Journal of Advanced Zoology

ISSN: 0253-7214
*Volume **44** Issue **04 Year 2023** Page **50:59***

Effect of Integrated Nitrogen and Mulching on Growth, Yield and Quality Characteristics of Broccoli (*Brassica oleracea* var. *italica*) cv. Palam Samridhi

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Article History

Received: 06 June 2023
Revised: 05 Sept 2023
Accepted: 30 Oct 2023

Abstract

Broccoli is an important cole crop, widely grown in India. The excessive use of inorganic fertilizer, resulting in infertility of soil and chemically toxic agricultural by-products, is one of the most limiting factors affecting the quality production and productivity of the crop. To evaluate the effect of different organic and inorganic nitrogen sources and the application of different mulching materials on productivity and quality aspects of broccoli cv Palam Samridhi, the experiment was conducted for two years during 2021-22 and 2022-23. Among the treatments, the highest plant height (36.12cm), leaf length (22.39cm), leaf width (13.30), stem diameter (2.5), plant spread (1687.60cm2), head weight (367.75g), head yield/ha (254.43q/ha), moisture (91.65%), TSS (8.10°B), head dry matter (12.54%) and protein (3.65%) were recorded in treatment N_5M_2 (50% Nitrogen with Urea (108kg/ha) along with 50% Nitrogen utilizing Poultry Manure (1.5t/ha) and black polythene mulch) and quality traits such as highest chlorophyll (19.83%) in N_3M_2 (50% N Urea(108kg/ha)+50% N FYM (10t/ha) + Black Polythene mulch). In contrast, Proline (36.58%) were recorded in treatment N4M1 (50% N Urea (108kg/ha) +50% N Vermicompost (4t/ha) + Paddy Straw mulch), which was found superior overall individual treatments and their combination.

Keywords: *Broccoli, Inorganic Fertilizer, Mulching, Organic.*

1. Introduction

Broccoli is an essential vegetable among the cole crops. It originated from the eastern Mediterranean region [1] and was introduced in India in the 19th century [2]. The global broccoli and cauliflower production scaled from roughly 15 million tonnes in 1999 to approximately 26.92 million in 2019. The cultivation of broccoli is gaining popularity in India, with increasing production in states such as Himachal Pradesh, Uttarakhand, Maharastra, Tamil Nadu and Gujrat. Farmers are becoming more interested in broccoli production due to its high nutritive value, high domestic demand, potential value addition, promising market and higher revenue. Despite the high nutritive value of this crop, the yield in the farmer's field is relatively low due to numerous factors such as excessive frost, high weed population pest disease and soil fertility problems. Among all these problems, high weed growth and soil fertility problems have become a severe threat to crop productivity with good quality.

Global food security depends deliberately on dry land regions where crop production is curtailed by water scarcity and infertile soil [3]. The excessive use of inorganic fertilizer resulted in infertility of soil and chemically toxic agricultural products. Excessive inorganic fertilizer is one of the most limiting factors affecting the crops' quality, production, and productivity. Inorganic fertilizer application is popular among Indian farmers, which is also necessary for brassicas' growth yield and quality [4]. It is tedious, responsible for destroying soil's inherent properties, increasing eutrophication due to the high mobility of urea [5] and directly or indirectly harmful to human health. Thus, integrated nitrogen management through organic and inorganic forms with mulching practices or their combination is necessary for better crop production.

Furthermore, the application of alternative urea along with organic manure such as Cow dung, vermicompost, poultry manure and FYM in combination will help to enhance the nutrient levels and reduce the harmful effect of the long-term application of chemical fertilizers [6] Furthermore, the use of urea along with organic manure with combination of mulching ensure to maintain long term nutrient balance in the soil, improves soil fertility, enhance moisture retention capacity and suppress the growth of unwanted weed [7]. Broccoli is an essential vegetable among the cole crops. It originated from the eastern Mediterranean region [1] and was introduced in India in the 19th century [2]. The global broccoli and cauliflower production scaled from roughly 15 million tonnes in 1999 to approximately 26.92 million in 2019. The cultivation of broccoli is gaining popularity in India, with increasing production in states such as Himachal Pradesh, Uttarakhand, Maharastra, Tamil Nadu and Gujrat. Farmers are becoming more interested in broccoli production due to its high nutritive value, high domestic demand, potential value addition, promising market and higher revenue. Despite the high nutritive value of this crop, the yield in the farmer's field is relatively low due to numerous factors such as excessive frost, high weed population pest disease and soil fertility problems. Among all these problems, high weed growth and soil fertility problems have become a serious threat to crop productivity with good quality.

Global food security depends deliberately on dry land regions where crop production is curtailed by water scarcity and infertile soil [3]. The excessive use of inorganic fertilizer resulted in infertility of soil and chemically toxic agricultural products. Excessive inorganic fertilizer is one of the most limiting factors affecting the crops' quality, production, and productivity. Inorganic fertiliser application is popular among Indian farmers, which is also necessary for the growth yield and quality of brassicas [4]. It is tedious, responsible for destroying soil's inherent properties, increasing eutrophication due to the high mobility of urea [5] and directly or indirectly harmful to human health. Thus, integrated nitrogen management through organic and inorganic formsforms with mulching practices or their combination is necessary for better crop production. Furthermore, the the application of alternative urea along with organic manure such as Cow dung, vermicopost, poultry manure and FYM in combination will help to enhance the nutrient levels and reduce the harmful effects of the long-term application of chemical fertilizers [6] furthermore the use of urea along with organic manure with combination of mulching ensure to maintain long term nutrient balance in the soil, improves soil fertility, enhance moisture retention capacity and suppress the growth of unwanted weed [7].

2. Materials And Methods

Experimental site

The experiment was conducted during the Rabi seasons of 2021–2022 and 2022–2023 at the research farm of Lovely Professional University Phagwara, Punjab.

Table 1 Initial properties of the soil

Characters	2021-22	2022-23	Method used
Coarse sand (%)	42.76	41.76	International Pipette Method, [8]
Fine sand (%)	41.18	41.89	International Pipette Method, [8]
Silt (%)	9.45	9.44	International Pipette Method, [8]
Clay (%)	6.18	6.19	International Pipette Method, [8]
PH (1:2.5) at 25°C	8.65	8.65	Potentiometer [9]
EC (1:2.5) at 25°C (dS/m)	0.18	0.17	Conductivity meter [9]
Organic carbon (%)	0.23	0.23	Modified Walkley and Black method [9]
Availability of N (kg/ha)	50.32	51.45	Micro-Kjeldhal method [10]
Availability of P_2O5(kg/ha)	33.46	34.52	Olsen's method, 11]
Availability of K_2O g/ha)	130.46	136.87	Neutral N NH4OAC Flame photometer method, [12]

Experimental design

The experimental laid out in Factorial Randomized Block Design with three replications. The treatment consisted of six levels of nitrogen (N_0- Control, N_1-100% N through Urea (217kg/ha), N_2- 50% N through Urea (108kg/ha) + 50% N via Cow dung (3t/ha), N_3- 50% N through Urea (108kg/ha) + 50% N through FYM (10t/ha), N_4-50% N through Urea (108kg/ha) + 50% N through Vermicompost (4t/ha) and N_5- 50% N through Urea (108kg/ha) + 50% N through Poultry manure (3t/ha) and three levels of mulching, M_0- Control, M_1- Paddy straw mulch and M_2 Black polythene mulch.

Raising seedlings and transplanting

Palam Samridhi variety of broccoli, was procured from CSKHPKV, Palampur, for the experiment. Seedlings of broccoli were raised at high-tech polyhouse in pro trays by using cocopeat: perlite: vermiculite (3:1:1). Four weeks old seedlings were transplanted in the first week of November with

spacing 60 x 45cm during both experimental seasons. The transplanting was done in the evening. Light irrigation was applied just after the transplanting, and gap filling was done seven days after transplanting. All agro techniques were performed as per the guidelines of Punjab Agriculture University.

Statistical analysis

All the recorded data were subjected to statistical analysis using OP STAT software developed by CCS HAU, Hisar. F value at a 5 % significance level was used to evaluate the statistical significance, and the critical difference was determined at a 5 % level of significance [13].

3. Results and Discussion

The pooled mean data revealed that applying different organic or inorganic nitrogen sources had a significant (p=0.05) impact on growth yield and quality parameters.

Plant height

The data illustrating the impact of integrated nitrogen management in plant height (cm) is presented in (Table 2 and Fig 1). The highest plant height, 32.68cm, was observed in N5, 50% N Urea + 50% N Poultry manure; in contrast, the lowest plant height in N0, 0% N (Control), i.e., 23.21cm. The mulching on broccoli crops has significantly affected growth and yield traits. The maximum plant height was found in the treatment M2, Black polythene mulch, i.e., 31.72cm, while the minimum value was obtained in M0, control, i.e., 28,53cm. This may be because black polythene mulch generally maintains soil temperatures, enhancing the microbial activity in the plant root zone [14]. Interaction between organic and inorganic manure and various mulching practices remarkably enhances the growth yield attributes of broccoli. The treatment combination N5M2 (50% N Urea + +50% N Poultry manure + Black Polythene mulch) was superior concerning growth yield and quality parameters. While the minimum values for plant height in treatment combination N0M0; 0%N i.e.,22.67cm. The application of poultry manure and urea with black polythene mulch significantly resulted in the overall treatment combination. The observed effect can be attributed to the benefits of poultry manure. It could be because 60 per cent of the nitrogen in poultry manure is found as uric acid. The quick conversion of uric acid to ammonia allows for the quick and effective use of that chemical for improved plant development and growth. These observations were supported by [15]. These results are also partially similar to the findings of [16].

Leaf length, leaf width

The data illustrating the impact of integrated nitrogen management on Leaf length and leaf width (cm) is presented in Table 2, Fig 1. The more considerable Leaf length and width of 20.20cm and 12.96cm were observed in treatment N5; 50% N Urea + 50% N Poultry manure. While the minimum leaf length and width found in N0; 0% N (Control) were 14.80cm 7.10cm. The different mulching practices on broccoli crops have significantly affected leaf length and width. The maximum leaf length and width (11.69cm, 2.21cm) were observed in M2, black polythene mulch. At the same time, the minimum values obtained for leaf width and leaf length were 18.09cm and 10.41cm, respectively. The interaction effect of integrated Nitrogen management and mulching practices found the highest leaf length and leaf width in treatment combination N5M2 (50% N Urea +50% N Poultry manure + Black Polythene mulch) were 22.39 and 13.30cm, respectively. While the minimum values observed for leaf length and width in treatment combination N0M0; 0%N were 14.28 and 7.33 cm. The recorded effect can be attributed to the combined advantage of urea and poultry manure, and both are rich in nitrogen as a component of several coenzymes, amino acids, nucleotides, nucleic acids, auxins, cytokinins, and alkaloids; nitrogen promotes cell division, elongation, and enlargement which resulted in more considerable length and width of the broccoli crop. The outcomes of the current study support the findings in terms of leaf length and leaf width results [17].

Plant spread (cm^2)

Significant influence of different nitrogen treatments on the plant spread of broccoli was recorded (Table 2, Fig 1). The highest plant spread was recorded in N5; 50% N Urea + 50% N Poultry manure was 1591.43cm2. In contrast, the minimum plant spread (1295.32 cm2) in N0 0% N (Control). The increase in leaf length under different treatments can be attributed to increased plant spread. Similar findings have also been reported by [18]. Mulching material was found to be significant in the plant spread of the broccoli crop. The highest plant spread, 1574.27cm2, was recorded in M2, black polythene mulch. While the minimum value obtained for plant spread was 1410.32cm2 in M0; control. The interaction effect of integrated nitrogen management and different mulching practices was found

significantly in treatment combination N5M2 (50% N Urea +50% N Poultry manure + Black Polythene mulch) was 1687.60cm2. While the minimum values for plant spread in treatment combination N0M0; 0%N i.e.,1273.15cm2. Nitrogen is essential for the best possible growth and development of plants. The increased availability of primary nutrients and improved moisture retention capabilities of the soil are responsible for the improved plant spread those results from adding nitrogen through vermicompost and biofertilizer [19].

Stem diameter

The data illustrating the impact of organic and inorganic nitrogen management on stem diameter is in Table 2, Fig 1. The maximum diameter (2.4cm) was observed in N5, 50% N Urea + 50% N Poultry manure, While the minimum stem diameter (1.3cm) was observed in treatment N0; 0% N (Control). The present study indicates that the most practical combination of treatments provides sufficient vital nutrients, such as nitrogen and micronutrients, in a balanced way. This nutrient equilibrium promotes cell development and expansion, forming thicker stalks [20]. The data show the significant effect of different mulching practices on the stem diameter of broccoli. The maximum stem diameter was in M2, black polythene mulch (2.21cm). While the minimum values for stem diameter (1.16cm) were observed in M0; control. The interaction effect of integrated nitrogen and mulching practices was significant in treatment combination N5M2 (50% N Urea + +50% N Poultry manure + Black Polythene mulch) was 1.3cm. While the minimum value for stem diameter in treatment combination N0M0; 0%N was 1.3cm. Higher growth of crops due to the application of mulch along with poultry manure might have been attributed to the synergistic effect of mulching on the nutrient uptake efficiency of the plants [21].

Head diameter

Significant variation was recorded regarding head diameter due to the influence of organic and inorganic nitrogen management. The highest head diameter was observed in N5; 50% N Urea + 50% N Poultry manure was 14.73cm. The minimum head diameter was observed in N0; 0% N (Control), i.e.,13.37cm. The mulching on broccoli crops has shown a significant effect on the head diameter of broccoli. The maximum head diameter found in the treatment M2, Black polythene mulch, i.e. 14.76cm, while the minimum value obtained in M0, control, i.e. 9.23cm. Interaction effect of integrated effect of different nitrogen management and mulching practices on broccoli. The maximum head diameter found in treatment combination N5M2 (50% N Urea + 50% N Poultry manure + Black Polythene mulch) was 14.99 cm. While the minimum value for stem diameter in treatment combination N0M0; 0%N was 8.35cm. Considerable effects of good water holding capacity by using mulching techniques on the production and yield of broccoli. Notably, the maximum yields were obtained from black polyethene mulch, similar to the results published by [22].

Head weight, Head yield

The broccoli's head weight and head yield varied significantly due to different treatments (Table 2&3, Fig 1). The highest head weight and head yield were found in N5; 50% N Urea + 50% N Poultry manure was 381.73g/plant and 233.24q/ha, respectively. The minimum head diameter was observed in N0; 0% N (Control), i.e., 251.61g/plant and 190.13q/ha. Mulching practices the significance of head weight and head yield of broccoli. The highest head weight and yield were observed in treatment M2, Black polythene mulch, i.e., 387.36g/plant and 320.23q/ha. The minimum value obtained in M0 control is 263.64g/plant and 185.01 q/ha. The highest head weight and head yield values in treatment combination N5M2 (50% N Urea + 50% N Poultry manure + Black Polythene mulch) were 367.75g/plant and 254.43q/ha.

In comparison, the minimum values for stem diameter in treatment combination N0M0 (0%N+without mulch) was 199.16g/plant and 167.78q/ha. The possible reason for these findings might be due to the improved microclimate on the lower and upper surface of the soil and retaining the optimum moisture for growth, along with the inhibition of weed growth, particularly under black polythene mulch. Integrated nitrogen application, along with various mulching practices, shows significant results in terms of head weight and head of broccoli. The increase in yield parameter of nitrogen treatment was probably associated with the organic source of nitrogen, i.e. poultry manure, which enhance the flora of the soil, which resulted in more activities of microorganism and produced more plant metabolites, which helped to provide favorable condition to root to uptake efficient nutrient for proper growth of the plant [23, 24 and 25].

Table2. Effect of integrated nitrogen and mulching management on growth and yield attributes of broccoli. (Pooled mean)

Treatment		Plant height (cm)	Leaf length (cm)	Leaf width (cm)	Stem diameter (cm)	Plant spread (cm^2)	Head weight (g)	Head diameter (cm)	Head yield (q/ha
N_0	0% N	23.21	14.80	7.10	1.3	1295.32	251.61	9.27	190.13
N_1	100 % N Urea (217kg/ha)	32.29	20.76	12.13	2.2.	1586.91	364.42	13.37	223.26
N_2	50% N Urea(108kg/ha) +50% N Cowdung (3t/ha)	30.23	19.11	11.74	1.9	1488.88	313.01	10.98	211.25
N_3	50% N Urea(108kg/ha) +50% N FYM (10t/ha)	29.4	19.27	11.83	2.1	1455.48	332.77	12.87	201.82
N_4	50% N Urea (108kg/ha) +50% N Vermicompost (4t/ha)	30.55	20.66	11.07	1.6	1546.11	358.49	13.26	212.27
N_5	50% N Urea(108kg/ha) +50% N Poultry manure (1.5t/ha)	32.68	21.20	12.96	2.4	1591.43	381.73	14.73	233.24
SE(m)±		0.20	0.14	0.12	0.27	0.26	0.78	0.14	0.07
CD (P=0.05)		0.56	0.29	0.25	0.37	0.75	1.21	0.32	0.22
M_0	Without mulch (Control)	28.53	18.09	10.41	1.16	1410.32	263.44	9.23	185.01
M_1	Paddy Straw mulch	28.89	18.41	10.45	1.72	1449.48	367.37	13.98	288.82
M_2	Black Polythene mulch	31.72	20.05	11.69	2.21	1574.27	387.36	14.76	320.23
SE(m)±		0.20	0.19	0.12	0.15	0.32	1.11	0.05	0.16
CD (P=0.05)		0.56	0.54	0.25	0.44	0.92	1.91	0.12	NS

Table 3 Interaction effects of nitrogen and mulching management on growth and yield attributes on broccoli. (Pooled mean)

Treatment		Plant height (cm)	Leaf length (cm)	Leaf width (cm)	Stem Diameter (cm)	Plant spread (cm^2)	Head weight (g)	Head diameter (cm)	Head yield (q/ha
N_0M_0	0% N + Without mulch (Control)	22.67	14.18	7.33	1.3	1273.15	199.16	8.35	167.78
N_0M_1	0% N+ Paddy Straw mulch	23.63	15.08	6.19	1.2	1299.13	231.16	9.47	178.27
N_0M_2	0% N+Black Polythene mulch	23.13	14.98	7.11	1.3	1313.17	240.83	10.33	181.63
N_1M_0	100 % N Urea(217kg/ha)+Without Mulch	32.13	18.22	11.13	1.7	1576.97	232.16	10.46	198.93
N_1M_1	100 % N Urea(217kg/ha)+ Paddy Straw mulch	29.17	17.20	11.33	1.4	1528.16	316.15	12.49	212.53
N_1M_2	100 % N Urea(217kg/ha)+ Black Polythene mulch	35.15	21.12	12.81	2.3	1667.17	348.05	11.47	242.13
N_2M_0	50% N Urea(108kg/ha)+50% N Cow Dung(3t/ha) + Without Mulch	29.53	19.42	11.13	1.7	1446.13	332.65	13.26	218.83
N_2M_1	50% N Urea(108kg/ha)+50% N Cow Dung(3t/ha) + Paddy Straw mulch	30.19	19.15	11.33	1.9	1505.33	314.52	12.49	228.93
N_2M_2	50% N Urea(108kg/ha)+50% N Cow Dung(3t/ha) + Black Polythene mulch	30.23	19.4	12.77	2.2	1515.17	287.64	13.26	229.93
N_3M_0	50% N Urea(108kg/ha)+50% N FYM (10t/ha) + Without Mulch	27.13	16.83	10.19	1.6	1354.19	307.64	13.24	169.13
N_3M_1	50% N Urea(108kg/ha)+50% N FYM (10t/ha) + Paddy Straw mulch	30.37	20.54	12.57	1.9	1398.12	264.54	11.36	171.23
N_3M_2	50% N Urea(108kg/ha)+50% N FYM (10t/ha) + Black Polythene mulch	30.47	19.68	12.01	2.1	1613.33	314.57	12.48	210.83
N_4M_0	50% N Urea(108kg/ha)+50% N Vermi compost(4t/ha) + Without Mulch	28.93	19.61	11.12	1.6	1497.13	323.64	11.09	211.93
N_4M_1	50% N Urea(108kg/ha)+50% N Vermi compost(4t/ha) + Paddy Straw mulch	28.11	18.46	10.83	2.1	1491.83	275.94	12.49	214.93
N_4M_2	50% N Urea(108kg/ha)+50% N Vermi compost(4t/ha) + Black Polythene mulch	34.16	20.89	11.17	1.9	1649.12	312.96	13.25	210.53
N_5M_0	50% N Urea(108kg/ha)+50% N Poultry Manure(1.5t/ha) + Without Mulch	30.63	20.21	11.03	2.2	1613.11	337.28	12.45	197.43
N_5M_1	50% N Urea(108kg/ha)+50% N Poultry Manure(1.5t/ha)+ Paddy Straw mulch	31.12	19.01	9.73	2.1	1473.16	313.19	13.01	203.73
N_5M_2	50% N Urea(108kg/ha)+50% N Poultry Manure(1.5t/ha)+ Black polythene mulch	36.12	22.39	13.30	2.5	1687.60	367.75	14.99	254.43
SE(m)±		0.34	0.28	0.21	0.037	0.55	0.42	0.95	1.45
CD (P=0.05)		0.98	0.61	0.43	0.107	1.59	1.01	1.13	2.22

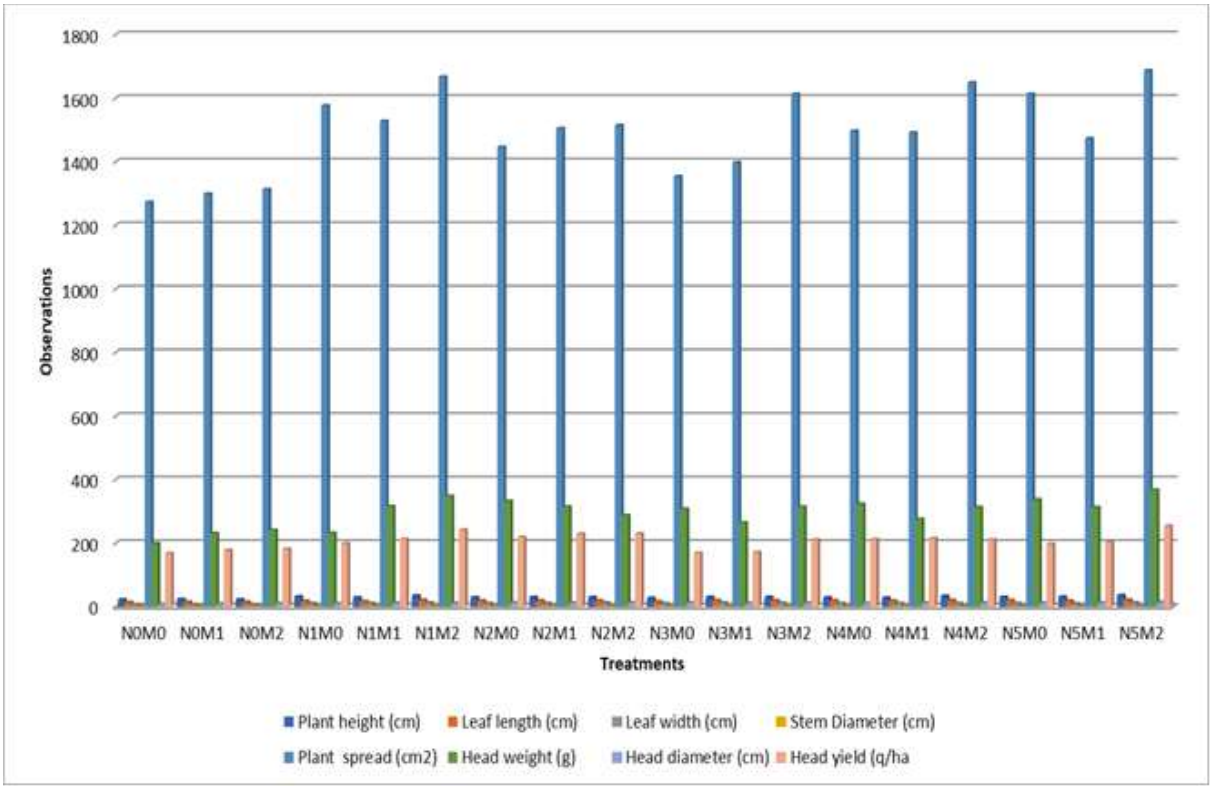

Fig 1. Interaction effects of nitrogen and mulching management on growth and yield attributes on broccoli. (Pooled mean)

Effect of integrated nitrogen application on quality attributes of broccoli

The results revealed that with the application of different sources of organic or inorganic nitrogen application on broccoli, there was no significant result concerning different sources of nitrogenous fertilizer in head dry matter (%) and moisture (%), TSS°B and fibre (%). However, it was found significant in the case of other quality parameters.

Total chlorophyll

Total chlorophyll content varied significantly due to the influence of different organic and inorganic nitrogen treatments (Table 4, Fig 2). The highest total chlorophyll per cent (15.20%) was found in treatment N3, 50% N Urea and 50% N FYM. While the minimum total chlorophyll (12.97%) was observed in N0; 0% N (Control). The data depicting the influence of different mulching materials on the total chlorophyll content of broccoli head. The maximum total chlorophyll (14.32) was recorded in M2, black polythene mulch. The lowest value (10.31%) was recorded for total chlorophyll in M1; paddy straw mulch). The interaction effect of integrated nitrogen management and mulching practises revealed a significant result in quality parameters among the other treatment combinations. Among the various treatment combinations, application of N3M2, 50% N Urea+50% N FYM + Black Polythene mulch was found superior in total chlorophyll i.e.19.83%. While the minimum value for total chlorophyll (10.08) was observed in N0M0; 0%N + without mulch. This may be due to the application of Paddy straw mulch, which plays a crucial role in altering the microclimate and growing conditions of crops. It is frequently used for vegetable crops to suppress weeds, improve soil organic matter and nutrient bank, and maintain optimal soil temperature for microbial activities in the root zone [26].

Protein

The data depicting the influence of integrated nitrogen management on protein have been displayed in (Table 4, Fig 2). Maximum protein content (3.91) in N4; 50% N Urea +50% N Vermicompost. While the minimum protein (1.55) content was observed in N0; 0% N (Control). The possible reason could be the integrated uses of chemical (urea) and organic (vermicompost) nitrogen sources. *Composting* is a biological process that works on the conversion of the organic matter (complex matter) available in the form of crop residues into simple material, where the generated compost can be used as organic fertilizer, which is a sustainable, natural, and effective way to increase plant growth and enhance the quality of plants. Its beneficial microorganisms, nutrient-rich composition, and soil-enhancing properties are the major factors in obtaining high-quality attributes in broccoli crops (Antunes *et al*.,

2021)—the data illustrating the impact of different Mulching practices on protein content in broccoli. The highest protein content (3.07%) was observed with applying M2, black polythene mulch. The minimum protein content (2.17%) was recorded in M0 (without mulch). This result recorded might be due to the mulching is responsible for conserving soil moisture, pest and disease infestation, suppressing weed growth, responsible for the physical, chemical and biological environment of soil, enhancing hydrothermal regimes, reducing nutrient and water losses, improving the organic matter build-up and nutrient recycling, which resulted obtaining maximum yield and water use efficiency of the plant. Plastic mulch regulates soil temperature fluctuation at night, enhancing the root microbial activity [27]. The interaction between integrated nitrogen and mulching practices remarkably influenced the protein content. The treatment was found superior regarding protein content in different treatment combinations. Application of N5M2 (50% N Urea + 50% N Poultry manure along with Black Polythene mulch) recorded higher protein content i.e.3.65%. While the control N0M0; 0% N + without mulch (control) found minimum protein content i.e. 2.39%. The possible reason might be that the Active rhizodeposition can stimulate the activity of soil microbial communities and help to enhance soil fertility by adding half a dose of organic matter and half inorganic mineralization or the solubilization of many soil nutrients such as P, K, Ca, and Fe, which can be unavailable for plants owing to only chemical fertilization in bare soils [28, 29].

Proline

The effect of integrated nitrogen management reveals a significant result on the proline content of broccoli. The application N5, 50% N Urea and 50% N Poultry manure recorded the highest proline content, i.e. (34.98%). While the minimum proline content (28.37%) was recorded in N0; 0% N (Control). The different mulching practices have shown a significant effect on the quality of broccoli. The maximum proline content (35.27%) was observed in M2, black polythene mulch. The minimum proline content (27.74) was observed in M0 without mulch (control). The interaction between organic and inorganic nitrogenous sources and different mulching practices remarkably enhances the quality of broccoli. The application of 50% N Urea and 50% N Poultry manure along with Black Polythene mulch) recorded higher proline content, i.e.34.78%. While the control N0M0; 0% N + without mulch (control) found minimum protein content i.e. 26.78%. The application of organic carbon may be due to the application of poultry manure and vermicompost, which promotes the efficient growth of microorganisms and helps with the decomposition of plant residue, which may result in the maximum carbon content in the plant. These similar findings were reported by [30].

Table 4. Effect of integrated nitrogen and mulching management on quality attributes of broccoli. (Pooled mean)

Treatment		Fiber (%)	Total chlorophyll (%)	Protein (%)	Proline (%)	TSS (^{0}B)	Moisture (%)	Head Dry matter (%)
Integrated Nitrogen Management								
N_0	**0% N (Control)**	0.87	12.97	1.55	28.37	4.34	71.47	4.19
N_1	**100 % N Urea (217kg/ha)**	1.12	11.84	2.77	30.72	6.84	75.27	8.05
N_2	**50% N Urea(108kg/ha) +50% N Cowdung (3t/ha)**	1.23	13.75	2.78	31.93	7.28	85.26	8.27
N_3	**50% N Urea(108kg/ha)+50% N FYM (10t/ha)**	1.17	15.20	2.82	32.64	7.47	81.64	6.71
N_4	**50% N Urea (108kg/ha)+50% N Vermicompost (4t/ha)**	1.41	10.06	3.20	32.98	6.78	84.73	6.97
N_5	**50% N Urea(108kg/ha)+50% N Poultry manure (1.5t/ha)**	1.22	9.37	3.38	34.98	7.24	87.83	8.86
SE(m)±		0.06	0.74	0.11	0.09	0.15	0.67	0.23
CD (P=0.05)		NS	1.23	0.12	0.12	NS	NS	NS
Mulching								
M_0	**Without mulch (Control)**	0.90	11.97	2.17	27.74	4.57	73.85	5.49
M_1	**Paddy Straw mulch**	1.10	10.31	2.81	32.36	5.42	84.63	6.28
M_2	**Black Polythene mulch**	1.41	14.32	3.07	35.27	6.83	89.74	7.87
SE(m)±		0.09	0.17	0.06	0.06	0.21	0.68	0.16
CD (P=0.05)		0.26	0.50	0.15	0.15	0.61	1.22	NS

Table 5. Interaction effect of nitrogen and mulching management on quality attributes of broccoli. (pooled mean)

Treatment Combination		Fiber (%)	Total chlorophyll (%)	Protein (%)	Proline (%)	TSS (^{0}B)	Moisture (%)	Head Dry matter (%)
N_0M_0	0% N + Without mulch (control)	0.94	10.08	2.39	26.78	4.30	70.53	6.86
N_0M_1	0% N+ Paddy Straw mulch	0.84	13.89	2.50	28.48	4.31	78.37	6.19
N_0M_2	0% N+ Black Polythene mulch	0.80	14.93	2.40	28.18	4.43	83.52	7.53
N_1M_0	100 % N Urea(217kg/ha)+Without Mulch	1.19	10.44	2.99	27.88	6.23	81.27	10.59
N_1M_1	100 % N Urea(217kg/ha)+ Paddy Straw mulch	1.04	11.39	2.61	32.28	6.57	82.64	7.87
N_1M_2	100 % N Urea(217kg/ha)+ Black Polythene mulch	1.73	18.01	2.77	32.38	7.73	78.35	10.87
N_2M_0	50% N Urea(108kg/ha)+50% N Cow Dung(3t/ha) + Without Mulch	1.14	13.59	2.88	29.08	7.83	86.56	11.31
N_2M_1	50% N Urea(108kg/ha)+50% N Cow Dung(3t/ha) + Paddy Straw mulch	0.84	10.02	2.90	33.38	7.33	87.65	10.99
N_2M_2	50% N Urea(108kg/ha)+50% N Cow Dung(3t/ha) + Black Polythene mulch	1.38	17.64	2.88	25.98	6.67	83.69	10.11
N_3M_0	50% N Urea(108kg/ha)+50% N FYM (10t/ha) + Without Mulch	1.15	11.72	2.78	29.38	6.97	79.63	11.23
N_3M_1	50% N Urea(108kg/ha)+50% N FYM (10t/ha) + Paddy Straw mulch	1.17	14.30	2.86	30.78	7.13	84.65	11.21
N_3M_2	50% N Urea(108kg/ha)+50% N FYM (10t/ha) + Black Polythene mulch	1.04	19.83	2.70	33.08	7.40	85.52	10.16
N_4M_0	50% N Urea(108kg/ha)+50% N Vermi compost(4t/ha) + Without Mulch	1.34	16.91	2.67	31.08	7.20	87.43	10.76
N_4M_1	50% N Urea(108kg/ha)+50% N Vermi compost(4t/ha) + Paddy Straw mulch	1.69	11.76	2.99	36.58	6.47	84.38	8.01
N_4M_2	50% N Urea(108kg/ha)+50% N Vermi compost(4t/ha) + Black Polythene mulch	1.38	15.52	3.08	25.38	6.67	86.87	10.08
N_5M_0	50% N Urea(108kg/ha)+50% N Poultry Manure(1.5t/ha) + Without Mulch	1.24	12.96	3.00	30.18	6.90	86.61	9.98
N_5M_1	50% N Urea(108kg/ha)+50% N Poultry Manure(1.5t/ha)+ Paddy Straw mulch	1.94	15.45	3.04	34.48	6.73	85.36	10.07
N_5M_2	50% N Urea(108kg/ha)+50% N Poultry Manure(1.5t/ha)+ Black polythene mulch	1.39	14.55	3.65	34.78	8.10	91.65	12.54
SE(m)±		0.16	0.82	0.11	0.10	0.37	0.33	0.41
CD (P=0.05)		NS	1.56	0.25	0.25	1.06	0.93	1.31

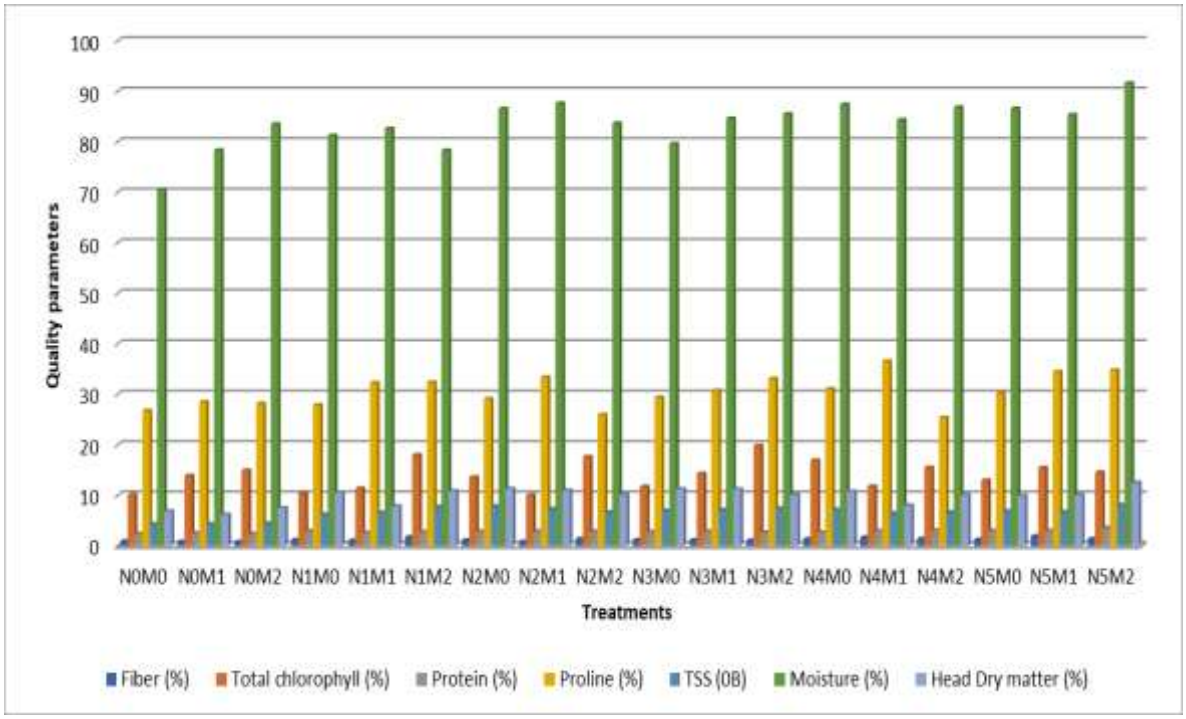

Fig 2. Interaction effect of nitrogen and mulching management on quality attributes of broccoli. (pooled mean)

Future Scope

The scope of this research might be an in-depth assessment of the long-term impact of integrated nitrogen sources and mulching techniques on the quality of crop yields, as well as the health of the soil. The present research, carried out throughout two seasons, has shown that these procedures have a good influence in the short run. On the other hand, the results of longitudinal research might show whether or not these favourable benefits can be maintained over a more extended period and throughout numerous growing seasons. Research is needed over extended periods to understand better the cumulative effects of integrated nitrogen management on soil fertility and crop yields.

4. Conclusion

It The present research shows that applying integrated nitrogen and different mulching materials significantly changes broccoli's growth yield and quality. Thus, the experiment concluded that the treatment combination of 50% N Urea (108kg/ha) + 50% N (Poultry Manure (1.5t/ha) + Black polythene mulch was found to be a superior combination for enhancing broccoli yield and can be adapted for higher broccoli production. Nonetheless, further research is required for more precise results.

Funding

There is no funding available to report.

Conflicts of interest

In this paper, the authors report no financial or other conflicts of interest.

Ethical approvals

This research experiment does not involve any animal or human subject.

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