung3t/ha + Without mulch	86.56	8.87	0.979	0.111	0.771	90.7	83.1
N ₂ M ₁	50% N Urea +50% N Cow Dung + Paddy Straw mulch	87.65	9.26	0.967	0.138	0.835	101.4	88.4
N ₂ M ₂	50% N Urea +50% N Cow Dung + Black Polythene mulch	83.69	8.36	1.018	0.161	0.816	87.2	83.2
N ₃ M ₀	50% N Urea +50% N FYM + Without Mulch	79.63	9.22	0.991	0.125	0.778	93.8	84.8
N ₃ M ₁	50% N Urea +50% N FYM + Paddy Straw mulch	84.65	9.36	0.974	0.131	0.807	94.2	86.8
N ₃ M ₂	50% N Urea +50% N FYM + Black Polythene mulch	85.52	8.46	1.038	0.148	0.841	98.7	85.9
N ₄ M ₀	50% N Urea +50% N Vermi compost + Without Mulch	87.43	7.57	1.014	0.118	0.794	86.3	81.6
N ₄ M ₁	50% N Urea +50% N Vermi compost + Paddy Straw mulch	84.38	8.26	1.027	0.168	0.831	104.3	87.9
N ₄ M ₂	50% N Urea +50% N Vermi compost + Black Polythene mulch	86.87	7.46	1.011	0.144	0.82	85.6	81.1
N ₅ M ₀	50%N Urea +50% N Poultry Manure + Without Mulch	86.61	9.65	0.987	0.134	0.789	95.6	82.1
N ₅ M ₁	50% N Urea +50% N Poultry Manure + Paddy Straw mulch	85.36	8.24	1.026	0.157	0.837	102.9	86.3
N ₅ M ₂	50% N Urea+50% N Poultry Manure+ Black Polythene mulch	91.65	9.88	1.041	0.164	0.824	86.1	84.6
(CD @ 5%)		0.33	0.28	0.025	0.022	0.029	0.041	0.030
SE(m)±		0.93	0.63	0.011	0.009	0.014	0.015	0.012

5. Conclusion

The different combination of organic and inorganic used in the present experiment explores the best treatment, i.e., (N₂M₂) 50 percent nitrogen from Urea + 50 percent nitrogen by poultry manure in combination of black polythene mulch which not only gives better yield and quality but also improves the availability of nutrients in the soil. Mulching, the practice of covering the soil surface with organic or inorganic materials, has become popular among farmers and gardeners to conserve soil moisture, reduce weeds and improve soil fertility. Application of various nitrogen fertiliser sources *viz.*, poultry manure, vermicompost, farm yard manure, cow dung and mulching can dramatically influence plant nutrient uptake, resulting in higher crop yields

and overall plant health. Mulching is essential in maximizing the effects of nitrogen fertilisers by stimulating root development and nutrient uptake. It assists in nutrient retention, microbial activity, soil temperature regulation and weed control. Subsequently, the combined impacts of mulching and diverse nitrogen fertiliser sources can result in more balanced and effective plant nutrient uptake. Several factors, including crop type, soil conditions and management objectives, influence the choice between organic and inorganic sources. Mulching improves the overall effectiveness of nutrient management systems, encouraging sustainable and productive agricultural practices.

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