EFFECT OF INTEGRATED NITROGEN MANAGEMENT AND MULCHING ON SPROUTING BROCCOLI

[*Brassica oleracea* var. *italica*]

Thesis Submitted for the Award of the Degree of

DOCTOR OF PHILOSOPHY

in

Horticulture-Vegetable Science

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2024

DECLARATION

I, hereby declared that the presented work in the thesis entitled "Effect of integrated nitrogen management and mulching on sprouting broccoli [*Brassica oleracea* var. *italica*]" in fulfilment of degree of **Doctor of Philosophy (Ph.D.) Horticulture (Vegetable Science)** is outcome of research work carried out by me under the supervision of Dr. Thenmeichon Chamroy, working as Assistant professor, in the, Department of Horticulture, School of Agriculture of Lovely Professional University, Punjab, India. In keeping with general practice of reporting scientific observations, due acknowledgements have been made whenever work described here has been based on findings of other investigator. This work has not been submitted in part or full to any other University or Institute for the award of any degree.

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CERTIFICATE

This is to certify that the work reported in the Ph.D. thesis entitled **"Effect of integrated nitrogen management and mulching on sprouting broccoli [*Brassica oleracea* var. *italica*]"** submitted in fulfillment of the requirement for the award of degree of **Doctor of Philosophy (Ph. D.) Horticulture (Vegetable Science)** in the Department of Horticulture, School of Agriculture, is a research work carried out by Vinay Kumar Mashkey, 12014432, is a bonafide record of his original work carried out under my supervision and that no part of thesis has been submitted for any other degree, diploma or equivalent course.

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ACKNOWLEDGEMENT

I am thankful to the, Dean ***Dr. Ramesh Sadawarti*** *School of Agriculture,* ***Dr. Anis Ahmed Mirza****, Head of the department, for providing a conducive academic environment. Your leadership has fostered an atmosphere of learning and growth.*

I express my sincere thanks to my advisor, ***Dr. Themmeichon Chamroy****, Assistant professor Department of Horticulture for her guidance, mentorship and insightful feedback. Her expertise and encouragement have been instrumental in the development of this thesis. I am grateful to my co-advisor,* ***Dr. Monisha Rawat****, Assistant professor Department of Horticulture, for her valuable contributions and collaborative spirit*

To my parents, Father ***Mr. Vasudeo Mashkey*** *and Mother* ***Mrs. Hemlata Mashkey*** *and my beloved sister,* ***Mrs. Ruchi wanjare*** *and brother* ***Mr. Vijay Mashkey****, for unwavering support, sacrifices and boundless love have been the driving force behind my accomplishments. I am truly grateful for the values you instilled in me and the encouragement that has shaped my path.*

I would like to express my gratitude to my dynamic and wonderful my beautiful and ever ready fellow research scholars ***Diksha Choudhary*** *and* ***Mohita Srivastava*** *for their inspiration, encouragement and co-operation at various aspects*

Place: LPU Phagwara **Vinay Kumar Mashkey**

Date:

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LIST OF ABBREVIATIONS

S. No.	Symbol	Legend
1	@	At the rate
2	%	Percent
3	&	And
4	µ	Micro
5	^{o}B	Degree Brix
6	^{o}C	Degree Celsius
7	cm^2	Centimetre Square
8	DAT	Days after transplanting
9	*et al.*	Et alia (and others)
10	etc.	Et cetera
11	g	Gram
12	ha	Hectare
13	HCl	Hydrochloric acid
14	INM	Integrated Nitrogen Management
15	kg	Kilogram
16	l	Litre
17	mm	Millimetre
18	m	Metre
19	M	Molar
20	ml	Millilitre
21	N	Normal
22	NaOH	Sodium hydroxide
23	Na_2CO_3	Sodium carbonate
24	No.	Number
25	ppm	Parts per million
26	pH	Potential/Power of hydrogen
27	q	Quintal
28	RDF	Recommended Dose of Fertiliser
29	Rs.	Rupees
30	rpm	Rotations per minute
31	TSS	Total Soluble Solids
32	Vit.	Vitamin

Abstract

Title:	"Effect of integrated nitrogen management and mulching on sprouting broccoli [*Brassica oleracea* var. *italica*]"
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The present research study entitled **"Effect of integrated nitrogen management and mulching on sprouting broccoli [*Brassica oleracea* var. *italica*]"** was laid out at the Agriculture farm of Lovely Professional University, phagwara Punjab during 2021-22 and 2022-23. The research work was carried out in FRBD with 3 replications. The treatments consisted of 6 levels of nitrogen viz., $\mathbf{N_0}$: control, $\mathbf{N_1}$: 100 % N through Urea, $\mathbf{N_2}$: 50% N through Urea + 50% N through Cow dung, $\mathbf{N_3}$: 50% N through Urea + 50% N through FYM, $\mathbf{N_4}$: 50% N through Urea + 50% N through Vermicompost, $\mathbf{N_5}$: 50% N through Urea + 50% N through Poultry Manure and 3 levels of mulching $\mathbf{M_0}$: Control, $\mathbf{M_1}$: Paddy straw mulch and $\mathbf{M_2}$: Black polythene mulch. Among the different levels of integrated nitrogen sources, N_5 recorded significantly higher plant height (32.68 cm), number of leaf (23.00), leaf length (20.40 cm), leaf width (12.96 cm), leaf area (294.48 cm^2), plant spread (1591.43 cm^2), girth of stem (2.12 cm), head weight (367.73 g) and head yield (127.32 qha^{-1}). The quality parameters such as; TSS (7.83°B), protein (1.81%), ascorbic acid (78.92 mg/100g), total sugar (4.00 %), sulforaphane (633.54 µg/g dry matter), nutrient uptake i.e., N @ 27.23 kg ha^{-1} and K @ 30.02 kg ha^{-1}were also found in N_5. Whereas, the maximum dry matter content (9.52%) and Total chlorophyll content (17.76 mg/g) were recorded in N_3, the maximum uptake of P @ 3.85 kg ha^{-1} was observed in N_4.

Among the mulching treatment, M_2 proved to be the most superior treatment recording maximum plant height (31.72 cm), number of the leaf (22.22), leaf length (20.05 cm), leaf width (11.69 cm), leaf area (262.18 cm^2), plant spread (1574.27 cm^2), girth of stem (2.20 cm), head weight (365.03g), head yield (126.39 q ha^{-1}) and also the maximum quality parameters such as; TSS (7.43°B), dry matter content (9.16%),total chlorophyll content (16.96 mg/g), protein (1.53%), ascorbic acid (79.17 mg/100g), total sugar (3.95%) and uptake of P (3.53 kg ha^{-1}) and K (27.86 kg ha^{-1}), whereas, M_1 recorded highest Sulforaphane (623.97µg/g dry matter) and uptake of N (23.92 kg ha^{-1}). Among the treatment combination N_5M_2recorded significantly higher plant height (36.20 cm), leaf width (13.30 cm), leaf length (21.39 cm), number of leaf (23.66), leaf area (287.42 cm^2), plant spread (1687.60 cm^2), girth of the stem (2.38 cm), head weight (389.00g) and head yield (134.69q ha^{-1}). The maximum dry matter content (11.41%) was recorded in N_1M_2 and maximum total chlorophyll content (21.91mg/g) in N_3M_2, while the maximum protein content (2.03 %) was found in the treatment N_5M_1. The highest benefit cost ratio (3.87) was recorded in the treatment N_5M_2 and therefore, it can be concluded that the integration of 50% N through Urea +50% N through Poultry Manure + Black Polythene mulch is worth recommendable for successful production of sprouting broccoli under Punjab region.

Keywords: *Brassica oleracea*var. *italica*, growth, nutrient management, nutrient uptake, mulching, manure, quality and yield.

CHAPTER I

INTRODUCTION

Broccoli [*Brassica oleracea* var. *italica*], is a nutritious vegetable within the crucifer family, prized for its tender heads. While cole crops traditionally thrive in temperate zones, it is also cultivated in tropical and subtropical regions. Broccoli, in particular, has seen a surge in popularity among vegetable growers due to increased demand in urban areas. Globally, around 40% of broccoli is sold fresh, while the remaining 60% is utilized in frozen form.

Broccoli cultivation is gaining popularity in Indian states like; Uttarakhand, Maharastra, Himachal Pradesh, T.N. and Gujarat. The cultivation area for broccoli production across India during the fiscal year 2021 is estimated to have accounted for approximately 4,73,000 hectares and production of 92,25,000 MT (Anonymous, 2021).

Broccoli has enormous medicinal and nutritional values. According to Pankaj *et al* (2018) 100g of raw broccoli heads contains; energy (34 kcal), sugars (1.6 g), water (89.31 g), protein (2.81 g), vitamin A (4%), calcium (47 mg), potassium (316 mg) and carbohydrates (6.64 g). Broccoli also consists of 3, 3-di-indolyl methane, which has anti-viral and anti-bacterial properties. It is an effective innate immune response system modulator. It is suggested to steam broccoli for 3-4 minutes in order to optimize the anti-cancer properties of chemicals like sulforaphane. According to a USDA analysis (2008), boiling broccoli lowers its potentially cancer-causing chemicals by 20–30%, 40–50% and 77% after 5, 10 and 30 minutes respectively. It is commonly incorporated into dishes like curries, soups and pickles frequently enjoyed raw in salads or cooked to create a variety of delightful meals (Thamburaj and Singh, 2001).

Plant nutrients play an important role in fostering growth of the plant, ensuring robust development and yielding high-quality produce. With the advent of advanced agricultural technologies for vegetable cultivation, the emphasis on synthetic chemicals like fertilizers and pesticides has notably boosted productivity, catering to the needs of a burgeoning population. However, the heavy dependency of

contemporary Indian agriculture on chemical fertilizers, pesticides and fungicide are contributing to the degradation of soil health while witnessing an escalation in plant nutrient deficiencies. To address this, the strategic use of fertilizers and organic manures in integration is seen as pivotal in increasing the soil fertility and productivity. Emphasizing the consistent and appropriate integration of farm organic waste play an important role in preserving the productivity of agricultural soils and to mitigate the adverse effects caused by excessive fertilization (Yadav, 2009).

Use of inorganic and organic manures could increase yields and protect the environment (Hsieh *et al*., 1996). Excessive use of inorganic fertilizers poses a public health and environmental hazard. In addition, there is substantial proof that the adoption of intensive farming methods has also resulted in a decrease in the amount of vitamins and minerals present in fresh fruits and vegetables. Therefore, consequently, there's a shift in focus from inorganic to organic sources of nutrients. The farmers are combining substantial amounts of fertilizers with organic manure and mulching so as to optimize the yield and quality. The advocacy for using organic manure, such as compost and farmyard and poultry manure aims to mitigate reliance on chemical fertilizers (Bhardwaj *et al*., 2000). Furthermore, the association of organic and chemical sources of nutrient aims to minimize expenses on costly fertilizers while enhancing nutrient utilization efficiency (Sharma *et al*., 2008).

As broccoli is a heavy feeder of nitrogenous nutrients, it requires an adequate nutrient to supply plants with the energy to produce healthy heads. Excessive and inefficient use of nitrogenous fertilizer is detrimental for growth and yield of broccoli. Therefore, farmers must control plant nutrition in a way that maintains and restores soil fertility and yield of the crop. Integrated nitrogen management not only maintains and enhances soil qualities but also guards against micronutrient shortages. Mulching is an another important agro-technique for the healthy and productive growth of vegetable crops, since it regulates soil temperature, maintains soil moisture, boosts soil fertility, prevents weed growth and enhances the area's aesthetic appeal. To change the growing environment and increase crop yield, mulching often includes spreading of organic and inorganic mulches layers of 5 inches on the surface of soil around the target crop. Its main applications include reducing nutrient leaching, changing pest

and disease pressures, improving soil organic matter with nutrient content, controlling temperature at the root zone and aboveground growth environment and increasing soil porosity (Coolong *et al.*, 2012). By preventing light from entering the canopy, mulches inhibit the appearance and growth of weeds but mulches cannot eradicate perennial weeds. Though they can't provide season-long weed control, organic mulches can slow the sprouting of weeds. Shallow cultivation can effectively manage weeds and to some extent, enrich the soil with organic matter when it is combined with a mid-season application of organic mulches. Combined effects of mulch and nitrogen application at optimum levels can play an important role in increasing crop growth and water use efficiency. Therefore, considering the above discussed facts on the importance of agro techniques in broccoli cultivation, the research was undertaken with the following objectives:

1. To study the effect of integrated nitrogen management on the growth, yield and quality of sprouting broccoli.

2. To study the effect of mulching practices on the growth, yield and quality of sprouting broccoli.

3. To assess the interactive effect of integrated nitrogen management practices and mulching on sprouting broccoli.

4. To work out the economics of sprouting broccoli under integrated nitrogen management practices and mulching.

CHAPTER II

REVIEW OF LITERATURE

Available literature related to integrated nutrient management mulching on broccoli and other similar crops of *Brassica* family are mentioned under suitable headings:

2.1 Impact of integrated nitrogen management on growth, yield and quality of broccoli

Chaterjee *et al.* (2005) examined the effect of manures amendment on broccoli in a field experiment. The combination of oil cake (mustard) with biofertilizers resulted in higher yield and benefit cost ratio. Poultry manure plus biofertilizers resulted in curds with the increased levels of ascorbic acid, chlorophyll and decrease sugar content. **Chaubey *et al.* (2006)** observed the highest growth parameters under the interaction of vermicompost at 5.0 tons $ha^{-1}$and 125% RDF. **Raghav and Kamal (2007)** assessed the impact of inorganic fertilizers and (VAM) on broccoli and documented the highest levels of chlorophyll (39.7 mg/100g),Vitamin A content and reducing sugar in the treatment involving mycoplex at 250 kg/ha combined with N: P: K at a 60:50:50 kg ha^{-1} ratio. **Ghuge *et al.* (2007)** reported the impact of combined chemical and organic manure on cabbage and reported that, the use of 50 percent of the RDF (125:40:37 kg NPK ha^{-1}) with 50 percent vermicompost (2.5 t ha^{-1}) recorded highest plant growth and spread in cabbage. **Maurya *et al.* (2008)** investigated the influence of nutrition strategies on broccoli in a field experiment consisting of different levels of NPK with organic manure such as neem cake, vermicompost, FYM and poultry manure and observed that the crop applied with poultry manure along with 50% RDF produced highest number of leaves, plant height, leaf breadth and yield. **Khare and Singh *et al.* (2008)** investigated the impact of biofertilizer and nitrogen on cabbage consisting of three levels of biofertilizers: *Azospirillum, Azotobacter* and no biofertilizer and 4 N levels (0, 50, 75 and 100 percent). Applying

75 percent nitrogen (135 kg ha^{-1}) combined with *Azotobacter* enhanced the growth parameters. **Ouda and Mahadeen (2008)** conducted an experiment using green-house cultivation to examine the response of chemical and organic manures on broccoli production and quality using 4 levels of manure and 3 levels of chemical fertilizers. The maximum broccoli yield (41.06 t ha^{-1}) was obtained by applying 60 kg inorganic fertilizers coupled with 60 t organic manure ha^{-1}. When organic and inorganic fertilizers were combined, the chlorophyll content, head weight and head diameter were higher as compare to separate application. Leaf macro and micro nutrient content increases in combination of organic manure and inorganic manures. **Akbar *et al.* (2009)** examined the impacts of vermicompost and biofertilizers on cole crop. The results showed that, applying vermicompost @10 t ha^{-1} led to the maximum plant spread while using 5 t ha^{-1}vermicompostrecorded in the maximum number of leaves and plant height. Among the different levels of biofertilizer inoculation, Azotobacter at 10 kg/ha led to the highest number of leaves and plant height. **Uddin *et al.* (2009)** recorded the highest values for various growth attributes, including plant height, plant canopy, leaf length, leaf breadth and fresh leaf weight per plant by application of poultry manure. **Padamwar and Dakore (2009)** examined the effect of FYM, vermicompost & biofertilizers on production and nutritional value of cauliflower and found that, the application of vermicompost was proved to be the best treatment for highest yield characters and quality of cauliflower. **Magd *et al.* (2010)** investigated the response of various levels of N, *viz.,* organic manure and mineral fertilizer, on two broccoli varieties, viz., Hybrid Southern Star and Broccoli Calabrese and recorded the tallest plant, head weight and the quality parameters *viz*., ascorbic acid, TSS and dry matter, under treatment with 75% organic manure with 25 % mineral. **Kumar *et al.* (2010)** investigated the response of inoculation of VAM and vermicompost on cauliflower growth and yield. The interaction of highest amounts of vermicompost (10 t/ha) with 2.0 kg/ha of VAM produced significant results for curd weight and curd diameter among all the treatments.

Dalal *et al.* (2010) discovered that applying organic fertilizer with urea improved the yield and growth characteristics of cabbage. The highest plant height was found in the treatment applied with 50 percent N (urea) and 50 percent N (vermicompost). **Padamwar and Dakore (2010)** investigated the impact of biofertilizers, vermicompost and FYM on quality of cole crops such as cabbage, knol-khol and cauliflower. The treatment includes: Control, FYM, vermicompost and biofertilizers mixture (*Azotobactor*, *phosphorous solubilizing bacteria* and VAM). The use of vermicompost resulted in a considerable rise in the protein, vitamin C, dry matter %, carbohydrate and calcium content of edible part of cole crops. **Meena *et al.* (2011)** found that, use of N:P:K @180:80:40 kg/ha through inorganic fertilizer resulted in highest number of leaves (23.33) and plant height (28.93 cm). **Upadhyay *et al.* (2012)** investigated the influence of inorganic and organic manure on sprouting broccoli and reported the maximum yield (17.4 t ha^{-1}) and sugar content with the sole application of Vermicompost. Whereas, the highest total ascorbic acid in the head was recorded in the combined application of Vermicompost with Azotobacter. **Merentola *et al.* (2012)** found that applying 50% RDF by fertilizer and vermicompost @ 2.5 t/ha resulted in the superior values for various growth attributes such as: plant height (56.56 cm), plant spread, leaf width, number of leaves, leaf area and leaf length. **Mishra and Aishah (2013)** documented that a treatment consisting of 100 percent NPK (150:38:63 kg/ha) in combination with vermicompost (9.25 t/ha) and bio-fertilizers (2 kg/ha each of PSB and Azotobacter) yielded maximum values for Total Soluble Solids (3.10 °B), ascorbic acid content (55.2 mg/100g) and protein content in cauliflower. **Acharya *et al.* (2015)** recorded the highest canopy area (47.62 cm^2) and plant height (46.83 cm) under the use of poultry manure (2 tonnes/ha). Additionally, the maximum no. of green leaves (10.25) was observed in the treatment involving farmyard manure@ of 10 t $ha^{-1}$with poultry manure @1 t/ha in sprouting broccoli.

Srichandan *et al.* (2015) recorded the highest growth parameters such as plant height (41.58 cm), leaf area (363.32 cm^2), curd diameter (46.91 cm) and yield (149.43 q ha^{-1}) in the treatment T_{10} (75% NP +100% K + Bioinoculant + 100% vermicompost). **Srimathi (2015)** found that applying 100 % RDF through vermicompost @3.1 t ha^{-1}, along with 0.1 % humic acid, resulted to increase in number of leaves, plantheight and yield in cauliflower. **Lal *et al.* (2015)** investigated the impact of biofertilizers on the growth, yield and quality of sprouting broccoli and found that applying various biofertilizers and different Zn levels increased the yield of broccoli. Specifically, the best result was observed when 20 kg of $ZnSO_4$ was applied and inoculated with Azotobacter and PSB (phosphate-solubilizing bacteria). This treatment showed favorable outcomes regarding the number of days taken for central head initiation of sprouting broccoli and the head yield 223.40 q/ha. **Jigme *et al.* (2015)** recorded that highest growth parameters in broccoli such as plant height number of leaves plant canopy and various quality parameter were recorded in the treatment under application in farm yard manure @ 10 t ha^{-1} with poultry manure @ 1 t ha^{-1}. **Mal *et al.* (2015)** conducted an experiment on broccoli and resulted that the maximum growth parameters and quality parameters observed in the treatment combination with the application of vermicompost @ 10 t ha^{-1}**. Ghurbati *et al.* (2016)** reported significant positive differences in all vegetative characteristics, including increased leaf area, No. of branches, plant height and no. of leaves per plant with application of organic fertilizer.

Yadav *et al.* (2016) observed that, a single-row spacing of sprouting broccoli applied with vermicompost resulted in the maximum values for plant height (63.9 cm), number of leaves (28.6) and number of sprouts per plant. **Yadav *et al.* (2016)** noted that the combination of vermicompost application in broccoli this combination resulted in the maximum weight of the main yield of sprouts per plant (407.6 g), head girth (15.2 cm), yield (610.9 g) and total yield ha^{-1} (301.7 q). **Pawar and Barkule (2017)** found that, combination of 75 percent (RDF) with (FYM) and Azotobacter & Azospirillum (T_6) resulted to maximum growth parameters such as plant height (12.10 cm) and stem diameter (2.10 cm). **Singh *et al.* (2017)** reported significant results in all growth parameters viz., maximum leaf length, plant height and plant spread of sprouting broccoli in the treatment T_7 (Vermicompost + poultry manure +

Azotobacter), While the maximum number of leaves was recorded in T_6 (poultry manure + Azotobacter). **Changkija *et al.* (2017)** investigated the impact of combine application of NPK, Vermicompost and biofertilizers and found highest plant height, stem diameter, plant spread, head size, head yield and head weight in the treatment that consisted of 50 % NPK + vermicompost + Biofertilizers. **Chand *et al.* (2017)** discovered that applying bio-fertilizers, specifically Azotobacter combined with PSB (phosphate-solubilizing bacteria), significantly enhanced yield attributes and parameters. This included an increase in the volume anddiameter of the head, as well as the weight of both the main and secondary heads. Additionally, the head yield ha^{-1}. **Ekta *et al.* (2017)** reported that, application of farmyard manure combined with biofertilizers, stood out due to its consistent performance in terms of achieving yield i.e., 39.25 t $ha^{-1.}$ **Devi *et al.* (2018)** examined the effects of integrated nitrogen management on both the yield of cauliflower and the fertility of the soil. A notable increase in cauliflower yield was observed, particularly in treatment T_5, which involved the use of 100 percent N:P:K along with (FYM) at the (RDF). Post-harvest soil status assessment revealed increased nutrient concentration within the soil due to the combined use of fertilizers. **Sharma *et al.* (2018)** reported the highest levels of ascorbic acid (84.17 mg per100 g) and Total Soluble Solids (14.77 °B) when the plants were applied with 75 percent RDF+ biofertilizers+ Vermicompost. Whereas the total sugar (3.97%) was recorded in the treatment consisting of 25% RDF + 50% vermicompost + 50% Azotobacter + 25% Azospirillum. **Atal *et al.*(2019)** noted that the treatment T_7 (Biofertilizers + Vermicompost) resulted in maximum curd diameter, curd weight, curd yield, fresh plant weight, plant dry weight, root fresh weight, root spread and root length. **Lal *et al.* (2020)** conducted a trial to assess the interaction effect of inorganic and organic manure on quality and yield of *Brassica oleracea* L. var. *gongylodes* and recorded highest yield and quality parameters *viz*., protein, TSS and total dry matter in the treatment consisted of vermicompost**. Singh *et al.* (2021)** investigated the impact of Integrated Nitrogen Management in broccoli. The study findings indicated that applying Vermicompost at a rate of 2.5 tons ha_{-1}yielded significant results., with half of the RDF of NPK by chemical fertilizer, led to significantly higher head weight, i.e., 386.80 g, total yield, i.e., 204.76 q ha^{-1}, net income, i.e., Rs. 1,08,832 ha^{-1} and (B: C ratio) of 3.15. **Gogoi *et al.* (2021)** assessed the impact of different nitrogen dose (120, 100, 80 kg ha^{-1}) on Broccoli (KTS-1). The

treatments notably influenced crop growth parameters, including leaf length, plant height and leaf width. A higher dose of nitrogen (120 kg ha^{-1}) significantly improved several crop growth parameters while reducing the time required for heading. **Tiwari *et al.* (2021)** recorded the impact of integrated nitrogen management on broccoli for improved head yield. The results indicated that treatment T_7 (FYM 5 t/ha, vermicompost @ 1.25 t/ha and 50% PSB) exhibited the maximum values for various parameters including plant spread in the East-West direction (51.46 cm), plant spread in the North-South direction (53.12 cm), plant height (50.45 cm), leaf length (38.18 cm), number of leaves (22.50), leaf width (21.15 cm) and head weight (512.60 g). **Walling *et al.* (2022)** assessed the impact of integrated nitrogen management on broccoli and obtained maximum plant spread (69.2 cm), stem diameter (20.7 mm) and number of leaves (18.2) under the full dose of RDF. **Zargar *et al.* (2022)** evaluated the impact of INM on cabbage. The findings indicated that the combination involving 75% inorganic nitrogen and Vermicompost produced significantly higher values for all morphological and yield parameters than other combinations and the control group. **Sagar *et al.* (2023)** found that the combination of ¼ nitrogen (FYM), ¼ N (Vermicompost) produced the most favorable outcomes for growth and yield parameters. This treatment resulted in the tallest height of the plant, highest no. of leaves/plant, widest diameter of stem and highest yield per plot in broccoli plant.

2.2 Effect of mulching on growth, yield and quality of vegetables

Sarker *et al.* (2003) conducted a research to examine the responses of various fertilizer sources and various mulching on cabbage. The study included 3 levels of mulching and 4 levels of nutrients and the results depicted that, applying black polythene mulch obtained highest marketable yield and thereby most economical. **Faruque (2004)** studied the response of various nutrients with mulches on growth of broccoli head and recorded that the use of organic and chemical fertilizer with black polythene mulch obtained maximum yield (18.2 t ha^{-1}). **Díaz-Pérez (2009)** observed that mulches made of colored plastic film affected soil root zone temperature. Specifically, it is directly responsible for providing a favourable environment to plant roots, which enhances the broccoli yield. **Jasim *et al.* (2014)** evaluated the outcome of polythene mulch along with foliar application of urea and recorded more synthesis of antioxidant mechanisms, which helps to improve yield in comparison to control

treatments. **Kosterna *et al.* (2014)** reported the impact of mulching on weed irradiation in broccoli grown using polypropylene fiber mulch and without mulch. The use of polypropylene fiber resulted in an enhanced yield of broccoli (5.25 t ha^{-1}). **Islam *et al.* (2014)** conducted an experiment with four mulching levels: No mulch (M_0), Water hyacinth (M_1), Black polythene mulch (M_2) and Rice straw (M_3) and observed the maximum leaf length, number of leaf, leaf area, curd weight and yield in M_2. **Khatun (2016)** evaluated the impact of various mulches on broccoli and observed the maximum curd yield (23.7 t ha^{-1}) under the use of black polythene mulch**. Mohammed *et al.* (2016)** studied the response of mulches on quality of broccoli crop and their results indicated that, mulching caused significant increase in fiber (2.56%), total sugar (2.52%), carbohydrate (5.08%), TSS (7.27%) and chlorophyll (56.34%) as compared with no mulching in cabbage. **Saloom and AL-Sahaf (2016)** evaluated the response of mineral and organic fertilization and various mulches on quality attributes of broccoli and reported that TSS % was significantly affected by the black color plastic mulch i.e. TSS (8.83%) followed by blue plastic (8.27%). Ascorbic acid was also higher in black plastic mulch (89.62 mg) and lowest (77.26 mg) in no-mulch plants. **Helaly *et al.* (2017)** assessed the effect of polyethylene mulching on husk tomato growth and yield and observed that using black colored polyethylene mulching influenced the chlorophyll content of the tomato leaves. The highest value of growth and yield parameter was achieved using black plastic mulch. **El-Rahman *et al.* (2018)** investigated the impact of various mulching colors on green bean Cv. Paulista over two successive seasons and found that black mulching resulted to maximum quality attributes *viz*., total chlorophyll contents, TSS and ascorbic acid. **Regar *et al.* (2018**) investigated the impact of various mulches and bio fertilizers on broccoli and found that, the black polythene mulch had maximum values for crude protein (2.33%), Vit.C (81.00 mg/100 g) and TSS (0.35°B). **Char *et al.* (2020**) investigated the impact of bio-fertilizers and mulching on broccoli. The experiment consisted of different mulch types (black polythene sheet and rice straw) and biofertilizers. T_{12} (Black polythene + Azotobacter + PSB) demonstrated significant superiority among the treatments. It showed notable enhancements in the number of leaves (13.7), plant height (24.5 cm), leaf area (230.2 cm^2) and chlorophyll (3.0 mg/g). **Punetha *et al.* (2020)** examined the impact of mulching material on broccoli under various mulches *viz*., Dry Grass, Clear

polythene, Red polythene and Black polythene. The growth parameters *viz*., length of the leaf, width of leaf, diameter of head, weight of the head and yield were recorded superior in black polythene mulch among all mulching material. **Bhandari *et al.* (2021)** examined the response of various mulches viz., maize stalk, needle wood tree twigs and leaves, black plastic mulch and no mulch on broccoli and recorded the highest plant height and all yield related characters in the plants applied with black plastic mulch**. Kaur *et al.* (2021) i**nvestigated the response of spacing and mulching on broccoli and found the maximum chlorophyll content, ascorbic acid and TSS (°B) in black plastic mulch with spacing of 45×60 cm. **Yasmin *et al.* (2021)** investigated the response of seedling age with mulching on broccoli growth and observed the maximum No. of leaves (16.66) and height of the plant (33.55 cm) with black polythene mulch (T_2), while the (T_0) performed poorly on most of the studied parameters. **Agarwal *et al.* (2022)** found the impact of inorganic and organic mulching on weed density and the productivity of tomato plants and recorded that all types of mulches enhanced the yield of tomatoes compared to the no-mulch.

2.3 Impact of integrated nitrogen management and various mulching practices on Economics of cole crops

Sharma *et al.* (2005) investigated the impact of organic sources with different RDF and observed the maximum net returns of Rs 1,32,220 ha^{-1} and B: C ratio of 3.27 with application of 20 tons farmyard manure ha^{-1} + 150% NPK. **Chaubey *et al.* (2006)** observed a significant increased in the net return and B:C ratio (4.09), under the combination of 125% of the RDF and vermicompost at 5.0 t ha^{-1} compared to the other treatments. **Saikia *et al.* (2010)** reported that application of 100% recommended N doses through fertigation proved to be the most effective approach for obtaining highest B:C of 1:4. **Sentiyangla *et al.* (2010**) reported the highest B: C ratio i.e., 1:3 and net returnof Rs. 77,932 in the treatment combination of bio fertilizers along with 50% (FYM) and 50% NPK, where by surpassing the results obtained from using 100% NPK alone. **Katiyar *et al.* (2011)** investigated the effect of different levels of nitrogen and phosphorus in broccoli. The treatment consisted of four levels of nitrogen (30, 60, 90, & 120 kg ha^{-1}) and phosphorus (30, 60, 90, & 120 kg ha^{-1}) with basal dose and found that the maximum net returns and B: C ratio under the application of the N and P @ 90 kg ha^{-1}.**Choudhary *et al.* (2012)** examined the response of fertility levels on the economics of broccoli and recorded the most prominent B:C ratio of 4.09 in the

treatment applied with poultry manure. **Mohapatra *et al.* (2013)** recorded the highest gross income of Rs. 2,09,235 ha^{-1} and B: C of 5.1 from broccoli using a combination of 150:45:80 $kgha^{-1}$ of N:P:K and biofertilizers: *Azospirillum, Azotobacter* and *PSB* (2 kg ha^{-1}), FYM (5 t ha^{-1}) and vermicompost (2.5 tons ha^{-1}). **Ekta *et al.* (2017)** investigated the effect of different organic manures and biofertilizers on broccoli and recorded the highest gross income (3, 14, 561 ₹ ha^{-1}), net returns (2, 52, 982 Rs. ha^{-1}) and benefit-cost ratio (1:4.10) in the treatment, FYM + Bio-fertilizer. **Mohanta *et al.* (2018)** examined the impact of INM on economics of Broccoli cv. Shayali and observed that T_7 (50% NPK and vermicompost @2.5t/ha) had the maximum values of gross returns, net returns and B: C ratio. **Singh *et al.* (2019)** reported the effect of various mulch (control, paddy straw, and sawdust) and bio fertilizers (PSB and *Azotobacter*) on cauliflower and reported the maximum net return i.e., Rs. 2,08,054 under the treatment PSB (1g/plant) with paddy straw mulch, while the highest B: C ratio was recorded in the crop applied PSB(1 g/plant), while the minimum benefit-cost ratio was reported in control.

CHAPTER III

MATERIALS AND METHODS

The research entitled **"Effect of integrated nitrogen management and mulching on sprouting broccoli [*Brassica oleracea* var. *italica*]"** was performed at Agriculture farm of Lovely Professional University, Punjab, in the months of September to February during the year 2021-22 and 2022-23. The materials used and the techniques adopted are described as under.

3.1 EXPERIMENTAL DETAILS

The research plot was laid out using RBD design with three replications. The soil of Research field was sandy loam and analysis was done starting of experiment to evaluate initial status of soil nutrients.

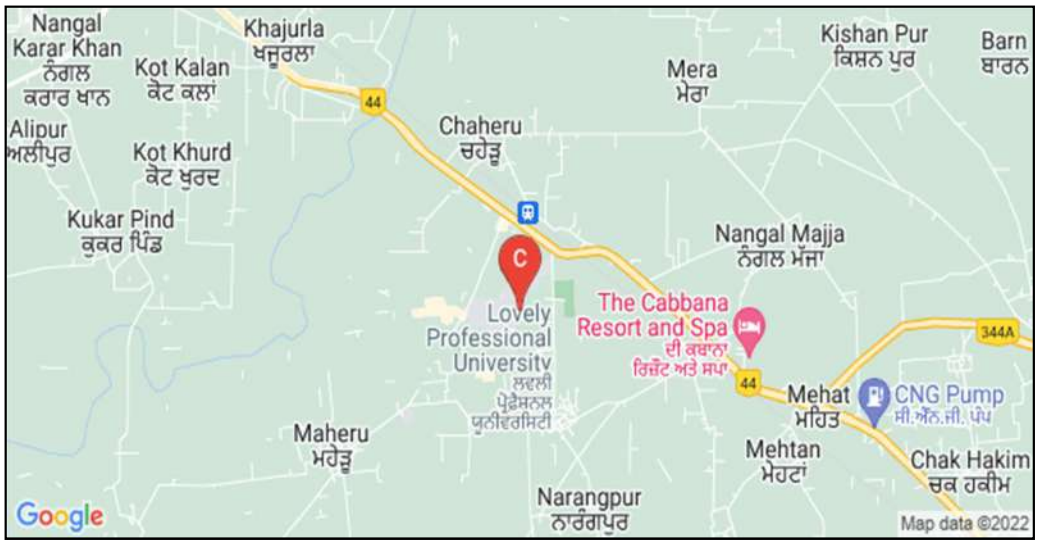


Fig. 3.1: Map of experimental site

3.2 WEATHER AND CLIMATE

The experimental farm's weather and environment were influenced by its location near the Himalayan foothills. The temperature during the crop growth period ranges between 8-27.5°Cand rainfall ranges between 17.2 -67.9 mm.

Table- 3.1 Meteorological data

Month	Highest temp. (°C)		Lowest temp. (°C)		Average temperature (°C)		Rainfall (mm)		Relative humidity (%)	
	2021-22	2022-23	2021-22	2022-23	2021-22	2022-23	2021-222	2022-23	2021-22	2022-23
December	22	26	12	10	17	14	17.2	19	22-24	48-50
January	18	19	9	8	14	16.5	67.7	45.3	27-29	44-46
February	20	22.2	11	11	16	15.7	81.4	55.3	41-23	46-48
March	26	27.5	14	12	21	23.9	51.7	67.9	40-42	49-51

3.3 SOIL CHARACTERISTICS

Soil samples were randomly taken, using an auger at a depth of 5 to 10 cm from 4-5 places in the experimental field to assess the soil's current nutrient condition. The soil samples were thoroughly mixed, dried in the sun and filtered. The physical characteristics and chemical characteristics of the soil sample were analysed. The research plot was found to have an alkaline pH of 7.35 and 1.3% organic carbon. Table 3.2 shows the results of soil testing done before starting the trial.

Table- 3.2: Chemical and Physical properties of the soil.

S. No.	Properties of soil		Procedure used
	Chemical properties	readings	
i.	pH	7.5	pH meter (Glass electrode)
ii.	Electrical conductivity (EC) (dSm^{-1})	0.27	Jackson (1973)
iii.	N ($kg\ ha^{-1}$)	126.8	(Subbaiah and Asija, 1956) Alkaline Method
iv.	P ($k\ ha^{-1}$)	33.7	Olson's extraction pure method (Jackson,1958)
v.	K ($kg\ ha^{-1}$)	130.1	Flame photometer method by (Hanway 1952,)

Table- 3.3 Layout details of experimental site

Lay out details	
Location	Lovely Professional University
Crop	Broccoli (*Brassica oleracea* var. *italica*)
Variety	Palam Samridhi
Year	2021-22 or 2022- 2023
Design	FRBD
Replication	3
Total No. of plots	54
Gross experimental area	1039.95 m^2
Net plot size	810 m^2
Spacing	0.60 × 0.45 m
Gross plot size	5 × 3 m
Net plot area	4.4×2.10
No. of plants per plot	32
Replication Gap	0.75 m
Seed rate	250g ha^{-1}

3.4. Experimental materials

The proposed experiment was conducted with following technical programmed and treatments.

Table 3.4 Details of experimental material

Experimental material	Particulars	Characters
Variety	Palam Samridhi	It is green sprouting type broccoli. Its terminal heads are compact, green free from yellow eye and bracing. Average terminal head weight ranges from, 300-400g.
Mulch	Black polythene mulch (25 microns)	Black polythene mulch is specifically beneficial for plant growth as it absorbs and retains heat from the sun, creating a warmer microclimate for plants, promoting faster growth and earlier harvests.
	Paddy straw mulch (5 inch thickness)	Paddy straw mulch is important for plant growth as it helps to less weed competition retain soil moisture and change soil temperature. Additionally, as the mulch breaks down, it adds organic manure to the soil, improving its fertility and nutrient-holding capacity.
Nitrogen sources	Urea	Urea is a concentrated nitrogen fertilizer commonly used in agriculture. It provides a high amount of readily available nitrogen to plants, promoting rapid growth and enhancing overall plant productivity.
	Poultry Manure	Poultry manure is an excellent source of N, P and K which are vital nutrients for plant growth. It also contains essential micronutrients such as calcium, magnesium and sulphur, promoting overall plant health and robust growth.
	Vermi compost	Vermicompost is a nutrient-dense organic fertilizer that enriches plant growth with high nitrogen, phosphorus and potassium. It also enhances soil health by improving its structure, moisture-retention capacity and nutrient-holding capacity, resulting in healthy plants and increased yields.
	Farm yard manure (FYM)	Farmyard manure is a nutrient-rich organic fertilizer that enhances plant growth by providing a balanced blend of nitrogen, phosphorus and potassium. It also improves soil structure and fertility while supplying essential micronutrients like calcium, magnesium and trace elements, ensuring healthy and vigorous plant growth.
	Cow Dung	Cow dung is important for plant growth as it acts as a natural fertilizer, enrich the soil with necessary nutrients and organic matter necessary for healthy plant development.

Table 3.5 Nutrient of organic manures:

B	**Organic Manures**	**N%**	**P%**	**K%**
1	Cow dung	1.35	1.01	1.2
2	FYM	0.5	0.2	0.6
3	Vermicompost	1.5	1.10	1.4
4	Poultry Manure	3.03	2.63	1.4

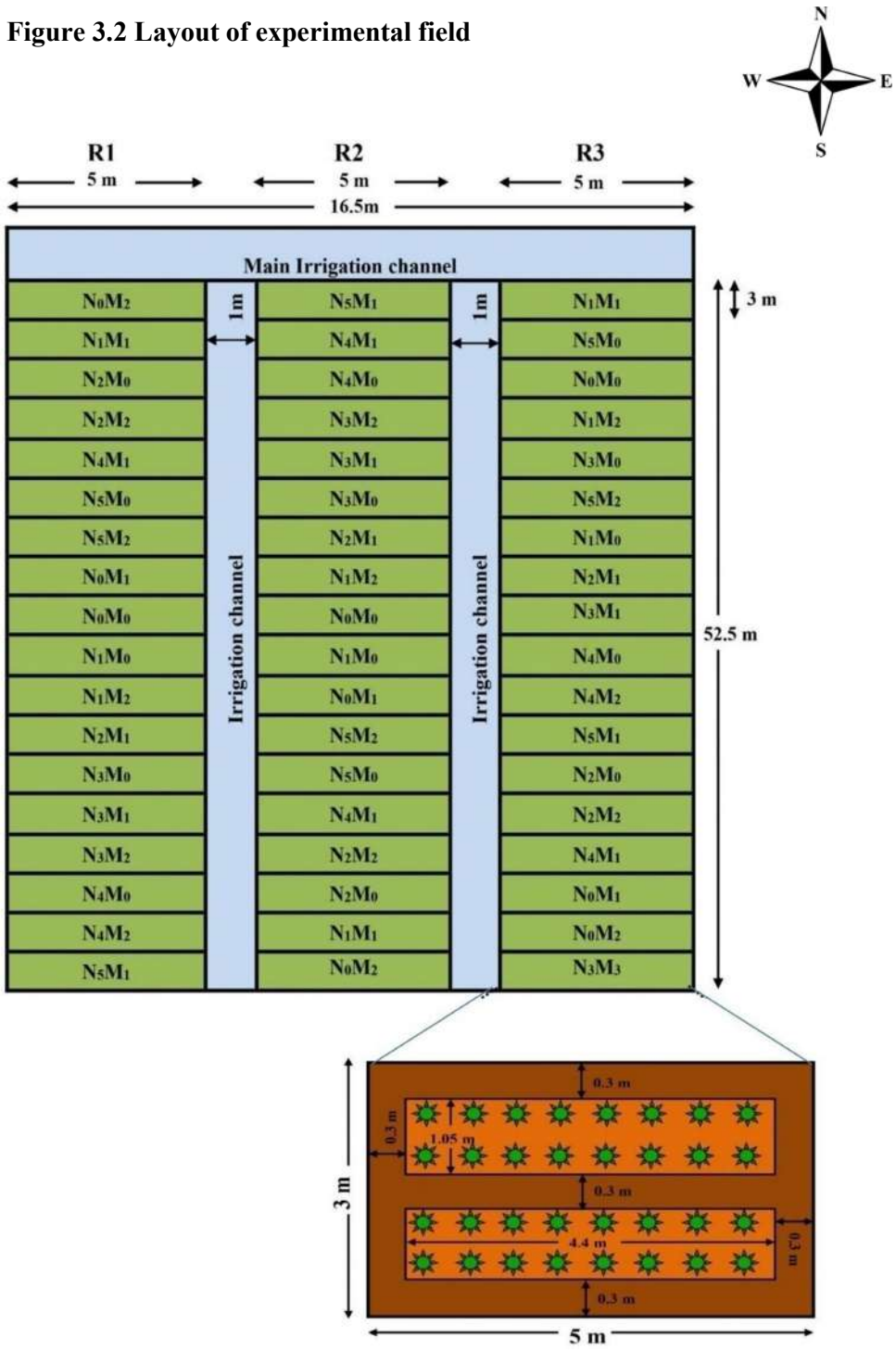
Table 3.6 Treatment details:

S. No.	**TREATMENTS**	**NOTATION**
Factor A - N sources		
1	0% N (Control)	**N_0**
2	100 % N through Urea	**N_1**
3	50% N through Urea + 50% N through Cow dung	**N_2**
4	50% N through Urea + 50% N through FYM	**N_3**
5	50% N through Urea + 50% N through Vermicompost	**N_4**
6	50% N through Urea + 50% N through Poultry Manure	**N_5**
Factor B – Mulching		
1	Without mulch (Control)	**M_0**
2	Paddy Straw mulch	**M_1**
3	Black Polythene mulch	**M_2**

Table 3.7: Treatment combinations:

S.No.	Treatments	Treatment combination
1	N_0M_0	0% N
2	N_0M_1	0% N +Paddy Straw mulch
3	N_0M_2	0% N + Black Polythene mulch
4	N_1M_0	100 % N through Urea + Without Mulch
5	N_1M_1	100 % N through Urea + Paddy Straw mulch
6	N_1M_2	100 % N through Urea + Black Polythene mulch
7	N_2M_0	50% N through Urea + 50% N through Cow Dung + Without Mulch
8	N_2M_1	50% N through Urea + 50% N through Cow Dung + Paddy Straw mulch
9	N_2M_2	50% N through Urea + 50% N through Cow Dung + Black Polythene mulch
10	N_3M_0	50% N through Urea + 50% N through FYM + Without Mulch
11	N_3M_1	50% N through Urea + 50% N through FYM + Paddy Straw mulch
12	N_3M_2	50% N through Urea + 50% N through FYM + Black Polythene mulch
13	N_4M_0	50% N through Urea + 50% N through Vermi compost + Without Mulch
14	N_4M_1	50% N through Urea + 50% N through Vermi compost + Paddy Straw mulch
15	N_4M_2	50% N through Urea + 50% N through Vermi compost + Black Polythene mulch
16	N_5M_0	50% N through Urea + 50% N through Poultry Manure + Without Mulch
17	N_5M_1	50% N through Urea + 50% N through Poultry Manure + Paddy Straw mulch
18	N_5M_2	50% N through Urea + 50% N through Poultry Manure + Black Polythene mulch

Figure 3.2 Layout of experimental field



3.8 Agronomic operations:

3.8.1 Field preparation

The field was prepared by one deep ploughing during the summer months in May-June and then left to eradicate harmful pathogens from the soil after 2-3 deep ploughing and leveling. The cultivated area was measured and laid out into three replications accommodated with 18 sub plot in each replication, one sub plot having two beds.

3.8.2 Raising seedlings and transplanting

The Palam Samridhi variety of broccoli, obtained from CSKHPKV in Palampur, was used for the study. Broccoli seedlings were nurtured under a high-technology polyhouse in pro trays using a soilless growing media such as cocopeat, perlite and vermiculite (3:1:1). The seedlings were transplanted at 45 days after sowing, at a spacing of 60 x 45 cm in both experimental periods. The transplantation process took place in the evening, followed by light irrigation immediately and gap filling was done at 5-7 days later. All agro technique adhered to the guidelines provided by Punjab Agriculture University.

3.8.3 Manures and Fertilizer application

The RDF for broccoli cultivation as per the package and practices of Punjab Agriculture University i.e., 100:80:60 Kg NPK ha^{-1} was applied to the crop. Nitrogen was applied through different sources such as urea, poultry manure, FYM, vermicompost and cow dung. All the organic manures were incorporated to the soil as per the treatments during bed preparation, while urea was applied at the time of transplanting and remaining applied as top dressing at 35 days after transplanting. The entire amount of recommended dosage of phosphorus and potassium were applied by using SSP and MOP at the time transplanting.

Table 3.9: Intercultural operations

S.No.	Cultural practices	2020-2021	2021-2022
1	Irrigation	5,15,23,29,-11-2021	9,16, 23,30-11-2022 ,
2	Weeding	30-11-2021, 20-12-2021	30-11-2022, 19-12-2022
3	Insecticidal spray	25-11-2021	27-11-2022
4	Earthing up	20-12-2021	22-12-2022

3.8.4 Mulching application

Mulching practices were performed after bed preparation, black polythene mulch (25 microns) was applied prior to transplanting and then holes (5-6 cm diameter) were made as per the spacing and transplanting was done at the centre. While, the paddy straw mulch (5 inch thickness) was applied at 5 days after transplanting.

3.8.5 Weeding

Primary weeding (manual) was carried out at 20 DAT and the second at 40 days after transplanting. Hoeing was done to a depth of soil not more than (5-6cm) because broccoli is a shallow-rooted crop and most feeding roots are concentrated at the upper surface.

3.8.6 Irrigation

Light Irrigation was done after transplanting and thereafter irrigation was administered at weekly intervals to promote better establishment of the crops. About 5 irrigation was given during the whole growing season by avoiding water logging. The primary medium for Irrigation in the field was channel irrigation.

3.8.7 Earthing up

Earthing up is an essential cultural practice in broccoli. It provides physical support to growing plants by promoting better root growth. This practice was done 30 days after transplanting, along with weeding practices.

3.9 Soil Analysis

3.9.1 Available nitrogen in soil: The available nitrogen was estimated by Alkaline Method (Subbaiah and Asija, 1956)

Reagents

1. Solution of 0.32% ($KMnO_4$)
2. ($NaOH$).2.5 % sodium hydroxide
3. Dissolved 20 -25 ml of mixed indicator per liter of 2 % boric acid solution.
4. 95% alcohol in 100ml with 0.99g bromocresol along with 0.66g methyl red (as a mixed indicator)
5. 0.02 N (H_2SO_4)

Procedure

•Transferred the prepared soil sample to the digestive tube after weighing it at five grams. To create a mixed indicator solution, started by preparing a 250 ml conical flask and mixed 20 ml of 2% boric acid solution. Placed the tube in the purification unit and loaded the other sides of the hose.

•The distillation unit program automatically added 25 ml of KMnO4 (0.32%) and NaOH (2.5%) solutions, respectively. The sample was heated by gradually adding steam, and the ammonia that was released was then absorbed in 20 ml of a mixed indicator solution containing 2% boric acid and stored in a 250 ml conical flask.

• The pinkish color turned green when ammonia was absorbed.

• In roughly ten minutes, nearly 150 ml of distillate had been collected.

• As the green distillate titrated with 0.02 N sulfuric acid, the hue returned to its natural tone, which was pink.

• A blank sample, devoid of soil, had to be run concurrently.

• Determined the amount of accessible nitrogen in the soil by noting the blank and sample titer readings (ml).

$$Available N(kg/\square a) = \frac{R(Titer\ reading - Blank\ reading \times Normality\ of acid \times Atomic\ weig\square t\ of\ nitrogen \times Weig\square t\ of soil)}{Sample\ weig\square(g) \times 1000}$$

3.9.2 Available Phosphorus in soil: The available phosphorus estimated by Olson's extraction pure method **(Jackson, 1958)**

Regents: Sodium bicarbonate, Active charcoal, Ammonium molybdate solution, Ascorbic acid antimony potassium tartrate solution and H_2SO_4.

Procedure

Placed 5.0 grams of finely powdered, air-dried soil, ground to a size of 2 millimeters, into a 250 milliliter flask. Added a small amount of activated charcoal to the flask. Then, poured 100 milliliters of a sodium bicarbonate ($NaHCO_3$) solution at 25°C into each flask. Proceeded to filter the resulting mixture using Whatman No. 40 and 42 filter paper. If the filtrate was visibly unclear, added a bit more charcoal and filtered again. Next, added 8 milliliters of the solution to the flask and adjusted the volume up to 50 milliliters using deionized water. Allowed the solution to sit for 15 minutes, then

measured the intensity of the blue color using a spectrophotometer set at 730 nanometers.

$$\text{available P } (\frac{\text{kg}}{\text{ha}}) = ppmreading \times volume\ of\ aliquot \times sample\ weight$$

3.9.3 Available Potassium in soil: the available potassium was estimated by using Flame photometer method (Hanway, 1952)

Regents: 1 N ammonium acetate, Standard potassium solution.

Procedure

Placed 5.0 grams of dried soil into a 100 milliliter flask. Added 25 milliliters of 1 N ammonium acetate solution to the soil in the conical flask, then shook the flask vigorously for 5 to 10 minutes. Proceeded to determine the potassium (K) content in the extract using a flame photometer equipped with a K filter, following the necessary instrument setting and calibration steps. Calibrated the instrument by adjusting the zero reading on the scale using the extract solution (CH_3COONH_4). Next, took the extract from the sample and fed it into the flame photometer. Recorded the sample and determined the potassium in the sample with the assistance of a standard curve

$$\text{available K } (\frac{\text{kg}}{\text{ha}}) = c \times \frac{25}{5} \times 2.24 = 2.24$$

Where C= K from standard curve

3.10 Observations recorded

For recording all the observations, five competitive plants were tagged from each plot excluding the border rows. The growth parameters were recorded at a regular interval of 15 days starting from 15 DAT until harvesting and their average was worked out, while the yield, quality and economic parameters were recorded after harvesting.

3.10.1 Growth parameters

3.10.1.1 Plant height (cm): The height of 5 healthy competitive plants from each plot was observed in cm from the soil surface to the leaf apex at 15, 30, 45 DAT and at harvest.

3.10.1.2 Number of leaves/plant: number of leaf for the 5 randomly marked competitive plants from every treatment was recorded at different plant growth stage 15, 30, 45 DAT and at harvest and averaged.

3.10.1.3 Leaf width (cm): The leaf width was measured with a precision scale in cm at 15, 30, 45 DAT and harvest.

3.10.1.4 Leaf length (cm): The observation for length of leaf was recorded in cm at 15, 30, 45 DAT and at harvest with a precision scale.

3.10.1.5 Plant Spread (cm^2): Plant spread of five marked competitive plants were measured and calculated in cm^2.

3.10.1.6 Leaf area (cm^2): The leaf area of the marked competitive plants were measured using leaf area meter at 15, 30, 45 DAT and at harvest.

3.10.1.7 Stem girth (cm): The stem girth was measured using a Vernier Calliper at 15,30, 45 DAT and at harvest.

3.10.1.8 Days to head initiation (days): The number of days from the date of transplanting to head initiation was recorded.

3.10.1.9 Days to 50 % head initiation (days): The number of days from date of transplanting to head initiation of 50 % plant population was calculated.

3.10.1.10 Days to harvest (days): Total number of days from transplanting to firstharvest was recorded.

3.11 Yield and yield attributes

3.11.1 Head diameter (cm): Diameter of head was measured by using Vernier calliper.

3.11.2 Average head weight (g): The weight of the head was recorded by weighing the individual head from the five selected plants using weighing balance and averaged.

3.11.3 Head yield/ plot (kg): The average head weight was multiplied by total number of plants in each plot to obtain the yield per experimental plot.

3.11.4 Yield of head/ha (q): The yield/plot was converted to yield ha^{-1} (quintals).

3.11.5 Harvesting duration (days): Days from 1^{st} harvest to last harvest was noted as harvesting duration.

3.12 Quality attributes

3.12.1 TSS (°Brix):

The TSS was estimated by using a refractometer (0-32^{o}Brix).

3.12.2 Ascorbic acid (mg/100g):

Ascorbic acid content of broccoli was estimated by the method (Redox Titration) introduced by Ranganna (1986)

Reagents:

Iodine solution preparation: (0.005 mol L^{-1}).

• Filled a 100ml beaker with 2g of potassium iodide by weight.

•Transferred 1.3g of iodine salt into the identical beaker.

• Swirled for a few minutes after adding a few ml of pure water to ensure the iodine dissolved. Poured the iodine solution into a volumetric flask (1-liter) and added distilled water to the mixture to bring it up to the 1L level.

Starch solution: (0.5%)

• Took soluble starch (0.25g) and added it to boiling water (50ml).

• Stirred to dissolve and then allowed it to cool.

Procedure:

Sample modification:

• Took 100 grams of fresh broccoli and crushed it. Added 10 ml of distilled water as required while crushing the samples.

• Strained the crushed specimen pulp with muslin cloth.

• Rinsed the pulp with portions of water (10 ml) and washed it in a volumetric flask after collecting all the filtrate.

• Prepared the filtered solution with distilled water (100 ml).

Titration:

• Pipetted out 20 ml of the prepared sample into a 250 ml conical flask and added 150 ml of distilled water to it. Then added 1 ml of starch indicator solution to it.

• Titrated the prepared sample against iodine solution (0.005 mol L^{-1}) until the first blue-black color appeared.

• Repeated the titration with further samples until concordant results were obtained.

- Total Soluble Protein content in the head (%): (Bradford, MM. 1976)**Reagents :**

1. Sodium phosphate buffer (pH 7.4)

- Solution A: Dissolved 13.9g of 0.1M sodium dihydrogen phosphate in distilled water and made the volume up to 1L.
- Solution B: Dissolved 26.82g of 0.1M disodium hydrogen phosphate in water and made the volume up to 1L.
- To make the sodium phosphate buffer, mixed Solution A and Solution B in a ratio of 19:81 and adjusted the final pH.

2. Dye:

• Mixed 100 mg of Coomassie Brilliant Blue G-250 with 50 ml of ethanol (95%). Added 100 ml of concentrated ortho-phosphoric acid and made the volume up to 200 ml using distilled water.

• Mixed the concentrated dye with distilled water in a ratio of 1:4 before use.

Procedure:

• Weighed 100 mg of plant sample and crushed it with a mortar and pestle by adding 10 ml of cold extraction until a fine slurry was made. During crushing, the mortar was kept in an ice container.

• Centrifuged the prepared sample at 15,000 rotations per minute for 15 minutes and collected the supernatant.

• Took 5 ml of diluted dye, 0.2 ml of crude protein extract (supernatant collected after centrifugation), and 0.8 ml of distilled water. Mixed them properly and allowed the color to develop for 5 minutes. Ensured not to exceed 30 minutes, as the red color of the dye would turn blue when it bound with the protein.

• Recorded the absorbance at 595 nm.

Calculations:

The benchmark curve was prepared using 0.1–1.0 ml of BSA. The standard curve was created by graphing the absorbance readings on the y-axis versus the protein concentration in the solution on the x-axis. The concentration of total soluble protein was estimated by plugging the absorbance value into the standard curve.

3.12.3 Fiber content (%): Crude fiber content in broccoli was estimated by the method of Ranganna (1986).

Procedure:

Ground the broccoli sample and took a 2 g sample with 200 ml of H_2SO_4. Boiled the sample for 30 minutes; added 200 ml of hot NaOH (1.25%) after filtration. Then dried it to a constant weight at 100 °C (W1). Placed it in a muffle furnace at 525 °C, cooled the ash material, and weighed it (W2).

$$\text{Crude fiber\%} = \frac{(W1 - W2 \times 100)}{W}$$

W_1= sample weight

W_2= acid and alkali digest

3.12.4 Head chlorophyll content (%): Broccoli head Chlorophyll was examined by the method introduced by Arnon DI. (1949).

Reagents:

- 80% Ethanol

Procedure:

• Crushed 1 g of the sample using 20 ml of 80% ethanol in a mortar.

• Centrifuged the extract at 3000 rotations per minute for 15 minutes. Saved the supernatant and made it up to 25 ml using 80% ethanol.

• Transferred the supernatant to a clear colorimeter tube and measured the readings at 645 nm and 663 nm against an 80% ethanol blank in a spectrophotometer.

- Level of **chlorophyll 'a'** and **chlorophyll 'b'** was also determined.

Calculations:

Chlorophyll 'a' (μ/g/ml) = (12.7 x O.D. at 663nm)-(2.69 x O.D. at 645nm)

Chlorophyll 'b' (μ/g/ml) = (22.9 x O.D. at 645nm)-(4.08 x O.D. at 663nm)

Total chlorophyll (μ/g/ml) = (20.2 x O.D. at 645nm)-(8.02 x O.D. at 663nm)

3.12.5 Dry matter content (%)

A composite of 100 g of plant sample from all tagged plants was taken from each plot. The samples were dried at 60°C until a uniform weight was obtained. The dried weight materials were recorded and expressed as a percentage. The dry matter production per hectare was calculated using the formula: Dry matter production of the plant per hectare.

3.12.6 Total sugar (mg) total sugar was examined by the protocols introduced by Sadasuvam and Manickam, 1992)

Reagents:

- 80% Ethanol
- Prepare anthrone reagent by adding anthrone (200 mg) in 100 ml ice cold 95% H_2SO_4).

Procedure:

Homogenized 100 mg of the sample with 80% ethanol until the material was digested. After homogenizing, centrifuged the sample at 5000 rpm for 15 minutes and then made the volume of the extract up to 100 ml with distilled water.

• Pipetted out 1 ml of the extract into a test tube, added 6 ml of anthrone reagent, and kept it in a water bath for 10 minutes then allowed it to cool.

• Let it sit for a few minutes. After some time, a blue color developed.

• Measured the intensity of the blue color at 620 nm with a spectrophotometer.

Calculation

$$\textbf{Total soluble sugar (mg)} = \frac{\boldsymbol{OD\ of\ test}}{\boldsymbol{OD\ of\ standard}} \times \mathbf{100}$$

3.12.7 Reducing sugar: (Folin Wu method)

Reagents:

• **Phospho Molybdic Acid:** Took a 1 L beaker and added 200 ml of 10% NaOH solution, 200 ml of distilled water, 35 g of molybdic acid, and 5 g of sodium tungstate. Mixed them well and boiled vigorously for 20-40 minutes. Allowed the solution to cool and diluted it to 350 ml. Added 125 ml of orthophosphoric acid to it and diluted to a final volume of 500 ml.

• **Alkaline Copper Solution:** Took a beaker, added 400 ml of water, and dissolved 40 g of Na_2CO_3 in it. Transferred this solution to a 1 L volumetric flask. Dissolved 7.5 g of tartaric acid in this solution and then added 4.5 g of $CuSO_4 \cdot 5H_2O$. Mixed it and diluted to 1 L. (Used the supernatant in case any sediments formed.)

Procedure:

• Took a test tube, added 2 ml of experimental broth to it, and then added 2 ml of alkaline copper sulfate.

• Kept them in a boiling water bath until a precipitate appeared (for at least 10 minutes).

• Allowed it to cool under running water, then added 2 ml of phosphomolybdic acid and made the volume up to 25 ml by adding distilled water.

•Recorded the absorbance of the blue color developed at 420 nm.

Calculations:

$$\text{Reducing sugar (mg)} = \frac{\text{OD of test}}{\text{OD of standard}} \times 100$$

3.12.8 Non Reducing sugar (mg): reducing sugar was determined by the method introduced by Somogyi, M. (1952).

Non-Redung Sugar (mg) = Total Soluble Sugar (mg) – Reducing Sugar (mg)

3.12.9 Uptake of Nitrogen (Kg/ha)

The digestion mixture (K_2SO_4:$CuSO_4$) and concentrated H_2SO_4 were used to break down the ground samples, with a powder ratio of 10:1:0.1. Afterwards, using Jackson's (1973) recommended micro-Kjeldahl method, the total nitrogen of the plant

was determined. The formula was then utilized to determine the amount of nitrogen absorbed by the plant:

$$\text{N uptake (kg/ha)} = \frac{\%\ \text{Nitrogen content} \times \text{Plant yield on dry basis (kg/ha)}}{100}$$

The uptake by curd and shoot was taken separately, was further added to calculate total uptake of nitrogen by plant

3.12.10 Phosphorus content in whole plant at harvest (%)-

The phosphorus content of plant sample was estimated by Vandomolyb data phosphoric yellow colour method (Piper, 1966) by measuring the readings of the solution in spectrophotometer at 430 nm. Phosphorous uptake was examined by the P content present in plant and expressed in kg per ha. The amount of nutrient taken by the plants is calculated by following formula. Phosphorous uptake (Kg/ha) = Phosphorous content of plant × yield kg /ha 100

3.12.11 Potassium content in whole plant at harvest (%)

Potassium content was evaluated using flame photometer.

Uptake of N, P, K by plant at harvest (kg ha^{-1}) the uptake of nutrient was carried out by using the of N, P and K % in the whole plant and dry weight of whole plant using the following formula.

$$\text{Uptake of nutrient} = \frac{\text{Total dry matter (g/plant)} \times \%\ \text{of nutrient in dry matter}}{100}$$

3.12.12 Phenol (mg/100gm):

The phenol content of broccoli was analyzed using the method introduced by Mahadevan and Sridhar (1982). One gram of healthy tissue was sliced into 1-2 centimeter fragments. These fragments were then submerged in 8-10 milliliters of 80% ethyl alcohol and boiled for 5-10 minutes in a hot water bath. After boiling, the extract was allowed to cool in a container of cold water. The tissues were subsequently properly crushed, followed by filtration through cloth. The ground tissue was then subjected to extraction in boiling 80% alcohol, cooled, and filtered using Whatman No. 1 filter paper.

3.12.13 Total Chlorophyll content (mg/g):

chlorophyll pigments, were calculated using the technique outlined by Lichtenthaler *et al*. (1996). For estimation of chlorophyll put one gram of the finely chopped head sample into a sanitized mortar. Add 20 milliliters of 80% acetone to the tissue and grind it into fine slurry. After five minutes of centrifuging at 3000 rpm, pour the supernatant into a volumetric flask (100ml). Continue doing this until the residue has no color. After completely cleaning the pestle mortar with 80% acetone, collect the clear washings in a flask. With 80% acetone, increase the volume to 100 millilitres. Measured the reading at 645, 663 and 652 nm using 80% acetone as the blank solvent.

The chlorophyll a and b formula

$$\text{chlorophyll a} = [-2.69\ (\text{OD } 645) - 12.7\ (\text{OD } 663) * \frac{\text{W} * \text{V}}{100}$$

$$\text{chlorophyll b} = [-4.68\ (\text{OD } 663) - 22.9\ (\text{OD } 645) * \frac{W * V}{100}$$

total = chlorophyll. a and chlorophyll. b

$$\text{Total chlorophyll (mg/g of tissue)} = (\text{A652} \times 1000/34.5)\ \text{x} + \frac{V}{100}$$

V = Extract volume used (millilitres) W = The fresh leaf sample's weight (g).

3.12.14 Total soluble proteins:

Total soluble protein was estimated in an ice bath, 50 mM K_3PO_4 buffer (10 mL) with pH 7.8 was used to homogenize fresh leaf material (0.5 g). The aliquot was centrifuged for 15 minutes at 4 °C at 980 x g. Total soluble protein analysis was

performed using the supernatant, which was collected in a different centrifuge tube. The protein content of the extract was determined using a conventional procedure (Bradford, 1976). After the samples were centrifuged, the same amount of dye stock (Biorad, USA) was added. Following a vortex, the solution was kept at room temperature for 30 minutes. The absorbance of the final reaction mixture was measured at 595 nm. BSA (bovine serum albumin) was used as the industry standard.

3.13 Economic parameters

3.13.1 Cost of cultivation (Rs): The cost incurred for the cultivation was determined by using current pricing for all supplies and labour expenses at the time they were used.

3.13.2 Gross monetary returns (Rs): Per hectare gross return was estimated based on the current wholesale market price in rupees.

3.13.3 Net monetary returns (Rs): Net income of crop was determined by deducting cost of cultivation from the gross return.

3.13.4 Benefit cost ratio (B:C): The B:C ratio was estimated by given formula:

$$(\text{B:C}) = \frac{Net return}{Total cost of cultivation}$$

3.13.5 Statistical analysis

The data acquired on all observed parameters were represented using given statistical analysis.

Mean-

Mean of all the parameters in replication was observed as follows

$$\text{Mean} \quad (\bar{X}) = \frac{\sum X}{N}$$

Where,

$\sum x$= sum of observations

N=no. of observations

Analysis of variance–

According to Panse and Sukhatheme's study from 1954, "analysis of variance" was applied to the data recorded from the set of findings for each parameter. The table's ANOVA skeleton according to design.

Skeleton of analysis of variance

(Source of variation)	(Degree of freedom)	(Sum of square)	(Mean sum of square)	("F" Value Calculated)	("F"table at 5%)
Replication	(r-1)	RSS	RMS	RMS/EMS	
Treatment	(NM-1)	TSS	TMS	TMS/EM	
Nitrogen doses(N)	(N-1)	(N)SS	(N)MS	(N)MS/EMS	
Mulching(M)	(M-1)	(M)SS	(M)MS	(N×M)MS/EMS	
Interaction(N×M)	(N-1)(M-1)	(N×M)SS	(N×M)MS	(N×M)MS/EMS	
Error	(r-1)(NM-1)	ESS	EMS		
Total	(rNM-1)				

C.D. (Critical difference) was used to calculate the importance of the variation in treatment using the provided formula (Panse and Sukatme, 1954).

i. C.D. for Nitrogen doses (N)-

$$\sqrt{\frac{(EMS)\times 2}{r\times N=15}}\times t_{5\%}$$

ii. C.D. For Mulching (M)-

$$\sqrt{\frac{(EMS)\times 2}{r\times M=9}}\times t_{5\%}$$

iii. C.D. for interaction (N×M)-

$$\sqrt{\frac{(EMS)\times 2}{r=3}} \times t_{5\%}$$

Where,

N=No. of Nitrogen doses

t='t' T error degree of Freedom

r=Number of replication

M=Number of Mulching

CHAPTER- IV

RESULTS AND DISCUSSIONS

The research work entitled "**Effect of integrated nitrogen management and mulching on sprouting broccoli [*Brassica oleracea* var. *italica*]**" was laid out at the Agriculture farm of Lovely Professional University, phagwara, Punjab, India, in the rabi season of 2021-22 & 2022-23. The results for growth, yield and quality character of sprouting broccoli have been described, in results and discussion chapter by means of figures and tables wherever considered necessary. In this investigation, the following data associated with growth characters, yield attributes and quality have been recorded as follows.

4.1 Effect of integrated nitrogen management and mulching on growth parameters of broccoli

Growth is a continuous process: it is an irreversible increase in the size of the plant and it may be affected by different growing conditions such as different sources of nutrient management, intercultural operations like application of mulching material to the plant. Application of integrated nitrogen sources such as inorganic (urea) and organic *viz*., poultry manure, cow dung, vermicompost and FYM along with mulching material, i.e., black polythene mulch (25µ) and paddy straw mulch (5 inch thickness) showed a significant positive results for growth parameters.

4.1.1 Plant height (cm)

Plant height is a crucial component of plant growth parameters. The data regarding the plant height at different stages of the broccoli plant as response by integrated nitrogen management and mulching management is presented in tables 4.1, 4.2 and figures 4.1, 4.2.

The data confirm that the integration of nitrogen management, mulching practices and interaction significantly influenced plant height irrespective of growth stages.

At 15 DAT, the tallest plant height was recorded in N_5: 50 % nitrogen with Urea & 50 % nitrogen from Poultry Manure i.e., 15.48, 13.23 and 14.35 cm in 2021-22, 2022-23 and pooled mean respectively, followed by N_1: 100 % N through Urea i.e., 14.07,

12.04 and 13.05 cm in 2021-22, 2022-23 and pooled mean respectively, while the minimum values were recorded in control N_0 (control) i.e., 8.56, 6.76 and 7.69 cm in 2021-22, 2022-23 and pooled mean respectively.

Among the mulching treatment, maximum height for plants was recorded in M_2 (black polythene mulch) i.e.,14.66, 11.27 and 12.77 cm in 2021-22, 2022-23 and pooled data respectively, which were also statistically similar with M_1 (Paddy straw mulch) i.e., 14.25, 11.26 and 12.76 cm in 2021-22, 2022-23 and pooled mean respectively, while the minimum values were recorded in control M_0 (control) i.e., 12.96, 10.24 and 11.60 cm in 2021-22, 2022-23 and pooled mean respectively.

Among the combinations, N_5M_2: 50 percent N with Urea and 50 percent nitrogen from poultry manure + Black Polythene mulch was observed to have highest plant height, i.e., 17.67, 14.17 and 16.27 cm 2021-22, 2022-23 and pooled mean respectively, followed by N_1M_2: 100 % N through Urea + Black Polythene mulch i.e., 16.76, 13.47 and 15.93 cm 2021-22, 2022-23 and pooled mean respectively, while the minimum values were recorded in N_0M_0 (control) i.e., 8.33, 6.58 and 7.50 cm in 2021-22, 2022-23 and pooled mean respectively.

At 30 DAT, maximum plant height was recorded in N_5: 50 percent nitrogen with Urea and 50 percent N from poultry manure i.e., 25.70, 20.31 and 23.02 cm in 2021-22, 2022-23 and pooled data respectively, followed by N_1: 100 % N through Urea i.e., 24.03, 19.22 and 21.76 cm in 2021-22, 2022-23 and pooled data respectively, while the minimum values were recorded in N_0 (control) i.e., 14.07, 11.59 and 13.10 cm in 2021-22, 2022-23 and pooled mean respectively.

Among the mulching treatment, maximum plant height was observed in black polythene mulch M_2 (Black polythene mulch) i.e., 24.03, 19.23 and 21.78 cm in 2021-22, 2022-23 and pooled mean respectively, followed by M_1 (Paddy straw mulch) i.e., 21.07, 17.11 and 19.38 cm 2021-22, 2022-23 and pooled mean respectively, while the minimum values were recorded in M_0 (control) i.e., 20.91, 16.52 and 18.69 cm in 2021-22, 2022-23 and pooled mean respectively.

Among the treatment combinations, highest plant height was recorded in N_5M_2: 50 % nitrogen with Urea & 50 % nitrogen from Poultry Manure + Black Polythene mulch

i.e., 26.87, 22.23 and 24.57 cm 2021-22, 2022-23 and pooled mean respectively, followed by N_1M_2: 100 % N through Urea and Black Polythene mulch i.e., 26.73, 21.12 and 23.90 cm in 2021-22, 2022-23 and pooled mean respectively, while the minimum values were recorded in N_0M_0 (control) i.e., 13.00, 10.27 and 11.60 cm in 2021-22, 2022-23 and pooled mean respectively.

At 45 DAT, maximum plant height in was recorded N_5 (50 percent nitrogen applied with poultry manure and remaining 50% nitrogen by Urea) i.e., 30.26, 23.86 and 27.03 cm in 2021-22, 2022-23 and pooled data respectively, followed by N_1: 100 % N through Urea i.e. 30.08, 24.16 and 27.37 cm in 2021-22, 2022-23 and pooled data respectively, while the minimum values were recorded in N_0 (control) i.e., 18.36, 14.05 and 16.42 cm in 2021-22, 2022-23 and pooled mean respectively.

Among the mulching treatment, maximum height was recorded in M_2 (black polythene mulch) i.e., 27.73, 21.91 and 24.82 cm in 2021-22, 2022-23 and pooled data respectively, followed by M_1 (Paddy straw mulch) i.e., 26.65, 21.33 and 24.17 cm 2021-22, 2022-23 and pooled mean respectively, while the minimum values were recorded in M_0 (control) i.e., 25.98, 20.53 and 23.27 cm in 2021-22, 2022-23 and pooled mean respectively.

Among the interaction of mulching and integrated nitrogen was found significantly for plant height at 45 DAT, the highest plant height in N_5M_2: 50 % nitrogen with Urea & 50 % nitrogen from Poultry Manure + black polythene mulch i.e., 32.33, 25.54 and 28.90 cm 2021-22, 2022-23 and pooled mean respectively, followed by N_1M_2: 100 % N through Urea + black polythene mulch i.e., 31.04, 25.04 and 28.04 cm 2021-22, 2022-23 and pooled mean respectively, while the minimum values were recorded in control N_0M_0 (control) i.e., 15.03, 14.56 and 14.79 cm in 2021-22, 2022-23 and pooled mean respectively.

At harvest maximum plant height was recorded in N_5: 50 % nitrogen with Urea & 50 % nitrogen from Poultry Manure i.e., 34.58, 30.77 and 32.68 cm in 2021-22, 2022-23 and pooled data respectively, followed by N_1: 100 % N through Urea i.e., 34.16, 30.04 and 32.27 cm in 2021-22, 2022-23 and pooled mean respectively, while the

minimum values were recorded in N_0 (control) i.e., 24.56, 21.85 and 23.20 cm in 2021-22, 2022-23 and pooled mean respectively.

Among the mulching treatment, maximum plant height was recorded in black polythene mulch M_2: 33.58, 29.88 and 31.72 cm in 2021-22, 2022-23 and pooled mean respectively, followed by M_1 (Paddy straw mulch) i.e., 30.57, 27.21 and 28.89 cm in 2021-22 in 2022-23 and pooled mean respectively, while the minimum values were recorded in M_0 (control) i.e., 30.21, 26.88 and 28.53 cm in 2021-22, 2022-23 and pooled mean respectively.

Among the treatment combinations, the maximum plant height was recorded in, N_5M_2: 50 % nitrogen with Urea & 50 % nitrogen from Poultry Manure + Black Polythene mulch i.e., 38.30, 34.09 and 36.20 cm in 2021-22, 2022-23 and pooled mean respectively, followed by N_1M_2: 100 % N through Urea + Black Polythene mulch i.e., 37.06, 33.46 and 35.26 cm 2021-22, 2022-23 and pooled mean respectively, while the minimum values were recorded in N_0M_0 (control) i.e., 24.00, 21.36 and 22.67 cm in 2021-22, 2022-23 and pooled mean respectively.

The maximum plant height was observed in treatment N_5 may be attributed to the presence of sufficient nutrients in the root zone, facilitating optimal nutritional activity and fostering enhanced growth. Poultry manure contains micronutrients such as sulfur, iron and zinc, which increased the activity of beneficial microorganisms and improve the soil structure, resulting to higher nutrient uptake efficiency by plants and thereby increasing the plant height (Maurya *et al*., 2008).

Among the mulching treatment Maximum plant height in M_2 might be due to the black polythene mulch absorbs solar radiation, maintaining the soil temperature in winter and inhibiting weed growth, by which plants gate higher nutrients from the soil, resulting in the highest plant height (Punetha *et al*. (2020).

The maximum plant height in N_5M_2 might be possibly due to the favorable interaction between the nitrogen management and mulching. The addition of poultry manure enhanced the organic matter and C: N ratio in soil, which helps to increased the activities of microorganisms. At the same time, mulch provides a weed-free period and mitigates nutrient competition among other weed crops.

Table 4.1 Response of integrated nitrogen management and mulching practices on plant height at 15, 30, 45 DAT and at harvesting.

Plant height (cm)												
Treatment	15DAT			30DAT			45DAT			At harvest		
	2021-22	2022-23	Pooled mean	2021-22	2022-23	Pooled mean	2021-22	2022-23	Pooled mean	2021-22	2022-23	Pooled mean
Integrated nitrogen management (N)												
N_0	8.56	6.76	7.69	14.07	11.59	13.10	18.36	14.05	16.42	24.56	21.85	23.20
N_1	14.07	12.04	13.05	24.03	19.22	21.76	30.08	24.16	27.37	34.16	30.04	32.27
N_2	14.19	11.21	13.69	21.33	16.84	19.07	26.67	21.07	23.87	31.99	28.47	30.22
N_3	14.09	11.14	12.42	23.66	18.64	21.11	27.92	22.06	25.01	31.1	27.68	29.38
N_4	13.96	11.03	12.50	24.00	19.12	21.64	27.71	21.89	24.81	32.32	28.77	30.54
N_5	15.48	13.23	14.35	25.70	20.31	23.02	30.26	23.86	27.03	34.58	30.77	32.68
SE±	0.13	0.13	0.11	0.10	0.10	0.10	0.14	0.13	0.14	0.14	0.13	0.14
CD (P=0.05)	0.37	0.29	0.33	0.40	0.40	0.30	0.39	0.39	0.39	0.41	0.40	0.40
Mulching (B)												
M_0	12.96	10.24	11.60	20.91	16.52	18.69	25.98	20.53	23.27	30.21	26.88	28.53
M_1	14.25	11.26	12.76	21.07	17.11	19.38	26.65	21.33	24.17	30.57	27.21	28.89
M_2	14.66	11.27	12.77	24.03	19.23	21.78	27.73	21.91	24.82	33.58	29.88	31.72
SE±	0.18	0.14	0.16	0.2	0.1	0.2	0.19	0.17	0.19	0.23	0.19	0.20
CD (P=0.05)	0.52	0.41	0.47	0.5	0.5	0.4	0.55	0.63	0.55	0.58	0.56	0.56

DAT-Days after transplanting

Fig. 4.1 Response of integrated nitrogen management and mulching practices on plant height at 15, 30, 45 DAT and at harvesting.

Table 4.2 Combined effect of integrated nitrogen management and mulching practices on plant height at 15, 30, 45 DAT and at harvesting.

Plant height (cm)												
Treatment	15 DAT			30 DAT			45 DAT			At harvest		
	2021-22	2022-23	Pooled mean	2021-22	2022-23	Pooled mean	2021-22	2022-23	Pooled mean	2021-22	2022-23	Pooled mean
N_0M_0	8.33	6.58	7.50	13.00	10.27	11.60	15.03	14.56	14.79	24.00	21.36	22.67
N_0M_1	8.83	6.98	7.93	15.00	11.85	13.40	16.70	14.69	14.81	25.00	22.25	23.63
N_0M_2	8.50	6.72	7.63	16.00	12.64	14.30	20.53	16.22	18.37	24.67	21.95	23.30
N_1M_0	15.13	11.96	13.53	22.77	17.99	20.37	28.40	21.81	28.07	34.00	30.26	32.13
N_1M_1	15.30	12.09	13.70	23.47	18.54	21.23	28.63	22.62	25.63	30.87	27.47	29.17
N_1M_2	16.67	13.47	15.93	26.73	21.12	23.90	31.04	25.04	28.04	37.06	33.46	35.26
N_2M_0	13.00	10.27	11.63	17.47	13.80	15.63	25.67	20.28	22.97	31.27	27.83	29.53
N_2M_1	15.10	11.93	13.50	20.53	16.22	18.37	26.60	21.01	23.80	32.67	29.07	30.90
N_2M_2	14.47	11.43	12.93	25.93	20.49	23.20	27.73	21.91	24.83	32.03	28.51	30.23
N_3M_0	13.93	11.01	12.47	22.53	17.80	20.13	28.80	22.75	25.80	28.90	25.72	27.30
N_3M_1	16.03	13.10	15.07	23.67	18.70	21.20	31.02	24.33	27.67	32.13	28.60	30.37
N_3M_2	14.20	11.22	12.73	24.60	19.43	22.00	26.70	21.09	23.90	32.27	28.72	30.47
N_4M_0	13.27	10.48	11.90	24.33	19.22	21.77	29.70	23.46	26.60	30.63	27.26	28.93
N_4M_1	13.73	10.85	12.30	22.07	17.43	19.73	26.03	20.57	23.30	29.73	26.46	28.10
N_4M_2	14.87	11.75	13.30	26.20	20.70	21.43	27.40	21.65	24.53	36.60	32.57	34.60
N_5M_0	14.07	11.11	12.57	25.33	20.01	22.67	28.60	22.59	25.60	32.43	28.87	30.63
N_5M_1	15.70	11.11	14.03	25.20	19.91	22.57	29.67	23.44	26.60	33.00	29.37	31.20
N_5M_2	17.67	14.17	16.27	26.87	22.23	24.57	32.33	25.54	28.90	38.30	34.09	36.20
SE±	0.32	0.25	0.28	0.33	0.40	0.26	0.33	0.32	0.33	0.35	0.34	0.34
CD (P=0.05)	0.91	0.71	0.82	0.93	0.60	0.81	0.36	0.95	0.96	0.44	0.70	0.98

DAT-Days after transplanting

Fig. 4.2 Combined effect of integrated nitrogen management and mulching practices on plant height at 15, 30, 45 DAT and at harvesting.

4.1.2 Number of leaf

Number of leaf is a crucial component which enhances growth during crop production. The data regarding the number of leaf at various stages of the broccoli plant as affected by integrated nitrogen and mulching practices is presented in tables 4.3, 4.4 and figures 4.3, 4.4.

At 15 DAT, maximum number of leaf was recorded in N_5: 50 % nitrogen with Urea & 50 % nitrogen from Poultry Manure i.e., 9.12, 9.70 and 9.41 leaves in 2021-22, 2022-23 and pooled mean respectively, followed by N_1: 100 % N through Urea i.e., 8.01, 8.03 and 8.02 leaves in 2021-22, 2022-23 and pooled mean respectively and least values were recorded in N_0 (control) i.e., 6.14, 6.37 and 6.26 leaves in 2021-22, 2022-23 and pooled mean respectively.

Among the mulching treatment, highest number of leaf was recorded in M_2: Black polythene mulch i.e., 8.65, 8.04 and 8.35 leaves in 2021-22, 2022-23 and the pooled data respectively, followed by Paddy straw mulch (M_1) i.e., 7.03, 7.93 and 7.48 leaves in 2021-22, 2022-23 and pooled mean, respectively, while the minimum values were recorded in M_0: without mulch i.e., 6.20, 6.90 and 6.55 leaves in 2021-22, 2022-23 and pooled mean respectively.

Among the treatment combinations highest number of leaf was recorded in N_5M_2: 50 % nitrogen with Urea and 50 % nitrogen from Poultry Manure + Black Polythene mulch i.e., 9.90, 9.98 and 9.94 leaves in 2021-22, 2022-23 and pooled mean respectively, while the minimum values were recorded in N_0M_0 (control) i.e. 6.82, 6.32 and 6.57 in 2021-22, 2022-23 and pooled mean respectively.

At 30 DAT, maximum number of leaf was recorded in N_5: 50 percent nitrogen by Urea and 50 percent nitrogen from Poultry Manure i.e., 15.60, 15.15 and 15.38 leaves in 2021-22, 2022-23 and pooled data respectively, followed by N_1: 100 % N through Urea i.e., 14.67, 14.05 and 14.36 leaves in 2021-22, 2022-23 and pooled data and minimum values were recorded in N_0 (control) i.e. 13.88, 13.84 and 13.86 leaves in 2021-22, 2022-23 and pooled mean respectively.

Among the mulching treatment, maximum number of leaf was recorded in M_2 (Black polythene mulch) i.e., 14.27, 14.21 and 14.24 leaves in 2021-22, 2022-23 and pooled mean respectively, followed by M_1 (Paddy straw mulch) i.e., 13.85, 13.38 and 13.62 leaves in 2021-22, 2022-23 and pooled mean respectively and minimum values were recorded in M_0 (Control) i.e., 13.75, 13.01 and 13.38 leaves in 2021-22, 2022-23 and the pooled mean respectively.

Among the treatment combinations highest number of leaf was found in N_5M_2: 50 % nitrogen with Urea & 50 % nitrogen from Poultry Manure + Black Polythene mulch i.e., 15.78, 16.54 and 16.16 leaves in 2021-22, 2022-23 and pooled mean respectively, followed by N_1M_2: 100 % N through Urea + Black polythene mulch i.e., 15.20, 14.98 and 15.09 leaves in 2021-22, 2022-23 and respectively and minimum value was recorded in treatment combination N_0M_0 (control) i.e., 14.73, 13.70 and 14.22 leaves in 2021-22, 2022-23 respectively.

At 45 DAT, maximum number of leaf in was recorded N_5: 50 percent nitrogen from Urea & 50 percent of the nitrogen with Poultry Manure i.e., 21.46, 22.88 and 22.17 leaves in 2021-22, 2022-23 and pooled data respectively, followed by N_1: 100 % N through Urea i.e., 20.76, 19.93 and 20.35 leaves in 2021-22, 2022-23 and pooled data respectively, while the least values recorded in N_0 (control) i.e., 17.78, 17.60 and 17.69 leaves in 2021-22, 2022-23 and pooled data respectively.

Among the mulching treatment, highest number of leaf was recorded in M_2 (Black polythene mulch) i.e., 20.77, 20.34 and 20.56 leaves in 2021-22, 2022-23 and pooled data respectively, followed by Paddy straw mulch (M_1) i.e., 20.05, 19.98 and 20.02 leaves in 2021-22, 2022-23 and pooled mean respectively and minimum values were observed in M_0 (control) i.e. 19.92, 19.32 and 19.62 leaves in 2021-22, 2022-23 and pooled mean respectively.

Among the combinations highest number of leaf was recorded in N_5M_2: 50 percent nitrogen from Urea & 50 percent of the nitrogen with Poultry Manure with Black Polythene mulch i.e., 23.16, 22.54 and 22.95 leaves in 2021-22, 2022-23 and pooled mean respectively, followed by N_1M_2: 100 % N through Urea + Black polythene mulch i.e., 21.30, 21.65 and 21.44 leaves in 2021-22, 2022-23 and pooled mean

respectively and the least value was found in treatment combination N_0M_0 (control) i.e., 19.86, 20.32 and 20.09 leaves in 2021-22, 2022-23 and pooled mean respectively.

At harvest, maximum number of leaf in N_5: 50 percent nitrogen by Poultry manure + 50 % N through Urea i.e., 23.64, 22.35 and 23.00 leaves in 2021-22, 2022-23 and pooled data respectively, followed by N_1: 100 % N through Urea 21.94, 22.73 and 22.34 leaves in 2021-22, 2022-23 and pooled mean respectively and minimum values were observed in N_0 (control) i.e., 20.28, 21.74 and 21.01 leaves in 2021-22, 2022-23 and pooled mean respectively.

Among the mulching treatment, maximum number of leaf was recorded in M_2 (Black polythene mulch) 22.47, 21.97 and 22.22 leaves in 2021-22, 2022-23 and pooled mean respectively, followed by M_1 (Paddy straw mulch) i.e., 20.22, 20.92 and 20.57 leaves in 2021-22, 2022-23 and pooled mean, respectively and least values were recorded in M_0 (control) 20.02, 19.16 and 19.59 in 2021-22, 2022-23 and pooled mean respectively.

At harvest, in all the combinations, N_5M_2: 50 % nitrogen with Urea & 50 % nitrogen from Poultry Manure + Black Polythene mulch was recorded to have superior number of leaf, i.e., 23.32, 23.99 and 23.66 in 2021-22, 2022-23 and pooled mean respectively, followed by N_1M_2: 100 % N through Urea + Black Polythene mulch i.e., 22.23, 22.69 and 22.46 in 2021-22, 2022-23 and pooled mean respectively and the lowest value was observed in treatment combination N_0M_0 (control) 17.63, 17.73 and 17.68 in 2021-22, 2022-23 and pooled mean respectively.

The highest number of leaves recorded in N_5 might be due to the response of poultry manure is rich in essential nutrients, which is slowly released into the soil, providing nourishment to the plant, enhancing the activity of plant metabolism and helps synthesize chlorophyll resulting increases the number of leaves and provides good leaf growth. (Dalal *et al.* 2010).

The maximum number of leaves in M_2 might be due to optimum soil temperature and weed-free soil zone, reducing the crop competition and quickly making all nutrients available to the plant root (Islam *et al*. 2014)**.**

The maximum number of leaves in N_5M_2, possibly due to adding more organic matter through poultry manure, urea and mulched soil zones. The interactive effect provides a favorable temperature with maximum efficacy of nutrient uptake, resulting in the formation of more leaves in the plants.

Table 4.3 Response of integrated nitrogen management and mulching practices on number of leaf at 15, 30, 45 DAT and at harvesting

Treatment	15 DAT			30 DAT			45 DAT			At harvest		
	2021-22	2022-23	Pooled mean	2021-22	2022-23	Pooled mean	2021-22	2022-23	Pooled mean	2021-22	2022-23	Pooled mean
Integrated nitrogen management (N)												
N_0	6.14	6.37	6.26	13.88	13.84	13.86	17.78	17.60	17.69	20.28	21.74	21.01
N_1	8.01	8.03	8.02	14.67	14.05	14.36	20.76	19.93	20.35	21.94	22.73	22.34
N_2	7.55	8.04	7.80	13.98	13.94	13.90	19.54	19.21	19.38	21.27	21.12	21.20
N_3	7.73	7.58	7.66	13.50	13.26	13.38	19.36	19.62	19.49	21.58	20.74	21.16
N_4	7.84	7.26	7.55	14.28	13.98	14.13	19.56	18.32	18.94	20.54	21.64	21.09
N_5	9.12	9.70	9.41	15.60	15.15	15.38	21.46	22.88	22.17	23.64	22.35	23.00
SE±	0.07	0.10	0.09	0.13	0.12	0.13	0.19	0.21	0.20	0.10	0.15	0.13
CD (P=0.05)	0.21	0.32	0.27	0.26	0.36	0.31	0.39	0.36	0.38	0.27	0.34	0.31
Mulching (M)												
M_0	6.20	6.90	6.55	13.75	13.01	13.38	19.92	19.32	19.62	20.02	19.16	19.59
M_1	7.03	7.93	7.48	13.85	13.38	13.62	20.05	19.98	20.02	20.22	20.92	20.57
M_2	8.65	8.04	8.35	14.27	14.21	14.24	20.77	20.34	20.56	22.47	21.97	22.22
SE±	0.10	0.08	0.09	0.18	0.20	0.19	0.27	0.17	0.22	0.13	0.15	0.14
CD (P=0.05)	0.30	0.37	0.34	0.37	0.38	0.38	0.55	0.41	0.48	0.39	0.41	0.40

DAT-Days after transplanting

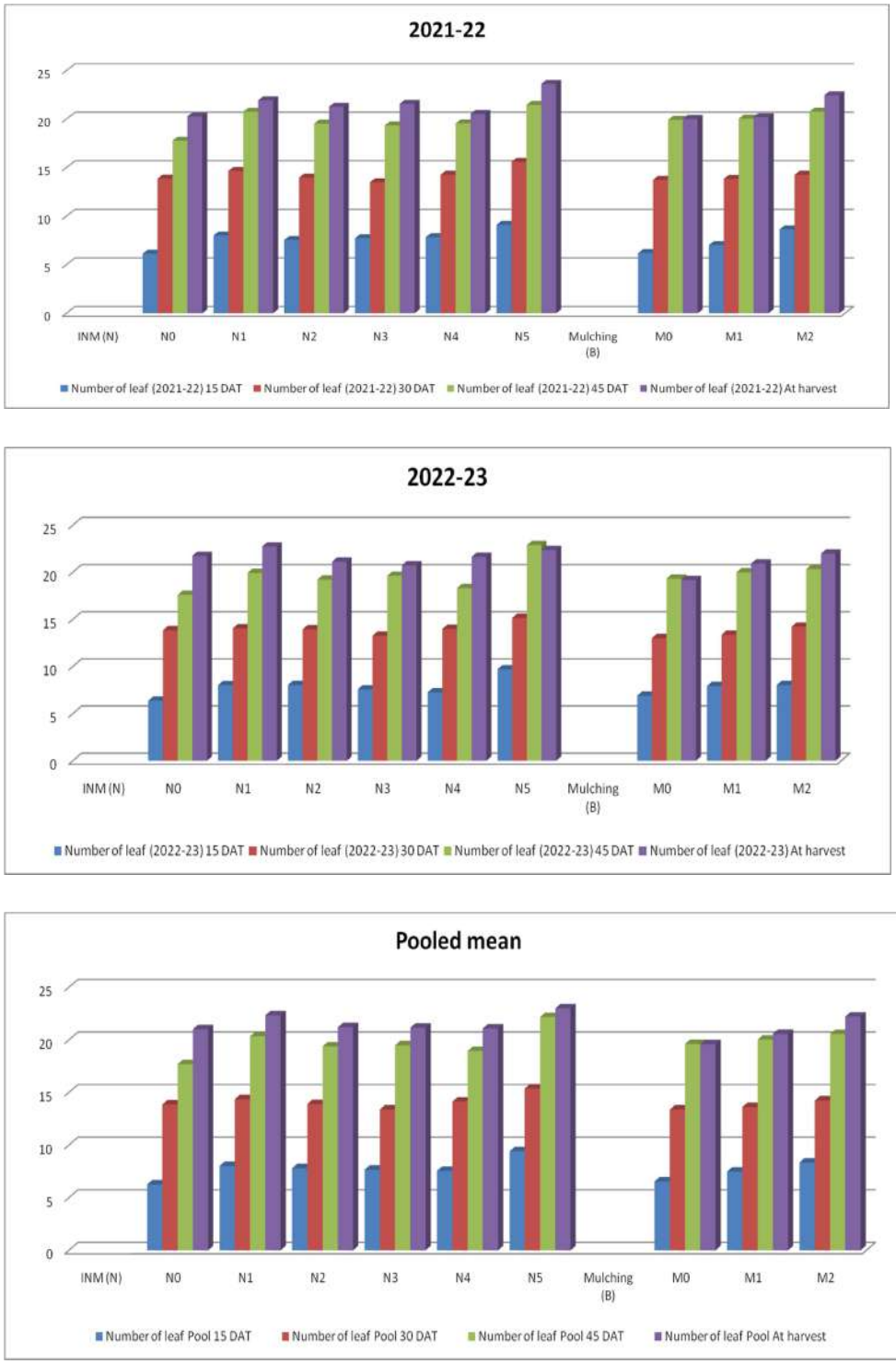


Fig 4.3: Response of integrated nitrogen management and mulching practices on number of leaf at 15, 30, 45 DAT and at harvesting.

Table 4.4 Interaction effect of integrated nitrogen management and mulching practices on number of leaf at 15, 30, 45 DAT and at harvesting

Treatment	15 DAT			30 DAT			45 DAT			At harvest		
	2021-22	2022-23	Pooled mean	2021-22	2022-23	Pooled mean	2021-22	2022-23	Pooled mean	2021-22	2022-23	Pooled mean
N_0M_0	6.82	6.32	6.57	14.73	13.70	14.22	19.86	20.32	20.09	17.63	17.73	17.68
N_0M_1	7.06	6.98	7.02	12.83	11.98	12.41	17.03	18.03	17.53	17.73	17.35	17.54
N_0M_2	7.80	7.02	7.41	12.66	12.90	12.78	18.80	19.32	19.06	18.80	18.49	18.65
N_1M_0	8.06	7.98	8.02	13.46	13.02	13.24	20.36	20.65	20.51	20.26	20.65	20.46
N_1M_1	8.03	7.67	7.85	13.93	13.11	13.52	20.00	19.87	19.94	20.23	20.85	20.54
N_1M_2	8.14	8.87	8.51	15.20	14.98	15.09	21.30	21.65	21.44	22.23	22.69	22.46
N_2M_0	7.00	6.34	6.67	13.93	14.03	13.98	20.20	19.98	20.09	20.13	19.29	19.71
N_2M_1	7.73	8.24	7.99	14.53	13.79	14.16	20.80	20.03	20.42	21.60	21.95	21.78
N_2M_2	7.93	6.67	7.30	13.40	14.93	14.17	20.63	20.45	20.54	22.10	21.14	21.62
N_3M_0	7.20	8.03	7.62	14.04	14.89	14.47	19.90	19.58	19.74	21.40	21.32	21.36
N_3M_1	7.46	7.87	7.67	14.30	13.67	13.99	20.66	20.53	20.60	20.46	21.06	20.76
N_3M_2	8.01	8.23	8.12	14.36	14.11	14.24	20.53	20.36	20.45	21.90	22.03	21.97
N_4M_0	8.06	8.02	8.04	14.13	14.34	14.24	20.53	20.92	20.73	22.13	21.39	21.76
N_4M_1	7.86	8.01	7.94	14.15	13.01	13.58	20.60	20.32	20.46	21.93	22.03	21.98
N_4M_2	7.60	6.78	7.19	12.78	13.77	13.28	20.56	19.96	20.26	21.56	21.05	21.31
N_5M_0	7.53	7.45	7.49	13.96	13.87	13.92	21.00	20.73	20.87	21.40	22.09	21.75
N_5M_1	7.93	7.87	7.90	14.40	14.34	14.37	21.23	20.90	21.07	22.26	21.43	21.85
N_5M_2	9.90	9.98	9.94	15.78	16.54	16.16	23.16	22.54	22.95	23.32	23.99	23.66
SE±	0.18	0.17	0.18	0.31	0.33	0.32	0.47	0.51	0.49	0.23	0.32	0.28
CD (P=0.05)	0.52	0.46	0.49	0.64	0.59	0.62	0.96	0.87	0.92	0.67	0.71	0.69

DAT-Days after transplanting

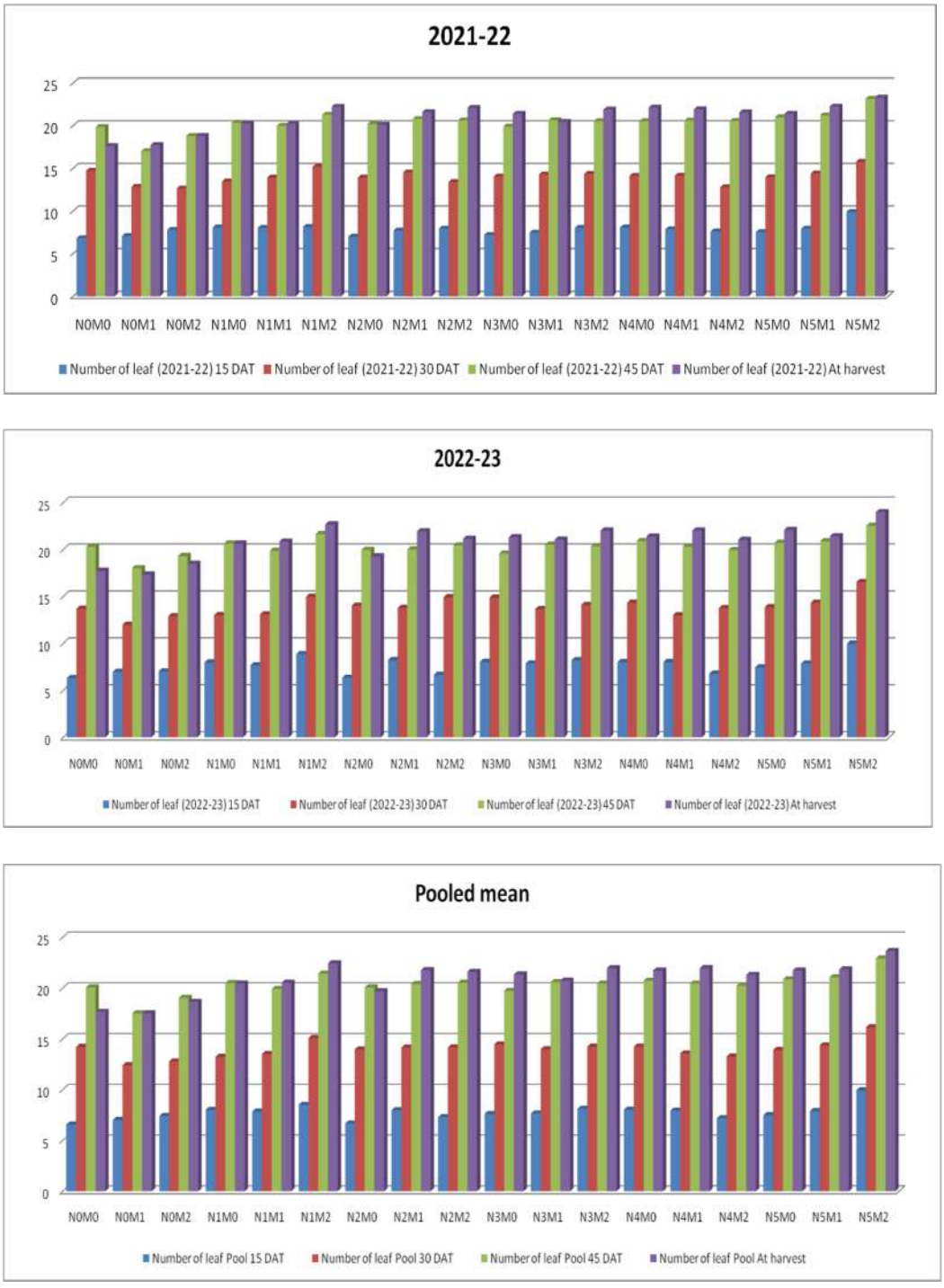


Fig. 4.4: Combined effect of integrated nitrogen management and mulching practices on number of leaf at 15, 30, 45 DAT and at harvesting.

4.1.3 Leaf length (cm)

The data regarding Leaf length at various stage of broccoli plant as affected by integrated nitrogen and mulching management is depicted in tables 4.5, 4.6 and figures 4.5, 4.6.

The data confirm that the integration of nitrogen management mulching practices and significantly influenced leaf length of broccoli irrespective of growth stages.

At 15 DAT, the highest leaf length was recorded in N_5: 50 % nitrogen with Urea & 50 % nitrogen from Poultry Manure i.e., 7.93, 5.21 and 6.88 cm in 2021-22, 2022-23 and pooled mean respectively, followed by N_1: 100 % N through Urea i.e., 7.60, 4.48 and 6.61 cm in 2021-22, 2022-23 and pooled mean respectively, while the minimum values recorded in N_0 (control) 5.44, 3.76 and 4.61 cm in 2021-22, 2022-23 and pooled mean respectively.

Among the mulching treatment, maximum leaf length was recorded in M_2 (Black polythene mulch) i.e., 7.53, 5.20 and 6.38 cm in 2021-22, 2022-23 and pooled data respectively, followed by Paddy straw mulch (M_1) i.e., 6.71, 4.64 and 5.67 cm 2021-22, 2022-23 and pooled mean respectively, while the lest values observed in M_0 (control) i.e., 6.22, 4.29 and 5.27 cm in 2021-22, 2022-23 and pooled mean respectively.

Among the treatment combinations maximum leaf length was recorded in N_5M_2: 50 % nitrogen with Urea and 50 % nitrogen from Poultry Manure + Black Polythene mulch i.e., 9.80. 6.97 and 7.97 cm in 2021-22, 2022-23 and pooled mean respectively, followed by N_1M_2: 100 % N through Urea + black polythene mulch i.e., 8.96, 6.16 and 7.37 cm in 2021-22, 2022-23 and pooled mean respectively, while the minimum values observed in N_0M_0 (control) i.e., 5.66, 3.91 and 4.80 cm 2021-22, 2022-23 and pooled mean respectively.

At 30 DAT, maximum leaf length was recorded in N_5: 50 % N through Urea poultry manure + 50 % through Poultry manure i.e., 13.39, 9.86 and 11.62 cm in 2021-22, 2022-23 and pooled data respectively, followed by N_1: 100 % N through Urea i.e., 12.02, 8.16 and 10.09 cm in 2021-22, 2022-23 and pooled mean respectively, while

the minimum values observed in N_0 (control) 8.60, 5.93 and 7.27 cm 2021-22, 2022-23 and pooled mean respectively.

Among the mulching treatment, maximum leaf length was recorded in M_2 (black polythene mulch) i.e., 12.88, 8.89 and 10.89 cm in 2021-22, 2022-23 and pooled mean respectively, followed by M_1 (Paddy straw mulch) i.e., 9.67, 6.67 and 8.17 cm 2021-22, 2022-23 and pooled mean respectively, while the minimum values observed in M_0 9.82, 6.78 and 8.31 cm in 2021-22, 2022-23 and pooled mean respectively.

Among the combinations, maximum leaf length was recorded in N_5M_2: 50 % nitrogen with Urea & 50 % nitrogen from Poultry Manure + Black Polythene mulch i.e., 15.41, 10.88 and 12.97 cm in 2021-22, 2022-23 and pooled data respectively, followed by N_1M_2: 100 % N through Urea + Black polythene mulch. 14.13, 10.04 and 11.80 cm in 2021-22, 2022-23 and pooled data respectively, while the minimum values recorded in treatment combination N_0M_0 (control) 7.67, 5.29 and 6.50 cm in 2021-22, 2022-23 and pooled data respectively.

At 45 DAT, maximum leaf length was recorded in N_5: 50 % nitrogen with Urea & 50 % nitrogen from Poultry Manure i.e., 19.36, 15.68 and 17.51 cm in 2021-22, 2022-23 and pooled data respectively, followed by N_1: 100 % N through Urea i.e., 18.68, 13.61 and 15.20 cm in 2021-22, 2022-23 and pooled data respectively, while the least values found in N_0 (control) 13.74, 11.13 and 12.46 cm in 2021-22, 2022-23 and pooled data respectively.

Among the mulching treatment, maximum leaf length was recorded in M_2 (black polythene mulch) i.e., 17.82, 14.43 and 16.12 cm in 2021-22, 2022-23 and pooled data respectively, followed by Paddy straw mulch (M_1) i.e., 17.01, 13.78 and 15.39 cm in 2021-22, 2022-23 and pooled mean respectively, while the minimum values recorded in M_0 (control) 16.20, 13.12 and 14.67 cm in 2021-22, 2022-23 and pooled data respectively.

Among the combinations, maximum leaf length was recorded in N_5M_2: 50 % nitrogen with Urea & 50 % nitrogen from Poultry Manure + Black Polythene mulch i.e., 19.40, 15.71 and 17.56 cm 2021-22, 2022-23 and pooled mean respectively, followed by N_1M_2: 100 % N through Urea + black polythene mulch i.e., 16.93, 15.15 and 16.04

cm 2021-22, 2022-23 and pooled mean respectively, while the least leaf length were recorded in treatment combination N_0M_0 (control) i.e., 13.00 10.53 and 11.77 cm 2021-22, 2022-23 and pooled mean respectively.

At harvest, maximum leaf length was recorded in N_5: 50 % nitrogen with Urea & 50 % nitrogen from Poultry Manure i.e., 22.32, 18.49 and 20.40 cm in 2021-22, 2022-23 and pooled data respectively, followed by N_1: 100 % N through Urea i.e., 21.82, 16.78 and 18.76 cm in 2021-22, 2022-23 and pooled mean respectively, while the least leaf length were recorded in N_0 (control) i.e., 16.33, 13.23 and 14.80 cm 2021-22, 2022-23 and pooled mean respectively.

Among the mulching treatment, maximum leaf length was recorded in M_2 (black polythene mulch) i.e., 22.15, 17.94 and 20.05 cm in 2021-22, 2022-23 and pooled data respectively, followed by M_1 (Paddy straw mulch) i.e., 20.33, 16.48 and 18.41 cm 2021-22, 2022-23 and pooled mean respectively, while the least leaf length were recorded in treatment combination M_0 (control) 19.97, 16.18 and 18.09 cm 2021-22, 2022-23 and pooled mean respectively.

Among the combinations, N_5M_2: 50 % nitrogen with Urea and 50 % nitrogen from Poultry Manure + Black Polythene mulch i.e., 23.63, 19.14 and 21.39 cm 2021-22, 2022-23 and pooled mean respectively, which was recorded at par with treatment N_3M_1: 50 % N through Urea + 50 % N through FYM + Paddy Straw mulch i.e., 22.80, 19.28 and 21.04 cm 2021-22, 2022-23 and pooled mean respectively, followed by N_1M_2: 100 % N through Urea + Black polythene mulch i.e., 22.00, 18.23 and 20.12 cm 2021-22, 2022-23 and pooled mean respectively, while the minimum leaf length were recorded in N_0M_0 (control) i.e., 15.66, 12.69 and 14.18 cm 2021-22, 2022-23 and pooled mean respectively.

The maximum leaf length was recorded in N_5 could be attributed to several factors, with the presence of poultry manure rich in organic matter playing a significant role, poultry manure is known to be a potent organic fertilizer, containing essential nutrients like nitrogen, phosphorus and potassium, along with various micronutrient vital for plant growth. When applied to the soil, it enriches it with these nutrients, thereby creating a favorable environment for plant growth (Mohanta *et al*., 2018).

The maximum leaf length in M_2 might be due to black polythene mulch having a high moisture-retaining capacity and inhibiting weed growth by blocking the sunlight from reaching the soil by which nutrient competition with other weed plants is less, resulting in maximum leaf length (Mohanta *et al*., 2018).

The Maximum leaf length in N_5M_2 this could be due to the interactive effect of manures and fertilizer along with mulch, which help in consistent moisture and nutrient supply which is crucial for optimal plant growth, as it ensure that plants have access to nutrients and water even during dry periods. With sufficient moisture and nutrient available, plants are able to carry out essential physiological process without being stressed, thus promoting growth and development

Table 4.5 Response of integrated nitrogen management and mulching practices on leaf length at 15, 30, 45 DAT and at harvesting

Treatment	15 DAT			30DAT			45DAT			At harvest		
	2021-22	2022-23	Pooled mean	2021-22	2022-23	Pooled mean	2021-22	2022-23	Pooled mean	2021-22	2022-23	Pooled mean
Integrated nitrogen management (N)												
N_0	5.44	3.76	4.61	8.60	5.93	7.27	13.74	11.13	12.46	16.33	13.23	14.80
N_1	7.60	4.48	6.61	12.02	8.16	10.09	18.68	13.61	15.20	21.82	16.78	18.76
N_2	6.34	4.18	5.36	11.05	7.99	9.52	15.37	12.45	13.90	20.35	17.30	19.11
N_3	6.56	4.01	5.56	10.60	7.31	8.96	17.34	13.26	14.59	19.38	17.33	19.27
N_4	7.22	3.98	6.12	10.18	7.02	8.60	17.44	13.14	14.71	20.82	18.08	19.45
N_5	7.93	5.21	6.88	13.39	9.86	11.62	19.36	15.68	17.51	22.32	18.49	20.40
SE±	0.11	0.15	0.09	0.11	0.13	0.14	0.13	0.11	0.12	0.13	0.12	0.27
CD (P=0.05)	0.31	0.34	0.18	0.31	0.39	0.35	0.38	0.29	0.33	0.37	0.39	0.37
Mulching (M)												
M_0	6.22	4.29	5.27	9.82	6.78	8.31	16.20	13.12	14.67	19.97	16.18	18.09
M_1	6.71	4.64	5.67	9.67	6.67	8.17	17.01	13.78	15.39	20.33	16.48	18.41
M_2	7.53	5.20	6.38	12.88	8.89	10.89	17.82	14.43	16.12	22.15	17.94	20.05
SE±	0.15	0.18	0.13	0.17	0.19	0.22	0.26	0.19	0.21	0.18	0.21	0.19
CD (P=0.05)	0.44	0.47	0.26	0.43	0.51	0.53	0.74	0.54	0.65	0.52	0.57	0.54

DAT-Days after transplanting

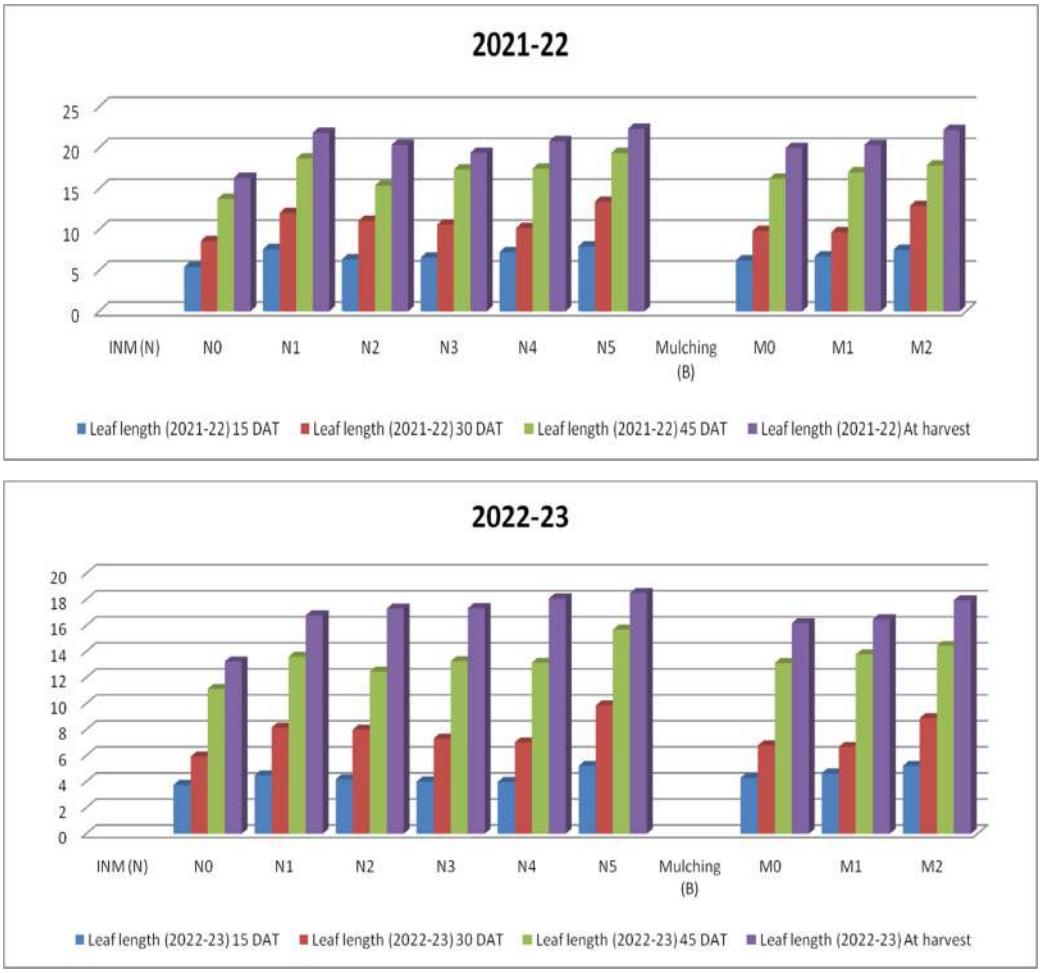
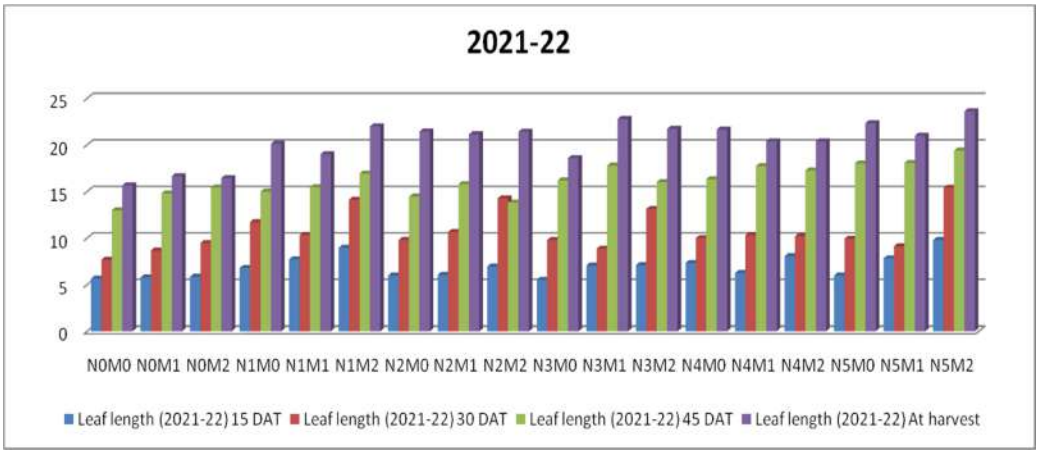


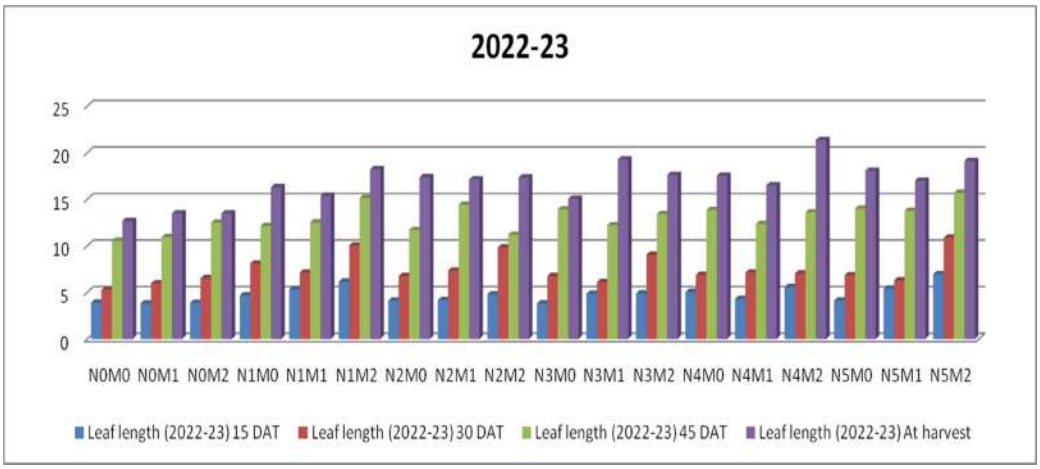
Fig.4.5: Response of integrated nitrogen management and mulching practices on leaf length at 15, 30, 45 DAT and at harvesting.

Table 4.6 Combined effect of Integrated nitrogen management and mulching practices on leaf length at 15, 30, 45 DAT and at harvesting.

Treatment	15 DAT			30DAT			45DAT			At harvest		
	2021-22	2022-23	Pooled mean	2021-22	2022-23	Pooled mean	2021-22	2022-23	Pooled mean	2021-22	2022-23	Pooled mean
N_0M_0	5.66	3.91	4.80	7.67	5.29	6.50	13.00	10.53	11.77	15.66	12.69	14.18
N_0M_1	5.79	3.93	4.81	8.67	5.98	7.33	14.80	10.94	12.87	16.66	13.50	15.08
N_0M_2	5.87	3.99	4.88	9.47	6.53	8.00	15.43	12.50	13.97	16.45	13.50	14.98
N_1M_0	6.80	4.69	5.77	11.73	8.10	9.93	15.00	12.15	13.58	20.13	16.31	18.22
N_1M_1	7.73	5.34	6.50	10.33	7.13	8.73	15.47	12.53	14.00	19.00	15.39	17.20
N_1M_2	8.96	6.16	7.37	14.13	10.04	11.80	16.93	15.15	16.04	22.00	18.23	20.12
N_2M_0	6.00	4.14	5.07	9.80	6.76	8.27	14.47	11.72	13.09	21.46	17.39	19.42
N_2M_1	6.06	4.19	5.13	10.67	7.36	9.00	15.80	14.42	15.11	21.16	17.15	19.15
N_2M_2	6.96	4.81	5.87	14.27	9.84	11.03	13.83	11.21	12.52	21.43	17.36	19.40
N_3M_0	5.53	3.82	4.70	9.80	6.76	8.27	16.20	13.93	15.07	18.60	15.07	16.83
N_3M_1	7.06	4.88	5.97	8.87	6.12	7.50	17.80	12.23	15.01	22.80	19.28	21.04
N_3M_2	7.10	4.90	6.00	13.13	9.06	11.10	16.03	13.42	14.73	21.73	17.63	19.68
N_4M_0	7.33	5.06	6.23	10.00	6.90	8.47	16.33	13.85	15.09	21.66	17.55	19.61
N_4M_1	6.26	4.32	5.30	10.33	7.13	8.73	17.73	12.36	15.05	20.40	16.52	18.46
N_4M_2	8.06	5.57	6.83	10.20	7.04	8.63	17.27	13.61	15.44	20.40	21.38	20.89
N_5M_0	6.00	4.14	5.07	9.93	6.85	8.40	18.02	14.01	16.02	22.33	18.09	20.21
N_5M_1	7.83	5.41	6.60	9.13	6.30	7.73	18.07	13.77	16.54	21.00	17.01	19.01
N_5M_2	9.80	6.97	7.97	15.41	10.88	12.97	19.40	15.71	17.56	23.63	19.14	21.39
SE±	0.27	0.26	0.22	0.26	0.24	0.31	0.44	0.33	0.34	0.31	0.35	0.32
CD (P=0.05)	0.76	0.56	0.45	0.81	0.72	0.83	1.28	0.98	0.99	0.90	0.88	0.90

DAT-Days after transplanting





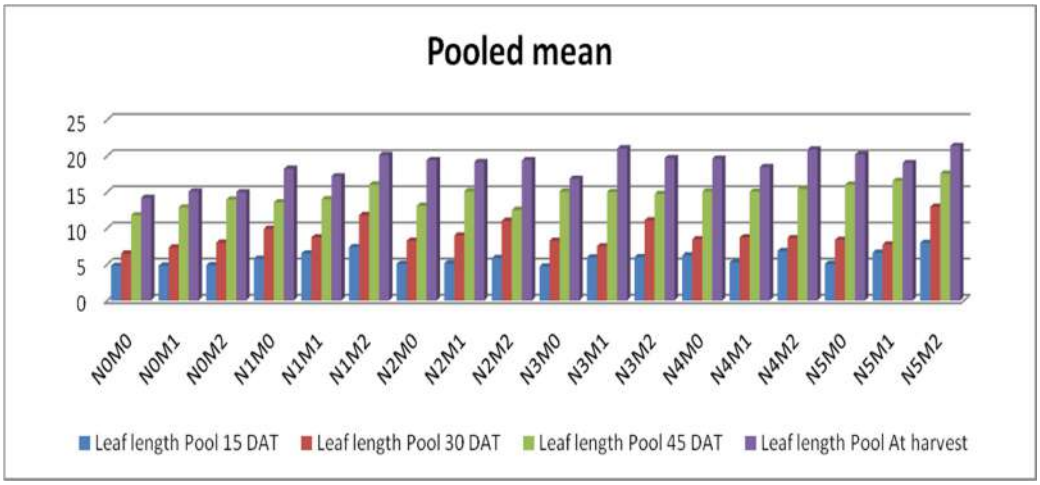


Fig: 4.6 Combined effect of integrated nitrogen management and mulching practices on leaf length at 15, 30,45 DAT and at harvesting.

4.1.4 Leaf width (cm)

Leaf width is a crucial component which enhances growth during crop production. The data regarding the leaf width at various stages of the broccoli plant as affected by integrated nitrogen and mulching management is depicted in tables 4.7, 4.8 and figures 4.7, 4.8.

The data confirm that the integration of nitrogen management mulching practices and interaction insignificantly influenced leaf width irrespective of growth stages.

At 15 DAT, the maximum leaf width was recorded in N_5: 50 % nitrogen with Urea & 50 % nitrogen from Poultry Manure i.e., 5.73, 4.61 and 5.17 cm in 2021-22, 2022-23 and pooled mean respectively, followed by N_1: 100 % N through Urea i.e., 5.55, 3.32 and 4.44 cm in 2021-22, 2022-23 and pooled mean respectively, while the minimum data were recorded in N_0 (control) i.e., 3.42, 2.16 and 2.79 cm in 2021-22, 2022-23 and pooled mean respectively.

Among the mulching treatment, maximum leaf width was recorded in M_2 (black polythene mulch) i.e., 5.79, 3.65 and 3.91 cm in 2021-22, 2022-23 and pooled data respectively, followed by M_1 (Paddy straw mulch) i.e., 4.79, 3.02 and 3.51 cm 2021-22, 2022-23 and pooled mean, respectively, while the minimum data were recorded in M_0 (control) 4.27, 2.70 and 3.48 cm in 2021-22, 2022-23 and pooled mean respectively.

Among the combinations, maximum leaf width was recorded in N_5M_2: 50 % nitrogen with Urea & 50 % nitrogen from Poultry Manure + Black Polythene mulch i.e., 6.93. 4.37 and 5.63 cm 2021-22, 2022-23 and pooled mean respectively, followed by N_1M_2: 100 % N through Urea + Black Polythene mulch i.e., 6.56, 4.06 and 5.23 cm 2021-22, 2022-23 and pooled mean respectively, while the minimum data were recorded in N_0M_0 (control) i.e., 3.13, 1.97 and 2.57 cm in 2021-22, 2022-23 and pooled mean respectively.

At 30 DAT, maximum leaf width was recorded in N_5: 50 % nitrogen with Urea & 50 % nitrogen from Poultry Manure) i.e., 8.69, 5.46 and 7.06 cm in 2021-22, 2022-23 and pooled mean respectively, followed by N_1: 100 % N through Urea 8.43, 5.09 and

6.74 cm in 2021-22, 2022-23 and pooled mean respectively, while the minimum data were recorded in N_0 (control) i.e., 4.54, 2.86 and 3.69 cm in 2021-22, 2022-23 and pooled mean respectively.

Among the mulching treatment, maximum leaf width was recorded in M_2 (Black polythene mulch) i.e., 9.80, 6.18 and 7.99 cm in 2021-22, 2022-23 and pooled mean respectively, followed by M_1 (Paddy straw mulch) i.e., 7.42, 4.05 and 5.73 cm 2021-22, 2022-23 and pooled mean respectively, while the minimum data were recorded in M_0 (control) i.e., 6.60, 4.16 and 5.38 cm in 2021-22, 2022-23 and pooled mean respectively.

Among the combinations, maximum leaf width was recorded in N_5M_2: 50 % nitrogen with Urea & 50 % nitrogen from Poultry Manure + black polythene mulch i.e., 12.53, 7.90 and 10.20 cm in 2021-22, 2022-23 and pooled data respectively, followed by N_1M_2: 100 % N through Urea + black polythene mulch i.e., 12.01, 7.39 and 9.59 cm in 2021-22, 2022-23 and pooled data respectively, while the least data were observed in N_0M_0 (control) i.e., 4.66, 2.94 and 3.80 cm in 2021-22, 2022-23 and pooled mean respectively.

At 45 DAT, maximum leaf width was recorded in N_5: 50 % N through Urea + 50 % through Poultry manure i.e., 13.28, 9.70 and 11.47 cm in 2021-22, 2022-23 and pooled data respectively, followed by N_1: 100 % N through Urea i.e., 12.73, 8.57 and 10.43 cm in 2021-22, 2022-23 and pooled data respectively, while the minimum data were recorded in N_0 (control) i.e., 6.78, 4.28 and 5.52 cm in 2021-22, 2022-23 and pooled mean respectively.

Among the mulching treatment, maximum leaf width was recorded in M_2 i.e. black polythene mulch i.e., 12.02, 8.68 and 12.69 cm in 2021-22, 2022-23 and pooled data respectively, followed by Paddy straw mulch (M_1) i.e., 11.08, 7.98 and 11.69 cm 2021-22, 2022-23 and pooled mean, respectively, while the least leaf width were recorded in M_0 (control) i.e., 10.65, 7.66 and 11.24 cm in 2021-22, 2022-23 and pooled mean respectively.

Among the combinations, maximum leaf width was recorded in N_5M_2: 50 % nitrogen with Urea & 50 % nitrogen from Poultry Manure + Black Polythene mulch i.e., 13.80,

10.07 and 11.93 cm 2021-22, 2022-23 and pooled mean respectively, followed by N_1M_2: 100 % N through Urea + Black Polythene mulch i.e., 13.13, 9.40 and 11.31 cm 2021-22, 2022-23 and pooled mean respectively, while the minimum data were recorded in N_0M_0 (control) 7.06, 4.45 and 5.73 cm in 2021-22, 2022-23 and pooled mean respectively.

At harvest, maximum leaf width was found in N_5: 50 % nitrogen with Urea & 50 % nitrogen from Poultry Manure i.e., 13.89, 12.03 and 12.96 cm in 2021-22, 2022-23 and pooled data respectively, followed by N_1: 100 % N through Urea 13.55, 10.71 and 12.13 cm in 2021-22, 2022-23 and pooled mean respectively, while the minimum data were recorded in N_0 (control) 7.93, 6.27 and 7.10 cm in 2021-22, 2022-23 and pooled mean respectively.

Among the mulching treatment, maximum leaf width was recorded in M_2 (black polythene mulch) i.e., 13.06, 10.32 and 11.69 cm in 2021-22, 2022-23 and pooled data respectively, followed by Paddy straw mulch (M_1) i.e., 11.67, 9.23 and 10.45 cm 2021-22, 2022-23 and pooled mean, respectively, while the minimum data were recorded in M_0 (control) i.e., 11.40, 9.15 and 10.41cm in 2021-22, 2022-23 and pooled mean respectively.

Among the combinations, maximum leaf width recorded in N_5M_2: 50 % nitrogen with Urea & 50 % nitrogen from Poultry Manure + Black Polythene mulch i.e., 14.90, 11.77 and 13.30 cm 2021-22, 2022-23 and pooled mean respectively, followed by N_1M_2: 100 % N through urea + black polythene mulch i.e., 14.43, 11.19 and 12.81 cm 2021-22, 2022-23 and pooled mean respectively, while the minimum data were recorded in N_0M_0 (control) 8.16, 6.45 and 7.33 cm in 2021-22, 2022-23 and pooled mean respectively.

Maximum leaf width in N_5 this could be due to the impact of poultry manure helps to maintain the soil's pH and good aeration by enhancing the organic manure in the soil, resulting in maximum absorption of minerals and water and significantly effective plant growth Dalal *et al.* (2010).

The maximum leaf width was recorded in M_2 this might be due to the high moisture-retaining capacity and inhibiting weed growth, by which nutrient competition among

the main crop and other weed plants is less. Similar findings were reported by Bhandari *et al*. (2021).

Maximum leaf width in N_5M_2 this might be due to the black polythene mulch and poultry manure, which enhances the microbial activity in the soil root zone. Black polythene mulch facilitates favorable moisture and no weed competition among the main crop.

Table 4.7 Response of integrated nitrogen management and mulching practices on leaf width at 15, 30, 45 DAT and at harvesting.

Treatment	Leaf width											
	15 DAT			30DAT			45DAT			At harvest		
	2021-22	2022-23	Pooled mean	2021-22	2022-23	Pooled mean	2021-22	2022-23	Pooled mean	2021-22	2022-23	Pooled mean
Integrated nitrogen management (N)												
N_0	3.42	2.16	2.79	4.54	2.86	3.69	6.78	4.28	5.52	7.93	6.27	7.10
N_1	5.55	3.32	4.44	8.43	5.09	6.74	12.73	8.57	10.43	13.55	10.71	12.13
N_2	4.75	3.00	3.87	8.11	5.11	6.63	11.51	8.40	9.94	13.12	10.37	11.74
N_3	5.08	3.21	4.14	8.08	5.03	6.60	12.28	8.97	10.62	13.22	10.45	11.83
N_4	5.07	3.20	4.13	6.73	4.24	5.49	11.93	8.71	10.33	12.36	9.77	11.07
N_5	5.73	4.61	5.17	8.69	5.46	7.06	13.28	9.70	11.47	13.89	12.03	12.96
SE±	0.05	0.04	0.04	0.07	0.05	0.08	0.08	0.13	0.12	0.06	0.07	0.12
CD (P=0.05)	0.13	0.12	0.12	0.19	0.15	0.17	0.24	0.37	0.25	0.16	0.18	0.25
Mulching (M)												
M_0	4.27	2.70	3.48	6.60	4.16	5.38	10.65	7.66	11.24	11.40	9.15	10.41
M_1	4.79	3.02	3.51	7.42	4.05	5.73	11.08	7.98	11.69	11.67	9.23	10.45
M_2	5.79	3.65	3.91	9.80	6.18	7.99	12.02	8.68	12.69	13.06	10.32	11.69
SE±	0.07	0.06	0.06	0.09	0.08	0.10	0.12	0.13	0.17	0.08	0.09	0.12
CD (P=0.05)	0.19	0.17	0.18	0.27	0.22	0.23	0.34	0.37	0.35	0.23	0.26	0.25

DAT-Days after transplanting

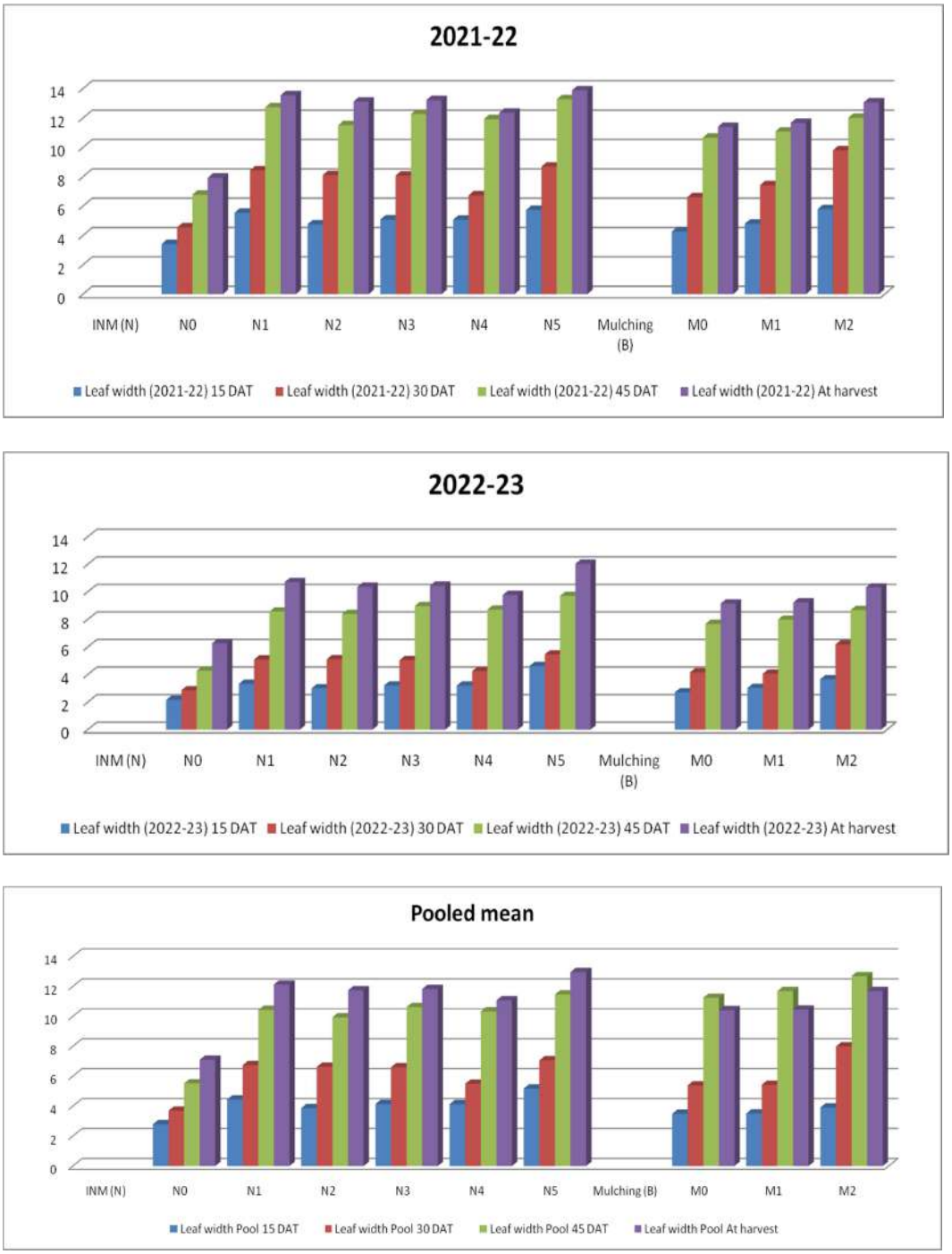
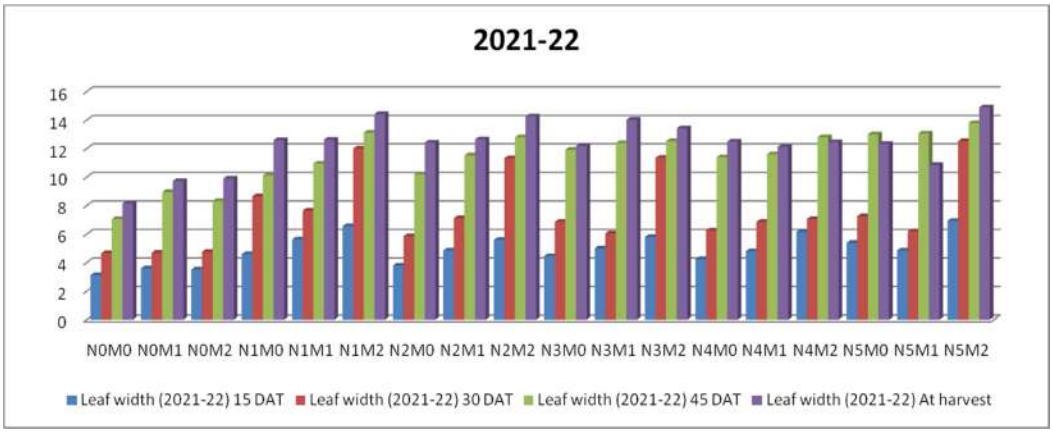


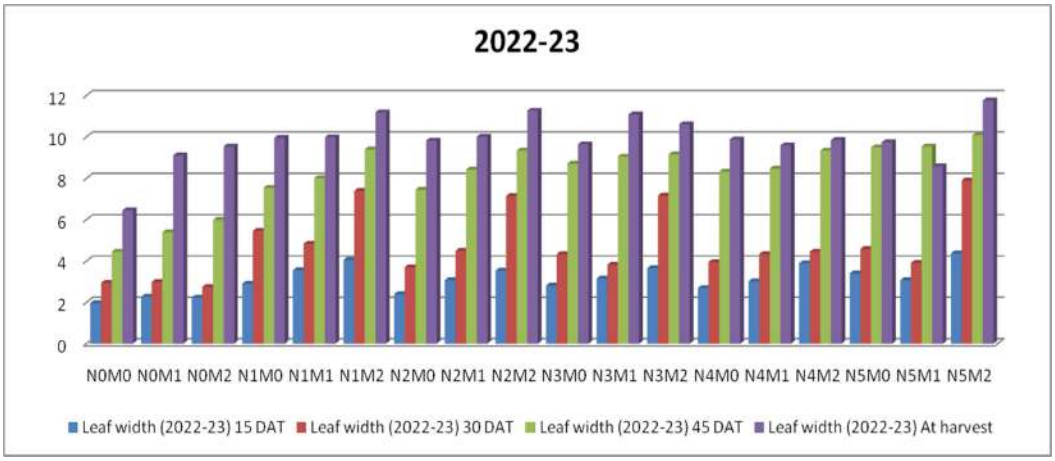
Fig.4.7 Response of integrated nitrogen management and mulching practices on leaf width at 15, 30, 45 DAT and at harvesting.

Table 4.8 Combined effect of integrated nitrogen management and mulching practices on leaf width at 15, 30, 45 DAT and at harvesting

Treatment	Leaf width											
	15 DAT			30 DAT			45 DAT			At harvest		
	2021-22	2022-23	Pooled mean	2021-22	2022-23	Pooled mean	2021-22	2022-23	Pooled mean	2021-22	2022-23	Pooled mean
N_0M_0	3.13	1.97	2.57	4.66	2.94	3.80	7.06	4.45	5.73	8.16	6.45	7.33
N_0M_1	3.60	2.27	2.93	4.69	2.99	3.84	8.96	5.39	6.67	9.73	9.11	9.45
N_0M_2	3.53	2.23	2.90	4.76	2.75	3.57	8.33	5.99	7.17	9.90	9.54	8.22
N_1M_0	4.60	2.90	3.73	8.66	5.46	7.07	10.13	7.54	8.93	12.60	9.95	11.30
N_1M_1	5.63	3.55	4.60	7.66	4.83	6.23	10.96	8.01	9.47	12.63	9.98	11.33
N_1M_2	6.56	4.06	5.23	12.01	7.39	9.59	13.13	9.40	11.31	14.43	11.19	12.81
N_2M_0	3.80	2.39	3.10	5.86	3.70	4.80	10.20	7.45	8.80	12.43	9.82	11.13
N_2M_1	4.86	3.07	3.97	7.13	4.49	5.83	11.53	8.42	9.97	12.66	10.01	11.33
N_2M_2	5.60	3.53	4.57	11.33	7.14	9.27	12.80	9.34	11.07	14.26	11.27	12.77
N_3M_0	4.46	2.81	3.60	6.86	4.33	5.60	11.93	8.71	10.33	12.20	9.64	10.90
N_3M_1	5.00	3.15	4.10	6.06	3.82	4.97	12.40	9.05	10.70	14.03	11.09	12.57
N_3M_2	5.80	3.65	4.70	11.36	7.16	9.23	12.53	9.15	10.83	13.43	10.61	12.00
N_4M_0	4.26	2.69	3.50	6.26	3.95	5.10	11.40	8.32	9.90	12.50	9.88	11.20
N_4M_1	4.80	3.02	3.90	6.86	4.33	5.60	11.60	8.47	10.00	12.13	9.59	10.83
N_4M_2	6.16	3.89	5.03	7.06	4.45	5.77	12.80	9.34	11.10	12.46	9.85	11.17
N_5M_0	5.40	3.40	4.40	7.26	4.58	5.90	13.00	9.49	11.20	12.33	9.74	11.03
N_5M_1	4.86	3.07	3.97	6.20	3.91	5.07	13.06	9.54	11.27	10.86	8.59	9.73
N_5M_2	6.93	4.37	5.63	12.53	7.90	10.20	13.80	10.07	11.93	14.90	11.77	13.30
SE±	0.90	0.11	0.10	0.16	0.13	0.18	0.20	0.22	0.30	0.14	0.15	0.21
CD (P=0.05)	0.33	0.29	0.30	0.47	0.38	0.32	0.58	0.65	0.60	0.40	0.45	0.43

DAT-Days after transplanting





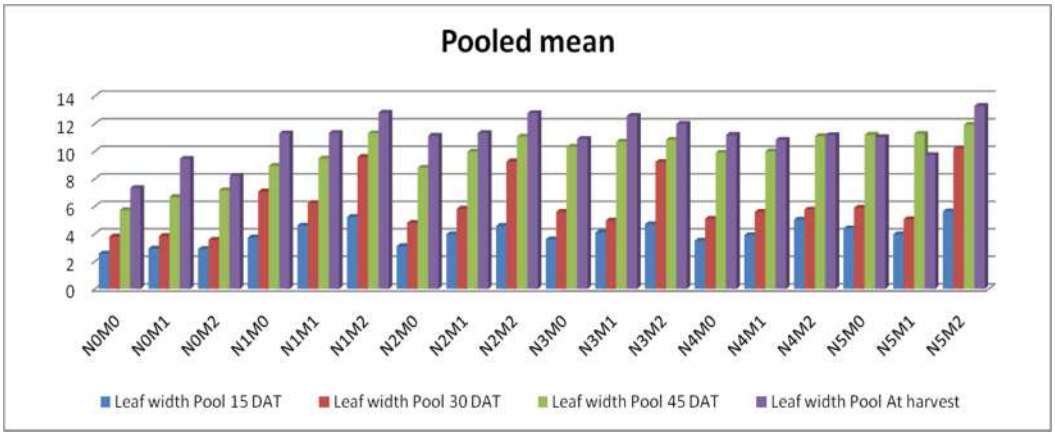


Fig: 4.8 Combined effect of integrated nitrogen management and mulching practices on leaf width at 15, 30, 45 DAT and at harvesting.

4.1.5 Leaf area (cm^2)

Leaf area is a crucial component which enhances growth during crop production. The data regarding the leaf area at various stages of the broccoli plant as affected by integrated N and mulching management is represented in tables 4.9, 4.10 and figures 4.9, 4.10.

At 15 DAT, the highest leaf area was recorded in N_5: 50 percent nitrogen from Urea & 50 percent of the nitrogen with Poultry Manure i.e., 45.44, 38.48 and 41.96 cm^2 in 2021-22, 2022-23 and pooled mean respectively, followed by N_1: 100 % N through Urea i.e., 42.18, 34.27 and 38.23 cm^2 in 2021-22, 2022-23 and pooled mean respectively, while the minimum data were recorded in N_0 (control) 18.60, 14.36 and 16.48 cm^2 and in 2021-22, 2022-23 and pooled mean respectively.

Among the mulching treatment, maximum leaf area was recorded in M_2 (Black polythene mulch) i.e., 43.60, 39.39 and 41.49 cm^2 in 2021-22, 2022-23 and pooled data respectively, followed by Paddy straw mulch (M_1) i.e., 32.14, 29.02 and 30.58 cm^2 2021-22, 2022-23 and pooled mean, respectively, while the minimum data were recorded in M_0 (control) i.e., 26.56, 20.37 and 23.46 cm^2 in 2021-22, 2022-23 and pooled mean respectively.

Among the combinations, highest leaf area was found in N_5M_2: 50 percent nitrogen from Urea & 50 percent of the nitrogen with Poultry Manure + black polythene mulch i.e., 60.98, 53.22 and 57.10 cm^2 2021-22, 2022-23 and pooled mean respectively**,** followed by N_1M_2: 100 % N through Urea + Black Polythene mulch i.e., 58.78, 40.67 and 49.72 cm^2 2021-22, 2022-23 and pooled mean respectively, while the minimum data were recorded in N_0M_0 (control) i.e., 17.72, 23.38 and 20.55 cm^2 in 2021-22, 2022-23 and pooled mean respectively.

At 30 DAT, maximum leaf area was recorded in N_5: 50 percent nitrogen from Urea & 50 percent of the nitrogen with Poultry Manure i.e., 116.35, 99.30 and 107.83 cm^2 in 2021-22, 2022-23 and pooled data respectively, followed by N_1: 100 % N through Urea i.e., 101.33, 96.47 and 98.90 cm^2 in 2021-22, 2022-23 and pooled mean respectively, while the minimum data were recorded in N_0 (control) 39.04, 29.48 and 34.26 cm^2 in 2021-22, 2022-23 and pooled mean respectively.

Among the mulching, highest leaf area was observed in M_2 (Black polythene mulch) i.e., 117.47, 109.48 and 113.48 cm^2 in 2021-22, 2022-23 and pooled mean respectively, followed by M_1 (Paddy straw mulch) i.e., 71.73, 67.49 and 69.61 cm^2 2021-22, 2022-23 and pooled mean respectively, while the minimum data were recorded in M_0 (control) i.e., 64.83, 44.93 and 54.88 cm^2 in 2021-22, 2022-23 and pooled mean respectively.

Among the combinations, highest leaf area was found in N_5M_2: 50 percent nitrogen from Urea & 50 percent of the nitrogen with Poultry Manure + Black Polythene mulch i.e., 133.09, 122.88 and 127.98 cm^2 in 2021-22, 2022-23 and pooled data respectively, followed by N_1M_2: 100 % N through Urea + black polythene mulch i.e., 112.55, 106.90 and 109.73 cm^2 in 2021-22, 2022-23 and pooled data respectively, while the minimum data were observed in N_0M_0 (control) i.e., 35.73, 31.21 and 33.47 cm^2 in 2021-22, 2022-23 and pooled mean respectively.

At 45 DAT, maximum leaf area was recorded in N_5: 50 % nitrogen with Urea & 50 % nitrogen from Poultry Manure i.e., 257.05, 233.45 and 245.25 cm^2 in 2021-22, 2022-23 and pooled data respectively, followed by N_1: 100 % N through Urea i.e., 237.80, 222.38 and 230.09 cm^2 in 2021-22, 2022-23 and pooled data respectively, while the least data were recorded in N_0 (control) 93.18, 56.84 and 75.01 cm^2 in 2021-22, 2022-23 and pooled mean respectively.

Among the mulching, maximum leaf area in M_2 (black polythene mulch) i.e., 214.16, 203.14 and 208.65 cm^2 in 2021-22, 2022-23 and pooled data respectively, followed by Paddy straw mulch (M_1) i.e., 188.48, 174.87 and 181.80 cm^2 2021-22, 2022-23 and pooled mean respectively, while the minimum leaf area were recorded in N_0 (control) i.e., 172.53, 167.74 and 170.14 cm^2 in 2021-22, 2022-23 and pooled mean respectively.

Among the combinations, the highest leaf area was recorded in N_5M_2: 50 percent nitrogen from Urea & 50 percent of the nitrogen with Poultry Manure + Black polythene mulch was found to have superior leaf area, i.e., 267.72, 194.94 and 231.33 cm^2 2021-22, 2022-23 and pooled mean respectively, followed by N_1M_2: 100 % N through Urea + black polythene mulch i.e., 222.33, 179.01 and 200.67 cm^2 2021-22,

2022-23 and pooled mean respectively, while the minimum data were recorded in N_0M_0 (control) 91.78, 83.52 and 87.65 cm^2 in 2021-22, 2022-23 and pooled mean respectively.

At harvest maximum leaf area was recorded in N_5: 50 % nitrogen with Urea & 50 % nitrogen from Poultry Manure i.e., 310.02, 278.94 and 294.48 cm^2 in 2021-22, 2022-23 and pooled data respectively, followed by N_1: 100 % N through Urea 295.66, 278.49 and 287.08 cm^2 in 2021-22, 2022-23 and pooled mean respectively, while the minimum data were recorded in N_0 (control) i.e., 129.50, 112.74 and 121.12 cm^2 in 2021-22, 2022-23 and pooled mean respectively.

Among the mulching, highest leaf area was observed in black polythene mulch (M_2) i.e., 289.28, 235.09 and 262.18 cm^2 in 2021-22, 2022-23 and pooled data respectively, followed by Paddy straw mulch (M_1) i.e., 237.25, 211.29 and 224.27 cm^2 in 2021-22, 2022-23 and pooled mean respectively, while the minimum data were recorded in M_0 (control) i.e., 227.66, 209.30 and 218.48 cm^2 in 2021-22, 2022-23 and pooled mean respectively.

Among the combinations, highest leaf area was recorded in N_5M_2: 50 % nitrogen with Urea & 50 % nitrogen from Poultry Manure + Black Polythene mulch was observed to have leaf area, i.e., 312.87, 261.97 and 287.42 cm^2 2021-22, 2022-23 and pooled mean respectively, followed by N_1M_2: 100 % N through Urea + black polythene mulch) i.e., 289.00, 276.98 and 282.99 cm^2 2021-22, 2022-23 and pooled mean respectively, while the minimum data were recorded in N_0M_0 (control) i.e., 127.79, 118.52 and 123.15 cm^2 in 2021-22, 2022-23 and pooled mean respectively.

Maximum leaf area was found in N_5 this because of poultry manure, helps to provide better growth, good aeration, water holding capacity by increasing organic matter and practical activity of manures in the soil. This might enhance the favorable environments for the plants root. Similar studies were recorded by Yasmin *et al*. (2021).

Maximum leaf area in M_2 could be due to the positive influence of black polythene mulch, i.e., mitigating the water requirement, enhancing soil porosity and covering the soil's upper layer to avoid unwanted environmental effects (Punetha *et al*., 2020)

Among the treatment combinations, the highest leaf area was reported in N_5M_2 this could be due to the rapid microbial activity in root zone of the soil and black polythene mulch facilitates favorable moisture and no weed competition among the main crop (Faruque *et al*., 2004).

Table 4.9 Response of integrated nitrogen management and mulching practices on leaf area at 15, 30, 45 DAT and at harvesting

Leaf area												
Treatment	**15 DAT**			**30DAT**			**45DAT**			**At harvest**		
	2021-22	**2022-23**	**pool**	**2021-22**	**2022-23**	**pool**	**2021-22**	**2022-23**	**pool**	**2021-22**	**2022-23**	**pool**
Integrated nutrient management (N)												
N_0	18.60	14.36	16.48	39.04	29.48	34.26	93.18	56.84	75.01	129.50	112.74	121.12
N_1	42.18	34.27	38.23	101.33	96.47	98.90	237.80	222.38	230.09	295.66	278.49	287.08
N_2	30.12	23.72	26.92	89.62	64.39	77.00	176.87	134.39	155.63	266.99	254.38	260.69
N_3	33.32	27.38	30.35	85.65	72.47	79.06	212.98	167.48	190.23	256.20	219.49	237.85
N_4	36.61	28.74	32.67	68.50	43.38	55.94	208.11	164.38	186.24	257.34	201.36	229.35
N_5	45.44	38.48	41.96	116.35	99.30	107.83	257.05	233.45	245.25	310.02	278.94	294.48
SE±	1.75	1.63	1.61	1.57	1.63	2.44	3.35	3.63	4.63	3.34	4.53	4.46
CD (P=0.05)	2.1	2.93	2.95	4.89	4.98	4.76	8.65	9.87	10.75	6.87	8.74	7.78
Mulching (M)												
M_0	26.56	20.37	23.46	64.83	44.93	54.88	172.53	167.74	170.14	227.66	209.30	218.48
M_1	32.14	29.02	30.58	71.73	67.49	69.61	188.48	174.87	181.80	237.25	211.29	224.27
M_2	43.60	39.39	41.49	117.47	109.48	113.48	214.16	203.14	208.65	289.28	235.09	262.18
SE±	0.42	0.61	0.52	1.44	1.45	1.37	2.42	3.32	4.44	4.34	3.46	3.41
CD (P=0.05)	2.98	2.92	2.97	3.87	2.88	3.95	7.86	8.76	8.82	6.67	5.87	6.87

DAT-Days after transplanting

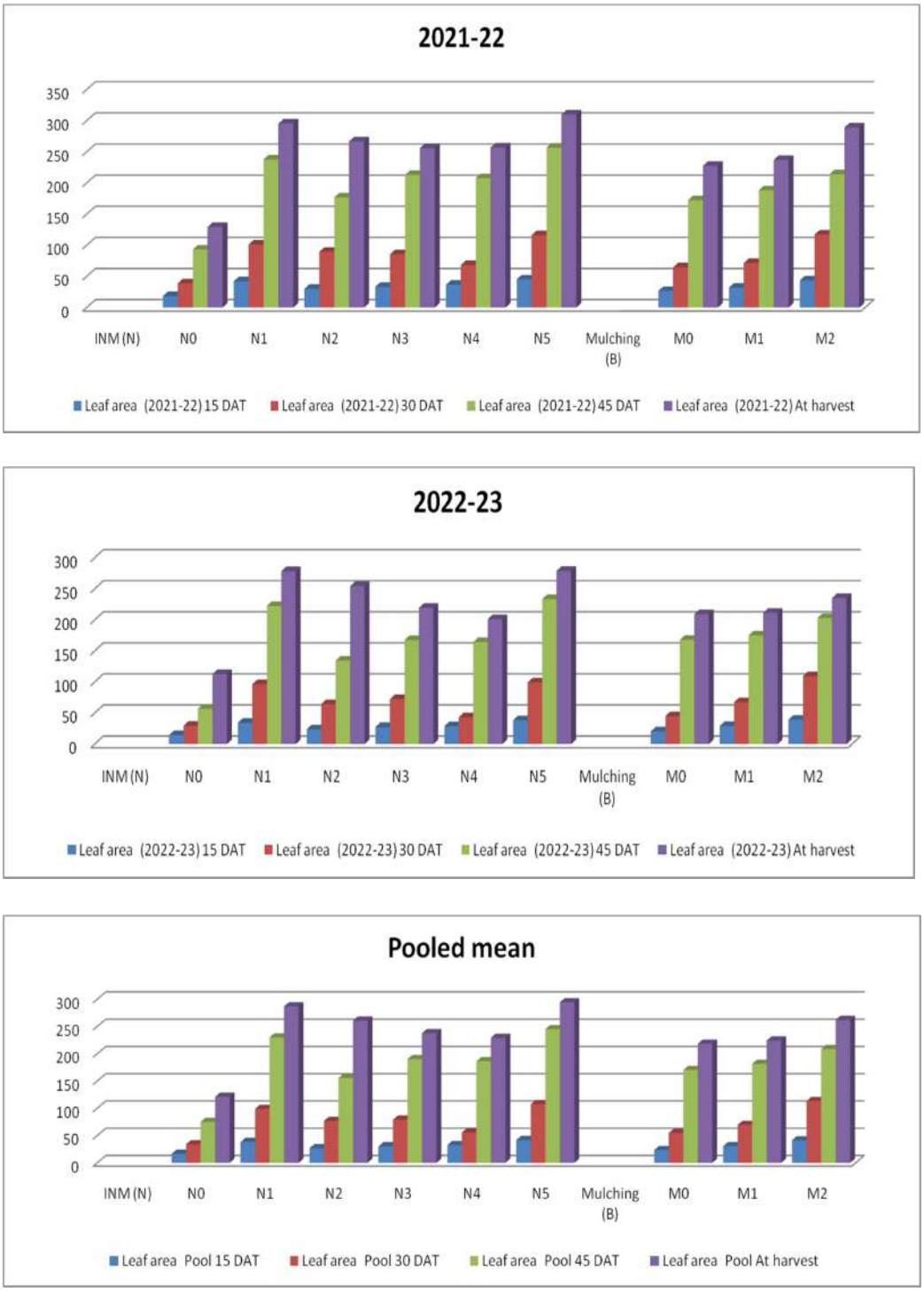
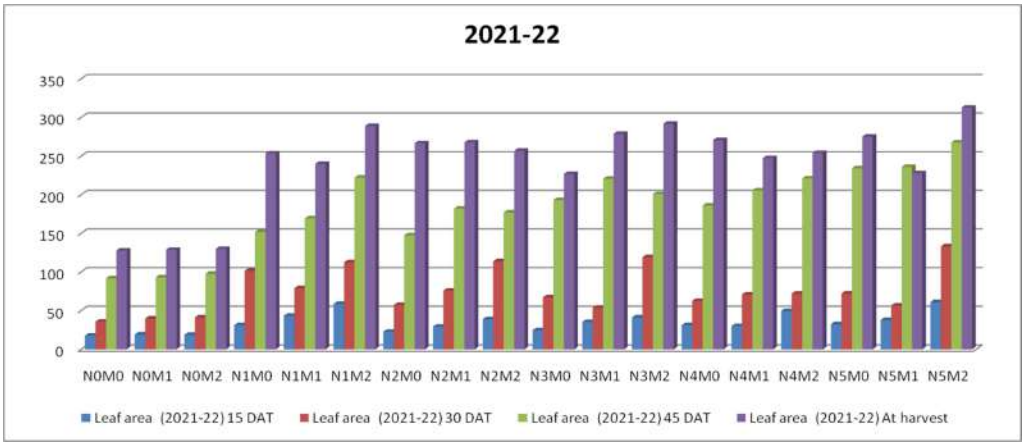


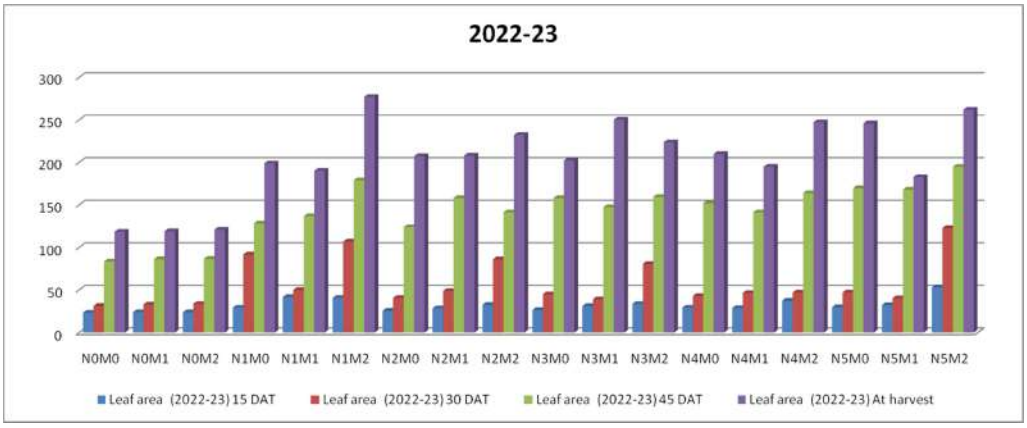
Fig 4.9 Response of integrated nitrogen management and mulching practices on leaf area at 15, 30, 45 DATand at harvesting

Table 4.10 Combined effect of integrated nitrogen management and mulching practices on leaf area at 15, 30, 45 DAT and at harvesting

Treatment	15 DAT			30DAT			45DAT			At harvest		
	2021-22	2022-23	Pooled mean	2021-22	2022-23	Pooled mean	2021-22	2022-23	Pooled mean	2021-22	2022-23	Pooled mean
N_0M_0	17.72	23.38	20.55	35.73	31.21	33.47	91.78	83.52	87.65	127.79	118.52	123.15
N_0M_1	19.19	24.01	21.60	39.87	32.99	36.43	93.09	86.15	89.62	128.78	119.11	123.95
N_0M_2	18.81	23.85	21.33	41.28	33.63	37.45	97.69	86.52	92.10	129.96	120.89	125.42
N_1M_0	31.28	29.26	30.27	101.61	91.76	96.68	151.95	128.29	140.12	253.64	198.97	226.30
N_1M_1	43.52	41.72	42.62	79.15	50.10	64.62	169.52	136.94	153.23	239.97	190.23	215.10
N_1M_2	58.78	40.67	49.72	112.55	106.90	109.73	222.33	179.01	200.67	289.00	276.98	282.99
N_2M_0	22.80	25.57	24.19	57.43	40.65	49.04	147.56	123.89	135.73	266.75	207.42	237.09
N_2M_1	29.45	28.49	28.97	76.06	48.74	62.40	182.17	158.03	170.10	267.89	208.21	238.05
N_2M_2	38.98	32.62	35.80	113.87	85.95	99.91	177.06	141.34	159.20	256.87	232.32	244.59
N_3M_0	24.66	26.40	25.53	67.23	44.91	56.07	193.27	158.00	175.63	226.92	202.45	214.69
N_3M_1	35.30	31.02	33.16	53.73	39.04	46.39	220.72	147.33	184.02	278.88	250.36	264.62
N_3M_2	41.18	33.56	37.37	119.19	80.54	99.87	200.89	159.39	180.14	241.83	223.74	232.79
N_4M_0	31.23	29.26	30.24	62.60	42.90	52.75	186.20	151.90	169.05	270.75	209.95	240.35
N_4M_1	30.05	28.74	29.39	70.88	46.50	58.69	205.70	141.34	173.52	247.45	195.02	221.24
N_4M_2	49.65	37.28	43.47	72.01	46.99	59.50	211.02	163.77	187.40	254.18	247.25	250.72
N_5M_0	32.40	29.74	31.07	72.11	47.04	59.58	214.26	169.59	291.93	275.33	245.89	260.61
N_5M_1	38.05	32.23	35.14	56.62	40.28	48.45	235.99	167.97	201.98	228.06	182.67	205.37
N_5M_2	60.98	53.22	57.10	133.09	122.88	127.98	267.72	194.94	231.33	312.87	261.97	287.42
SE±	1.67	2.86	1.74	2.54	3.62	2.76	5.65	5.88	6.56	6.56	7.56	6.58
CD (P=0.05)	5.12	4.57	5.34	8.56	8.65	7.77	14.89	13.95	13.84	14.54	15.87	17.89

DAT-Days after transplanting





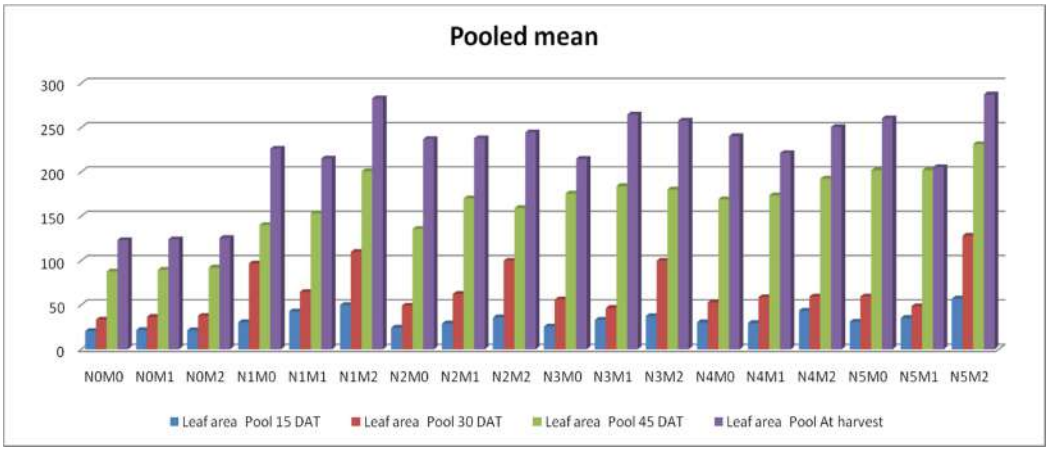


Fig 4.10 Combined effect of integrated nitrogen management and mulching practices on leaf area at 15, 30, 45DAT and at harvesting

4.1.5 Plant spread (cm^2)

Plant spread is a crucial component which enhances growth during crop production. The data regarding the plant spread at various stages of the broccoli plant as responded by integrated nitrogen and mulching management is represented in tables 4.11, 4.12 and figures 4.11, 4.12.

The data confirm that the integration of nitrogen management mulching practices and interaction insignificantly influenced plant spread irrespective of growth stages.

At 15 DAT, the maximum plant spread was observed in N_5: 50 % nitrogen with Urea & 50 % nitrogen from Poultry Manure i.e., 314.34, 248.33 and 281.35 cm^2 in 2021-22, 2022-23 and pooled mean respectively, followed by N_1: 100 % N through Urea i.e., 254.96, 204.42 and 231.18 cm^2 in 2021-22, 2022-23 and pooled mean respectively, while the least plant spread were reported in N_0 (control) i.e., 74.22, 58.64 and 66.42 cm^2 in 2021-22, 2022-23 and pooled mean respectively.

Among the mulching treatment, maximum plant spread in M_2 (black polythene mulch) i.e., 298.92, 236.14 and 267.52 cm^2 in 2021-22, 2022-23 and pooled data respectively, followed by Paddy straw mulch (M_1) i.e., 189.48, 149.69 and 161.58 cm^2 2021-22, 2022-23 and pooled mean, respectively, while the minimum plant spread were recorded in M_0 (control) i.e., 183.11, 144.65 and 153.89 cm^2 in 2021-22, 2022-23 and pooled mean respectively.

Among the combinations, maximum plant spread was recorded in N_5M_2: 50 % nitrogen with Urea & 50 % nitrogen from Poultry Manure + Black Polythene mulch i.e., 380.57 300.65 and 340.60 cm^2 in 2021-22, 2022-23 and pooled mean respectively**,** followed by N_1M_2: 100 % N through Urea + black polythene mulch i.e., 363.73, 287.35 and 325.53 cm^2 2021-22, 2022-23 and pooled mean respectively, while the least plant spread was found in N_0M_0 (control) 77.20, 60.99 and 69.10 cm^2 in 2021-22, 2022-23 and pooled mean respectively.

At 30 DAT, maximum plant spread in N_5: 50 % nitrogen with Urea & 50 % nitrogen from Poultry Manure i.e., 665.70, 525.90 and 595.80 cm^2 in 2021-22, 2022-23 and pooled data respectively, followed by N_1: 100 % N through Urea i.e., 643.98, 514.33

and 593.16 cm^2 in 2021-22, 2022-23 and pooled mean respectively, while the least plant spread was reported in treatment N_0 (control) 334.82, 264.51 and 299.67 cm^2 in 2021-22, 2022-23 and pooled mean respectively.

Among the mulching, maximum plant spread was recorded in M_2 (Black polythene mulch) i.e., 646.39, 510.65 and 578.53 cm^2 in 2021-22, 2022-23 and pooled mean respectively, followed by M_1 (Paddy straw mulch) i.e., 510.02, 400.55 and 473.80 cm^2 2021-22, 2022-23 and pooled mean respectively, while the least plant spread were recorded in M_0 (control) i.e., 509.11, 387.10 and 464.61 cm^2 in 2021-22, 2022-23 and pooled mean respectively.

Among the combinations, highest plant spread was recorded in N_5M_2: 50 % nitrogen with Urea & 50 % nitrogen from Poultry Manure + Black Polythene mulch i.e., 773.40, 610.99 and 692.17 cm^2 in 2021-22, 2022-23 and pooled data respectively, followed by N_1M_2: 100 % N through Urea + Black polythene mulch i.e., 750.17, 592.63 and 671.43 cm^2 in 2021-22, 2022-23 and pooled data respectively, while the least plant spread were recorded in N_0M_0 (control) i.e., 310.63, 245.40, 278.03 cm^2 in 2021-22, 2022-23 and pooled mean respectively.

At 45 DAT, maximum plant spread was recorded in N_5: 50 % nitrogen with Urea & 50 % nitrogen from Poultry Manure i.e., 1365.97, 1079.11 and 1222.54 cm^2 in 2021-22, 2022-23 and pooled data respectively, followed by N_1: 100 % N through Urea i.e., 1323.24, 1067.54 and 1220.91 cm^2 in 2021-22, 2022-23 and pooled data respectively, while the lowest plant spread was found in N_0 (control) i.e., 1035.09, 817.72 and 926.41 cm^2 in 2021-22, 2022-23 and pooled mean respectively.

Among the mulching, maximum plant spread was recorded in M_2 (Black polythene mulch) i.e., 1346.66, 1327.81 and 1205.27 cm^2 in 2021-22, 2022-23 and pooled data respectively, followed by Paddy straw mulch M_1: i.e., 1207.29, 1190.38 and 1080.53 cm^2 2021-22, 2022-23 and pooled mean respectively, while the minimum plant spread were recorded in N_0 (control) i.e., 1189.38, 1102.31 and 1011.35 cm^2 in 2021-22, 2022-23 and pooled mean respectively.

Among the combinations, maximum plant spread recorded in N_5M_2: 50 % nitrogen with Urea & 50 % nitrogen from Poultry Manure + black polythene mulch i.e.,

1473.67, 1164.20 and 1318.93 cm^2 2021-22, 2022-23 and pooled mean respectively, followed by N_1M_2: 100 % N through urea + black polythene mulch i.e., 1450.43, 1145.84 and 1298.17 cm^2 2021-22, 2022-23 and pooled mean respectively, while the minimum plant spread were recorded in N_0M_0 (control) i.e., 1010.90, 798.61 and 904.77 cm^2 in 2021-22, 2022-23 and pooled mean respectively.

At harvest maximum plant spread was recorded in N_5: 50 % nitrogen with Urea & 50 % nitrogen from Poultry Manure) i.e., 1778.14, 1414.73 and 1591.43 cm^2 in 2021-22, 2022-23 and pooled data respectively, followed by N_1: 100 % N through Urea i.e., 1773.54, 1404.26 and 1586.91 cm^2 in 2021-22, 2022-23 and pooled mean respectively, while the least plant spread was recorded in N_0 (control) 1447.28, 1143.35 and 1295.32 cm^2 in 2021-22, 2022-23 and pooled mean respectively.

Among the mulching treatment, maximum plant spread was recorded in M_2 (black polythene mulch) i.e., 1758.95, 1389.57 and 1574.27 cm^2 in 2021-22, 2022-23 and pooled data respectively, followed by Paddy straw mulch (M_1) i.e., 1619.53, 1279.43 and 1449.48 cm^2 2021-22, 2022-23 and pooled mean respectively, while the minimum plant spread were recorded in M_0 (control) 1601.62, 1218.98 and 1410.32 cm^2 in 2021-22, 2022-23 and pooled mean respectively.

Among the combinations, maximum plant spread was recorded in N_5M_2: 50 % nitrogen with Urea & 50 % nitrogen from Poultry Manure + Black Polythene mulch i.e., 1885.60, 1489.62 and 1687.60 cm^2 in 2021-22, 2022-23 and pooled mean respectively, followed by N_1M_2 100 % N through Urea + Black polythene mulch i.e., 1862.73, 1471.56 and 1667.17 cm^2 2021-22, 2022-23 and pooled mean respectively, whereas least plant spread was recorded in N_0M_0 (control) i.e., 1422.87, 1124.07 and 1273.50 cm^2 in 2021-22, 2022-23 and pooled mean respectively.

The highest plant spread recorded was recorded in N_5 could be due to using fertilizers and organic manures helps in nutrient retention, soil porosity and soil amendments, resulting in enhanced soil physical texture and mitigate soil bulk density, which gives better plant growth. Similar findings were observed by Dalal *et al,* (2010).

Maximum plant spread was found in M_2 could be due to the black polythene mulch regulating temperature and reducing soil erosion, by which plants quickly take

essential elements for performing their metabolic functions, which helps to increase the size of the foliar part of the plant (Bhandari *et al*., 2021).

Among the interaction maximum plant spread in N_5M_2 could be due to the nutrient less competition between weeds and the main crop by mulching application and organic manure enriching the soil, which helps to provide essential nutrients by which plants synthesize food, which directly increases the area of the plant.

Table 4.11 Response of integrated nitrogen management and mulching practices on plant spread (cm^2) at 15, 30, 45 DAT and at harvesting.

Plant spread (cm^2)												
Treatment	15DAT			30DAT			45DAT			At harvest		
	2021-22	2022-23	Pooled mean	2021-22	2022-23	Pooled mean	2021-22	2022-23	Pooled mean	2021-22	2022-23	Pooled mean
Integrated Nitrogen Management (N)												
N_0	74.22	58.64	66.42	334.82	264.51	299.67	1035.09	817.72	926.41	1447.28	1143.35	1295.32
N_1	254.96	204.42	231.18	643.98	514.33	593.16	1323.24	1067.54	1220.91	1773.54	1404.26	1586.91
N_2	194.35	153.53	173.92	550.85	435.17	493.02	1251.12	988.38	1119.74	1663.52	1314.19	1488.88
N_3	247.73	195.71	221.73	513.66	405.79	459.76	1213.92	959.00	1086.47	1626.22	1284.72	1455.48
N_4	257.40	203.35	230.38	615.05	485.89	550.47	1315.31	1039.10	1177.21	1727.50	1364.73	1546.11
N_5	314.34	248.33	281.35	665.70	525.90	595.80	1365.97	1079.11	1222.54	1778.14	1414.73	1591.43
SE±	3.61	3.74	3.62	4.73	4.86	4.99	4.98	4.03	4.12	5.02	6.02	6.24
CD (P=0.05)	10.42	9.37	9.39	8.92	10.48	11.46	9.38	9.98	10.33	14.49	13.85	13.45
Mulching (M)												
M_0	183.11	144.65	153.89	509.11	387.10	464.61	1189.38	1102.31	1011.35	1601.62	1218.98	1410.32
M_1	189.48	149.69	161.58	510.02	400.55	473.80	1207.29	1190.38	1080.53	1619.53	1279.43	1449.48
M_2	298.92	236.14	267.52	646.39	510.65	578.53	1346.66	1327.81	1205.27	1758.95	1389.57	1574.27
SE±	2.55	2.85	2.63	3.84	3.22	3.98	3.84	3.22	3.46	3.55	3.55	4.32
CD (P=0.05)	7.37	7.83	7.43	8.47	8.34	7.42	7.98	8.05	8.02	10.24	10.41	11.04

DAT days after harvesting

Fig 4.11 Response of integrated nitrogen management and mulching practices on plant spread (cm^2) at 15,30, 45 DAT and at harvesting.

Table 4.12 Combined effect of Integrated nitrogen management and mulching practices on plant spread (cm^2) at 15, 30, 45 DAT and at harvesting

Treatment	15 DAT			30 DAT			45 DAT			At harvest		
	2021-22	2022-23	Pooled mean	2021-22	2022-23	Pooled mean	2021-22	2022-23	Pooled mean	2021-22	2022-23	Pooled mean
N_0M_0	77.20	60.99	69.10	310.63	245.40	278.03	1010.90	798.61	904.77	1422.87	1124.07	1273.50
N_0M_1	78.33	61.88	70.10	339.17	267.94	303.57	1039.43	821.15	930.30	1451.73	1146.87	1299.30
N_0M_2	87.13	73.04	80.08	354.67	280.19	317.40	1054.93	833.40	944.17	1467.23	1159.11	1313.17
N_1M_0	163.80	129.40	146.60	649.37	513.00	581.17	1349.63	1066.21	1207.93	1761.93	1391.93	1576.97
N_1M_1	237.33	187.49	212.40	595.40	470.37	532.87	1295.67	1023.58	1159.63	1707.97	1349.29	1528.60
N_1M_2	363.73	287.35	325.53	750.17	592.63	671.43	1450.43	1145.84	1298.17	1862.73	1471.56	1667.17
N_2M_0	124.23	98.14	111.20	502.88	397.28	450.07	1203.15	950.49	1076.80	1615.77	1276.47	1446.13
N_2M_1	151.73	119.87	135.77	569.33	449.77	509.60	1269.60	1002.98	1136.30	1681.90	1328.70	1505.33
N_2M_2	307.07	242.58	274.80	580.33	458.46	519.40	1280.60	1011.67	1146.13	1692.90	1337.39	1515.17
N_3M_0	163.00	128.77	145.90	401.63	317.29	359.47	1101.90	870.50	986.20	1513.87	1195.96	1354.90
N_3M_1	202.33	159.84	181.10	449.67	355.24	402.50	1149.93	908.45	1029.20	1562.23	1234.16	1398.20
N_3M_2	377.87	298.52	338.20	689.67	544.84	617.30	1389.93	1098.05	1244.00	1802.57	1424.03	1613.33
N_4M_0	277.87	219.52	248.70	560.40	442.72	501.57	1260.67	995.93	1128.30	1672.97	1321.64	1497.30
N_4M_1	197.20	155.79	176.50	554.63	438.16	496.37	1254.90	991.37	1123.13	1666.87	1316.83	1491.83
N_4M_2	297.13	234.74	265.93	730.10	576.78	653.47	1430.37	1129.99	1280.20	1842.67	1455.71	1649.20
N_5M_0	292.53	231.10	261.83	689.77	544.92	617.37	1390.03	1098.13	1244.10	1802.33	1423.84	1613.10
N_5M_1	269.93	213.25	241.60	533.93	421.81	477.87	1234.20	975.02	1104.60	1646.50	1300.74	1473.60
N_5M_2	380.57	300.65	340.60	773.40	610.99	692.17	1473.67	1164.20	1318.93	1885.60	1489.62	1687.60
SE±	6.25	6.93	6.38	7.49	7.11	7.39	7.22	6.98	7.76	8.69	8.29	8.59
CD (P=0.05)	18.05	17.93	16.84	16.82	17.03	16.48	16.39	16.37	16.48	25.09	22.84	23.81

DAT-Days after transplanting

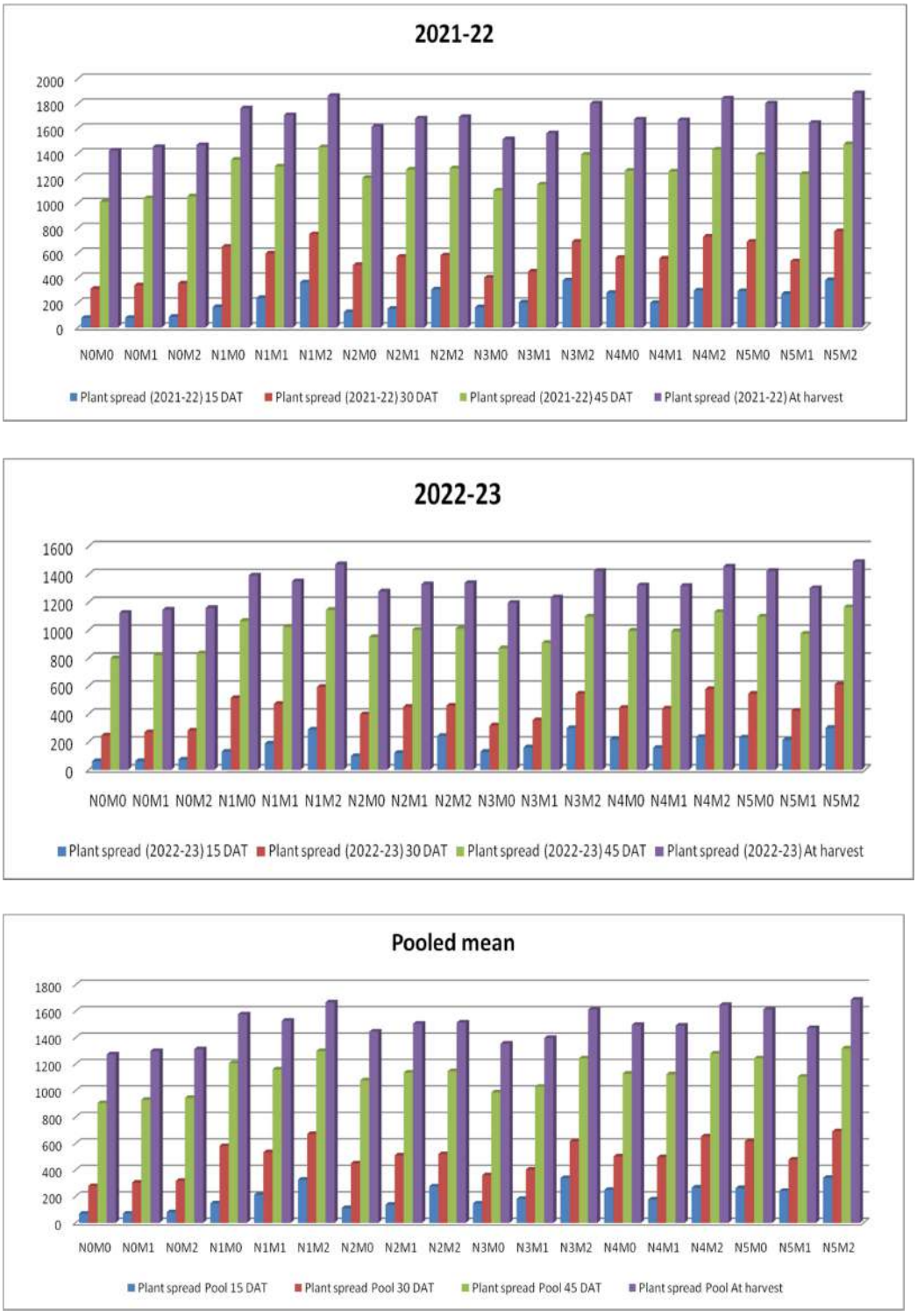


Fig 4.12 Combined effect of integrated nitrogen management and mulching practices on plant spread (cm^2) at 15, 30,45 DAT and at harvesting.

4.1.6 Girth of stem (cm)

Girth of stem is a crucial component which enhances growth during crop production. The data regarding the girth of stem at various stages of the broccoli plant as affected by integrated nitrogen and mulching management is represented in tables 4.13, 4.14 and figures 4.13, 4.14.

The data confirm that the integration of nitrogen management mulching practices and interaction insignificantly influenced girth of stem irrespective of growth stages.

At 15 DAT, the maximum girth of stem was found in N_5: 50 % nitrogen with Urea & 50 % nitrogen from Poultry Manure i.e., 0.48, 0.41 and 0.46 cm in 2021-22, 2022-23 and pooled mean respectively, followed by N_1: 100 % N through Urea i.e., 0.43, 0.34 and 0.42 cm in 2021-22, 2022-23 and pooled mean respectively and least girth of stem was recorded in N_0 (control) i.e., 0.24, 0.11 and 0.17 cm in 2021-22, 2022-23 and pooled mean respectively.

Among the mulching, maximum girth of stem was recorded in M_2 (Black polythene mulch) i.e., 0.43, 0.35 and 0.39 cm in 2021-22, 2022-23 and pooled data respectively, followed by Paddy straw mulch (M_1) i.e., 0.40, 0.31 and 0.34 cm 2021-22, 2022-23 and pooled mean, respectively and the least girth of stem was recorded in N_0M_0 (control) i.e., 0.36, 0.29 and 0.33 cm in 2021-22, 2022-23 and pooled mean respectively.

Among the treatment combinations, maximum girth of stem was recorded in N_5M_2: 50 % nitrogen with Urea & 50 % nitrogen from Poultry Manure + Black polythene mulch i.e., 0.68. 0.53 and 0.59 cm in 2021-22, 2022-23 and pooled mean respectively, followed by N_1M_2: 100 % N through Urea + Black polythene mulch i.e., 0.62, 0.48 and 0.51 cm 2021-22, 2022-23 and pooled mean respectively and the least girth of stem was found in N_0M_0 (control) i.e., 0.12, 0.10 and 0.11 cm in 2021-22, 2022-23 and pooled mean respectively.

At 30 DAT, maximum girth of stem was recorded in N_5: 50 % nitrogen with Urea & 50 % nitrogen from Poultry Manure i.e., 0.85, 0.67 and 0.77 cm in 2021-22, 2022-23 and pooled data respectively, followed by N_1: 100 % N through Urea i.e., 0.74, 0.59

and 0.67 cm in 2021-22, 2022-23 and pooled mean respectively, while the minimum girth of stem was recorded in N_0 (Control) i.e., 0.49, 0.39 and 0.46 cm in 2021-22, 2022-23 and pooled mean respectively.

Among the mulching treatment, maximum girth of stem was recorded in M_2 (Black polythene mulch) i.e., 0.78, 0.62 and 0.70 cm in 2021-22, 2022-23 and pooled mean respectively, followed by M_1 (Paddy straw mulch) i.e., 0.67, 0.53 and 0.60 cm 2021-22, 2022-23 and pooled mean respectively, while the least girth of stem was observed in M_0 (Control) i.e., 0.63, 0.50 and 0.58 cm in 2021-22, 2022-23 and pooled mean respectively.

Among the treatment combinations, maximum girth of stem was recorded in N_5M_2: 50 % nitrogen with Urea & 50 % nitrogen from Poultry Manure + Black polythene mulch i.e., 0.99, 0.74 and 0.87 cm in 2021-22, 2022-23 and pooled data respectively, followed by N_1M_2: 100 % N through Urea + Black polythene mulch 0.79, 0.55 and 0.67 cm in 2021-22, 2022-23 and pooled data respectively, while the least girth of stem was recorded in N_0M_0 (control) i.e., 0.47, 0.37 and 0.42 cm in 2021-22, 2022-23 and pooled mean respectively.

At 45 DAT, maximum girth of stem was recorded in N_5: 50 % nitrogen with Urea & 50 % nitrogen from Poultry Manure i.e., 1.34, 1.28 and 1.30 cm in 2021-22, 2022-23 and pooled data respectively, followed by N_1: 100 % N through Urea i.e., 1.27, 1.01 and 1.13 cm in 2021-22, 2022-23 and pooled data respectively, while the least girth of stem was found in N_0 (control) i.e., 0.81, 0.65 and 0.74 cm in 2021-22, 2022-23 and pooled mean respectively.

Among the mulching treatment, maximum girth of stem in M_2 (Black polythene mulch) i.e., 1.49, 1.18 and 1.33 cm in 2021-22, 2022-23 and pooled data respectively, followed by M_1 (Paddy straw mulch) i.e., 1.00, 0.80 and 0.91 cm 2021-22, 2022-23 and pooled mean, respectively, while the least girth of stem was recorded in M_0 (control) 1.03, 0.82 and 0.92 cm in 2021-22, 2022-23 and pooled mean respectively.

Among the combinations, maximum girth of stem was recorded in N_5M_2: 50 % nitrogen with Urea & 50 % nitrogen from Poultry Manure + Black polythene mulch i.e., 1.97, 1.65 and 1.81 cm 2021-22, 2022-23 and pooled mean respectively, followed

by N_1M_2: 100 % N through Urea + Black polythene mulch i.e., 1.79, 1.50 and 1.65 cm 2021-22, 2022-23 and pooled mean respectively, while the least girth of stem was observed in N_0M_0 (Control) i.e., 0.70, 0.55 and 0.63 cm in 2021-22, 2022-23 and pooled mean respectively.

At harvest, maximum girth of stem was recorded in N_5: 50 % nitrogen with Urea & 50 % nitrogen from Poultry Manure i.e., 2.42, 1.89 and 2.12 cm in 2021-22, 2022-23 and pooled data respectively, followed by N_1 : 100 % N through Urea i.e., 2.06, 1.79 and 1.82 cm in 2021-22, 2022-23 and pooled mean respectively, whereas the least girth of stem was recorded in N_0 (control) i.e., 1.40, 1.11 and 1.26 cm in 2021-22, 2022-23 and pooled mean respectively.

Among the mulching treatment, maximum girth of stem was recorded in M_2 (Black polythene mulch) i.e., 2.43, 1.92 and 2.20 cm in 2021-22, 2022-23 and pooled data respectively, followed by Paddy straw mulch (M_1) i.e., 1.95, 1.55 and 1.75 cm 2021-22, 2022-23 and pooled mean, respectively, while the least girth of stem was observed in M_0 (control) 1.88, 1.49 and 1.68 cm in 2021-22, 2022-23 and pooled mean respectively.

Among the treatment combinations, maximum girth of stem was recorded in N_5M_2: 50 % nitrogen with Urea & 50 % nitrogen from Poultry Manure + Black polythene mulch i.e., 2.65, 2.10 and 2.38 cm 2021-22, 2022-23 and pooled mean respectively, followed by N_1M_2: 100 % N through Urea + Black polythene mulch i.e., 2.42, 1.89 and 2.16 cm 2021-22, 2022-23 and pooled mean respectively, while the minimum girth of stem were recorded in N_0M_0 (control) 1.43, 1.13 and 1.28 cm in 2021-22, 2022-23 and pooled mean respectively.

The highest girth of the stem found in N_5 might be due to the production of compounds that encourage plant growth, which is another aspect influencing the improvement in growth characteristics, in addition to poultry manure along with urea having the capacity to fix soil microbes' activity which help in partially attributed to the creation of phytohormones from tryptophan, ethylene and vitamins, including gibberellins, cytokines-like compounds and auxins. These phytohormones promote the development of the roots of the plants, expanding the area available for the plants

to absorb water and nutrients and enhancing growth, which ultimately increases the girth of the stem.

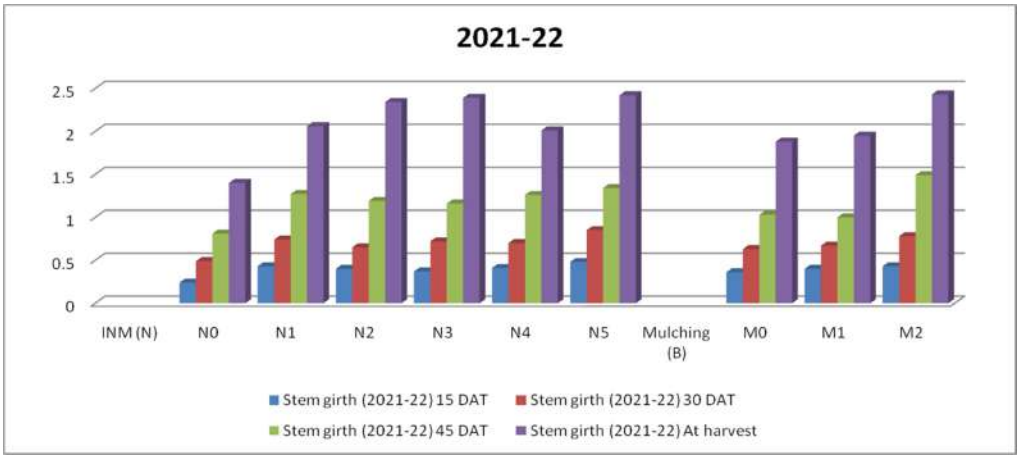
Among the mulch treatments, M_2 was found to be significant; this might be due to the Black polythene mulch's profound influence on plant growth, such as leaf index (LAI) and crop growth rate (CGR), which is responsible for the accumulation of more food synthesis by nutrient uptake from the soil resulted in high stem girth occur. Similar findings were found by Bhandari (2021).

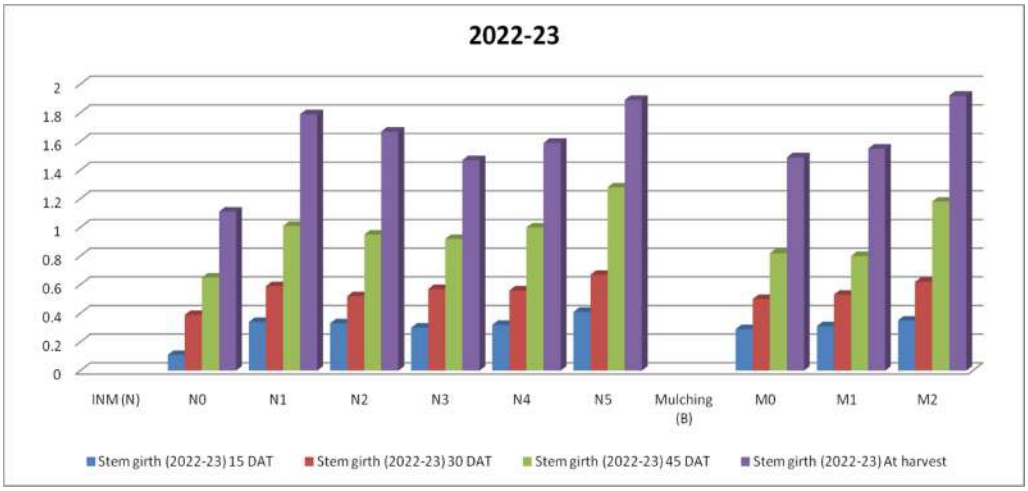
An interaction effect was found significant in N_5M_2 might be due to the integrated effect between mulching and organic manure, which increases the activities of soil organisms to enhance the organic manure in the soil. Mulch helps maintain the optimum temperature in winter and provides a favorable environment for the plant root zone to uptake nutrients, resulting in maximum stem girth.

4.13 Response of integrated nitrogen management and mulching practices on girth of stem (cm) at 15, 30, 45 DAT and at harvesting.

Treatment	Stem girth (cm)											
	15 DAT			30 DAT			45 DAT			At harvest		
	2021-22	2022-23	Pooled mean	2021-22	2022-23	Pooled mean	2021-22	2022-23	Pooled mean	2021-22	2022-23	Pooled mean
integrated nitrogen management (N)												
N_0	0.24	0.11	0.17	0.49	0.39	0.46	0.81	0.65	0.74	1.40	1.11	1.26
N_1	0.43	0.34	0.42	0.74	0.59	0.67	1.27	1.01	1.13	2.06	1.79	1.82
N_2	0.40	0.33	0.41	0.65	0.52	0.60	1.19	0.95	1.07	2.34	1.67	2.05
N_3	0.37	0.30	0.33	0.72	0.57	0.66	1.16	0.92	1.03	2.39	1.47	1.93
N_4	0.41	0.32	0.38	0.70	0.56	0.64	1.26	1.00	1.12	2.01	1.59	1.83
N_5	0.48	0.41	0.46	0.85	0.67	0.77	1.34	1.28	1.30	2.42	1.89	2.12
SE±	0.01	0.03	0.02	0.02	0.03	0.04	0.02	0.02	0.01	0.02	0.03	0.02
CD (P=0.05)	0.02	0.04	0.03	0.06	0.07	0.06	0.05	0.06	0.04	0.05	0.06	0.06
Mulching (M)												
M_0	0.36	0.29	0.33	0.63	0.50	0.58	1.03	0.82	0.92	1.88	1.49	1.68
M_1	0.40	0.31	0.34	0.67	0.53	0.60	1.00	0.80	0.91	1.95	1.55	1.75
M_2	0.43	0.35	0.39	0.78	0.62	0.70	1.49	1.18	1.33	2.43	1.92	2.20
SE±	0.01	0.02	0.02	0.03	0.03	0.04	0.02	0.03	0.30	0.03	0.04	0.01
CD (P=0.05)	0.02	0.03	0.04	0.08	0.07	0.09	0.06	0.07	0.80	0.08	0.09	0.04

DAT-Days after transplanting





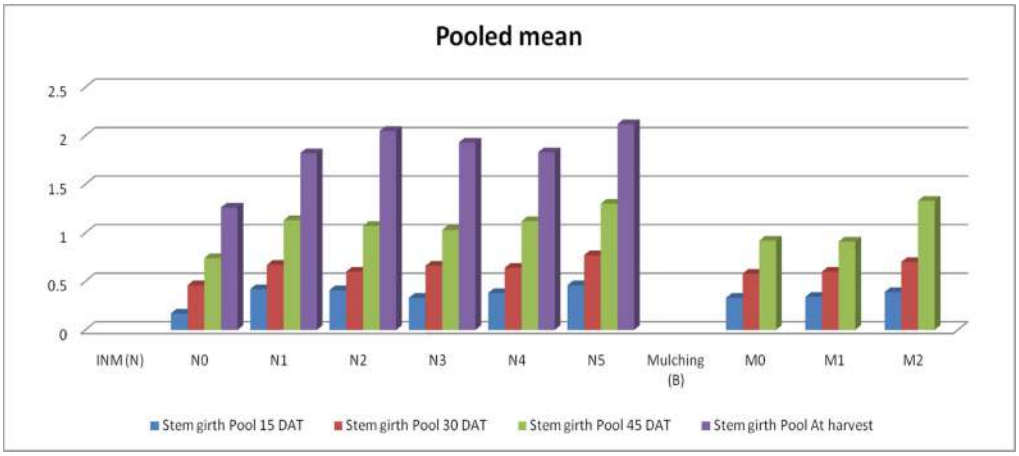


Fig 4.13 Response of integrated nitrogen management and mulching practices on girth of stem at 15, 30, 45DAT and at harvesting.

Table 4.14 Combined effect of integrated nitrogen management and mulching practices on girth of stem at 15, 30, 45 DAT and at harvesting.

Treatment	15DAT			30DAT			45DAT			At harvest		
	2021-22	2022-23	Pooled mean	2021-22	2022-23	Pooled mean	2021-22	2022-23	Pooled mean	2021-22	2022-23	Pooled mean
N_0M_0	0.12	0.11	0.10	0.47	0.37	0.42	0.70	0.55	0.63	1.43	1.13	1.28
N_0M_1	0.14	0.13	0.12	0.58	0.46	0.52	0.88	0.70	0.79	1.63	1.65	1.64
N_0M_2	0.15	0.12	0.13	0.44	0.46	0.45	0.86	0.69	0.77	1.53	1.19	1.36
N_1M_0	0.43	0.34	0.40	0.64	0.51	0.58	1.16	0.92	1.04	1.92	1.52	1.72
N_1M_1	0.55	0.44	0.50	0.66	0.53	0.59	0.89	0.71	0.80	1.60	1.27	1.44
N_1M_2	0.62	0.48	0.51	0.79	0.55	0.67	1.79	1.50	1.65	2.42	1.89	2.16
N_2M_0	0.50	0.40	0.47	0.60	0.42	0.51	1.00	0.79	0.90	1.90	1.50	1.70
N_2M_1	0.43	0.34	0.40	0.63	0.50	0.57	1.10	0.87	0.99	2.13	1.69	1.91
N_2M_2	0.43	0.36	0.43	0.73	0.51	0.62	1.48	1.17	1.33	2.11	1.67	2.19
N_3M_0	0.33	0.26	0.30	0.64	0.47	0.56	1.10	0.87	0.99	1.79	1.42	1.61
N_3M_1	0.45	0.36	0.40	0.66	0.43	0.55	0.90	0.71	0.81	2.24	1.78	2.01
N_3M_2	0.35	0.28	0.30	0.76	0.34	0.55	1.50	1.19	1.34	2.06	1.71	1.89
N_4M_0	0.40	0.32	0.37	0.63	0.50	0.57	1.04	0.83	0.93	1.74	1.38	1.56
N_4M_1	0.41	0.35	0.37	0.66	0.54	0.60	1.30	1.03	1.16	2.17	1.72	1.95
N_4M_2	0.45	0.34	0.40	0.78	0.53	0.66	1.43	1.13	1.28	2.13	1.69	1.91
N_5M_0	0.40	0.32	0.37	0.49	0.42	0.45	1.16	0.92	1.04	2.14	1.19	1.67
N_5M_1	0.44	0.35	0.40	0.73	0.48	0.61	0.96	0.76	0.86	2.26	1.79	2.03
N_5M_2	0.68	0.53	0.59	0.99	0.74	0.87	1.97	1.65	1.81	2.65	2.10	2.38
SE±	0.03	0.02	0.03	0.05	0.06	0.07	0.05	0.04	0.03	0.05	0.05	0.05
CD (P=0.05)	0.05	0.04	0.06	0.14	0.17	0.18	0.11	0.10	0.10	0.13	0.14	0.14

DAT-Days after transplanting

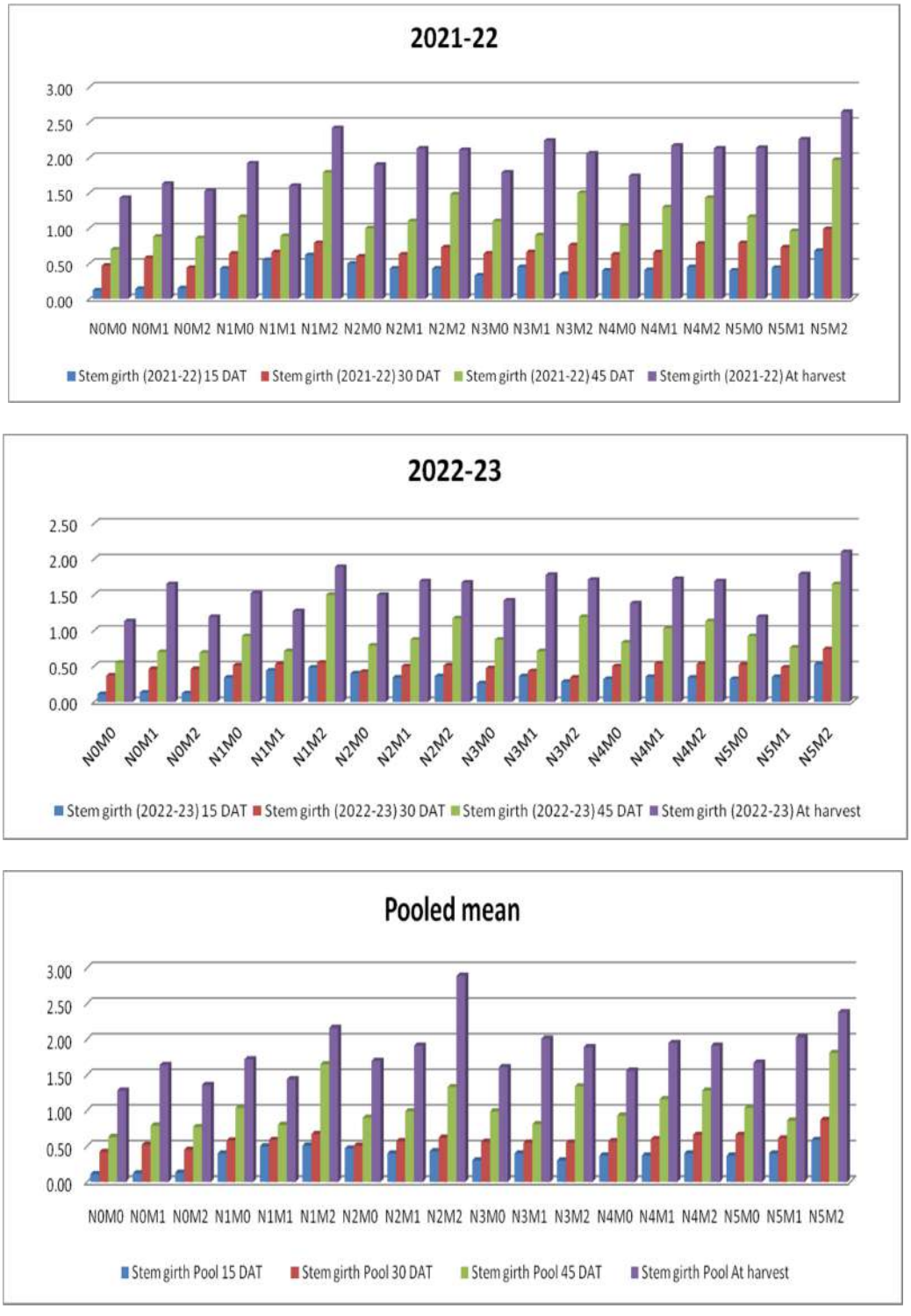


Fig: 4.14 Combined effect of integrated nitrogen management and mulching practices on girth of stem at 15, 30, 45 DAT and at harvesting.

4.1.7 Days required for head initiation (days)

Days to head initiation is an important factor which enhances early growth early during crop production. The data regarding the days to head initiation of the broccoli plant as influenced by integrated nitrogen and mulching management is represented in tables 4.15, 4.16 and figures 4.15, 4.16.

The data confirm that the integration of nitrogen management significantly influenced days to head initiation the earliest head initiation occur in the treatment N_5: 50 % nitrogen with Urea & 50 % nitrogen from Poultry Manure i.e., 42.71, 32.60 and 37.66 days in 2021-22, 2022-23 and pooled mean respectively, followed by N_2: 50 percent nitrogen through Urea & 50 percent nitrogen from Cow dung i.e., 43.90, 34.31 and 39.10 days in 2021-22, 2022-23 and pooled mean days respectively, while the maximum days to head initiation were found in N_0 (control) 53.88, 44.50 and 49.19 days in 2021-22, 2022-23 and pooled mean respectively.

It was found that, mulching treatment had no significant difference in the days to head initiation.

Among the treatment combinations, minimum days to head initiation were recorded in N_5M_2: 50 percent nitrogen from urea & 50 percent of the nitrogen with poultry Manure + Black polythene mulch i.e., 41.06, 32.34 and 36.97 days respectively in 2021-22, 2022-23 respectively and pooled mean found non significant, followed by N_2M_1: 50 % N through Urea + 50 % N through Cowdung + Black polythene mulch i.e., 41.33, 33.10 and 37.21 days respectively 2021-22, 2022-23 and pooled mean was recorded non significant, while the maximum days to head initiation were found in N_0M_0 (control) i.e., 53.53, 45.03 and 49.28 days respectively in 2021-22, 2022-23 and pooled mean found non significant.

The minimum days required to head initiations in N_5, this might be due to the might be due to the quick response of organic and inorganic fertilizer, which allows the plant to proliferate; nitrogen is an essential element for the plant, which enhances the plant's vegetative growth; rapid plant growth also initiates the broccoli head earlier (Changkija *et al*., 2017).

Among the mulches, M_2 was found significant; this could be due to the Black polythene mulch maintaining the root temperature on winter days, which helps the formation of the head early. Kaur *et al*., 2021 also noticed mulching on sprouting broccoli's growth, yield and quality.

An interaction effect was found significant in N_5M_2. This might be due to the mulch helping to make all essential nutrients available from well-decomposed soil, leading to minimum days to head formation.

Table 4.15 Response of integrated nitrogen management and mulching practices on days required to head initiation

Treatment	Days to head initiation		
	2021-22	2022-23	Pooled mean
INTEGRATED NITROGEN MANAGEMENT(N)			
N_0	53.88	44.50	49.19
N_1	45.71	35.46	40.59
N_2	43.90	34.31	39.10
N_3	44.54	34.80	39.67
N_4	45.67	35.19	40.43
N_5	42.71	32.60	37.66
SE±	0.25	0.78	0.97
CD (P=0.05)	0.73	1.09	1.06
Mulching (M)			
M_0	48.48	39.85	44.90
M_1	45.78	37.42	42.41
M_2	44.79	35.83	40.31
SE±	0.17	0.97	0.06
CD (P=0.05)	NS	NS	NS

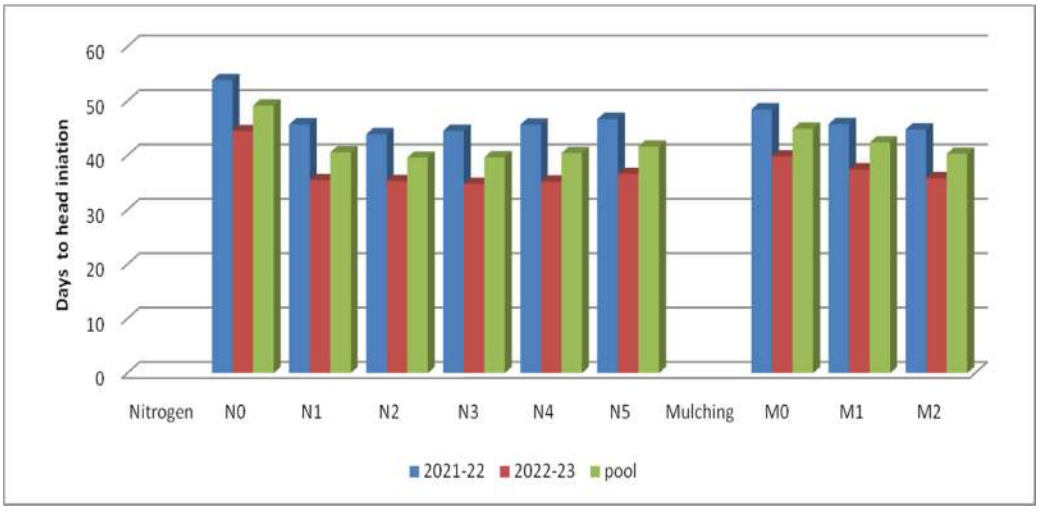


Fig 4.15 Response of integrated nitrogen management and mulching practices on days required for headinitiation

Table 4.16 Combined effect of integrated nitrogen management and mulching practices on days required for headinitiation

Treatment	Days to head initiation		
	2021-22	2022-23	Pooled mean
N_0M_0	53.53	45.03	49.28
N_0M_1	51.63	45.10	48.37
N_0M_2	52.47	43.45	47.96
N_1M_0	47.97	37.13	42.55
N_1M_1	46.00	36.34	41.17
N_1M_2	48.38	37.50	42.94
N_2M_0	47.73	36.92	42.33
N_2M_1	41.33	33.10	37.21
N_2M_2	42.63	35.55	39.09
N_3M_0	45.77	33.97	39.87
N_3M_1	41.80	34.60	38.20
N_3M_2	46.07	35.81	40.94
N_4M_0	46.00	36.34	41.17
N_4M_1	48.17	37.92	43.05
N_4M_2	42.53	33.60	38.07
N_5M_0	45.77	36.60	41.19
N_5M_1	45.43	35.55	40.49
N_5M_2	41.06	32.34	36.97
SE±	0.31	0.43	1.65
CD (P=0.05)	0.91	1.26	NS

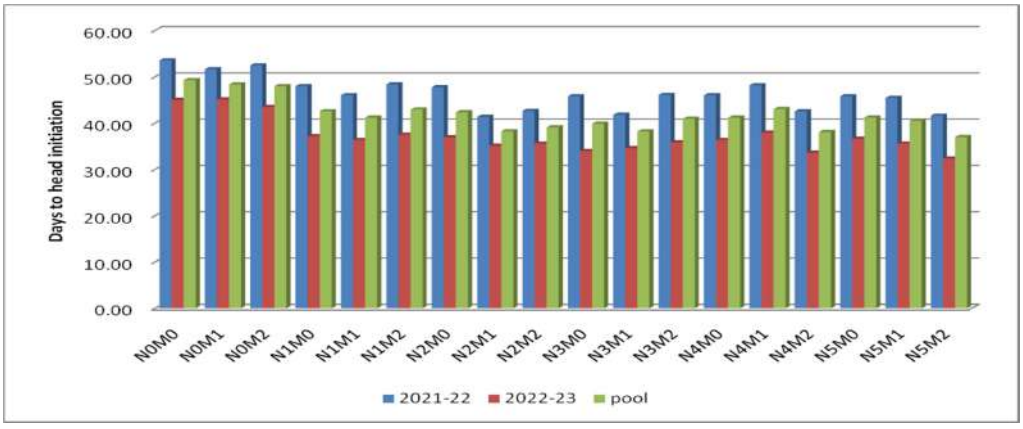


Fig 4.16 Combined effects of integrated nitrogen management and mulching practices on days required forhead initiation

4.1.8 Response of integrated nitrogen management and mulching practices on days require to 50 % head initiation

Days to 50 percent initiation of head is an important factor which enhances growth early during crop production. The data regarding the days to 50 % head initiation of the broccoli plant as affected by integrated nitrogen and mulching management is represented in tables 4.17, 4.18 and figures 4.17, 4.18.

The data confirm that the integration of nitrogen management significantly influenced days require to initiation of the head and least days to 50 percent head initiation of the head was recorded in N_5: 50 % nitrogen with Urea & 50 % nitrogen from Poultry Manure i.e., 43.98, 32.13 and 38.05 days in 2021-22, 2022-23 and pooled mean respectively, followed by N_2: 50 percent nitrogen through Urea + 50 percent nitrogen through Cow dung i.e., 43.33, 38.67 and 44.00 days in 2021-22, 2022-23 and pooled mean respectively, while the highest days to 50 % head initiation were recorded in N_0 (control) 61.48, 48.57 and 55.02 days in 2021-22, 2022-23 and pooled mean respectively.

Among the mulching treatment, minimum days to 50 % head initiation was recorded in M_2 (Black polythene mulch) i.e., 50.66, 39.68 and 45.17 days in 2021-22, 2022-23 and pooled data respectively, followed by Paddy straw mulch (M_1) i.e., 53.56, 42.44 and 46.34 days 2021-22, 2022-23 and pooled mean respectively, while the highest days to 50 % head initiation were recorded in M_0 (control) 54.47, 43.89 and 47.76 days in 2021-22, 2022-23 and pooled mean respectively.

Among the treatment combinations, earliest days to 50 % head initiation was recorded in N_5M_2: 50 percent nitrogen with Poultry manure + 50 percent nitrogen through Urea + Black polythene mulch i.e., 49, 38.70 and 43.87 days 2021-22, 2022-23 and pooled mean respectively**,** followed by N_4M_2: 50 percent nitrogen from urea & 50 percent of the nitrogen with FYM + Black polythene mulch i.e., 50.07, 39.57 and 44.80 days in 2021-22, 2022-23 and pooled mean respectively, while the highest days to 50 % head initiation were found in N_0M_0 (control) 61.33, 48.98 and 55.50 days in 2021-22, 2022-23 and pooled mean respectively.

The least days for 50 % head initiation was found in N_5 might be due to the rapid reaction of urea and organic manure by improving aeration, water holding capacity and fertilizer use efficiency. The beneficial effect of poultry manure on vegetable production has also been reported by Mohanta *et al*. (2018).

The least days required for 50 % head initiation were found in M_2. This could be due to Black polythene mulch works increased the head growth early by suppressing weed growth and providing aeration and water-holding capacity to plants (Kaur *et al.*, 2021)

An interaction effect was found significant in N_5M_2 could be due to the efficient availability of micro and macronutrients, high moisture retention and regulation of favorable temperature, which helped grow plants well.

4.17. Response of integrated nitrogen management and mulching practices on days require for 50 % headinitiation

Treatment	Days to 50 % head initiation		
	2021-22	2022-23	Pooled mean
integrated nitrogen management (N)			
N_0	61.48	48.57	55.02
N_1	52.54	41.02	46.78
N_2	49.33	38.67	44.00
N_3	51.42	40.88	46.15
N_4	50.61	39.86	45.24
N_5	43.98	32.13	38.05
SE±	0.13	0.23	0.18
CD (P=0.05)	0.37	0.66	NS
Mulching (M)			
M_0	54.47	43.89	47.76
M_1	53.56	42.44	46.34
M_2	50.66	39.68	45.17
SE±	0.18	0.32	0.25
CD (P=0.05)	0.52	0.93	0.73

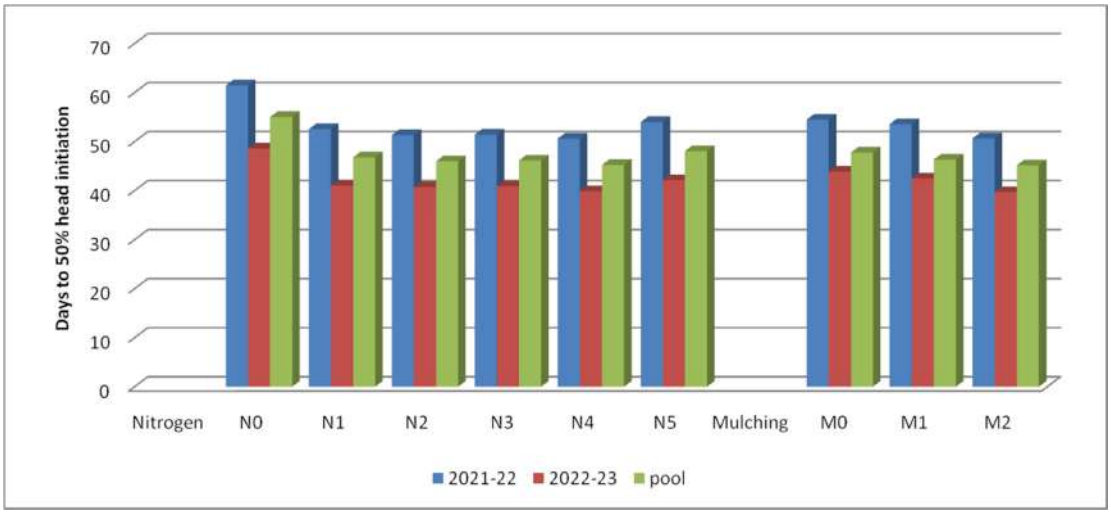


Fig 4.17 Response of integrated nitrogen management and mulching practices on days require to 50 % headinitiation

Table 4.18 Combined effect of integrated nitrogen management and mulching practices on days require for 50 %head initiation

Treatment	Days to 50 % head initiation		
	2021-22	2022-23	Pooled mean
N_0M_0	61.33	48.98	55.50
N_0M_1	61.90	49.16	55.70
N_0M_2	61.20	47.56	53.87
N_1M_0	50.57	39.93	45.20
N_1M_1	52.33	41.35	46.83
N_1M_2	53.03	41.89	47.43
N_2M_0	50.77	40.09	45.40
N_2M_1	50.67	40.37	45.73
N_2M_2	52.57	41.55	47.03
N_3M_0	50.67	40.04	45.33
N_3M_1	51.82	41.45	46.97
N_3M_2	51.80	41.16	46.60
N_4M_0	54.13	41.34	46.80
N_4M_1	52.77	41.31	46.77
N_4M_2	50.07	39.57	44.80
N_5M_0	52.16	41.33	47.97
N_5M_1	51.90	40.99	46.40
N_5M_2	49.00	38.70	43.87
SE±	0.31	0.56	0.44
CD (P=0.05)	0.89	1.62	1.27

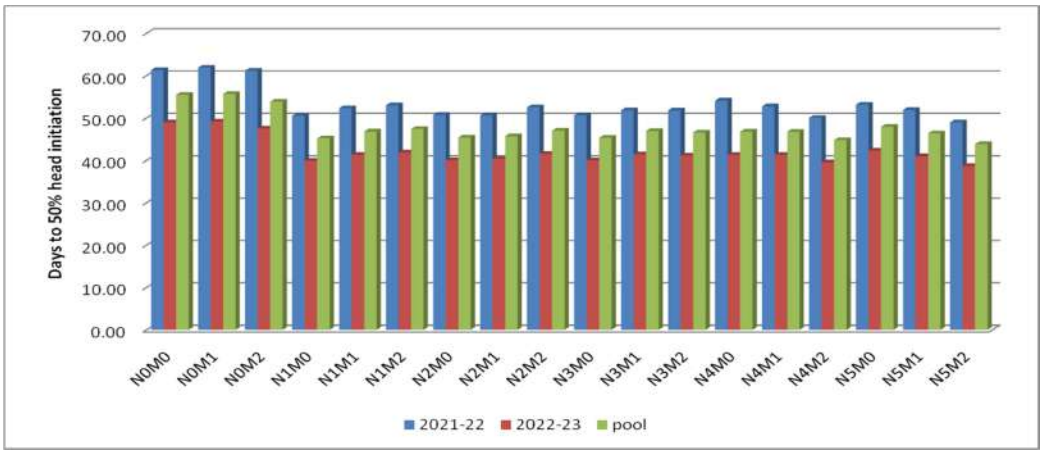


Fig 4.18 Combined effect of integrated nitrogen management and mulching practices on days require to 50 %head initiation

4.1.9 Response of integrated nitrogen management and mulching practices on days for first harvesting

Days required for 1st harvesting (days) is an important factor which enhances growth early during crop production. The data regarding the days required for 1st harvesting of the broccoli plant as influenced by integrated nitrogen and mulching management is represented in tables 4.19, 4.20 and figures 4.19, 4.20.

The data confirm that the integration of nitrogen management significantly influenced days to head initiation; minimum days required for 1st harvesting in N_5: 50 % nitrogen with Urea & 50 % nitrogen from Poultry Manure i.e., 64.04, 49.83 and 56.93 days in 2021-22, 2022-23 and pooled mean respectively, followed by N_2: 50 percent nitrogen through Urea + 50 percent N through Cow dung i.e., 65.99, 51.99 and 58.99 days in 2021-22, 2022-23 and pooled mean respectively, while the maximum days required for 1st harvesting were recorded in N_0 (control) i.e., 69.23, 65.09 and 67.16 days in 2021-22, 2022-23 and pooled mean respectively.

Among the mulching treatment, minimum days required for 1st harvesting was recorded in M_2 (Black polythene mulch) i.e., 65.96, 51.80 and 58.83 days in 2021-22, 2022-23 and pooled data respectively, followed by Paddy straw mulch (M_1) i.e., 66.75, 52.19 and 59.17 days 2021-22, 2022-23 and pooled mean respectively, while the maximum days required for 1st harvesting were recorded in M_0 (control) i.e., 67.35, 53.30 and 60.28 days in 2021-22, 2022-23 and pooled mean respectively.

The interaction between integrated nitrogen and mulching was significant for days required for 1st harvesting in N_5M_2: 50 % nitrogen with Urea & 50 % nitrogen from Poultry Manure + Black polythene mulch i.e., 62.17, 48.26 and 51.17 days in 2021-22, 2022-23 and pooled mean respectively**,** followed by N_2M_1: 50 % N through Urea + 50% N through cow dung + black polythene mulch i.e., 63.17,49.93 and 56.57 days in 2021-22, 2022-23 and pooled mean respectively, while the maximum days required for 1st harvesting were recorded in N_0M_0 (control) i.e., 70.67, 56.06 and 63.53 days in 2021-22, 2022-23 and pooled mean respectively.

The highest plant spread recorded in N_5 could be due to the fact that using fertilizers and organic manures helps in nutrient retention, soil porosity and amendments of the

soil, resulting in enhanced soil properties, which gives better plant growth. Similar findings were observed by Mohanta *et al*. (2018).

Maximum plant spread was found in M_2. This could be due to the black polythene mulch regulating temperature and reducing soil erosion, by which plants quickly take essential elements for performing their metabolic functions, which helps to increase the size of the foliar part of the plant (Bhandari *et al*., 2021).

The combine impact was recorded highest in N_5M_2 could be due to the nutrient uptake between main crop and weeds the by mulching application and organic manure enriching the soil, which helps to provide essential nutrients by which plants synthesize food, which directly increases the area of the plant.

Table 4.19 Response of integrated nitrogen management and mulching practices on days required for 1st harvesting.

Days required for 1st harvesting.			
Treatment	**2021-22**	**2022-23**	**Pooled mean**
INTEGRATED NITROGEN MANAGEMENT (N)			
N_0	69.23	65.09	67.16
N_1	68.41	57.48	62.94
N_2	65.99	51.99	58.99
N_3	68.32	54.19	61.25
N_4	67.40	53.25	60.32
N_5	64.04	49.83	56.93
SE±	0.38	0.43	0.53
CD (P=0.05)	0.78	0.76	0.89
Mulching (M)			
M_0	67.35	53.30	60.28
M_1	66.75	52.19	59.17
M_2	65.96	51.80	58.83
SE±	0.19	0.23	0.30
CD (P=0.05)	0.54	0.67	0.86

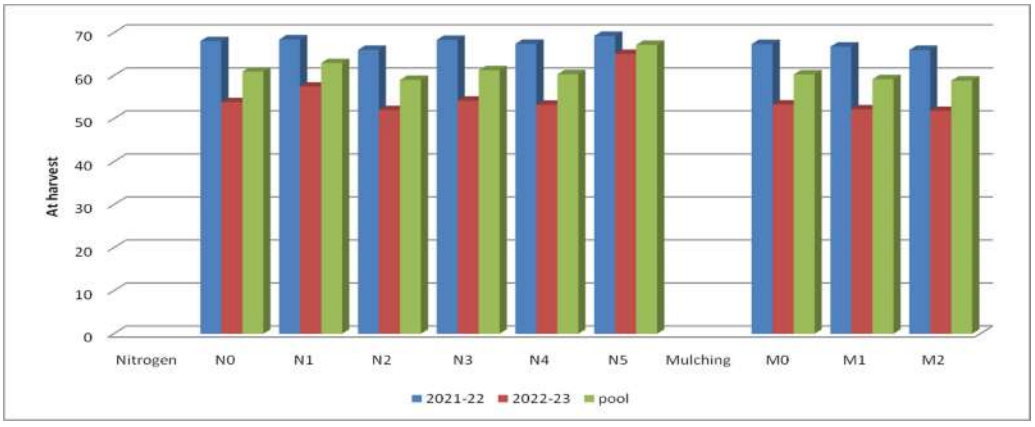


Fig 4.19 Response of integrated nitrogen management and mulching practices on days required for 1st harvesting of broccoli

Table 4.20 Combined effect of integrated nitrogen management and mulching practices on days required for1st harvesting

Days required for 1st harvesting			
Treatment	**2021-22**	**2022-23**	**Pooled mean**
N_0M_0	70.67	56.06	63.53
N_0M_1	68.67	54.25	61.50
N_0M_2	64.80	51.19	59.00
N_1M_0	60.13	57.13	58.63
N_1M_1	63.87	50.97	57.77
N_1M_2	68.70	52.17	60.43
N_2M_0	67.70	53.03	60.10
N_2M_1	63.17	49.93	56.57
N_2M_2	67.10	53.03	60.10
N_3M_0	69.47	54.85	61.17
N_3M_1	69.17	54.65	61.93
N_3M_2	67.18	53.06	60.13
N_4M_0	68.07	53.77	60.93
N_4M_1	66.97	52.91	59.97
N_4M_2	67.19	53.07	60.13
N_5M_0	65.73	51.95	58.87
N_5M_1	64.67	54.24	61.47
N_5M_2	62.17	48.26	51.17
SE±	0.32	0.41	0.52
CD (P=0.05)	0.93	1.17	1.49

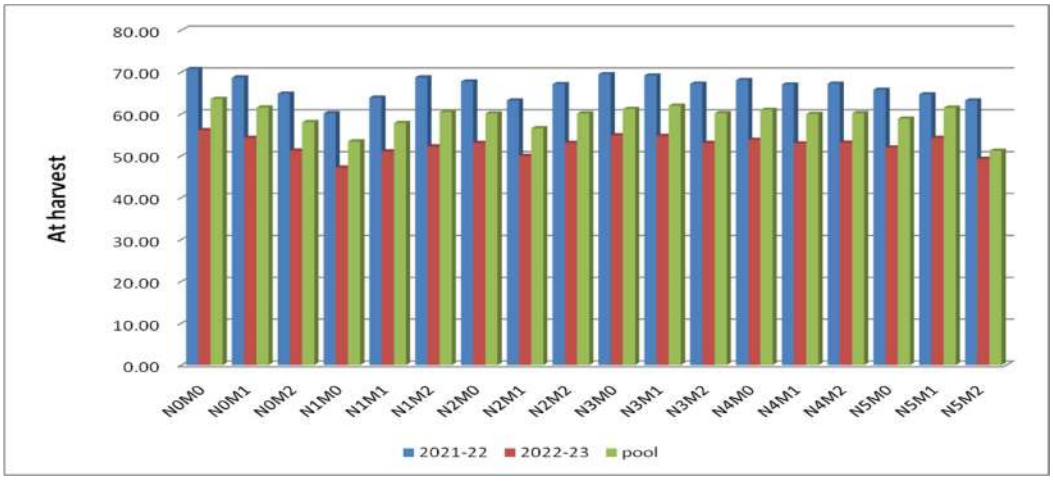


Fig 4.20 Combined effect of integrated nitrogen management and mulching practices on days required for1st harvesting

4.1.10 Response of integrated nitrogen management and mulching practices on harvesting duration

The data related to harvesting duration by broccoli plant as influenced by integrated nitrogen and mulching management is represented in tables 4.21, 4.22 and figures 4.21, 4.22.

The data confirmed that the harvesting duration in integration of nitrogen management significantly influenced was maximum in N_5: 50 percent nitrogen from urea & 50 percent of the nitrogen with poultry Manure i.e., 13.22, 14.67 and 13.94 in 2021-22, 2022-23 and pooled mean and second highest recorded in N_1: 100 % N through Urea i.e., 11.44, 12.76 and 12.10 in 2021-22, 2022-23 and pooled mean respectively and the least values were observed in N_0: (Control) i.e., 9.72, 8.78 and 9.25 in 2021-22, 2022-23 and pooled mean respectively.

Among the mulching, maximum harvesting duration in M_1 (Paddy straw mulch) i.e., 11.25, 13.21 and 12.23 in 2021-22, 2022-23 and pooled data respectively, followed by M_2 (Black polythene mulch) i.e., 10.84, 11.56 and 11.20 in 2021-22, 2022-23 and pooled mean respectively, while the least harvesting duration observed in M_0 (control) i.e. 10.09, 11.12 and 10.60 in 2021-22, 2022-23 and pooled mean days respectively.

The combine effect of nitrogen and mulching found significant for harvesting duration was recorded in N_5M_2: 50 % nitrogen with Urea & 50 % nitrogen from Poultry Manure + Black polythene mulch i.e., 14.66, 15.85 and 15.25 in 2021-22, 2022-23 and pooled mean respectively**,** followed by N_5M_1: 50 % nitrogen with Urea & 50 % nitrogen from Poultry Manure + Black polythene mulch i.e., 13.33, 13.78 and 13.55 in 2021-22, 2022-23 and pooled mean respectively, while the least harvesting days observed in N_0M_0 (control) i.e., 7.16, 7.99 and 7.57 in 2021-22, 2022-23 and pooled mean respectively.

The maximum harvesting duration was found in N_5. This could be due to the high organic percentage in the soil and the high nutrient uptake by the root, which helps the growth of the head of broccoli. (Choudhary *et al*., 2012)

The maximum harvesting duration was found in M_1 this might be due to the fact that the paddy straw the mulch acting as an insulation to regulate the optimum temperature

in hot and cool temperatures resulting enhances the overall growth of the plant (Mohanta *et al*., 2018).

The maximum harvesting duration was found in the treatment combination by application of urea, poultry manure with paddy straw mulch. This might be due to the growth of the plant performing well in mulch treatment; mulch helps to continue growth and suppress the weed and nutrient competition from the other non-crop plants.

Table 4.21 Response of integrated nitrogen management and mulching practices on harvesting duration

Treatment	2021-22	2022-23	Pooled mean
Integrated Nitrogen Management (N)			
N_0	9.72	8.78	9.25
N_1	11.44	12.76	12.10
N_2	9.91	8.94	8.92
N_3	9.74	9.10	9.42
N_4	10.64	11.23	10.93
N_5	13.22	14.67	13.94
SE±	0.23	0.21	0.22
CD (P=0.05)	0.67	0.78	0.72
Mulching (M)			
M_0	10.09	11.12	10.60
M_1	11.25	13.21	12.23
M_2	10.84	11.56	11.20
SE±	0.32	0.43	0.375
CD (P=0.05)	0.94	0.89	0.915

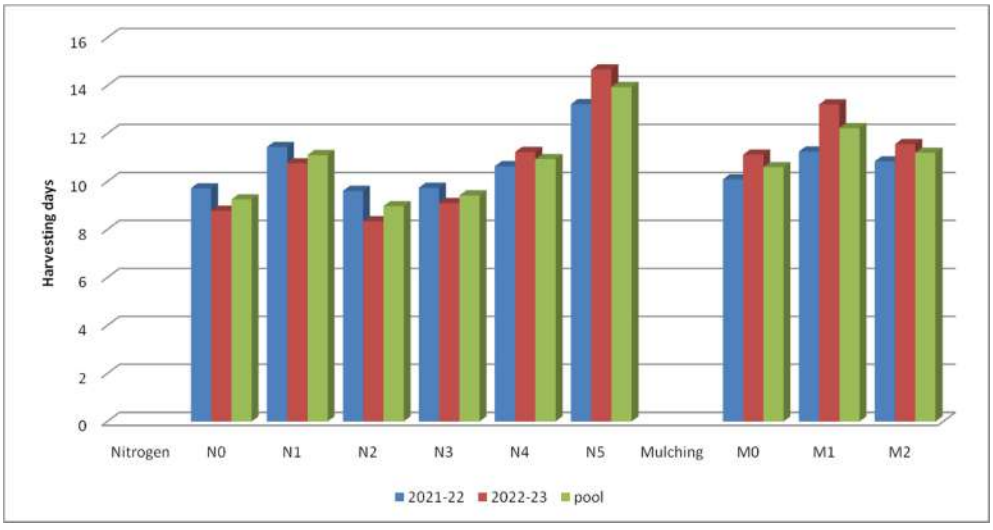


Fig 4.21 Response of integrated nitrogen management and mulching practices on harvesting duration ofbroccoli

Table 4.22 Combined effect of integrated nitrogen management and mulching practices on harvesting duration

Interaction harvesting days			
Treatment	**2021-22**	**2022-23**	**Pooled mean**
N_0M_0	7.16	7.99	7.57
N_0M_1	11.33	11.21	11.27
N_0M_2	8.66	9.01	8.85
N_1M_0	11.5	10.89	11.19
N_1M_1	10.66	10.21	10.43
N_1M_2	12.16	12.09	12.12
N_2M_0	10.00	9.99	9.99
N_2M_1	9.88	9.21	9.54
N_2M_2	9.96	9.75	9.85
N_3M_0	9.28	9.32	9.3
N_3M_1	11.00	12.01	11.50
N_3M_2	8.96	8.56	8.76
N_4M_0	8.93	8.57	8.75
N_4M_1	11.33	12.05	11.69
N_4M_2	11.66	11.78	11.72
N_5M_0	11.66	11.74	11.7
N_5M_1	13.33	13.78	13.55
N_5M_2	14.66	15.85	15.25
SE±	0.57	0.41	0.49
CD (P=0.05)	1.64	1.17	1.405

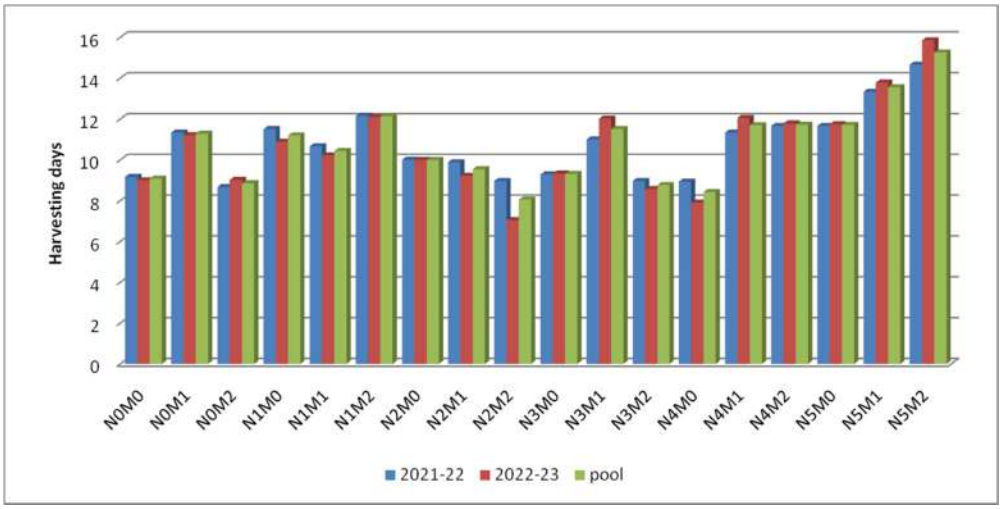


Fig 4.22 Combined effect of integrated nitrogen management and mulching practices on harvesting durationof broccoli

4.2 Effect of integrated nitrogen and mulching and their interaction on yield and yield attribute:

4.2.1 Diameter of head (cm)

The data related to head diameter by broccoli plant as influenced by integrated nitrogen and mulching management is represented in tables 4.23, 4.24 and figures 4.23, 4.24.

The data confirmed that the diameter of head in integration of nitrogen management significantly influenced maximum was recorded in N_5: 50 percent nitrogen from urea & 50 percent of the nitrogen with poultry Manure i.e., 13.13, 14.67 and 13.9 cm in 2021-22, 2022-23 and pooled mean and second highest found in N_4: 50 % N through Urea + 50 % N through vermicompost i.e., 12.78, 12.87 and 12.82 cm in 2021-22, 2022-23 and pooled mean respectively than other treatments of integrated nitrogen management and lowest observed in N_0 (control) i.e., 9.05, 8.89 and 8.97 cm in 2021-22, 2022-23 and pooled mean respectively.

Among the mulching treatment, highest maximum head diameter was recorded in M_2 (Black polythene mulch) i.e., 12.49, 13.67 and 13.08 cm in 2021-22, 2022-23 and pooled data respectively, followed by Paddy straw mulch (M_1) i.e., 12.28, 13.21 and 12.75 cm in 2021-22, 2022-23 and pooled mean, respectively but recorded lowest in M_0 (control) i.e., without mulch i.e., 11.40, 11.12 and 11.26 cm in 2021-22, 2022-23 and pooled mean respectively.

The interaction between integrated nitrogen and mulching was significantly observed for head diameter in treatment combinations N_5M_2: 50 % nitrogen with Urea & 50 % nitrogen from Poultry Manure + Black polythene mulch i.e., 16.35, 17.42 and 16.88 cm 2021-22, 2022-23 and pooled mean respectively, followed by N_1M_2: 100 % N through Urea + Black polythene mulch i.e., 15.8, 15.67 and 15.73 cm 2021-22, 2022-23 and pooled mean respectively and lowest in N_0M_0 (control) i.e., 8.05, 7.89 and 7.97 cm 2021-22, 2022-23 and pooled mean respectively.

The maximum head diameter was found in N_5. This could be due to the half dose of urea and poultry manure containing protein in the form of amino acid, which provides

favorable micro and macro flora of the soil, resulting in the accumulation of amino acid and another nutrient compound by which growth of the broccoli head enhanced (Choudhary *et al*., 2012)

The maximum head diameter in M_2 helps to absorb heat from the sunlight and maintain the temperature of the root zone, which also helps to survive beneficial microorganisms in the soil. This practice makes essential nutrients available to the plant root more prominent, with a good-quality head obtained (Islam *et al*., 2014).

The interaction impact of urea, Black polythene mulch and poultry manure with the highest head diameter. This might be due to the heavy feeder nitrogenous fertilizer, which works as cell division and elongation, ultimately increasing the head diameter; mulch acts as a temperature regulator with water holding capacity, which also helps increase the head diameter.

Table 4.23 Response of integrated nitrogen management and mulching practices on diameter of head (cm)

Treatment	2021-22	2022-23	Pooled mean
integrated nitrogen management (N)			
N_0	9.05	8.89	8.97
N_1	11.8	10.32	11.06
N_2	11.46	11.23	11.34
N_3	12.05	11.99	12.02
N_4	12.78	12.87	12.82
N_5	13.13	14.67	13.9
SE±	0.05	0.09	0.07
CD (P=0.05)	0.14	0.21	0.17
Mulching (M)			
M_0	11.40	11.12	11.26
M_1	12.28	13.21	12.75
M_2	12.49	13.67	13.08
SE±	0.07	0.03	0.05
CD (P=0.05)	0.2	0.23	0.21

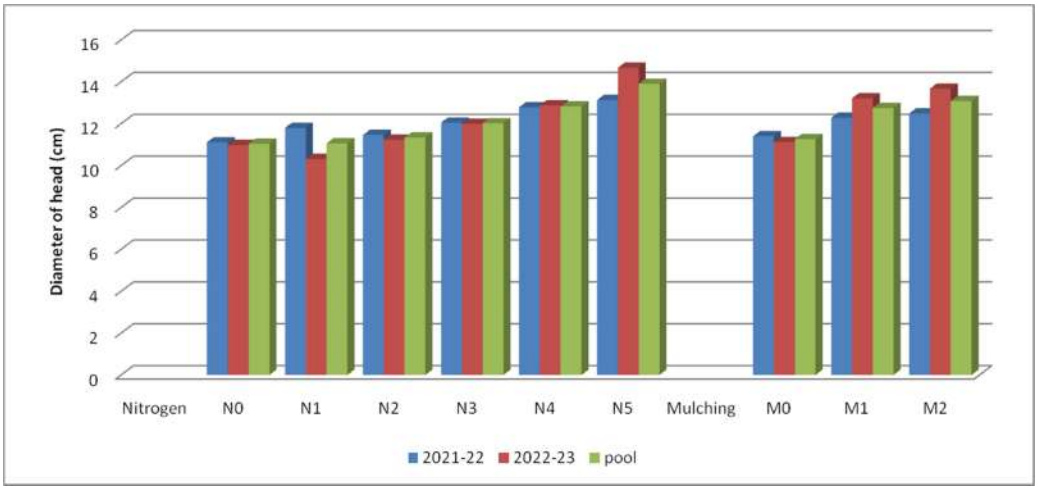


Fig 4.23 Response of integrated nitrogen management and mulching practices on diameter of head (cm) ofbroccoli

Table 4.24 Combined effect of integrated nitrogen management and mulching practices on diameter of head (cm)

Head diameter (cm)			
Treatment	**2021-22**	**2022-23**	**Pooled mean**
N_0M_0	8.05	7.89	7.97
N_0M_1	10.7	10.31	10.50
N_0M_2	10.9	11.09	10.99
N_1M_0	11.75	11.23	11.49
N_1M_1	11.55	10.98	11.26
N_1M_2	15.8	15.67	15.73
N_2M_0	13.5	14.56	14.03
N_2M_1	11.7	10.87	11.28
N_2M_2	9.02	9.45	9.325
N_3M_0	12.15	13.14	12.64
N_3M_1	13.25	13.89	13.57
N_3M_2	10.75	11.01	10.88
N_4M_0	12.55	13.26	12.90
N_4M_1	13.85	14.54	14.19
N_4M_2	11.95	12.01	11.98
N_5M_0	10.41	10.21	10.31
N_5M_1	12.65	13.01	12.83
N_5M_2	16.35	17.42	16.88
SE±	0.12	0.17	0.14
CD (P=0.05)	0.35	0.41	0.38

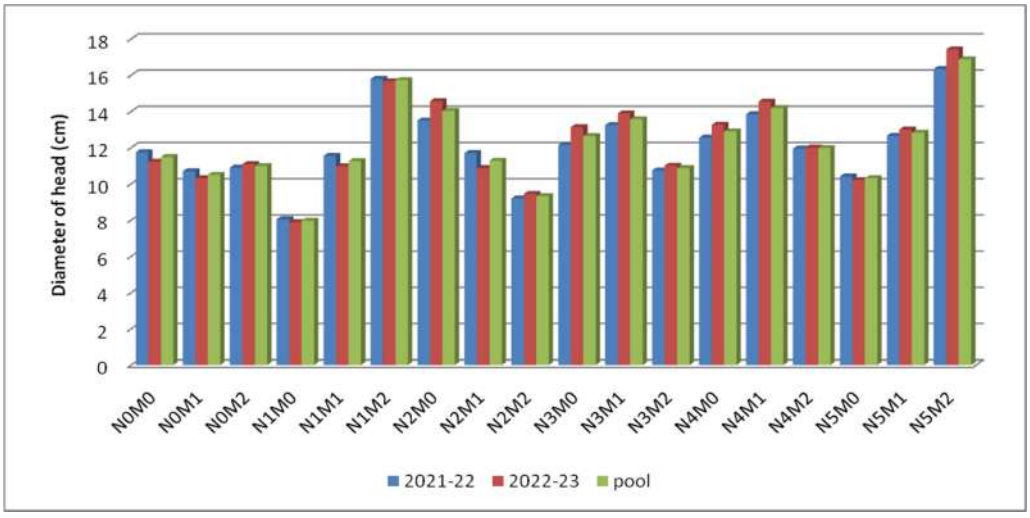


Fig 4.24 Combined effect of integrated nitrogen management and mulching practices on diameter of head(cm) of broccoli

4.2.2 Head weight (g)

The data related to head weight by broccoli plant affected by integrated nitrogen and mulching management is depicted in tables 4.25, 4.26 and figures 4.25, 4.26.

The data confirmed that the weight of head in integration of nitrogen management significantly influenced was maximum in N_5: 50 % nitrogen with Urea & 50 % nitrogen from Poultry Manure i.e., 353.76, 381.70 and 367.73 g in 2021-22, 2022-23 and pooled mean and second highest recorded in N_1: 100 % N through Urea i.e., 348.54, 358.30 and 353.42 g in 2021-22, 2022-23 and pooled mean respectively than other treatments of integrated nitrogen management and lowest observed in N_0 (control) i.e., 250.54, 252.67 and 251.60 g in 2021-22, 2022-23 and pooled mean respectively.

Among the mulching treatment, maximum head weight was recorded in M_2 (Black polythene mulch) i.e., 353.54, 376.53 and 365.03 g in 2021-22, 2022-23 and pooled data respectively, followed by Paddy straw mulch (M_1) i.e., 336.54, 334.26 and 335.40 g in 2021-22, 2022-23 and pooled mean, respectively but recorded lowest in M_0 (control) i.e., 220.23, 306.64 and 263.43 g in 2021-22, 2022-23 and pooled mean respectively.

The interaction between integrated nitrogen and mulching was significant observed for head weight in treatment combinations N_5M_2: 50 % nitrogen with Urea & 50 % nitrogen from Poultry Manure + Black polythene mulch i.e., 390.54, 387.46 and 389.00 g 2021-22, 2022-23 and pooled mean respectively**,** followed by N_1M_2: 100 % N through Urea + Black polythene mulch i.e., 385.76, 376.33 and 381.05 g in 2021-22, 2022-23 and pooled mean respectively and lowest in N_0M_0 (control) i.e., 201.87, 196.44 and 199.16 g 2021-22, 2022-23 and pooled mean respectively.

The maximum head weight was recorded in N_5 (poultry manure with urea) this could be due to maximum amount of nutrient availability uniform and continuous supply of nitrogen that enhance maximum marketable head weight, the highest total broccoli yield (Shree *et al.* (2014)

Maximum head weight was found in M_2 while in black polythene; this might be due to the high water holding capacity and good porosity in the root zone, which enhances the plant's growth. Similar findings were recorded by Punetha *et al*. (2020).

Among the interaction effects, N_5M_2 was recorded significant. This might be due to the urea and poultry manure and black polythene mulch, which is responsible for vegetative growth utilizing accumulation of chlorophyll carbohydrates and protein in the leaf, which help to make broccoli head larger along with good quality.

Table 4.25 Response of integrated nitrogen management and mulching practices on head weight (g)

Head weight (g)			
Treatment	**2021-22**	**2022-23**	**Pooled mean**
Integrated Nitrogen Management (N)			
N_0	250.54	252.67	251.60
N_1	348.54	358.30	353.42
N_2	302.65	325.36	314.73
N_3	334.42	331.11	332.76
N_4	312.32	324.66	318.49
N_5	353.76	381.70	367.73
SE±	0.33	0.47	0.45
CD (P=0.05)	0.67	0.87	1.21
Mulching (M)			
M_0	220.23	306.64	263.43
M_1	336.54	334.26	335.40
M_2	353.54	376.53	365.03
SE±	0.13	0.23	0.51
CD (P=0.05)	0.36	0.67	1.91

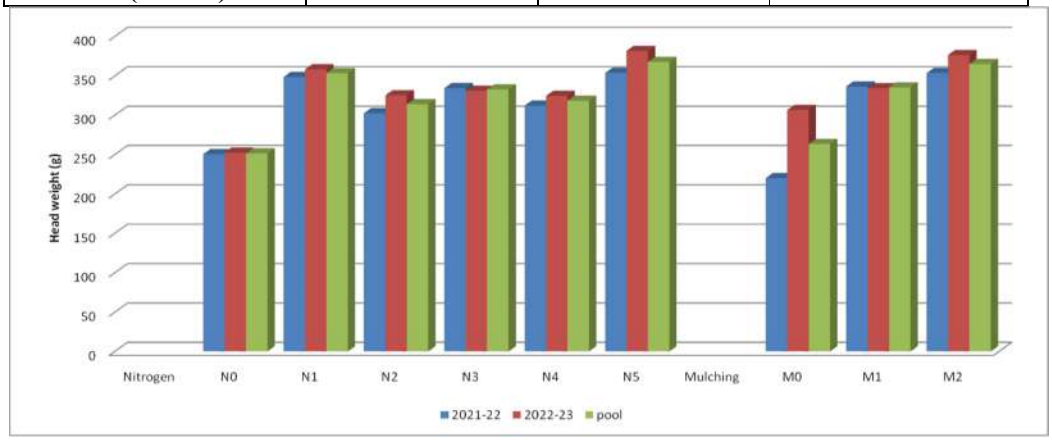


Fig 4.25 Response of integrated nitrogen management and mulching practices on diameter of head (cm)

Table 4.26 Combined effect of integrated nitrogen management and mulching practices on head weight (g)

Head weight (g)			
Treatment	2021-22	2022-23	pool
N_0M_0	201.87	196.44	199.16
N_0M_1	233.87	228.44	231.16
N_0M_2	243.54	238.11	240.83
N_1M_0	234.87	229.44	232.16
N_1M_1	378.86	373.43	376.15
N_1M_2	385.76	376.33	381.05
N_2M_0	335.36	329.93	332.65
N_2M_1	367.23	361.80	364.52
N_2M_2	290.35	284.92	287.64
N_3M_0	310.35	304.92	307.64
N_3M_1	267.25	261.82	264.54
N_3M_2	365.35	365.37	365.36
N_4M_0	336.35	340.92	338.64
N_4M_1	278.65	273.22	275.94
N_4M_2	365.67	360.24	362.96
N_5M_0	379.99	374.56	377.28
N_5M_1	355.90	350.47	353.19
N_5M_2	390.54	387.46	389.00
SE±	0.22	0.41	0.95
CD (P=0.05)	1.63	1.17	2.13

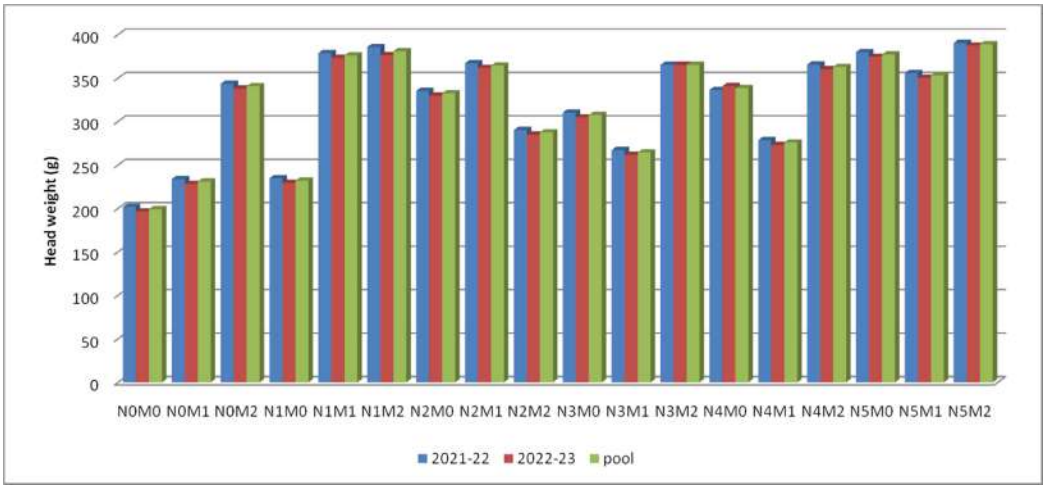


Fig 4.26 Response of integrated nitrogen management and mulching practices on head weight (g)

4.2.3 Head yield/plot (kg) and head yield/ha (q) of broccoli.

The data related to head yield by broccoli plant as affected by integrated nitrogen and mulching management is represented in tables 4.27, 4.28 and figures 4.27, 4.28.

4.2.3.1 Yield (kg/plot)

The data was confirmed that the yield kg/plot in integration of nitrogen management found significantly highest recorded in N_5: 50 % nitrogen with Urea & 50 % nitrogen from Poultry Manure i.e., 11.320, 12.214 and 11.767 kg/plot in 2021-22, 2022-23 and pooled mean respectively and second highest recorded in N_1: 100 % N through urea i.e., 11.153, 11.466 and 11.309 kg/plot in 2021-22, 2022-23 and pooled mean respectively, while the minimum values were recorded in N_0 (control) i.e., 8.017, 8.085 and 8.051 kg/plot in 2021-22, 2022-23 and pooled mean respectively.

Among the mulching treatment, maximum yield kg/plot was recorded in M_2 (Black polythene mulch) i.e., 11.313, 12.049 and 11.681 kg/plot in 2021-22, 2022-23 and pooled data respectively, followed by Paddy straw mulch (M_1) i.e., 10.769, 10.696 and 10.733 kg/plot in 2021-22, 2022-23 and pooled mean, respectively, while the lowest yield recorded in M_0 (control) i.e., 7.047, 9.812 and 8.430 kg/plot in 2021-22, 2022-23 and pooled mean respectively.

The combined effect of nitrogen and mulching was observed maximum in N_5M_2: 50 % nitrogen with Urea & 50 % nitrogen from Poultry Manure + Black polythene mulch i.e., 12.497, 12.399 and 12.448 kg/plot in 2021-22, 2022-23 and pooled mean respectively, followed by N_1M_2: 100 % N through Urea + Black polythene mulch i.e., 12.344, 12.043 and 12.194 kg/plot in 2021-22, 2022-23 and pooled mean respectively, while the minimum yield found in N_0M_0 (control) i.e., 6.460, 6.286 and 6.373 kg/plot in 2021-22, 2022-23 and pooled mean respectively.

4.2.3.2 Yield (q/ha)

The data confirmed that the yield ha^{-1} (q) in integration of nitrogen management found significantly highest in N_5: 50 % nitrogen with Urea & 50 % nitrogen from Poultry Manure i.e., 122.48, 132.16 and 127.32 q ha^{-1} in 2021-22, 2022-23 and pooled mean respectively and second highest recorded in N_1: 100 % N through Urea i.e., 120.68, 124.06 and 122.36 q ha^{-1} in 2021-22, 2022-23 and pooled

mean respectively, while the minimum values were recorded in N_0 (control) i.e., 86.74, 87.48 and 87.11 q ha^{-1} in 2021-22, 2022-23 and pooled mean respectively.

Among the mulching treatment, maximum yield was recorded in Black polythene mulch M_2: i.e., 122.41, 130.37 and 126.39 q ha^{-1} in 2021-22, 2022-23 and pooled data respectively, followed by paddy straw mulch M_1: i.e., 116.52, 115.73 and 116.13 q ha^{-1} in 2021-22, 2022-23 pooled mean, respectively, whereas the least yield recorded in M_0 (control) i.e., 76.25, 106.17 and 91.21 q ha^{-1} in 2021-22, 2022-23 and pooled mean respectively.

Among the interaction effect high yield was recorded in N_5M_2: 50 % nitrogen with Urea & 50 % nitrogen from Poultry Manure + Black polythene mulch i.e., 135.22, 134.16 and 134.69 q/ha in 2021-22, 2022-23 and pooled mean respectively, followed by N_1M_2: 100 % N through urea + Black polythene mulch i.e., 133.56, 130.31 and 131.94 q/ha in 2021-22, 2022-23 and pooled mean respectively, while the least value obtained in treatment combination N_0M_0 (control) i.e., 69.90, 68.01 and 68.96 q/ha in 2021-22, 2022-23 and pooled mean respectively.

The increase in broccoli yield could potentially be attributed to the enhanced effect of poultry manure application, nitrification and cellulose decomposition, activities of rhizosphere bacteria involved in ammonification, anaerobic, resulting in a favourable root environment lad to maximum head weight, which is directly related to high yield of broccoli head. The results agreed with the findings of (Maurya *et al*., 2008).
The Black polythene mulch absorbs maximum heat from sun radiation, which helps maintain the soil root temperature and enhances the amount of humus with carbon in the soil, which causes higher head growth (Yasmin *et al*., 2021).

A combination urea of and poultry manure with the interaction of black polythene mulch observed the highest yield. This might be because organic manure increases soil fertility by improving aeration, porosity and soil texture, which results in active root absorption of minerals and nutrients in whole plants, resulting in high yield.

Table 4.27 Response of integrated nitrogen management and mulching practices Head yield per plot (kg) and Head yield per ha (q) of broccoli.

Treatment	Yield/plot (kg)			Yield/ha (q)		
	2021-22	2022-23	Pooled mean	2021-22	2022-23	Pooled mean
Integrated Nitrogen Management (N)						
N_0	8.017	8.085	8.051	86.74	87.48	87.11
N_1	11.153	11.466	11.309	120.68	124.06	122.36
N_2	9.685	10.412	10.071	104.79	112.66	108.97
N_3	10.701	10.596	10.648	115.78	114.65	115.21
N_4	9.994	10.389	10.192	108.14	112.41	110.28
N_5	11.320	12.214	11.767	122.48	132.16	127.32
SE±	0.015	0.018	0.017	1.69	1.98	1.87
CD (P=0.05)	0.044	0.039	0.041	4.88	4.91	4.9
Mulching (M)						
M_0	7.047	9.812	8.430	76.25	106.17	91.21
M_1	10.769	10.696	10.733	116.52	115.73	116.13
M_2	11.313	12.049	11.681	122.41	130.37	126.39
SE±	0.011	0.130	0.120	1.190	1.210	1.200
CD (P=0.05)	0.031	0.330	0.032	3.450	3.510	3.480

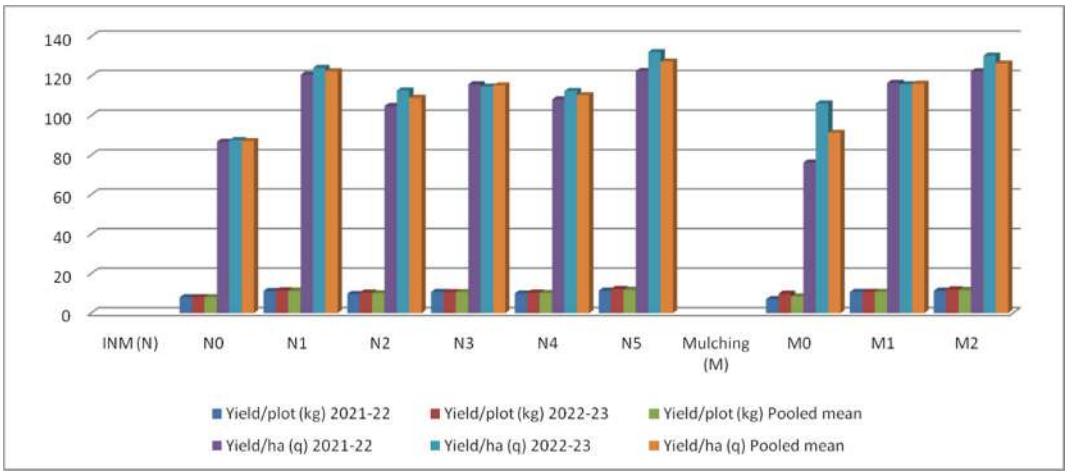


Fig 4.27 Response of Integrated Nitrogen management and mulching practices Head yield /plot (kg) and headyield/ha (q)

Table 4.28 Combined effect of integrated nitrogen management and mulching practices on head yield /plot (kg) andhead yield/ha (q)

Treatment	Yield/plot (kg)			Yield/ha (q)		
	2021-22	2022-23	Pooled mean	2021-22	2022-23	Pooled mean
N_0M_0	6.460	6.286	6.373	69.90	68.01	68.96
N_0M_1	7.4843	7.310	7.397	80.98	79.09	80.04
N_0M_2	7.793	7.620	7.707	84.32	82.45	83.39
N_1M_0	10.716	10.382	7.349	115.95	112.33	79.52
N_1M_1	12.124	11.950	12.037	131.18	129.30	130.24
N_1M_2	12.344	12.043	12.194	133.56	130.31	131.94
N_2M_0	10.732	10.558	10.645	116.12	114.24	115.18
N_2M_1	11.751	11.578	11.665	127.15	125.27	126.22
N_2M_2	9.291	9.117	9.204	100.53	98.65	99.59
N_3M_0	9.931	9.757	9.844	107.45	105.57	106.51
N_3M_1	8.552	8.378	8.465	92.53	90.65	91.59
N_3M_2	11.691	11.692	11.692	126.50	126.51	126.51
N_4M_0	10.763	10.909	10.836	116.46	118.04	117.25
N_4M_1	8.917	8.743	8.830	96.48	94.60	95.54
N_4M_2	11.691	11.528	11.615	126.50	124.73	125.67
N_5M_0	12.16	11.986	12.073	131.57	129.69	130.63
N_5M_1	11.389	11.215	11.302	123.23	121.35	122.29
N_5M_2	12.497	12.399	12.448	135.22	134.16	134.69
SE±	0.025	0.310	0.290	2.930	2.780	2.710
CD (P=0.05)	0.073	0.810	0.790	8.450	8.970	8.910

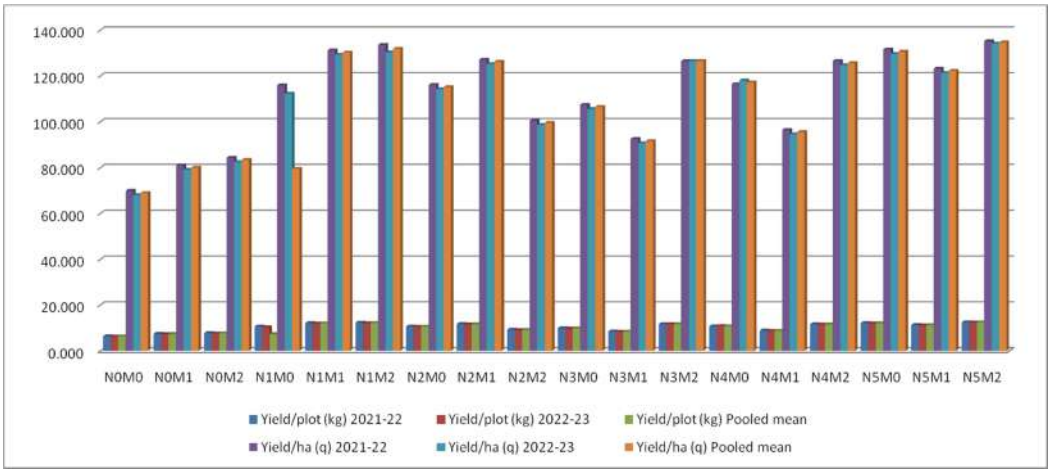


Fig 4.28 Combined effect of integrated nitrogen management and mulching practices on head yield /plot (kg) and head yield/ha (q) of broccoli.

4.2.4 Harvesting index (%)

The observations in relation to harvesting index content by broccoli plant as influenced by integrated nitrogen and mulching management is represented in tables 4.29, 4.30 and figures 4.29, 4.30.

The data confirmed that the harvesting index in integration of nitrogen management significantly influenced was maximum in N_5: 50 % nitrogen with Urea & 50 % nitrogen from Poultry Manure i.e., 37.88, 37.56 and 37.72 % in 2021-22, 2022-23 and pooled mean and second highest recorded in N_1: 100 % N through Urea i.e., 36.98, 36.48 and 36.73 % in 2021-22, 2022-23 and pooled mean respectively than other treatments of integrated nitrogen management and lowest observed in N_0: (Control) i.e., 26.84, 25.36 and 26.10 % in 2021-22, 2022-23 and pooled mean respectively.

Among the mulching treatment, maximum harvesting index in M_2 (Black polythene mulch) i.e., 37.85, 36.59 and 37.22 % in 2021-22, 2022-23 and pooled data respectively, followed by no mulch M_1 (Paddy straw mulch) i.e., 34.86, 33.27 and 34.07 % in 2021-22, 2022-23 and pooled mean, respectively while the lowest Hrvest index recorded in M_0 (control) i.e., 27.48, 26.48 and 26.98 % in 2021-22, 2022-23 and pooled mean respectively

The interaction between integrated nitrogen and mulching for harvesting index in treatment combinations, N_5M_2: 50 percent nitrogen with Urea & 50 percent nitrogen from Poultry Manure + Black polythene mulch was found to have i.e., 36.27, 36.40 and 36.34 % in 2021-22, 2022-23 and pooled mean respectively**,** followed by N_1M_2: 100 % N through urea + Black polythene mulch i.e. 35.47, 35.87 and 35.67 % 2021-22, 2022-23 and pooled mean respectively, while the minimum harvesting index content recorded in treatment combination N_0M_0 (control) i.e., 26.07, 25.92 and 26.09 % 2021-22, 2022-23 and pooled mean respectively.

The maximum harvesting index was recorded in N_5 could be due to the use of poultry manure causing higher biomass in the soil, which helps to micro and macronutrients in the soil, which plant measure affected by the uptake of nutrients and enhancing the growth and yield of the economic part (Ouda and Mahadeen. 2008).

The highest harvest index was found in M_2. This could be due to the application of black polythene mulch favorable temperature-efficient nutrient uptake, along with inhibiting weed growth, resulting in the highest growth (Islam *et al*., 2014).

The highest harvest index was found in N_5M_2, which could be due to the fact that the integrated use of urea, poultry manure and black polythene mulch increases the micro flora of the soil root zone by increasing organic manure and urea.

Table 4.29 Response of integrated nitrogen management and mulching practices on harvesting index

Treatment	Harvesting index		
	2021-22	2022-23	Pooled mean
integrated nitrogen management (N)			
N_0	26.84	25.36	26.10
N_1	36.98	36.48	36.73
N_2	35.42	34.83	35.13
N_3	34.27	33.72	34.00
N_4	32.75	31.11	31.93
N_5	37.88	37.56	37.72
SE±	0.10	0.11	0.10
CD (P=0.05)	0.29	0.32	0.28
Mulching (M)			
M_0	27.48	26.48	26.98
M_1	34.86	33.27	34.07
M_2	37.85	36.59	37.22
SE±	0.07	0.09	0.11
CD (P=0.05)	0.21	0.31	0.32

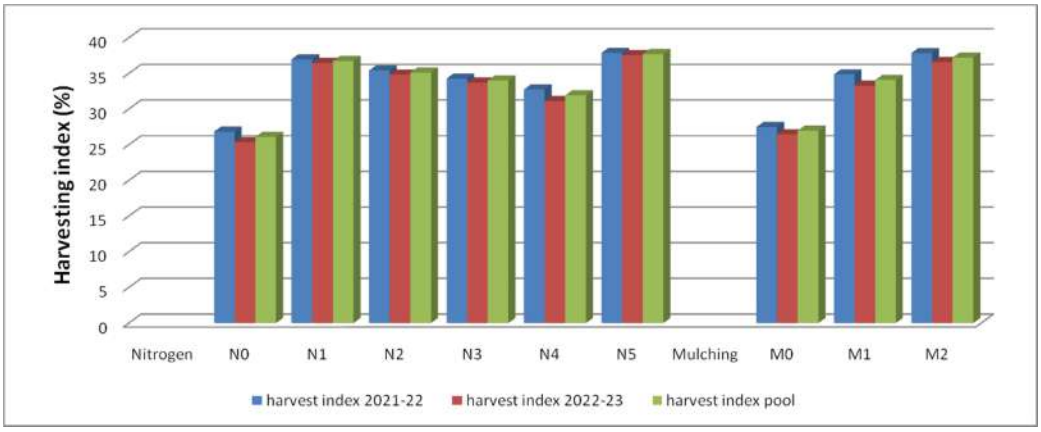


Fig 4.29 Response of integrated nitrogen management and mulching practices on harvesting index

Table 4.30 Combined effect of integrated nitrogen management and mulching practices on harvesting index

Treatment	Harvesting index		
	2021-22	2022-23	Pooled mean
N_0M_0	26.07	25.92	26.09
N_0M_1	26.66	26.47	26.57
N_0M_2	26.76	26.74	26.75
N_1M_0	34.20	35.20	34.07
N_1M_1	35.21	35.25	35.23
N_1M_2	35.47	35.87	35.67
N_2M_0	36.02	35.08	35.55
N_2M_1	36.11	35.01	35.56
N_2M_2	36.17	35.46	36.02
N_3M_0	34.78	34.76	34.77
N_3M_1	35.41	35.45	35.43
N_3M_2	34.86	35.84	35.35
N_4M_0	34.66	34.58	34.62
N_4M_1	35.27	35.81	35.54
N_4M_2	35.15	35.54	35.35
N_5M_0	31.91	31.97	31.94
N_5M_1	32.65	32.43	32.54
N_5M_2	36.27	36.40	36.34
SE±	0.18	0.20	0.19
CD (P=0.05)	0.51	0.65	0.61

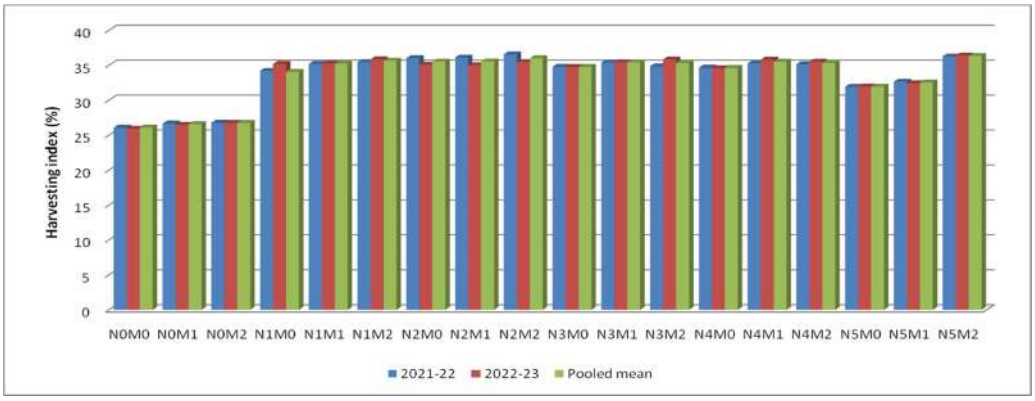


Fig 30 Combined effects of integrated nitrogen management and mulching practices on harvesting index

4.3 Effect of integrated nitrogen, mulching and their interaction on quality attributes characters:

4.3.1 Dry matter content (%) affected by integrated nitrogen and mulching management is depicted in tables 4.31, 4.32 and figures 4.31, 4.32.

The data confirmed that the dry matter content in integration of nitrogen management significantly influenced was maximum recorded in N_2: 50 percent nitrogen by urea + 50 percent nitrogen by Cow dung i.e., 9.40, 9.89 and 9.64 % in 2021-22, 2022-23 and pooled mean and second highest in N_5: 50 % nitrogen with Urea & 50 % nitrogen from Poultry Manure i.e., 9.02, 10.03 and 9.52 % in 2021-22, 2022-23 and pooled mean respectively than other treatments of integrated nitrogen management and lowest observed in N_0 (control) i.e., 4.68, 4.56 and 4.62 % in 2021-22, 2022-23 and pooled mean respectively.

Among the mulching treatment, maximum dry matter content in M_2 (Black polythene mulch) i.e., 8.91, 9.42 and 9.16 % in 2021-22, 2022-23 and pooled data respectively, followed by no mulch M_0 (control) i.e., 8.36, 8.23 and 8.29 % in 2021-22, 2022-23 and pooled mean, respectively whereas the least dry matter content recorded in M_1 (Paddy straw mulch) treatment i.e., 7.01, 6.98 % and 6.99 % in 2021-22, 2022-23 and pooled mean respectively

The interaction between integrated nitrogen and mulching for dry matter content in treatment combinations was recorded in N_1M_2: 100 % N through Urea + Black polythene mulch i.e., 11.85, 10.98 and 11.41 % 2021-22, 2022-23 and pooled mean respectively**,** followed by N_5M_2: 50 percent nitrogen with Poultry manure and nitrogen from Urea + Black polythene mulch i.e., 10.6 11.01 and 10.80 % 2021-22, 2022-23 and pooled mean respectively, while the least dry matter found in combination N_0M_2: 0 % N + Black polythene mulch i.e., 4.53, 3.99 and 4.26 % 2021-22, 2022-23 and pooled mean respectively.

The highest dry matter content was found in N_2 might be due to the application of cow dung with urea-enhanced microbial activity, which provides additional potassium and slow-release sources of nutrition in soil and enriches the soil, which leads to higher dry matter accumulation in broccoli head (Padamwar and Dakore. 2010).

The highest dry matter was found in M_2 black polythene mulch, providing good water-holding capacity, moderate soil temperature during extreme weather conditions and a stable environment for the plant root zone, which enhances the dry matter in the edible portion of the broccoli (Punetha *et al*., 2020).

The maximum dry matter was found in N_1M_2 could be due to the application of urea and black polythene mulch, which helps to uptake high nitrogen and regulates the plant's metabolism. Nitrogen is responsible for the plant's vegetative growth by activating cell development, which synthesizes food material in the plant, directly enhancing the broccoli head's weight and quality, leading to high dry matter content.

Table 4.31 Response of integrated nitrogen management and mulching practices on dry matter content (%) of broccoli

Treatment	2021-22	2022-23	Pooled mean
integrated nitrogen management (N)			
N_0	4.68	4.56	4.62
N_1	8.44	9.01	8.72
N_2	9.40	9.89	9.64
N_3	9.23	9.45	9.34
N_4	7.78	6.89	7.33
N_5	9.02	10.03	9.52
SE±	0.20	0.15	0.17
CD (P=0.05)	0.40	0.51	0.45
Mulching (M)			
M_0	8.36	8.23	8.29
M_1	7.01	6.98	6.99
M_2	8.91	9.42	9.16
SE±	0.08	0.08	0.09
CD (P=0.05)	0.32	0.28	0.42

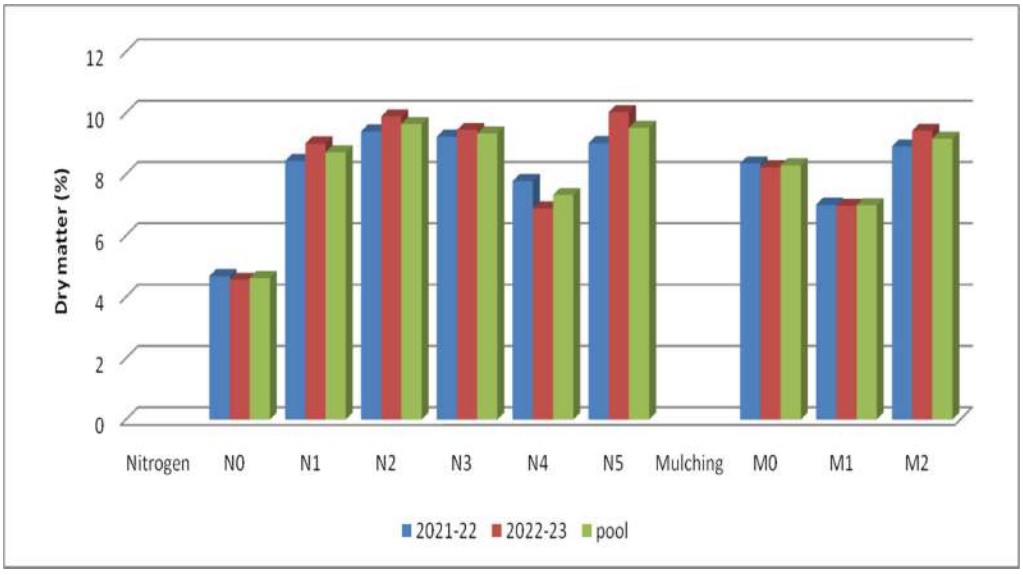


Fig 4.31 Response of integrated nitrogen management and mulching practices on dry matter content (%) of broccoli

Table 4.32 Interaction effect of integrated nitrogen management and mulching practices on dry matter content (%)of broccoli

Dry matter content (%)			
Treatment	**2021-22**	**2022-23**	**Pooled mean**
N_0M_0	4.96	4.21	4.58
N_0M_1	4.56	4.67	4.61
N_0M_2	4.53	3.99	4.26
N_1M_0	8.53	9.01	8.77
N_1M_1	4.93	4.28	4.60
N_1M_2	11.85	10.98	11.41
N_2M_0	9.78	9.31	9.54
N_2M_1	9.71	9.56	9.63
N_2M_2	8.73	7.89	8.31
N_3M_0	9.28	9.65	9.46
N_3M_1	9.46	9.37	9.41
N_3M_2	8.96	8.10	8.53
N_4M_0	8.93	8.34	8.63
N_4M_1	5.63	6.02	5.82
N_4M_2	8.78	8.23	8.50
N_5M_0	8.70	7.90	8.30
N_5M_1	7.76	8.03	7.89
N_5M_2	10.60	11.01	10.80
SE±	0.48	0.17	0.32
CD (P=0.05)	0.97	0.41	0.69

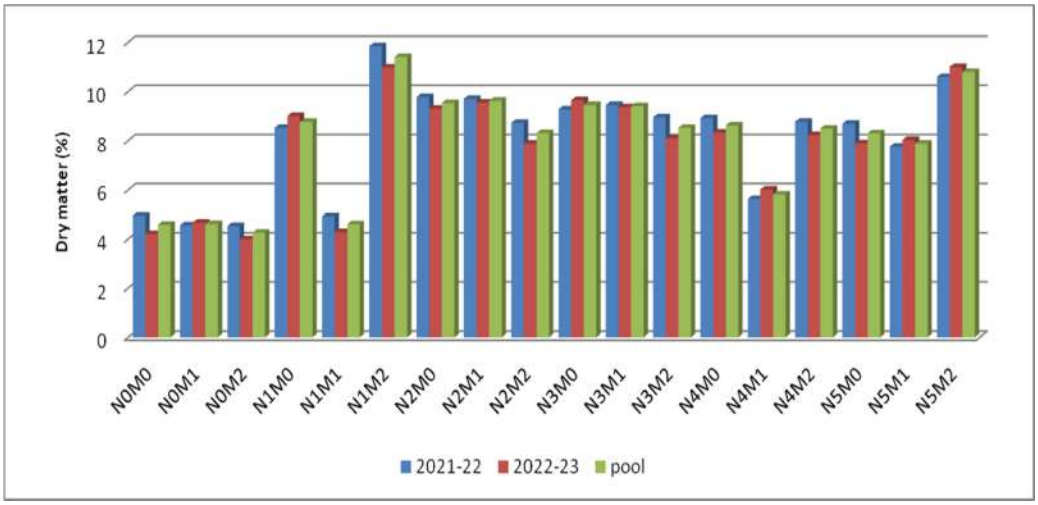


Fig 4.32 Combined effects of integrated nitrogen management and mulching practices on dry matter content (%) of broccoli

4.3.2 TSS (°B)

The data revealed that related to total soluble solids by broccoli plant as influenced by integrated nitrogen and mulching management is represented in tables 4.33, 4.34 and figures 4.33, 4.34.

The data confirmed that the total soluble solids content in integration of nitrogen management significantly influenced was maximum recorded in N_5: 50 % nitrogen with Urea & 50 % nitrogen from Poultry Manure i.e., 7.55, 8.12 and 7.83 °B in 2021-22, 2022-23 and pooled mean respectively and second highest recorded in N_1: 100 % N through Urea i.e., 7.37, 8.01 and 7.69 °B in 2021-22, 2022-23 and pooled mean respectively than other treatments of integrated nitrogen management and lowest observed in N_0 (control) i.e., 4.5, 5.1 and 4.8 °B in 2021-22, 2022-23 and pooled mean respectively.

Among the mulching treatment, maximum TSS in M_2 (Black polythene mulch) i.e., 7.18, 7.69 and 7.43 °B in 2021-22, 2022-23 and pooled data respectively, followed by Paddy straw mulch (M_1) i.e., 6.52, 6.61 and 6.56 °B in 2021-22, 2022-23 and pooled mean respectively, whereas the least recorded in M_0 (control) i.e., without mulch i.e., 6.69, 6.89 and 6.79°B in 2021-22, 2022-23 and pooled mean respectively.

The interaction between mulching and integrated nitrogen management practices was found non significant.

The highest TSS was found in N_5. This could be due to better nutrition, increased photosynthetic activity, improved root environment and better food accumulation in edible sections contributing to sprouting broccoli heads. This result was consistent with those of Shree *et al.* (2014).

The highest TSS was found in M_2. This might be due to the application of Black polythene mulch, which helps enhance soil texture by enhances porosity among the soil particles and also helps to suppress weed growth and less competition for nutrient uptake results, resulting in higher TSS accumulation in the edible head of the broccoli (Punetha *et al*., 2020).

Table 4.33 Response of integrated nitrogen management and mulching practices on TSS °B

Treatment	2021-22	2022-23	Pooled mean
integrated nitrogen management (N)			
N_0	4.50	5.10	4.80
N_1	7.37	8.01	7.69
N_2	7.27	7.23	7.24
N_3	7.26	7.21	7.23
N_4	6.83	6.45	6.64
N_5	7.55	8.12	7.83
SE±	0.08	0.07	0.07
CD (P=0.05)	0.23	0.21	0.22
Mulching (M)			
M_0	6.69	6.89	6.79
M_1	6.52	6.61	6.56
M_2	7.18	7.69	7.43
SE±	0.11	0.13	0.12
CD (P=0.05)	0.32	0.28	0.30

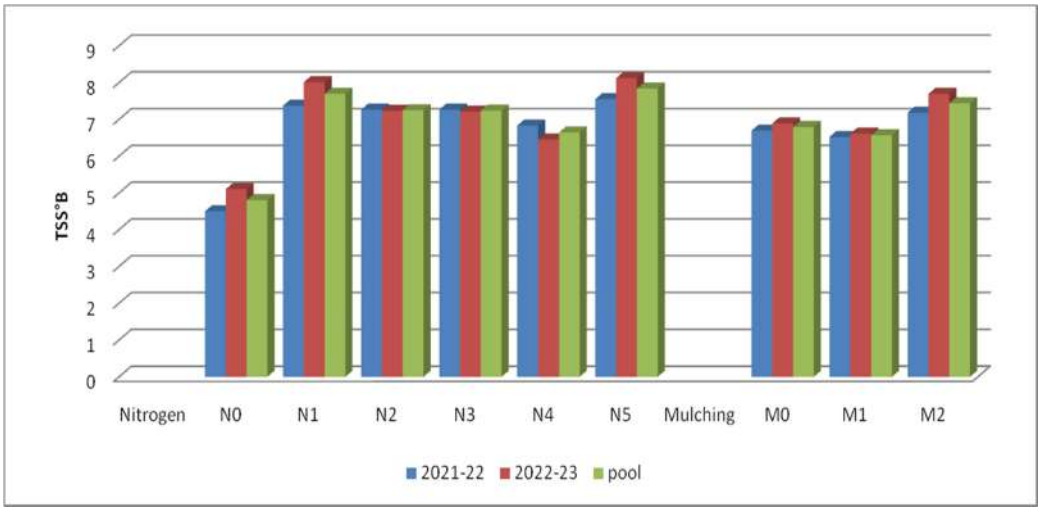


Fig 4.33 Response of integrated nitrogen management and mulching practices on TSS (°B) of broccoli

4.3.3 Crude fiber content (%)

The data related to crude fiber by broccoli plant as influenced by integrated nitrogen and mulching management is depicted in tables 4.34, 4.35 and figures 4.34, 4.35.

The data confirmed that the crude fiber content in integration of nitrogen management significantly influenced was highest recorded in N_4: 50 percent nitrogen by Urea with 50 percent nitrogen from vermicompost i.e., 1.46, 1.78 and 1.62 % in 2021-22, 2022-23 and pooled mean respectively and second highest recorded in N_1: 100 % N through Urea i.e., 1.33, 1.46 and 1.39 % in 2021-22, 2022-23 and pooled mean respectively, while the lowest crude fiber in N_0 (control) i.e., 0.87, 0.98 % and 0.92 % in 2021-22, 2022-23 and pooled mean respectively.

Among the mulching maximum crude fiber % in M_2 (Black polythene mulch) i.e., 1.34, 1.46 and 1.40 % in 2021-22, 2022-23 and pooled data respectively, followed no mulch M_0 (control) i.e., 1.17, 1.21 and 1.19 % in 2021-22, 2022-23 and pooled mean, respectively but recorded lowest in M_1: paddy straw mulch i.e., 1.08, 1.05 and 1.06 % in 2021-22, 2022-23 and pooled mean respectively.

The combined effect of integrated nitrogen and mulching was recorded to be non-significant for crude fiber in broccoli.

The maximum crude fiber was found in N_4, might be due to the urea and vermicompost enhancing the pH, which increases the ammonical nitrogen concentration of the soil, which is directly responsible for increasing the amount of organic matter in the soil root zone, resulting in high crude fiber accumulation in broccoli which leads to high crude fiber in the head (Punetha *et al.,* 2020).

The highest crude fiber was found in M_2, might be due to black polythene mulch provides weed-free environment to the plant root and regulate optimum temperature with increasing soil microbial activity, which help to uptake nutrient from the root, resulting in more food material, *viz*., protein, carbohydrates, vitamin etc. accumulation in the edible portion of the broccoli which leads to high crude fiber in the head (Punetha *et al.,* 2020).

Table 4.34 Response of integrated nitrogen management and mulching practices on crude fiber (%)

Treatment	Crude fiber (%)		
	2021-22	2022-23	Pooled mean
integrated nitrogen management (N)			
N_0	0.87	0.98	0.92
N_1	1.33	1.46	1.39
N_2	1.21	1.18	1.19
N_3	1.12	1.07	1.09
N_4	1.46	1.78	1.62
N_5	1.20	1.15	1.17
SE±	0.03	0.07	0.05
CD (P=0.05)	0.10	0.11	0.10
Mulching (M)			
M_0	1.17	1.21	1.19
M_1	1.08	1.05	1.06
M_2	1.34	1.46	1.40
SE±	0.05	0.04	0.04
CD (P=0.05)	0.14	0.19	0.16

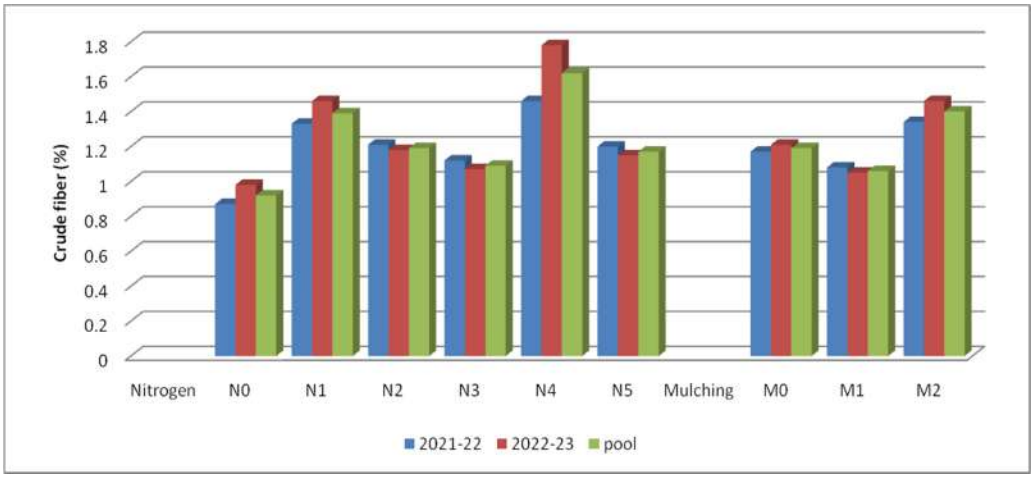


Fig 4.34 Response of integrated nitrogen management and mulching practices on crude fiber (%)

4.3.4 Head chlorophyll content (mg/g)

The data regarding the chlorophyll by broccoli plant as influenced by integrated nitrogen and mulching management is represented in tables 4.35, 4.36 and figures 4.35, 4.36.

Chlorophyll a, The data confirmed that the integration of nitrogen management significantly influenced was recorded maximum chlorophyll A in N_3: 50 percent nitrogen through Urea and 50 percent nitrogen by FYM i.e., 12.18, 13.02 and 12.6 mg/g in 2021-22, 2022-23 and pooled mean and second highest in N_5: 50 % nitrogen with Urea & 50 % nitrogen from Poultry manure i.e., 11.41, 12.01 and 11.71 mg/g in 2021-22, 2022-23 and pooled mean respectively than other treatments of integrated nitrogen management, while the minimum values recorded in treatment N_0 (control) 5.70, 5.20 and 5.45 mg/g in 2021-22, 2022-23 and pooled mean respectively.

Among the mulching treatment, maximum chlorophyll A was found in M_2 (Black polythene mulch) i.e., 10.61, 11.09 and 10.85 mg/g in 2021-22, 2022-23 and pooled data respectively, followed by Paddy straw mulch (M_1) i.e., 10.13, 10.03 and 10.08 mg/g in 2021-22, 2022-23 and pooled mean, respectively i.e., recorded but lowest in no mulch treatment. While the least values recorded in treatment M_0 (control) i.e. 10.04, 9.89 and 9.96 mg/g in 2021-22, 2022-23 and pooled mean respectively.

Among the treatment combinations, the highest chlorophyll A was recorded in N_3M_2: 50 % N through Urea + 50 % N through FYM + Black polythene mulch i.e. was found to have superior chlorophyll A content in mg/g, i.e., 13.66, 14.48 and 13.57mg/g in 2021-22, 2022-23 pooled mean respectively, followed by N_5M_0: 50 % nitrogen with Urea & 50 % nitrogen from Poultry Manure + without mulch i.e., 12.85, 12.45 and 12.65 mg/g in 2021-22, 2022-23 and pooled mean respectively, while the minimum values recorded in treatment N_0M_0 (control) 5.01, 4.97 and 4.99 mg/g in 2021-22, 2022-23 and pooled mean respectively.

Chlorophyll b, The data confirmed that the integration of nitrogen management found for chlorophyll B in N_3: 50 percent nitrogen by Urea and 50 percent nitrogen

with FYM i.e., 7.37, 6.99 and 7.18 mg/g in 2021-22, 2022-23 and pooled mean respectively, while the least values were found in N_0 (control) i.e., 5.06, 4.99 and 5.02 mg/g in 2021-22, 2022-23 and pooled mean respectively.

Among the mulching treatment, maximum chlorophyll B in M_2 (Black polythene mulch) i.e., 5.96, 6.29 and 6.12 mg/g in 2021-22, 2022-23 and pooled data respectively, followed by no mulch M_0 (control) i.e., 4.23, 5.01 and 4.62 mg/g in 2021-22, 2022-23 and pooled mean, respectively i.e., recorded lowest in paddy straw mulch treatment, while the minimum values recorded in M_1 i.e., 3.85, 4.35 and 4.10 mg/g in 2021-22, 2022-23 and pooled mean respectively.

The interaction between integrated nitrogen and mulching was significant for chlorophyll B in N_3M_2: 50 percent nitrogen with urea + 50 percent nitrogen by FYM + Black polythene mulch i.e., 7.37, 7.16 and 7.27 mg/g in 2021-22, 2022-23 and pooled mean respectively, followed by N_1M_2: 100 % N through Urea + Black polythene mulch i.e., 6.41, 6.31 and 6.36 mg/g 2021-22, 2022-23 and pooled mean respectively, while the minimum values recorded in N_0M_0 (Control) i.e., 3.35, 2.04 and 2.35 mg/g in 2021-22, 2022-23 and pooled mean respectively.

Total chlorophyll The data confirmed that the integration of nitrogen management was found significant influenced for total chlorophyll in N_3: 50 percent nitrogen by urea + 50 percent nitrogen with FYM i.e., 17.29, 18.23 and 17.76 mg/g in 2021-22, 2022-23 and pooled mean respectively, followed by N_2: 50 percent nitrogen by urea + 50 percent nitrogen from Cow dung i.e., 15.67, 16.01 and 15.84 mg/g in 2021-22, 2022-23 and pooled mean respectively, while the lowest recorded in N_1: 100 % N through Urea i.e., 13.49, 12.99 and 13.24 mg/g in 2021-22 in 2022-23 and pooled mean respectively.

Among the mulching treatment, highest total chlorophyll was observed in M_2 (Black polythene mulch) i.e., 16.47, 17.46 and 16.96 mg/g in 2021-22, 2022-23 and pooled data respectively, followed by Paddy straw mulch (M_1) i.e., 13.73, 12.86 and 13.29 mg/g in 2021-22, 2022-23 and pooled mean, respectively, while the lowest in M_0 (control) i.e., without mulch i.e., 11.74, 11.9 and 11.82 mg/g in 2021-22, 2022-23 and pooled mean respectively.

The interaction between integrated nitrogen and mulching was significant for total chlorophyll in N_3M_2: 50 % N through Urea + 50 % N through FYM + Black polythene mulch i.e., 22.33, 21.49 and 21.91 mg/g 2021-22, 2022-23 and pooled mean respectively, followed by N_1M_2: 100 % N through Urea + Black polythene mulch: i.e. 21.29, 22.34 and 21.82 mg/g in 2021-22, 2022-23 and pooled mean respectively, while the lowest in N_0M_0 (Control) i.e., 5.50, 6.81 and 6.15 mg/g in 2021-22, 2022-23 and pooled mean respectively.

The maximum chlorophyll in N_3 might be due to the application of FYM along with urea resulted in higher net photosynthetic rates, enhanced the supply of carbohydrates to the plants; FYM helps to enrich the soil by increasing the organic matter in soil and also increases the insect resistance and protect the crop which leads to the synthesis of chlorophyll by photosynthesis in leaf and head. The almost identical findings were also recorded by Regar *et al*. (2018).

The maximum chlorophyll content was found in M_2 might be due to the black polythene mulch helps in the maintain of moisture along with maintaining the temperature beneath the mulch layer, which help to make available mineral for active absorption of nutrient to the roots, which enhance the accumulation of magnesium and potassium ions which are the major constitution of chlorophyll resulting high accumulation of chlorophyll in leaf and head. The same findings align with the findings of Kosterna *et al*. (2014).

The highest chlorophyll content was found in N_3M_2. This could be due to the application of urea, FYM and black polythene mulch increases the organic manures in the soil, which helps to increase microbial activity and black polythene mulch retains moisture with weed-free soil.

Table 4.35 Response of integrated nitrogen management and mulching practices on chlorophyll (mg/g)

Treatment	Chlorophyll A			Chlorophyll B			Total chlorophyll		
	2021-22	2022-23	Pooled mean	2021-22	2022-23	Pooled mean	2021-22	2022-23	Pooled mean
Integrated Nitrogen Mnagement (N)									
N_0	5.70	5.20	5.45	5.06	4.99	5.02	10.79	10.89	10.84
N_1	11.03	10.87	10.95	6.41	7.23	6.82	13.49	12.99	13.24
N_2	11.36	11.04	11.20	5.48	5.32	5.40	15.67	16.01	15.84
N_3	12.18	13.02	12.60	7.37	6.99	7.18	17.29	18.23	17.76
N_4	9.87	8.78	9.32	5.51	6.01	5.76	11.42	12.01	11.71
N_5	11.41	12.01	11.71	5.93	5.89	5.91	11.22	11.56	11.39
SE±	0.08	0.06	0.07	0.10	0.11	0.10	0.05	0.09	0.07
CD (P=0.05)	0.22	0.19	0.20	0.29	0.37	0.33	0.15	0.16	0.15
Mulching (M)									
M_0	10.04	9.89	9.96	4.23	5.01	4.62	11.74	11.9	11.82
M_1	10.13	10.03	10.08	3.85	4.35	4.10	13.73	12.86	13.29
M_2	10.61	11.09	10.85	5.96	6.29	6.12	16.47	17.46	16.96
SE±	0.11	0.19	0.15	0.14	0.18	0.16	0.07	0.04	0.05
CD (P=0.05)	0.31	0.35	0.33	0.41	0.41	0.41	0.21	0.37	0.29

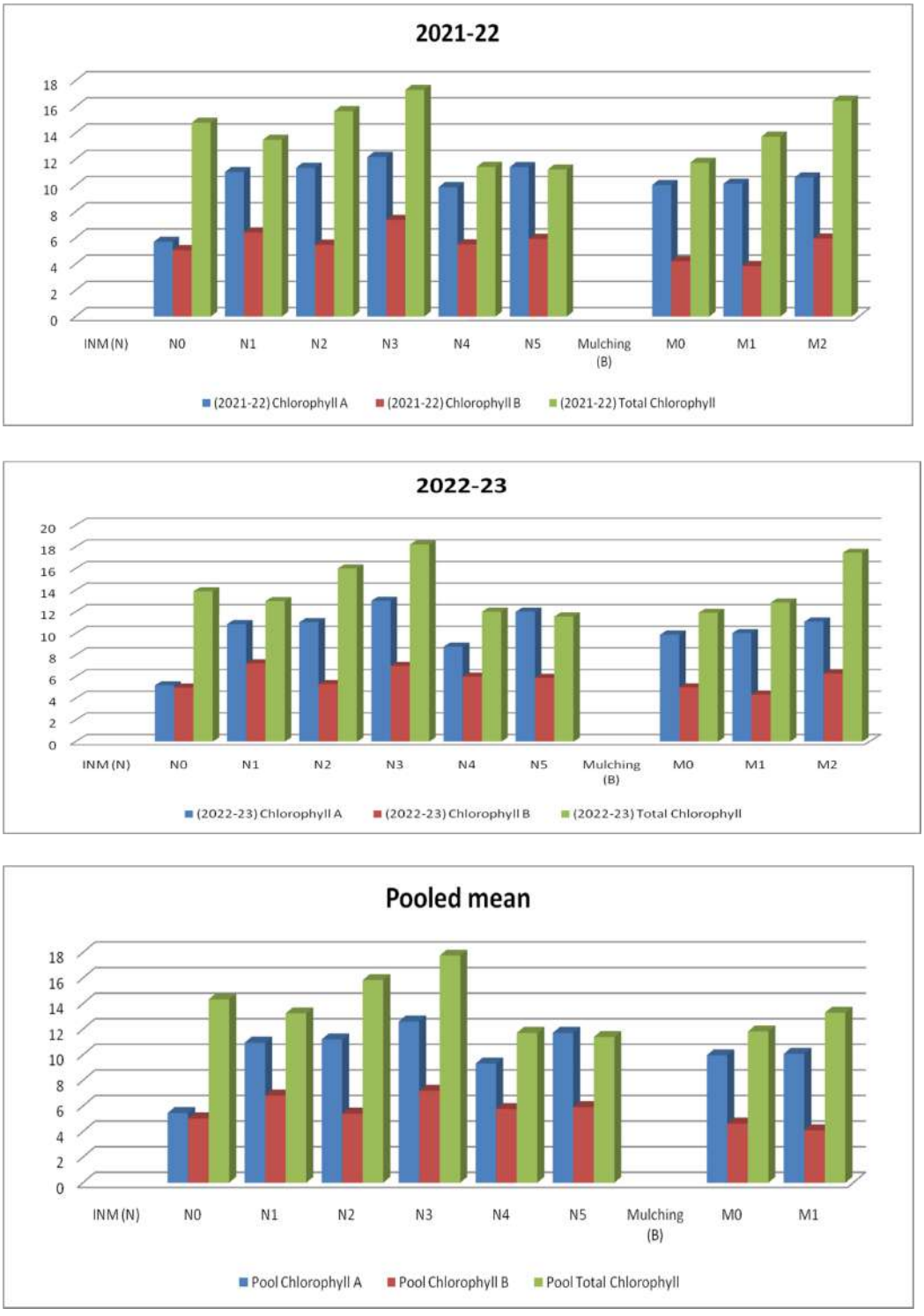


Fig 4.35 Response of integrated nitrogen management and mulching practices on Chlorophyll (mg/g)

Table 4.36 Combined effect of integrated nitrogen management and mulching practices on chlorophyll (mg/g)

Treatment	Chlorophyll A			Chlorophyll B			Total chlorophyll		
	2021-22	2022-23	Pooled mean	2021-22	2022-23	Pooled mean	2021-22	2022-23	Pooled mean
N_0M_0	5.01	4.97	4.99	3.35	2.04	2.35	5.50	6.81	6.15
N_0M_1	6.64	6.43	6.54	3.64	2.90	3.27	15.84	14.58	15.21
N_0M_2	5.45	5.26	5.36	5.06	4.78	4.92	17.03	16.67	16.85
N_1M_0	9.77	9.98	9.88	3.76	3.62	3.69	6.21	7.02	6.62
N_1M_1	9.75	9.78	9.77	3.74	3.26	3.50	12.98	11.79	12.39
N_1M_2	12.38	12.01	12.15	6.41	6.31	6.36	21.29	20.34	20.88
N_2M_0	11.80	10.99	11.40	4.27	4.20	4.24	15.47	14.78	15.13
N_2M_1	8.94	8.38	8.66	3.46	3.29	3.38	11.43	12.01	11.72
N_2M_2	12.34	12.24	12.31	5.48	5.89	5.69	20.12	21.53	20.83
N_3M_0	10.21	10.10	10.16	3.68	4.92	4.30	13.38	14.68	14.03
N_3M_1	12.66	11.90	12.28	4.16	5.02	4.59	16.16	17.18	16.67
N_3M_2	13.66	14.48	13.57	7.37	7.16	7.27	22.33	21.49	21.91
N_4M_0	10.60	11.32	10.96	4.66	3.95	4.31	14.71	15.02	14.87
N_4M_1	10.22	11.87	11.05	3.89	4.33	4.11	13.25	13.59	13.42
N_4M_2	8.79	8.35	8.57	5.51	4.89	5.20	6.30	6.34	6.32
N_5M_0	12.85	12.45	12.65	5.29	4.58	4.94	9.25	9.56	9.41
N_5M_1	12.56	12.98	12.77	4.25	3.91	4.08	12.69	12.47	12.58
N_5M_2	8.83	8.65	8.74	5.93	6.03	5.98	11.73	10.89	11.31
SE±	0.19	0.16	0.18	0.25	0.20	0.23	0.13	0.16	0.15
CD (P=0.05)	0.54	0.51	0.53	0.71	0.69	0.70	0.36	0.31	0.34

Fig 4.36 Combined effect of integrated nitrogen management and mulching practices on chlorophyll (mg/g) ofbroccoli

4.3.5 Uptake of nutrient of Nitrogen, Phosphorus and Potassium (kg ha^{-1})

The data regarding the nutrient uptake by broccoli plant as affected by integrated nitrogen and mulching management is presented in tables 4.37 and figures 4.37.

Nitrogen uptake: The Maximum nitrogen uptake by plant was observed in N_5: 50 % nitrogen with Urea & 50 % nitrogen from Poultry Manure i.e., 27.76, 27.09 and 27.23 kg ha^{-1} in 2021-22, 2022-23 and pooled mean respectively than other treatments of integrated nitrogen management, followed by N_1: 100 % N through Urea i.e., 27.15, 26.06 and 26.60 kg ha^{-1} 2021-22, 2022-23 and pooled mean respectively, while the least nitrogen uptake was recorded in N_0: (Control) i.e., 14.15, 16.04 and 15.60 kg ha^{-1} 2021-22, 2022-23 and pooled mean respectively.

Among the mulching treatment, maximum nitrogen uptake was recorded in M_1 (Paddy straw mulch) i.e., 30.44, 31.26 and 30.85 kg ha^{-1} in 2021-22, 2022-23 and pooled data respectively, followed by M_2 (Black polythene mulch) i.e., 24.57, 23.27 and 23.92 kg ha^{-1} in 2021-22, 2022-23 and pooled mean respectively, while the minimum values were recorded in M_0 (Control) i.e., 24.35, 23.04 and 23.25g 2021-22, 2022-23 and pooled mean respectively.

The combined between integrated nitrogen and mulching found non-significant for nitrogen uptake by the plant.

Phosphorus uptake: The maximum phosphorus uptake by plant was observed in N_5: 50 % nitrogen with urea & 50 % nitrogen from poultry Manure i.e., 3.98, 3.33 and 3.66 kg/ha in 2021-22, 2022-23 and pooled mean respectively, while minimum values were observed in N_0 (control) i.e., 2.65, 2.36 and 2.51 kg ha^{-1} in 2021-22, 2022-23 and pooled mean respectively.

Among the mulching treatment, maximum phosphorus in M_2 (Black polythene mulch) i.e., 3.71, 3.34 and 3.53 kg ha^{-1} in 2021-22, 2022-23 and pooled mean respectively, followed by paddy straw mulch M_1 (Paddy straw mulch) i.e., 3.44, 3.92 and 3.68 kg ha^{-1} in 2021-22, 2022-23 and pooled mean respectively i.e., recorded but lowest found in M_0 (Control) i.e., 2.99, 2.78 and 2.89 kg ha^{-1} in 2021-22, 2022-23 and pooled mean respectively.

The interaction between integrated nitrogen and mulching recorded non significant for phosphorus uptake by the plant.

Potassium uptake: The highest potassium uptake by plant was observed potassium uptake which was found highest in N_5: 50 % nitrogen with Urea & 50 % nitrogen from Poultry Manure i.e., 30.26, 29.78 and 30.02 kg ha^{-1} in 2021-22, 2022-23 and pooled mean respectively, followed by N_1: 100 % N through Urea i.e., 29.08, 29.21 and 29.16 kg ha^{-1} in 2021-22, 2022-23 and pooled mean respectively, whereas the least values were found in N_0 (control) treatment i.e., 18.36, 17.67 and 18.02 kg ha^{-1} in 2021-22, 2022-23 and pooled mean respectively.

Among the mulching treatment, maximum potassium was recorded in M_2 (Black polythene mulch) i.e., 27.73, 27.98 and 27.86 kg ha^{-1} in 2021-22, 2022-23 and pooled data respectively, followed by M_1 (Paddy straw mulch) i.e., 26.65, 25.78 and 26.21 kg ha^{-1} in 2021-22, 2022-23 and pooled mean respectively, while the minimum were recorded in M_0 (control) i.e., 25.98, 23.67 and 24.82 kg ha^{-1} in 2021-22, 2022-23 and pooled mean respectively.

The combined between integrated nitrogen and mulching was found non significant for potassium uptake by the plant.

Maximum nitrogen uptake was found in N_5 likely due to the nitrogen % in poultry manure and urea is 46 and 5% kg ha^{-1}, respectively; broccoli is a heavy feeder of nitrogen. Organic and inorganic sources help to enhance nitrogen to the plant root zone by which plants can perform active absorption of the minerals, resulting in maximum amount of N P and K uptake by the plant. Manures having all micro and macronutrients i.e., needed for all deficiencies to fulfill the crop growth and requirement and manure response with a combination of chemical fertilizers (Shree *et al.* 2014).

Maximum nutrient uptake was found in M_2. This might be because of more nutrient uptake in black polythene mulch due to less interference of weeds, water scarcity, and nutrient competition, which provides a favourable soil environment. Integration of manure also regulates pH, which helps to enhance the nutrient cycle; organic manure

contributes to the plant's overall health. Dalal *et al*. (2010) reported maximum nutrient uptake using black polythene mulch in broccoli.

Table 4.37 Response of integrated nitrogen management and mulching practices on nutrient uptake (kg/ha)

Treatment	Nitrogen (kg/ha)			Phosphorus (kg/ha)			Potassium (kg/ha)		
	2021-22	2022-23	Pooled mean	2021-22	2022-23	Pooled mean	2021-22	2022-23	Pooled mean
integrated nitrogen management (N)									
N_0	14.15	16.04	15.60	2.65	2.36	2.51	18.36	17.67	18.02
N_1	27.15	26.06	26.60	3.72	3.24	3.48	29.08	29.21	29.16
N_2	26.90	24.21	25.56	3.25	3.27	3.26	26.67	25.45	26.06
N_3	27.12	24.67	25.90	2.98	3.01	3.00	27.92	22.06	24.99
N_4	24.82	23.03	23.93	3.86	3.84	3.85	27.71	21.89	24.80
N_5	27.76	27.09	27.23	3.98	3.33	3.66	30.26	29.78	30.02
SE±	0.14	0.13	0.14	0.10	0.11	0.11	0.14	0.13	0.14
CD (P=0.05)	0.41	0.32	0.37	0.40	0.39	0.40	0.39	0.36	0.38
Mulching (M)									
M_0	24.35	23.04	23.25	2.99	2.78	2.89	25.98	23.67	24.83
M_1	30.44	31.26	30.85	3.44	3.92	3.68	26.65	25.78	26.22
M_2	24.57	23.27	23.92	3.71	3.34	3.53	27.73	27.98	27.86
SE±	0.20	0.19	0.20	0.20	0.21	0.21	0.19	0.17	0.18
CD (P=0.05)	0.57	0.49	0.53	0.50	0.47	0.49	0.55	0.61	0.58

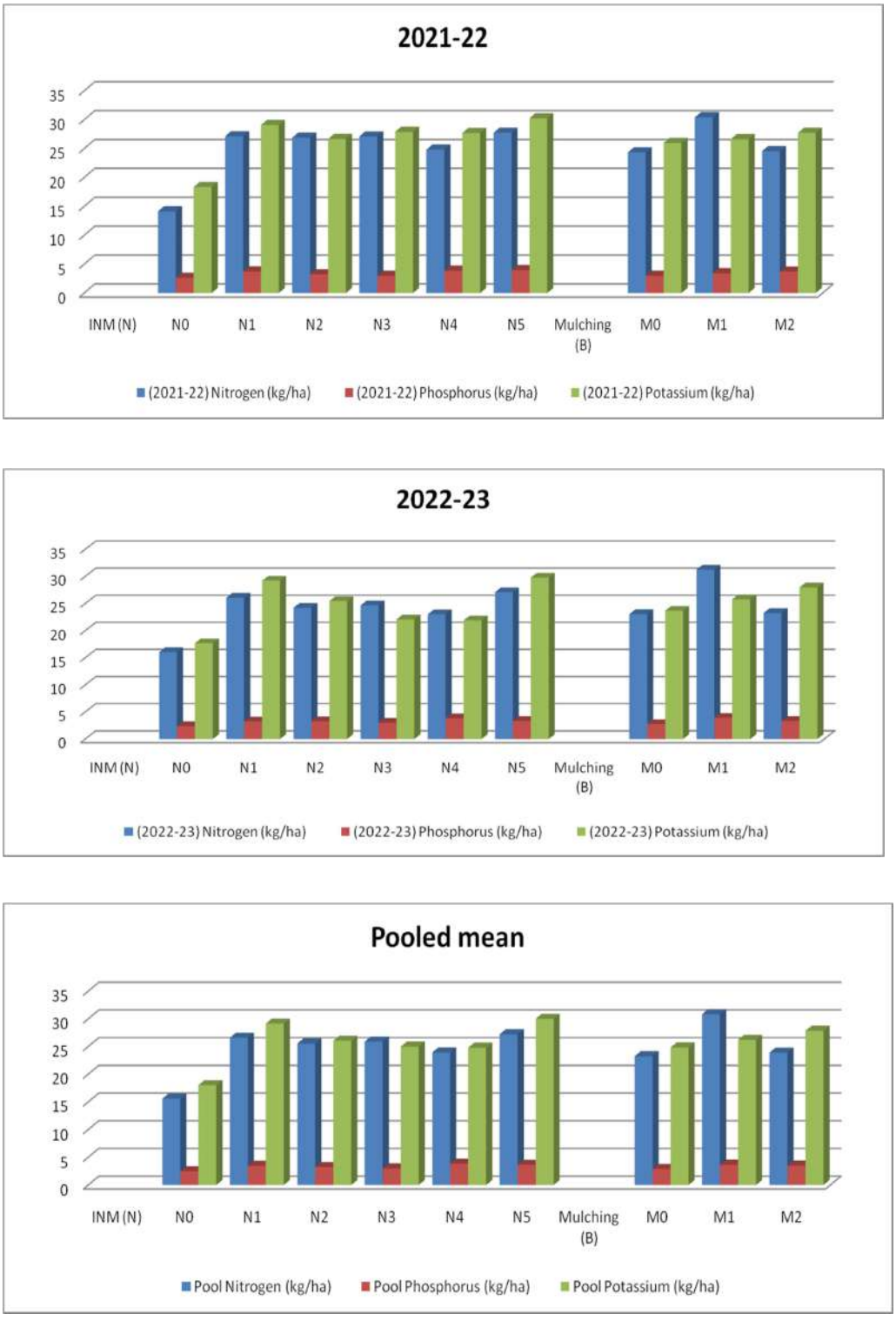


Fig 4.37 Response of integrated nitrogen management and mulching practices on nutrient uptake (kg ha^{-1})

4.3.6 Protein (%)

The data revealed to protein by broccoli plant as influenced by integrated nitrogen and mulching management is represented in tables 4.38, 4.39 and figures 4.38, 4.39.

The data confirmed that the protein content in integration of nitrogen management significantly influenced was maximum recorded in N_5: 50 % nitrogen with Urea & 50 % nitrogen from Poultry Manure i.e., 1.99, 1.69 and 1.81 (%) in 2021-22, 2022-23 and pooled mean and second highest recorded in N_1: 100 % N through urea i.e., 1.68, 1.52 and 1.61 (%) in 2021-22, 2022-23 and pooled mean respectively than other treatments of integrated nitrogen management and lowest observed in N_0 (Control) i.e., 0.99, 0.56 and 0.78 g in both years and pooled mean respectively.

Among the mulching treatment, maximum protein content was recorded in Black polythene mulch M_2 (Black polythene mulch) i.e., 1.56, 1.51 and 1.53 (%) in 2021-22, 2022-23 and pooled data respectively, followed by M_1 (Paddy straw mulch) i.e., 1.34, 1.47 and 1.40 (%) in 2021-22, 2022-23 and pooled mean, respectively but recorded lowest in M_0 (control) i.e., 1.02, 1.15 and 1.08 (%) in 2021-22, 2022-23 and pooled mean respectively.

Among the interaction highest protein was recorded in N_5M_1: 50 % nitrogen with Urea & 50 % nitrogen from Poultry Manure + Paddy straw mulch i.e., 2.01, 2.05 and 2.03 (%) 2021-22, 2022-23 and pooled mean respectively followed by N_2M_2: 50 % N through Urea + 50 % N through Cow dung + Black polythene mulch i.e., 1.83, 1.95 and 1.88 (%) 2021-22, 2022-23 and pooled mean respectively, while the minimum protein content in treatment combination N_0M_0 (Control) 1.02, 1.37 and 1.20 (%) 2021-22, 2022-23 and pooled mean respectively.

The maximum protein was recorded in N_5 might be due to fact that the application of chemical urea and organic manure, i.e., poultry manure and urea, the organic manure present in the soil, enhances microbial activity and helps to make available all essential macro and micro nutrient uptake by plant roots and the synthesis of nutritional factors like protein in plant or broccoli head (Shree *et al.* (2014).

Maximum protein content was found in M_2 black polythene mulch. This could be due to the fact that mulch provides a favorable environment to the plant by maintaining the optimum temperature mean (Punetha *et al.*, 2020).

Maximum protein content was found in treatment combination N_5M_1 incorporating nitrogenous fertilizer, i.e., urea and poultry manure with paddy straw mulch, which shows the highest protein content in broccoli heads by providing favorable soil root relations with organic matter at optimum temperature.

Table 4.38 Response of integrated nitrogen management and mulching practices on protein (%)

Treatment	Protein (%)		
	2021-22	2022-23	Pooled mean
integrated nitrogen management (N)			
N_0	0.99	0.56	0.78
N_1	1.68	1.52	1.61
N_2	1.29	1.49	1.39
N_3	1.48	1.34	1.41
N_4	1.10	1.47	1.39
N_5	1.99	1.69	1.81
SE±	0.09	0.02	0.05
CD (P=0.05)	0.10	0.07	0.12
Mulching (M)			
M_0	1.02	1.15	1.08
M_1	1.34	1.47	1.40
M_2	1.56	1.51	1.53
SE±	0.02	0.04	0.03
CD (P=0.05)	0.09	0.06	0.08

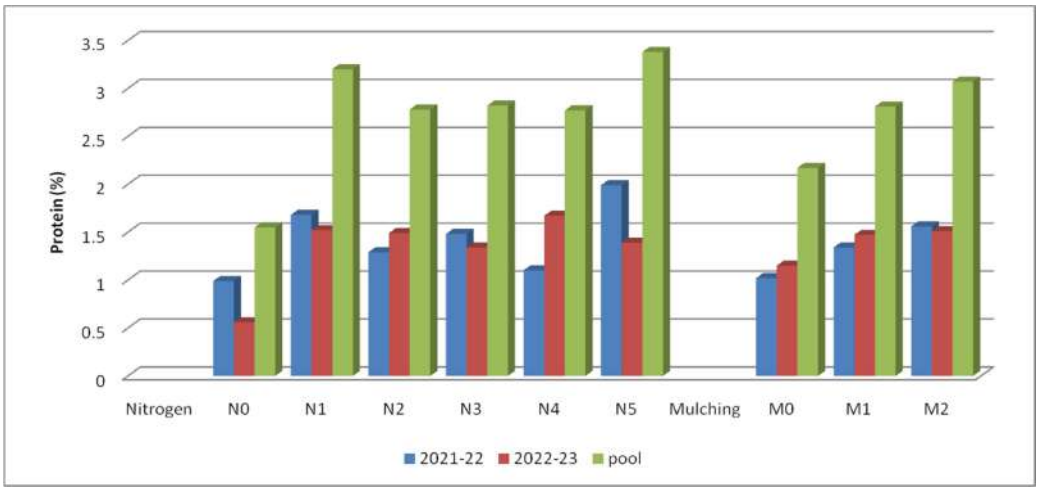


Fig 4.38 Response of integrated nitrogen management and mulching practices on Protein (%)

Table 4.39 Combined effect of integrated nitrogen management and mulching practices on Protein (%)

Protein (%)			
Treatment	**2021-22**	**2022-23**	**Pooled mean**
N_0M_0	1.02	1.37	1.20
N_0M_1	1.11	1.39	1.25
N_0M_2	1.13	1.47	1.30
N_1M_0	1.45	1.54	1.50
N_1M_1	1.23	1.38	1.31
N_1M_2	1.19	1.58	1.39
N_2M_0	1.56	1.32	1.44
N_2M_1	1.38	1.52	1.45
N_2M_2	1.83	1.95	1.88
N_3M_0	1.38	1.40	1.39
N_3M_1	1.53	1.33	1.46
N_3M_2	1.38	1.32	1.35
N_4M_0	1.82	0.85	1.34
N_4M_1	1.69	1.30	1.49
N_4M_2	1.09	1.19	1.15
N_5M_0	1.59	1.41	1.50
N_5M_1	2.01	2.05	2.03
N_5M_2	1.54	1.76	1.65
SE±	0.03	0.08	0.07
CD (P=0.05)	0.13	0.12	0.11

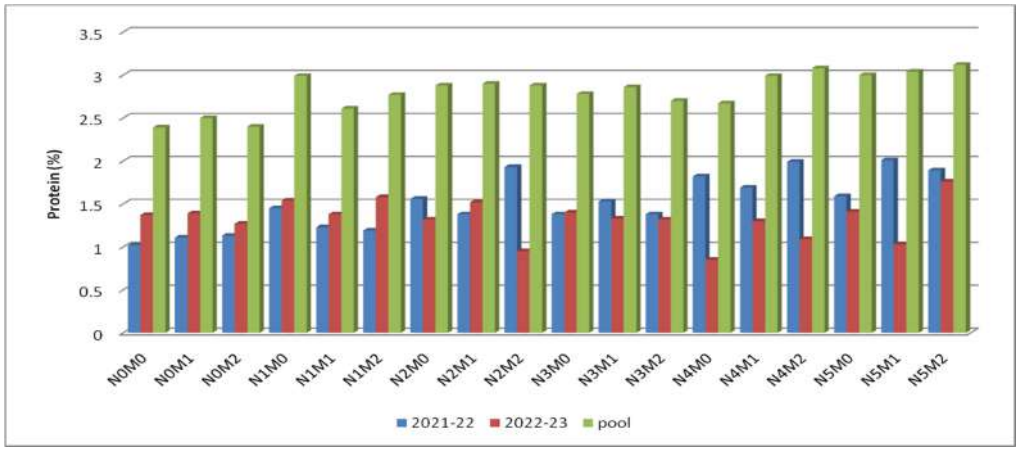


Fig 4.39 Integrated effect of nitrogen management and mulching practices on protein (%)

4.3.7 Ascorbic acid (mg/100g)

The data reported of ascorbic acid by broccoli plant as affected by integrated nitrogen and mulching management is presented in tables 4.40 and figures 4.40.

The data confirmed that the ascorbic acid in integration of nitrogen management significantly influenced was recorded maximum in N_5: 50 % nitrogen with Urea & 50 % nitrogen from Poultry Manure i.e., 78.94, 78.88 and 78.92 mg/100g in 2021-22, 2022-23 and pooled mean and second highest recorded in N_1: 100 % N through Urea i.e., 77.78, 77.46 and 77.62 mg/100g in 2021-22, 2022-23 and pooled mean respectively, while the least values were observed in N_0 (Control) i.e., 75.34, 74.68 and 75.01 mg/100g in 2021-22, 2022-23 and pooled mean respectively.

Among the mulching treatment, maximum ascorbic acid in M_2 (Black polythene mulch) i.e., 79.12, 79.23 and 79.17 mg/100g in 2021-22, 2022-23 and pooled data respectively, followed by Paddy straw mulch (M_1) i.e., 78.49, 77.89 and 78.19 mg/100g in 2021-22, 2022-23 and pooled mean, respectively but recorded lowest in M_0 (control) i.e., 77.03, 76.93 and 76.98 mg/100g in 2021-22, 2022-23 and pooled mean respectively.

The highest ascorbic acid was observed in N_5 could be due to the use of urea and poultry manure increases organic manure in the soil, which helps to make all essential macro and micronutrient uptake by plant roots and the synthesis of nutritional factors like protein in broccoli head available (Shree *et al.*, 2014).

Maximum ascorbic acid was found in M_2 could be due to the black polythene mulch provides a favorable environment to the plant by maintaining the optimum temperature mean and facilitates the weed-free zone with a good C: N ratio by which plants maintain their metabolism, which helps to synthesize ascorbic acid in broccoli heads (Saloom and AL-Sahaf 2016).

Table 4.40 Response of integrated nitrogen management and mulching practices on ascorbic acid (mg/100g) of broccoli

Treatment	Ascorbic acid (mg/100 g)		
	2021-22	2022-23	Pooled mean
integrated nitrogen management (N)			
N_0	75.34	74.68	75.01
N_1	77.78	77.46	77.62
N_2	76.03	76.23	76.13
N_3	75.98	75.23	75.60
N_4	76.67	76.89	76.78
N_5	78.94	78.88	78.92
SE±	0.33	0.34	0.33
CD (P=0.05)	0.75	1.01	0.77
Mulching (M)			
M_0	77.03	76.93	76.98
M_1	78.49	77.89	78.19
M_2	79.12	79.23	79.17
SE±	0.37	0.33	0.35
CD (P=0.05)	1.03	0.99	1.01

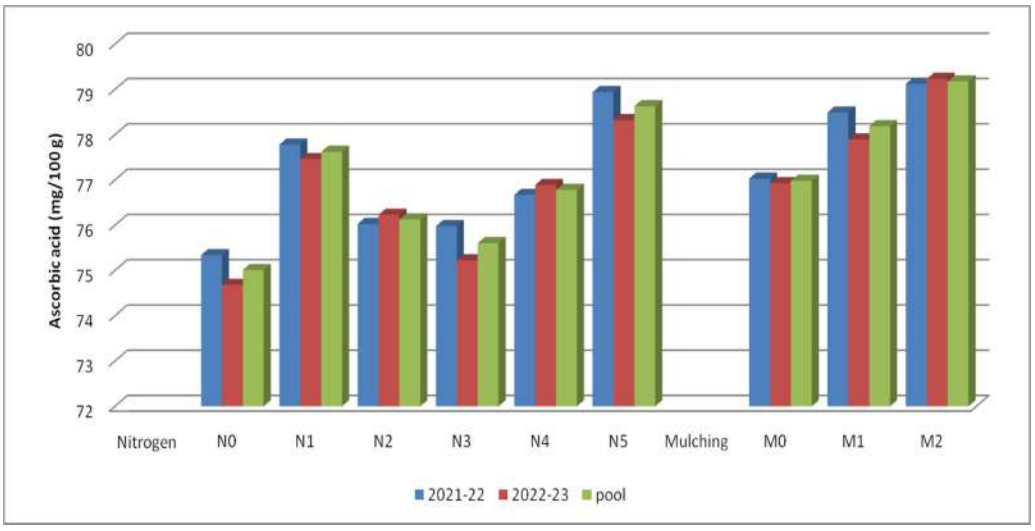


Fig 4.40 Response of integrated nitrogen management and mulching practices on ascorbic acid (mg/100g)

4.3.8 Total sugar, Reducing, Non-reducing (%)

The data regarding the reducing, non-reducing, total sugar by broccoli plant as affected by integrated nitrogen and mulching management is presented in tables 4.41 and figures 4.41.

Reducing sugar (%): The maximum reducing sugar was found in N_5: 50 % nitrogen with Urea & 50 % nitrogen from Poultry Manure i.e., 3.38, 3.54 and 3.43 % in 2021-22, 2022-23 and pooled mean respectively, followed by N_1: 100% urea i.e., 2.30, 2.34 and 2.32 % in 2021-22, 2022-23 and pooled mean respectively and lowest values were recorded in N_0 (control) i.e., 2.09, 2.11 and 2.10 % in 2021-22, 2022-23 and pooled mean respectively.

Among the mulching treatment, maximum reducing sugar was recorded in M_2 (Black polythene mulch) i.e., 3.34, 3.38 and 3.36 % in 2021-22, 2022-23 and pooled data respectively, followed by Paddy straw mulch (M_1) i.e., 2.29 2.32 and 2.30 % in 2021-22, 2022-23 and pooled mean, respectively, while the least reducing sugar in M_0 (control) i.e., 2.27, 2.03 and 2.17 % in 2021-22, 2022-23 and pooled mean respectively.

The combined effect of mulching and integrated nitrogen management was found to be non-significant in reducing the sugar content of broccoli.

Non-Reducing sugar (%): The maximum non reducing sugar was obtained in N_5: 50 % nitrogen with Urea & 50 % nitrogen from Poultry Manure i.e., 0.99, 0.93 % and 0.95 % 2021-22, 2022-23 and pooled mean respectively, followed by N_1: 100% N through urea i.e., 0.90, 0.76 and 0.83 % in 2021-22, 2022-23 and pooled mean respectively, while the low values recorded in N_0 (control) i.e., 0.59, 0.61 and 0.60 % in 2021-22, 2022-23 and pooled mean respectively. The near resulted were reported by Choudhary *et al.* (2012).

Among the mulching treatment, maximum non-reducing sugar was observed in M_2 (Black polythene mulch) i.e., 0.78, 0.65 and 0.71 % in 2021-22, 2022-23 and pooled data respectively, followed by Paddy straw mulch (M_1) i.e., 0.64, 0.62 and 0.63 % in 2021-22, 2022-23 and pooled mean, respectively, while the low values obtained in M_0

(control) i.e., 0.62, 0.56 and 0.59 % in 2021-22, 2022-23 and pooled mean respectively.

The combined effect between integrated nitrogen and mulching was obtained non significant for non-reducing sugar in broccoli.

Total sugar (%): The data confirmed that the integration of nitrogen management significantly influenced the total sugar in N_5: 50 % nitrogen with Urea & 50 % nitrogen from Poultry Manure i.e., 3.99, 4.01 and 4.0 % in 2021-22, 2022-23 and pooled mean respectively, followed by N_1: 100 % N through Urea i.e., 3.89, 3.65 and 3.76 % in 2021-22, 2022-23 and pooled mean respectively, while the lowest value were recorded in N_0 (control) i.e., 2.99, 2.87 and 2.93 % in 2021-22, 2022-23 and pooled mean respectively.

Among the mulching treatment, maximum total sugar content in M_2 (Black polythene mulch) i.e., 3.91, 3.99 and 3.95 % in 2021-22, 2022-23 and pooled data respectively, followed by Paddy straw mulch (M_1) i.e., 3.69, 3.65 and 3.67 % in 2021-22, 2022-23 and pooled mean respectively, while the least data observed in M_0 (Control) i.e., 3.59, 3.51 and 3.54 % in 2021-22, 2022-23 and pooled mean respectively.

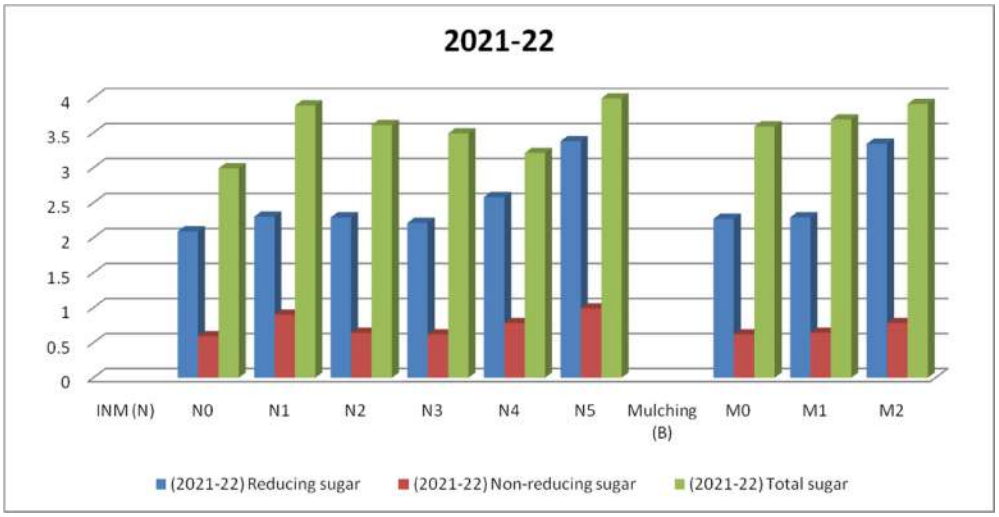
The combined of mulching and integrated nitrogen was recorded non significant for total sugar in broccoli.

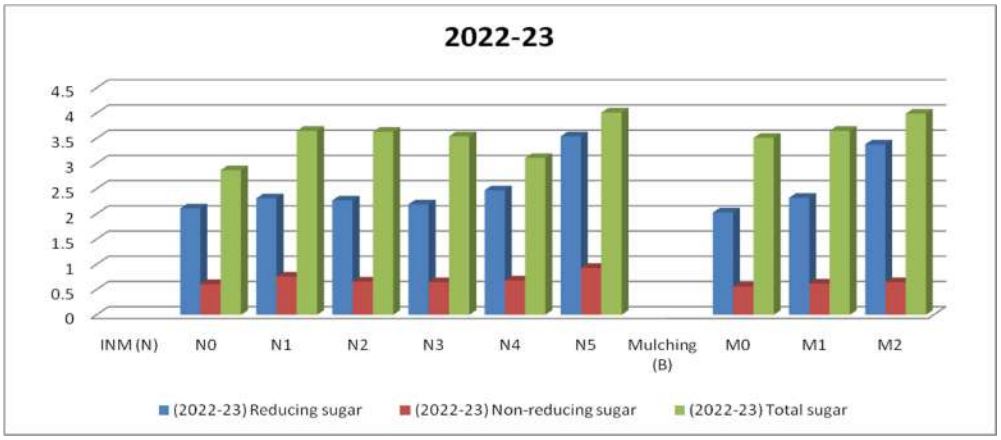
The highest sugar was recorded in N_5 could be due to the fact that the enhancements in sugar content is due to the accelerate activity of nitrate reductase, which is responsible for the synthesis of sugar and better nutrition, increased photosynthetic activity, improved root environment and better food deposit accumulation in edible sections could all be contributing factors to enhance sugar content in broccoli head (Healy *et al.*, 2017).

Maximum sugar was found in M_2 could be due to the black polythene mulch maintains the soil macro and microflora, which helps to increase the organic matter and helps plants to grow in high nutrient uptake and weed-free zones (Kosterna *et al*., 2014).

Table 4.41 Response of integrated nitrogen management and mulching practices on Reducing, non-reducing, total sugar (%) of broccoli

Treatment	Reducing sugar			Non-reducing sugar			Total sugar		
	2021-22	2022-23	Pooled mean	2021-22	2022-23	Pooled mean	2021-22	2022-23	Pooled mean
Integrated nitrogen management (N)									
N_0	2.09	2.11	2.10	0.59	0.61	0.60	2.99	2.87	2.93
N_1	2.30	2.34	2.32	0.90	0.76	0.83	3.89	3.65	3.76
N_2	2.29	2.27	2.28	0.64	0.66	0.65	3.61	3.63	3.62
N_3	2.21	2.19	2.20	0.62	0.65	0.64	3.49	3.54	3.53
N_4	2.58	2.47	2.52	0.78	0.68	0.73	3.21	3.11	3.16
N_5	3.38	3.54	3.43	0.99	0.93	0.95	3.99	4.01	4.00
SE±	0.17	0.12	0.15	0.05	0.03	0.04	0.08	0.11	0.10
CD (P=0.05)	0.49	0.45	0.47	0.11	0.09	0.10	0.37	0.31	0.34
Mulching (M)									
M_0	2.27	2.03	2.17	0.62	0.56	0.59	3.59	3.51	3.54
M_1	2.29	2.32	2.30	0.64	0.62	0.63	3.69	3.65	3.67
M_2	3.34	3.38	3.36	0.78	0.65	0.71	3.91	3.99	3.95
SE±	0.17	0.19	0.18	0.07	0.04	0.06	0.15	0.19	0.17
CD (P=0.05)	0.51	0.55	0.53	0.16	0.19	0.18	0.42	0.47	0.45





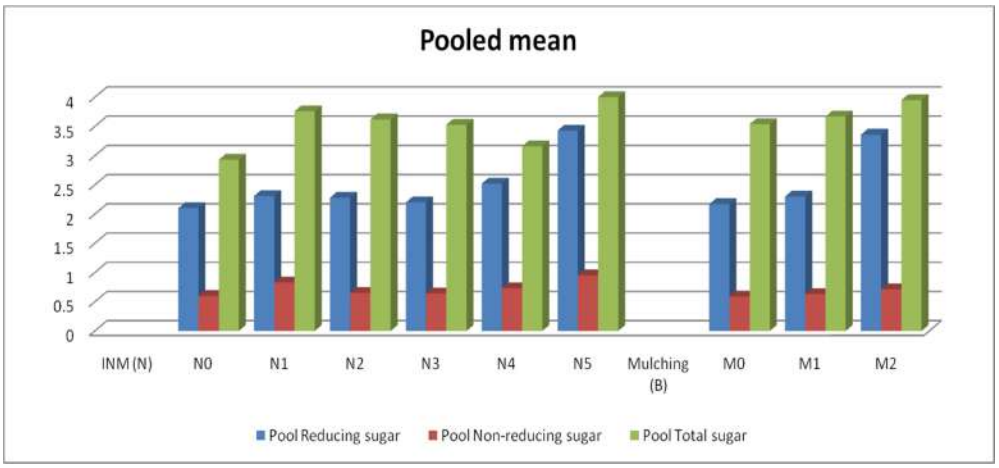


Fig 4.41 Response of integrated nitrogen management and mulching practices on Reducing, non-reducing, total sugar (%)

4.3.9 Sulforaphane (µg/g dry matter)

The data noticed for sulforaphane by broccoli plant as affected by integrated nitrogen and mulching management is presented in tables 4.42 and figures 4.42.

The data confirmed that the sulforaphane in integration of nitrogen management significantly influenced maximum was recorded in N_5: 50 % nitrogen with Urea & 50 % nitrogen from Poultry Manure i.e., 633.29, 633.78 and 633.54 µg/g dry matter in 2021-22, 2022-23 and pooled mean respectively and second highest recorded in N_4: 50 % N through urea and 50 %N through vermicompost i.e., 631.38, 630.28 and 630.83 µg/g dry matter in 2021-22, 2022-23 and pooled mean respectively, while the minimum readings were recorded in N_3: 50 percent nitrogen with urea + 50 percent nitrogen with FYM i.e., 518.30, 516.60 and 517.45 µg/g dry matter in 2021-22, 2022-23 and dry matter and pooled mean respectively.

Among the mulching treatment, maximum sulforaphane in M_1 (Paddy straw mulch) i.e., 643.23, 643.20 and 643.21 µg/g dry matter in 2021-22, 2022-23 and pooled data respectively, followed by M_2 (Black polythene mulch) i.e., 623.55, 624.38 and 623.97 µg/g dry matter in 2021-22, 2022-23 and pooled mean respectively, while the lowest values recorded in M_0 (control) i.e., 593.61, 592.69 and 593.15 µg/g dry matter in 2021-22, 2022-23 and pooled mean respectively.

The combined of mulching and integrated nitrogen was observed non-significant for sulforaphane in broccoli.

The maximum Sulforaphane was recorded in N_5. This could be because the application of poultry manure along with urea organic manure release sufficient nutrients by the constant mineralization activity and is also rich in sulfur, which makes it available for active absorption of nutrient by root, resulting in maximum accumulation of sulfur compound, which convert into precursor, i.e., glucoraphanin then it converts into Sulforaphane that helps synthesizes sulfur content in broccoli.
Maximum Sulforaphane was found in M_1. This might be due to the fact that paddy straw mulch enhances the C: N ratio of the soil, which is responsible for the rapid growth of soil microorganisms and helps make all the essential nutrients available to the plant, resulting in Sulforaphane accumulation in broccoli.

Table 4.42 Response of integrated nitrogen management and mulching practices on Sulforaphane (µg/g dry matter)

Treatment	Sulforaphane (µg/g dry matter)		
	2021-22	2022-23	Pooled mean
integrated nitrogen management (N)			
N_0	538.10	537.30	537.70
N_1	542.90	546.30	544.60
N_2	564.10	564.40	564.25
N_3	518.30	516.60	517.45
N_4	631.38	630.28	630.83
N_5	633.29	633.78	633.54
SE±	0.48	0.46	0.47
CD (P=0.05)	1.68	1.34	1.51
Mulching (M)			
M_0	593.61	592.69	593.15
M_1	643.23	643.20	643.22
M_2	623.55	624.38	623.97
SE±	0.57	0.61	0.59
CD (P=0.05)	1.22	1.28	1.25

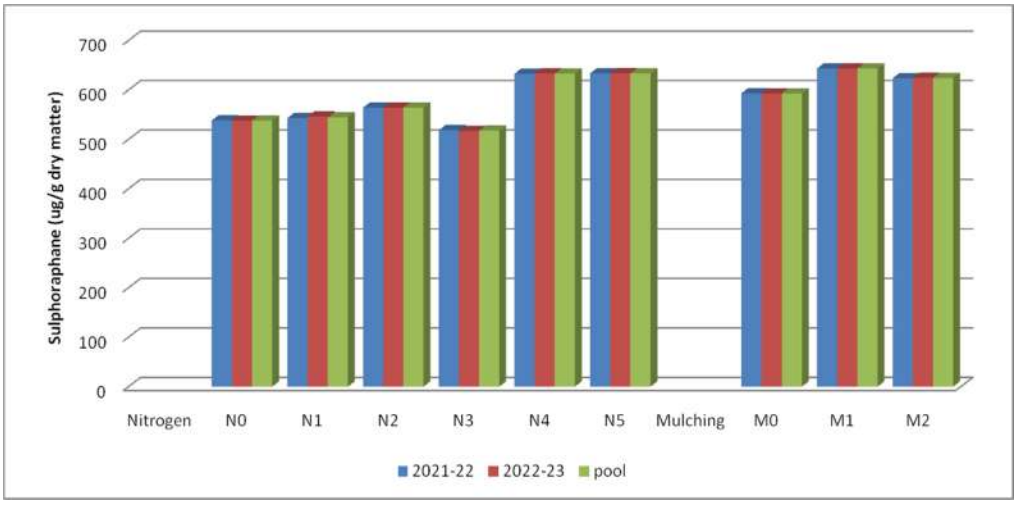


Fig 4.42 Response of integrated nitrogen management and mulching practices on Sulforaphane (µg/g drymatter)

4.4 Effect of integrated nitrogen management and mulching practices on economy of broccoli

Data depicted in Table 4.43 the economics of broccoli cultivation i.e., Benefit cost ratio (B:C), Gross monetary returns (/ha), Net monetary returns (/ha), Total cost of cultivation (/ha), during both the year of the study (2021-22 and 2022-23) were significantly affected with integrated nitrogen management and mulching practices as well as with their interaction.

4.4.1 Total cost of cultivation (/ha)

The combined effect of mulching and integrated nitrogen management practices denoted significant influence on economy of broccoli. The minimum total cost of cultivation found in N_0M_0 (control) i.e., 80740, (/ha), while the maximum total cost of cultivation found N_3M_2; 50 % N through Urea + 50 % N through FYM + Black polythene mulch i.e., 147898 (/ha).

The least cost of cultivation recorded in N_0M_0 (control). The enhancement in broccoli yield might be attributed to the absence of nitrogenous fertilizer application and mulches leading to decreases the input cost, on the other hand the application of bulk quantities of FYM along with black polythene mulch led to the increased in the input cost resulting to maximum cost of cultivation in the treatment N_3M_2. The similar finding reported by Maurya *et al.* (2008)

4.4.2 Gross monetary returns (/ha)

Among the treatment combination the superior gross monetary returns (ha^{-1}) was recorded in treatment combinations, N_5M_2: 50 % nitrogen with Urea & 50 % nitrogen from Poultry Manures + Black Polythene mulch was found to have total cost of cultivation i.e., 473261, 536629 and 538749 (ha^{-1}) in 2021-22, 2022-23 and pooled mean respectively. It was significantly superior over combination N_1M_2: 100 % N through Urea + Black polythene mulch i.e., 467467, 521221 and 527756 (ha^{-1}) in 2021-22, 2022-23 and pooled mean respectively, while the low gross monetary recorded in treatment combinations N_0M_0 (control) i.e., 244640, 272058 and 275823 (ha^{-1}) in 2021-22, 2022-23 and pooled mean respectively. The similar findings were recorded by Shree *et al.* (2014).

The maximum gross monetary return found in N_5M_2 might be due to the effect of urea and poultry manure along with black polythene mulch responses better in terms of obtaining maximum yield with good quality attributes, which gives maximum out, which ultimately raises the gross monetary returns, while the minimum gross monetary return found in N_0M_0 (control) this might be due to in control treatment no input of any fertilizer and input applied. These similar findings were reported by Chaterjee *et al*. (2005)

4.4.3 Net monetary returns (/ha)

Among the combination the superior net monetary returns (ha^{-1}) was recorded in treatment combinations, N_5M_2: 50 % nitrogen with Urea & 50 % nitrogen from Poultry Manure s + Black polythene mulch i.e., 376029, 439397 and 441517 (ha^{-1}) in 2021-22, 2022-23 and pooled mean respectively. It was found significantly superior over combination N_1M_2: 100 % N through Urea + Black polythene mulch i.e., 370322, 424076 and 430611 (ha^{-1}) in 2021-22, 2022-23 and pooled mean respectively, while the minimum net monetary returns in treatment combinations N_0M_0: control i.e., 163900, 191318 and 195083 (ha^{-1}) in 2021-22, 2022-23 and pooled mean respectively.

The maximum net monitory return was recorded in N_5M_2, might be due to applying 50 % nitrogen with Urea & 50 % nitrogen from Poultry Manure + Black polythene mulch, providing favourable environments to the plant, resulting in proper growth and good quality edible head obtained; higher yield leads to high profit. The minimum net monetary return observed in N_0M_0 (control) could be due to the no application of urea and fertilizers, which reduces the net return. Similar findings were recorded by Parmar and Sharma (2000)

4.4.4. Benefit cost ratio (B: C)

Among all the given treatments the maximum benefit cost ratio (B: C) was obtained in treatment combinations, N_5M_2: 50 % nitrogen with Urea & 50 % nitrogen from Poultry Manures + Black polythene mulch i.e., 3.87, 4.52 and 4.54 in 2021-22, 2022-23 and pooled mean respectively. It was significantly superior over combination N_4M_2: 50 % N through Urea + 50 % N through Vermicompost + Black polythene

mulch i.e., 3.85, 4.47 and 4.51 in 2021-22, 2022-23 and pooled mean respectively, whereas the least total cost of cultivation observed in combinations N_3M_1: 50 percent N by Urea + 50 percent nitrogen through FYM + Paddy straw mulch i.e., 1.30, 1.60 and 1.62 in 2021-22, 2022-23 and pooled mean respectively.

The highest benefit cost of cultivation was recorded in N_5M_2 could be due to the application of 50 % nitrogen with Urea & 50 % nitrogen from Poultry Manure + Black polythene mulch, nitrogen is an essential macro nutrient responsible for vegetative growth of the plant with good quality where the paddy straw mulch provide favourable soil root environment which resulted high yield obtained which leads high profitability (Parmar and Sharma 2000).

Table 4.43 Effect of integrated nitrogen management and mulching practices on economics of broccoli

Treatment	Total cost of cultivation			Gross monetary returns			Net monetary returns			Benefit cost ratio		
	2021-22	2022-23	pool	2021-22	2022-23	pool	2021-22	2022-23	pool	2021-22	2022-23	pool
N_0M_0	80740	80740	80740	244640	272058	275823	163900	191318	195083	2.03	2.37	2.42
N_0M_1	94202	94202	94202	283430	316377	320142	189228	222175	225940	2.01	2.36	2.40
N_0M_2	83451	83451	83451	295121	329794	333559	211670	246343	250108	2.54	2.95	3.00
N_1M_0	85400	85400	85400	405815	449333	318065	320415	363933	323860	3.75	4.26	3.79
N_1M_1	97962	97962	97962	459136	517196	520961	361174	419234	422999	3.69	4.28	4.32
N_1M_2	97145	97145	97145	467467	521221	527756	370322	424076	430611	3.81	4.37	4.43
N_2M_0	110456	110456	110456	406421	456950	460716	295965	346494	350260	2.68	3.14	3.17
N_2M_1	123916	123916	123916	445010	501096	504861	321094	377180	380945	2.59	3.04	3.07
N_2M_2	112384	112384	112384	351850	394584	398349	239466	282200	285965	2.13	2.51	2.54
N_3M_0	145970	145970	145970	376087	422283	426048	230117	276313	280078	1.58	1.89	1.92
N_3M_1	139432	139432	139432	323864	362600	366365	184432	223168	226933	1.30	1.60	1.62
N_3M_2	147898	147898	147898	442738	506030	506030	294840	358132	358132	1.99	2.42	2.42
N_4M_0	119400	119400	119400	407595	472142	468982	288195	352742	349582	2.41	2.95	2.93
N_4M_1	132862	132862	132862	337687	378397	382162	204825	245535	249300	1.54	1.85	1.88
N_4M_2	91231	91231	91231	442738	498932	502697	351507	407701	411466	3.85	4.47	4.51
N_5M_0	105304	105304	105304	460499	518754	522519	355195	413450	417215	3.37	3.92	3.96
N_5M_1	108766	108766	108766	431301	485385	489151	322535	376619	380385	2.97	3.46	3.50
N_5M_2	97232	97232	97232	473261	536629	538749	376029	439397	441517	3.87	4.52	4.54

Plate 1 Nursery raising

Nursery raising (manual irrigation)

Irrigation by sprinkler

Hardening off of seedling

Plate 2 Field preparations and transplanting

	
Spreading of black polythene mulch	**Transplanting**


Overview of experimental field

Plate 3 Intercultural operation on different crop stages.

	
Mulch application	**Plant protection practices**

Irrigation

Plate 4 Treatment with the best result

Treatment with the best result: N_5M_2

CHAPTER V

SUMMARY AND CONCLUSION

The research entitled **"Effect of integrated nitrogen management and mulching on sprouting broccoli [*Brassica oleracea* var. *italic*a]"** was laid out at research field of Lovely Professional University, phagawara, Punjab, during 2021-22 and 2022-23. Six organic and inorganic nitrogenous sources viz., **N_0:** 0 percent N, **N_1:** 100 percent N through Urea, **N_2:** 50 percent N through Urea + 50 percent N through Cowdung, **N_3:** 50 percent N through Urea + 50 percent N through FYM, **N_4:** 50 percent N through Urea + 50 percent N through Vermicompost, **N_5:** 50 percent N through Urea + 50 percent N through Poultry manure and mulches i.e., **M_0** Without mulch (Control), **M_1 (**Paddy Straw mulch) and **M_2** (Black Polythene mulch) were taken under study and significant response was found for the growth yield attributes and quality attributes of broccoli. The results recorded in the present experiment are summarized below

- The plant heights at 15, 30, 45 and at harvest were found significant by various treatments of nitrogen mulch and their interaction. The highest plant height was observed all respective growth stages in treatment N_5M_2: 50 % nitrogen with Urea and 50 % nitrogen from Poultry Manure + Black Polythene mulch than other treatments, while the minimum plant height at all respective growth stages was found in N_0M_0 (control) during two years.
- The no. of leaves at 15, 30, 45 DAT and at harvest was observed to have increased significantly by different treatments of integrated nitrogen management and their interaction. The highest number of leaves was found in the treatment in N_5M_2 compared to other treatments, whereas the minimum number of leaves was found in N_0M_0 (Control) in irrespective of growth stages.
- Leaf length at 15, 30, 45 and at harvest were found to increased significantly by various treatment of integrated nitrogen management and their interaction. The maximum leaf length was found in N_5M_2 then the other treatments, while the least leaf length was found in N_0M_0 (control) during both years irrespective of growth stage.
- Leaf areas at 15, 30, 45 and at harvest were found to increased significantly by

different treatment of integrated nitrogen management and their interaction. The maximum leaf area was found in treatment in N_5M_2 then the other treatments, while the minimum leaf area recorded in N0M0 (control) during both the years irrespective growth stage.

- Plant spread at 15, 30, 45 and at harvest was increased significantly by different treatment of integrated nitrogen management mulches and interaction. The highest plant spread was found in N_5M_2 then the other treatments, while the least plant spread was reported in N_0M_0 (control) during both the years irrespective growth stages.
- The girth of stem at 15, 30, 45 and harvest was found to increased significantly by different treatment of integrated nitrogen management and mulches and their interaction. The maximum girth of the stem was found in N_5M_2 than the other applied treatment combinations, while the least girth of the stem was found in N_0M_0 (control) during both the years irrespective growth stages.
- The days required for head initiation was recorded to increased significantly by different treatment of integrated nitrogen management and mulches and their combination the least days required for head initiations was recorded in treatment N_5M_2 than other treatments, while the highest days required for head initiation recorded in N_0M_0 (control) during both the years.
- The days required for 50 % head initiation showed significant result with different treatment of integrated nitrogen management and mulches and their interaction the least days to 50 % head initiation had been observed in treatment N_5M_2 than other treatments, while the maximum days required for 50 % head initiation recorded in N_0M_0 (control) during both the years.
- The days required to 100 % head initiation were observed to increased significantly by different treatment of combined nitrogen mulches and their combination the least days to 100 % head initiation had been observed in treatment N_5M_2 than other treatments, while the highest days required for head initiation recorded in N_0M_0 (control) during both the years.
- The harvesting duration was found to increased significantly by different treatment of integrated nitrogen management and mulches and their interaction the maximum harvesting duration observed in treatment N_5M_2 than other

treatments, while the least harvesting duration was found in N_0M_0 (control) during both the years.

- The highest head size was found significantly increased by different treatment of integrated nitrogen management and mulches and their interaction. The head size recorded in treatment N_5M_2 than other treatments, while the least head size was found in (control) N_0M_0 during both the years.
- The highest head weight was found to increase significantly by different treatment of integrated nitrogen management and mulches and their interaction. The head weight treatment N_5M_2 than other treatments, while the least head weight was reported in N_0M_0 (control) during both the years.
- The highest head yield (kg/plot) was found to increased significantly by different treatment of integrated nitrogen management and mulches and their interaction. The head yield recorded in treatment N_5M_2 than other treatments, while the least head yield (kg/plot) was found in N_0M_0 (control) during both the years.
- The highest head yield (q/ha) was increased significantly by different treatment of integrated nitrogen management and mulches and their interaction. The head yield affected by treatment combination N_5M_2 than other treatments, while the least head yield (q/ha) was reported in N_0M_0 (control) during both the years.
- The maximum harvesting index percent was increased significantly by various treatments of integrated nitrogen management and mulches and their interaction. The harvesting index (%) was recorded in treatment N_5M_2 then other given treatment, while the least harvesting index was found in N_0M_0 (control) during both the years.
- The highest dry matter (%) was increased significantly by different treatment ofintegrated nitrogen management and mulches and their interaction. The dry matter content (%) was recorded in treatment N_1M_2 then rest of treatment, while the least dry matter content (%) was reported in N_0M_0 (control) during two years of study.
- TSS (°B) was recorded non significant with various treatment of combined nitrogen management and mulches and their interaction.
- The highest total chlorophyll (mg/g) was increased significantly by different treatment of integrated nitrogen management and mulches and their

interaction. The chlorophyllcontent (mg/g) in treatment N_3M_2: 50 % N through Urea + 50 % N through FYM + Black polythene mulch then rest of treatment, while the minimum chlorophyll content (mg/g) was found in N_0M_0 (control) during two years of study.

- The uptake of nutrients (kg/ha) was observed non significant with different treatment of integrated nitrogen management and mulches and their interaction.
- The maximum protein (%) was increased significantly by different treatment of integrated nitrogen management and mulches and their interaction. The protein (%) was observed in the treatment combination: N_5M_1: 50 % nitrogen with Urea 50% % nitrogen from Poultry Manure + Paddy straw mulch then rest of treatment, while the least protein (%) was found in N_0M_0 (control) during both the years.
- The ascorbic acid (mg/100g) was found no significantly by different treatment of integrated nitrogen management and mulches and their interaction.
- The total, reducing and non-reducing sugar were recorded to be non significant by various treatments of integrated nitrogen management and mulches and their combination.
- The Sulforaphane (ug/g dry matter) was observed to be non significant by different treatments of integrated nitrogen mulches and their interaction.
- The total cost of cultivation (ha^{-1}) was found significant with different treatment of integrated nitrogen management and mulches and their interaction. The minimum total cost of cultivation (ha^{-1}) was observed in treatment N_0M_0 (control) then rest of treatment, while the maximum total cost of cultivation (ha^{-1}) was recorded in N_5M_2: 50% N through Urea + 50% N through poultry manure + Black Polythene mulch during both the years.
- The gross monetary returns (ha^{-1}) was significant with different treatment of integrated nitrogen management and mulches and their interaction. The gross monetary returns (ha^{-1}) was recorded in treatment N_5M_2 then rest of treatment, while the minimum gross monetary returns (ha^{-1}) was recorded in N_0M_0 (control) during both the years.
- The net monetary returns (ha^{-1}) was found significant with different treatment of integrated nitrogen management and mulches and their

interaction. The total net monetary returns (ha^{-1}) was recorded in treatment N_5M_2 then rest of treatment, while the minimum net monetary returns (ha^{-1}) was found in N_0M_0 (control) during both the years.

- The B:C ratio was found significant with different treatment of integrated nitrogen management and mulches and their interaction. The benefit cost ratio (B:C) was recorded in N_5M_2 then rest of treatment, while the least benefit cost ratio (B:C) was observed in N_3M_1 during both the years.

Conclusion

Based upon the results recorded in the experiment, it was found that the treatment N_5M_2: 50 % nitrogen with Urea and 50 % nitrogen from Poultry Manure + Black polythene mulch was recorded as the best treatment concerning growth and yield attributing characters in broccoli cv. Palam Samridhi. Whereas, in terms of quality parameters of broccoli *viz*., protein (%) was found highest in treatment N_5M_1, highest chlorophyll content (mg/g) in N_3M_2 and maximum dry matter (%) in N_1M_2 the highest benefit-cost ratio (B: C) was recorded in the treatment N_5M_2. Thus, it can be concluded that the combined application of 50 % nitrogen with Urea and 50 % nitrogen from Poultry Manure + Black polythene mulch is worth recommendable to fetch maximum yield and net returns ha^{-1} from sprouting broccoli for Punjab region.

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APPENDICES

TREATMENT 1 (N_0M_0)						
S.No	**Item**	**Unit**		**Input/ha**	**Cost/Unit of input(Rs)**	**Total cost/ha(Rs)**
1	**2**	**3**		**4**	**5**	**6**
1	**Hired Human Labour**					
	Land preparation	Male	Day	36	300	10800
	Weeding	Male	Day	40	300	12000
	Transplanting cost	Male	Day	30	300	9000
	Fertilizer application	Male	Day	40	300	12000
	Harvesting (3)	Male	Day	15	300	4500
2	Machine Charges	Male	Hours	5	400	2000
3	Nursery Raising	Seed Cost	g	500	3.4	1700
		Protray		380	15	5700
		Cocopeat	Kg	60	36	2160
		Perlite	Kg	12.5	25	300
		Vermicompost	Kg	40	10	400
		Vermiculite		12.5	35	450
4	Fertilizer	N	Kgs.	0	0	0
		P	Kgs.	80	30	2400
		K	Kgs.	60	36	2160
5	Irrigation Charges	(Rs)				1500
6	Incidental Charges	(Rs)				500
7	Repairing Charges	(Rs)				500
8	**Working Capital (1to 7)**	**(Rs)**				**68070**
9	Interest on working capital@6% annum (Rs)					2170
10	Depreciation In implements and Farm buildings	(Rs)				400
11	Land Revenue cess and taxes	(Rs)				100
12	**COST "A"(Items 9-11)**	**(Rs)**				**70740**
13	Rental Value of land	(Rs)	Months	2	5000	10000
14	**COST "B"(Items 12-13)**	(Rs)				**80740**

Broccoli rate = 35/kg

TREATMENT 2 (N_0M_1)						
S.No	**Item**	**Unit**		**Input/ha**	**Cost/Unit of input(Rs)**	**Total cost/ha(Rs)**
1	**2**	**3**		**4**	**5**	**6**
1	**Hired Human Labour**					
	Land preparation	Male	Day	36	300	10800
	Weeding	Male	Day	40	300	12000
	Transplanting cost	Male	Day	30	300	9000
	Fertilizer application	Male	Day	40	300	12000
	Harvesting (3)	Male	Day	15	300	4500
2	Machine Charges		Hours	5	400	2000
3	Nursery Raising	Seed Cost	g	500	3.4	1700
		Protray		380	15	5700
		Cocopeat	Kg	60	36	2160
		Perlite	Kg	12.5	25	300
		Vermicompost	Kg	40	10	400
		Vermiculite		12.5	35	450
4	Fertilizer	N	Kgs.	0	0	0
		P	Kgs.	80	30	2400
		K	Kgs.	60	36	2160
	Mulching	rice straw mulch	q	63.5	200	12700
5	Irrigation Charges	(Rs)				1500
6	Incidental Charges	(Rs)				500
7	Repairing Charges	(Rs)				500
8	**Working Capital (1to 7)**	**(Rs)**				**80770**
9	Interest on working capital@6% annum (Rs)					2932
10	Depreciation In implements and Farm buildings	(Rs)				400
11	Land Revenue cess and taxes	(Rs)				100
12	**COST "A"(Items 9-11)**	**(Rs)**				**84202**
13	Rental Value of land	(Rs)	Months	2	5000	10000
14	**COST "B"(Items 12-13)**	**(Rs)**				**94202**

TREATMENT 3 (N_0M_2)						
S.No	**Item**	**Unit**		**Input/ha**	**Cost/Unit of input(Rs)**	**Total cost/ha(Rs)**
1	**2**	**3**		**4**	**5**	**6**
1	**Hired Human Labour**					
	Land preparation	Male	Day	36	300	10800
	Weeding	Male	Day	0	0	0
	Transplanting cost	Male	Day	30	300	9000
	Fertilizer application	Male	Day	20	300	6000
	Harvesting (3)	Male	Day	15	300	4500
2	Machine Charges		Hours	2	400	800
3	Nursery Raising	Seed Cost	g	500	3.4	1700
		Protray		380	15	5700
		Cocopeat	Kg	60	36	2160
		Perlite	Kg	12.5	25	300
		Vermicompost	Kg	40	10	400
		Vermiculite		12.5	35	450
4	Fertilizer	N	Kgs.	130.5	6	783
		P	Kgs.	80	30	2400
		K	Kgs.	60	36	2160
	Mulching	black polythene mulch	meter	7880.5	2.5	19700
5	Irrigation Charges	(Rs)				800
6	Incidental Charges	(Rs)				500
7	Repairing Charges	(Rs)				500
8	**Working Capital (1to 7)**	**(Rs)**				**68653**
9	Interest on working capital@6% annum (Rs)					4298
10	Depreciation In implements and Farm buildings	(Rs)				400
11	Land Revenue cess and taxes	(Rs)				100
12	**COST "A"(Items 9-11)**	**(Rs)**				**73451**
13	Rental Value of land	(Rs)	Months	2	5000	10000
14	**COST "B"(Items 12-13)**	**(Rs)**				**83451**

TREATMENT 4 (N_1M_0)						
S.No	**Item**	**Unit**		**Input/ha**	**Cost/Unit of input(Rs)**	**Total cost/ha(Rs)**
1	**2**	**3**		**4**	**5**	**6**
1	**Hired Human Labour**					
	Land preparation	Male	Day	36	300	10800
	Weeding	Male	Day	45	300	13500
	Transplanting cost	Male	Day	30	300	9000
	Fertilizer application	Male	Day	45	300	13500
	Harvesting (3)	Male	Day	15	300	4500
2	Machine Charges		Hours	5	400	2000
3	Nursery Raising	Seed Cost	g	500	3.4	1700
		Protray		380	15	5700
		Cocopeat	Kg	60	36	2160
		Perlite	Kg	12.5	25	300
		Vermicompost	Kg	40	10	400
		Vermiculite		12.5	35	450
4	Fertilizer	N (Urea)	Kgs.	261	6	1566
		P	Kgs.	80	30	2400
		K	Kgs.	60	36	2160
5	Irrigation Charges	(Rs)				1500
6	Incidental Charges	(Rs)				500
7	Repairing Charges	(Rs)				500
8	**Working Capital (1to 7)**	**(Rs)**				**72636**
9	Interest on working capital@6% annum (Rs)					2264
10	Depreciation In implements and Farm buildings	(Rs)				400
11	Land Revenue cess and taxes	(Rs)				100
12	**COST "A"(Items 9-11)**	**(Rs)**				**75400**
13	Rental Value of land	(Rs)	Months	2	5000	10000
14	**COST "B"(Items 12-13)**	**(Rs)**				**85400**

Treatment 5 N_1M_1						
S.No.	**Item**	**Unit**		**Input/ ha**	**Cost/Unit of input(Rs)**	**Total cost/ha(Rs)**
1	**2**	**3**		**4**	**5**	**6**
1	**Hired Human Labour**					
	Land preparation	Male	Day	36	300	10800
	Weeding	Male	Day	42	300	12600
	Transplanting cost	Male	Day	30	300	9000
	Fertilizer application	Male	Day	45	300	13500
	Harvesting (3)	Male	Day	15	300	4500
2	Machine Charges		Hours	5	400	2000
3	Nursery Raising	Seed Cost	g	500	3.4	1700
		Protray		380	15	5700
		Cocopeat	Kg	60	36	2160
		Perlite	Kg	12.5	25	300
		Vermicompost	Kg	40	10	400
		Vermiculite		12.5	35	450
4	Fertilizer	N (Urea)	Kgs.	261	6	1566
		P	Kgs.	80	30	2400
		K	Kgs.	60	36	2160
	Mulching	rice straw mulch	q	63.5	200	12700
5	Irrigation Charges	(Rs)				1500
6	Incidental Charges	(Rs)				500
7	Repairing Charges	(Rs)				500
8	**Working Capital (1to 7)**	**(Rs)**				**84436**
9	Interest on working capital@6% annum (Rs)					3026
10	Depreciation In implements and Farm buildings	(Rs)				400
11	Land Revenue cess and taxes	(Rs)				100
12	**COST "A"(Items 9-11)**	**(Rs)**				**87962**
13	Rental Value of land	(Rs)	Months	2	5000	10000
14	**COST "B"(Items 12-13)**	**(Rs)**				**97962**

TREATMENT 6 (N_1M_2)						
S.No	**Item**	**Unit**		**Input/ha**	**Cost/Unit of input(Rs)**	**Total cost/ha(Rs)**
1	**2**	**3**		**4**	**5**	**6**
1	**Hired Human Labour**					
	Land preparation	Male	Day	40	300	12500
	Weeding	Male	Day	0	0	0
	Transplanting cost	Male	Day	35	300	10500
	Fertilizer application	Male	Day	45	300	13500
	Harvesting (3)	Male	Day	15	300	4500
2	Machine Charges		Hours	5	400	2000
3	Nursery Raising	Seed Cost	g	500	3.4	1700
		Protray		380	15	5700
		Cocopeat	Kg	60	36	2160
		Perlite	Kg	12.5	25	300
		Vermicompost	Kg	40	10	400
		Vermiculite		12.5	35	450
4	Fertilizer	N (Urea)	Kgs.	130.5	6	783
		P	Kgs.	80	30	2400
		K	Kgs.	60	36	2160
	Mulching	black polythene mulch	meter	7880.5	2.5	19700
5	Irrigation Charges	(Rs)				1000
6	Incidental Charges	(Rs)				500
7	Repairing Charges	(Rs)				2000
8	**Working Capital (1to 7)**	**(Rs)**				**82253**
9	Interest on working capital@6% annum (Rs)					4392
10	Depreciation In implements and Farm buildings	(Rs)				400
11	Land Revenue cess and taxes	(Rs)				100
12	**COST "A"(Items 9-11)**	**(Rs)**				**87145**
13	Rental Value of land	(Rs)	Months	2	5000	10000
14	**COST "B"(Items 12-13)**	**(Rs)**				**97145**

TREATMENT 7 (N_2M_0)						
S.No	**Item**	**Unit**		**Input/ha**	**Cost/Unit of input(Rs)**	**Total cost/ha(Rs)**
1	**2**	**3**		**4**	**5**	**6**
1	**Hired Human Labour**					
	Land preparation	Male	Day	36	300	10800
	Weeding	Male	Day	40	300	12000
	Transplanting cost	Male	Day	30	300	9000
	Fertilizer application	Male	Day	40	300	12000
	Harvesting (3)	Male	Day	15	300	13500
2	Machine Charges		Hours	5	400	2000
3	Nursery Raising	Seed Cost	g	500	3.4	1700
		Protray		380	15	5700
		Cocopeat	Kg	60	36	2160
		Perlite	Kg	12.5	25	300
		Vermicompost	Kg	40	10	400
		Vermiculite		12.5	35	450
4	Fertilizer	N (Urea)	Kgs.	130.5	6	783
		N(Cow dung)	Kgs.	3706.67	5	18553
		P	Kgs.	80	30	2400
		K	Kgs.	60	36	2160
5	Irrigation Charges	(Rs)				1500
6	Incidental Charges	(Rs)				500
7	Repairing Charges	(Rs)				500
8	**Working Capital (1to 7)**	**(Rs)**				**96406**
9	Interest on working capital@6% annum (Rs)					3550
10	Depreciation In implements and Farm buildings	(Rs)				400
11	Land Revenue cess and taxes	(Rs)				100
12	**COST "A"(Items 9-11)**	**(Rs)**				**100456**
13	Rental Value of land	(Rs)	Months	2	5000	10000
14	**COST "B"(Items 12-13)**	**(Rs)**				**110456**

TREATMENT 8 (N_2M_1)						
S.No	**Item**	**Unit**		**Input/ ha**	**Cost/Unit of input(Rs)**	**Total cost/ha(Rs)**
1	**2**	**3**		**4**	**5**	**6**
1	**Hired Human Labour**					
	Land preparation	Male	Day	36	300	10800
	Weeding	Male	Day	40	300	12000
	Transplanting cost	Male	Day	30	300	9000
	Fertilizer application	Male	Day	40	300	12000
	Harvesting (3)	Male	Day	15	300	13500
2	Machine Charges		Hours	5	400	2000
3	Nursery Raising	Seed Cost	g	500	3.4	1700
		Protray		380	15	5700
		Cocopeat	Kg	60	36	2160
		Perlite	Kg	12	25	300
		Vermicompost	Kg	40	10	400
		Vermiculite		12	35	450
4	Fertilizer	N (Urea)	Kgs.	130	6	783
		N(Cow dung)	Kgs.	3706.67	5	18553
		P	Kgs.	80	30	2400
		K	Kgs.	60	36	2160
	Mulching	rice straw mulch	q	63	200	12700
5	Irrigation Charges	(Rs)				1500
6	Incidental Charges	(Rs)				500
7	Repairing Charges	(Rs)				500
8	**Working Capital (1to 7)**	**(Rs)**				**109106**
9	Interest on working capital@6% annum (Rs)					4313
10	Depreciation In implements and Farm buildings	(Rs)				400
11	Land Revenue cess and taxes	(Rs)				100
12	**COST "A"(Items 9-11)**	**(Rs)**				**113919**
13	Rental Value of land	(Rs)	Months	2	5000	10000
14	**COST "B"(Items 12-13)**	**(Rs)**				**123916**

TREATMENT 9 (N_2M_2)						
S.No	**Item**	**Unit**		**Input/ha**	**Cost/Unit of input(Rs)**	**Total cost/ha(Rs)**
1	**2**	**3**		**4**	**5**	**6**
1	**Hired Human Labour**					
	Land preparation	Male	Day	36	300	10800
	Weeding	Male	Day	0	0	0
	Transplanting cost	Male	Day	30	300	9000
	Fertilizer application	Male	Day	20	300	6000
	Harvesting (3)	Male	Day	45	300	13500
2	Machine Charges		Hours	2	400	800
3	Nursery Raising	Seed Cost	g	500	3.4	1700
		Protray		380	15	5700
		Cocopeat	Kg	60	36	2160
		Perlite	Kg	12.5	25	300
		Vermicompost	Kg	40	10	400
		Vermiculite		12.5	35	450
4	Fertilizer	N (Urea)	Kgs.	130.5	6	783
		N(Cow dung)	Kgs.	3706.67	5	18553
		P	Kgs.	80	30	2400
		K	Kgs.	60	36	2160
	Mulching	black polythene mulch	meter	7880.5	2.5	19700
5	Irrigation Charges	(Rs)				800
6	Incidental Charges	(Rs)				500
7	Repairing Charges	(Rs)				500
8	**Working Capital (1to 7)**	**(Rs)**				**96206**
9	Interest on working capital@6% annum (Rs)					5678
10	Depreciation In implements and Farm buildings	(Rs)				400
11	Land Revenue cess and taxes	(Rs)				100
12	**COST "A"(Items 9-11)**	**(Rs)**				**102384**
13	Rental Value of land	(Rs)	Months	2	5000	10000
14	**COST "B"(Items 12-13)**	**(Rs)**				**112384**

TREATMENT 10 (N_3M_0)						
S.No	**Item**	**Unit**		**Input/ha**	**Cost/Unit of input(Rs)**	**Total cost/ha(Rs)**
1	**2**	**3**		**4**	**5**	**6**
1	**Hired Human Labour**					
	Land preparation	Male	Day	36	300	10800
	Weeding	Male	Day	40	300	12000
	Transplanting cost	Male	Day	30	300	9000
	Fertilizer application	Male	Day	40	300	12000
	Harvesting (3)	Male	Day	15	300	4500
2	Machine Charges		Hours	5	400	2000
3	Nursery Raising	Seed Cost	g	500	3.4	1700
		Protray		380	15	5700
		Cocopeat	Kg	60	36	2160
		Perlite	Kg	12.5	25	300
		Vermicompost	Kg	40	10	400
		Vermiculite		12.5	35	450
4	Fertilizer	N (Urea)	Kgs.	130.5	6	783
		N (FYM)	Kgs.	10000	5	50,000
		P	Kgs.	80	30	2400
		K	Kgs.	60	36	2160
5	Irrigation Charges	(Rs)				1500
6	Incidental Charges	(Rs)				500
7	Repairing Charges	(Rs)				500
8	**Working Capital (1to 7)**	**(Rs)**				**118853**
9	Interest on working capital@6% annum (Rs)					16617
10	Depreciation In implements and Farm buildings	(Rs)				400
11	Land Revenue cess and taxes	(Rs)				100
12	**COST "A"(Items 9-11)**	**(Rs)**				**135970**
13	Rental Value of land	(Rs)	Months	2	5000	10000
14	**COST "B"(Items 12-13)**	**(Rs)**				**145970**

TREATMENT 11 (N_3M_1)						
S.No	**Item**	**Unit**		**Input/ha**	**Cost/Unit of input(Rs)**	**Total cost/ha(Rs)**
1	**2**	**3**		**4**	**5**	**6**
1	**Hired Human Labour**					
	Land preparation	Male	Day	36	300	10800
	Weeding	Male	Day	40	300	12000
	Transplanting cost	Male	Day	30	300	9000
	Fertilizer application	Male	Day	40	300	12000
	Harvesting (3)	Male	Day	15	300	4500
2	Machine Charges		Hours	5	400	2000
3	Nursery Raising	Seed Cost	g	500	3.4	1700
		Protray		380	15	5700
		Cocopeat	Kg	60	36	2160
		Perlite	Kg	12.5	25	300
		Vermicompost	Kg	40	10	400
		Vermiculite		12.5	35	450
4	Fertilizer	N (Urea)	Kgs.	130.5	6	783
		N (FYM)	Kgs.	10000	5	50,000
		P	Kgs.	80	30	2400
		K	Kgs.	60	36	2160
	Mulching	rice straw mulch	q	63.5	200	12700
5	Irrigation Charges	(Rs)				1500
6	Incidental Charges	(Rs)				500
7	Repairing Charges	(Rs)				500
8	**Working Capital (1to 7)**	**(Rs)**				**121553**
9	Interest on working capital@6% annum (Rs)					17379
10	Depreciation In implements and Farm buildings	(Rs)				400
11	Land Revenue cess and taxes	(Rs)				100
12	**COST "A"(Items 9-11)**	**(Rs)**				**129432**
13	Rental Value of land	(Rs)	Months	2	5000	10000
14	**COST "B"(Items 12-13)**	**(Rs)**				**139432**

TREATMENT 12 (N_3M_2)						
S.No	**Item**	**Unit**		**Input/ha**	**Cost/Unit of input(Rs)**	**Total cost/ha(Rs)**
1	**2**	**3**		**4**	**5**	**6**
1	**Hired Human Labour**					
	Land preparation	Male	Day	36	300	10800
	Weeding	Male	Day	0	0	0
	Transplanting cost	Male	Day	30	300	9000
	Fertilizer application	Male	Day	20	300	6000
	Harvesting (3)	Male	Day	15	300	4500
2	Machine Charges		Hours	2	400	800
3	Nursery Raising	Seed Cost	g	500	3.4	1700
		Protray		380	15	5700
		Cocopeat	Kg	60	36	2160
		Perlite	Kg	12.5	25	300
		Vermicompost	Kg	40	10	400
		Vermiculite		12.5	35	450
4	Fertilizer	N (Urea)	Kgs.	130.5	6	783
		N (FYM)	Kgs.	10000	5	50,000
		P	Kgs.	80	30	2400
		K	Kgs.	60	36	2160
	Mulching	Black polythene mulch	meter	7880.5	2.5	19700
5	Irrigation Charges	(Rs)				800
6	Incidental Charges	(Rs)				500
7	Repairing Charges	(Rs)				500
8	**Working Capital (1to 7)**	**(Rs)**				**118653**
9	Interest on working capital@6% annum (Rs)					18745
10	Depreciation In implements and Farm buildings	(Rs)				400
11	Land Revenue cess and taxes	(Rs)				100
12	**COST "A"(Items 9-11)**	**(Rs)**				**137898**
13	Rental Value of land	(Rs)	Months	2	5000	10000
14	**COST "B"(Items 12-13)**	**(Rs)**				**147898**

TREATMENT 13 (N_4M_0)						
S.No	**Item**	**Unit**		**Input/ha**	**Cost/Unit of input(Rs)**	**Total cost/ha(Rs)**
1	**2**	**3**		**4**	**5**	**6**
1	**Hired Human Labour**					
	Land preparation	Male	Day	36	300	10800
	Weeding	Male	Day	40	300	12000
	Transplanting cost	Male	Day	30	300	9000
	Fertilizer application	Male	Day	40	300	12000
	Harvesting (3)	Male	Day	15	300	4500
2	Machine Charges		Hours	5	400	2000
3	Nursery Raising	Seed Cost	g	500	3.4	1700
		Protray		380	15	5700
		Cocopeat	Kg	60	36	2160
		Perlite	Kg	12.5	25	300
		Vermicompost	Kg	40	10	400
		Vermiculite		12.5	35	450
4	Fertilizer	N (Urea)	Kgs.	130.5	6	783
		N (vermicompost)	Kgs.	3333.33	10	33330.33
		P	Kgs.	80	30	2400
		K	Kgs.	60	36	2160
5	Irrigation Charges	(Rs)				1500
6	Incidental Charges	(Rs)				500
7	Repairing Charges	(Rs)				500
8	**Working Capital (1to 7)**	**(Rs)**				**102183**
9	Interest on working capital@6% annum (Rs)					6717
10	Depreciation In implements and Farm buildings	(Rs)				400
11	Land Revenue cess and taxes	(Rs)				100
12	**COST "A"(Items 9-11)**	**(Rs)**				**109400**
13	Rental Value of land	(Rs)	Months	2	5000	10000
14	**COST "B"(Items 12-13)**	**(Rs)**				**119400**

TREATMENT 14 (N_4M_1)						
S. No	**Item**	**Unit**		**Input/ha**	**Cost/Unit of input(Rs)**	**Total cost/ha(Rs)**
1	**2**	**3**		**4**	**5**	**6**
1	**Hired Human Labour**					
	Land preparation	Male	Day	36	300	10800
	Weeding	Male	Day	40	300	12000
	Transplanting cost	Male	Day	30	300	9000
	Fertilizer application	Male	Day	40	300	12000
	Harvesting (3)	Male	Day	15	300	4500
2	Machine Charges		Hours	5	400	2000
3	Nursery Raising	Seed Cost	g	500	3.4	1700
		Protray		380	15	5700
		Cocopeat	Kg	60	36	2160
		Perlite	Kg	12.5	25	300
		Vermicompost	Kg	40	10	400
		Vermiculite		12.5	35	450
4	Fertilizer	N (Urea)	Kgs.	130.5	6	783
		N (vermicompost)	Kgs.	3333.33	10	33330.33
		P	Kgs.	80	30	2400
		K	Kgs.	60	36	2160
	Mulching	rice straw mulch	q	63.5	200	12700
5	Irrigation Charges	(Rs)				1500
6	Incidental Charges	(Rs)				500
7	Repairing Charges	(Rs)				500
8	**Working Capital (1to 7)**	**(Rs)**				**114883**
9	Interest on working capital@6% annum (Rs)					7479
10	Depreciation In implements and Farm buildings	(Rs)				400
11	Land Revenue cess and taxes	(Rs)				100
12	**COST "A"(Items 9-11)**	**(Rs)**				**122862**
13	Rental Value of land	(Rs)	Months	2	5000	10000
14	**COST "B"(Items 12-13)**	**(Rs)**				**132862**

TREATMENT 15 (N_4M_2)						
S.No	**Item**	**Unit**		**Input/ha**	**Cost/Unit of input(Rs)**	**Total cost/ha(Rs)**
1	**2**	**3**		**4**	**5**	**6**
1	**Hired Human Labour**					
	Land preparation	Male	Day	36	300	10800
	Weeding	Male	Day	0	0	0
	Transplanting cost	Male	Day	30	300	9000
	Fertilizer application	Male	Day	20	300	6000
	Harvesting (3)	Male	Day	15	300	4500
2	Machine Charges		Hours	2	400	800
3	Nursery Raising	Seed Cost	g	500	3.4	1700
		Protray		380	15	5700
		Cocopeat	Kg	60	36	2160
		Perlite	Kg	12.5	25	300
		Vermicompost	Kg	40	10	400
		Vermiculite		12.5	35	450
4	Fertilizer	N (Urea)	Kgs.	130.5	6	783
		N (vermicompost)	Kgs.	3333.33	33330.33	3333.33
		P	Kgs.	80	30	2400
		K	Kgs.	60	36	2160
	Mulching	Black polythene mulch	meter	7880.5	2.5	19700
5	Irrigation Charges	(Rs)				800
6	Incidental Charges	(Rs)				500
7	Repairing Charges	(Rs)				500
8	**Working Capital (1to 7)**	**(Rs)**				**71986**
9	Interest on working capital@6% annum (Rs)					8845
10	Depreciation In implements and Farm buildings	(Rs)				400
11	Land Revenue cess and taxes	(Rs)				100
12	**COST "A"(Items 9-11)**	**(Rs)**				**81231**
13	Rental Value of land	(Rs)	Months	2	5000	10000
14	**COST "B"(Items 12-13)**	**(Rs)**				**91231**

TREATMENT 16 (N_5M_0)						
S.No	**Item**	**Unit**		**Input/ha**	**Cost/Unit of input(Rs)**	**Total cost/ha(Rs)**
1	**2**	**3**		**4**	**5**	**6**
1	**Hired Human Labour**					
	Land preparation	Male	Day	36	300	10800
	Weeding	Male	Day	40	300	12000
	Transplanting cost	Male	Day	30	300	9000
	Fertilizer application	Male	Day	40	300	12000
	Harvesting (3)	Male	Day	15	300	4500
2	Machine Charges		Hours	5	400	2000
3	Nursery Raising	Seed Cost	g	500	3.4	1700
		Protray		380	15	5700
		Cocopeat	Kg	60	36	2160
		Perlite	Kg	12.5	25	300
		Vermicompost	Kg	40	10	400
		Vermiculite		12.5	35	450
4	Fertilizer	N (Urea)	Kgs.	130.5	6	783
		N (Poultry manure)	Kgs.	1656	5	8,280
		P	Kgs.	80	30	2400
		K	Kgs.	60	36	2160
5	Irrigation Charges	(Rs)				1500
6	Incidental Charges	(Rs)				500
7	Repairing Charges	(Rs)				500
8	**Working Capital (1to 7)**	**(Rs)**				**77133**
9	Interest on working capital@6% annum (Rs)					7671
10	Depreciation In implements and Farm buildings	(Rs)				400
11	Land Revenue cess and taxes	(Rs)				100
12	**COST "A"(Items 9-11)**	**(Rs)**				**85304**
13	Rental Value of land	(Rs)	Months	2	5000	10000
14	**COST "B"(Items 12-13)**	**(Rs)**				**95304**

TREATMENT 17 (N_5M_1)						
S.No	**Item**	**Unit**		**Input/ha**	**Cost/Unit of input(Rs)**	**Total cost/ha(Rs)**
1	**2**	**3**		**4**	**5**	**6**
1	**Hired Human Labour**					
	Land preparation	Male	Day	36	300	10800
	Weeding	Male	Day	40	300	12000
	Transplanting cost	Male	Day	30	300	9000
	Fertilizer application	Male	Day	40	300	12000
	Harvesting (3)	Male	Day	15	300	4500
2	Machine Charges		Hours	5	400	2000
3	Nursery Raising	Seed Cost	g	500	3.4	1700
		Protray		380	15	5700
		Cocopeat	Kg	60	36	2160
		Perlite	Kg	12.5	25	300
		Vermicompost	Kg	40	10	400
		Vermiculite		12.5	35	450
4	Fertilizer	N (Urea)	Kgs.	130.5	6	783
		N (Poultry manure)	Kgs.	1656	5	8,280
		P	Kgs.	80	30	2400
		K	Kgs.	60	36	2160
	Mulching	rice straw mulch	q	63.5	200	12700
5	Irrigation Charges	(Rs)				1500
6	Incidental Charges	(Rs)				500
7	Repairing Charges	(Rs)				500
8	**Working Capital (1to 7)**	**(Rs)**				**89833**
9	Interest on working capital@6% annum (Rs)					8433
10	Depreciation In implements and Farm buildings	(Rs)				400
11	Land Revenue cess and taxes	(Rs)				100
12	**COST "A"(Items 9-11)**	**(Rs)**				**98766**
13	Rental Value of land	(Rs)	Months	2	5000	10000
14	**COST "B"(Items 12-13)**	**(Rs)**				**108766**

TREATMENT 18 (N_5M_2)						
S.No	**Item**	**Unit**		**Input/ha**	**Cost/Unit of input(Rs)**	**Total cost/ha(Rs)**
1	**2**	**3**		**4**	**5**	**6**
1	**Hired Human Labour**					
	Land preparation	Male	Day	36	300	10800
	Weeding	Male	Day	0	0	0
	Transplanting cost	Male	Day	30	300	9000
	Fertilizer application	Male	Day	20	300	6000
	Harvesting (3)	Male	Day	15	300	4500
2	Machine Charges		Hours	2	400	800
3	Nursery Raising	Seed Cost	g	500	3.4	1700
		Protray		380	15	5700
		Cocopeat	Kg	60	36	2160
		Perlite	Kg	12.5	25	300
		Vermicompost	Kg	40	10	400
		Vermiculite	Kg.	12.5	35	450
4	Fertilizer	N (Urea)	Kgs.	130	6	783
		N (Poultry manure)	Kgs.	1656	5	8,280
		P	Kgs.	80	30	2400
		K	Kgs.	60	36	2160
	Mulching	Black polythene mulch	meter	7880.5	2.5	19700
5	Irrigation Charges	(Rs)				800
6	Incidental Charges	(Rs)				500
7	Repairing Charges	(Rs)				500
8	**Working Capital (1to 7)**	**(Rs)**				**76933**
9	Interest on working capital@6% annum (Rs)					9799
10	Depreciation In implements and Farm buildings	(Rs)				400
11	Land Revenue and taxes	(Rs)				100
12	**COST "A"(Items 9-11)**	**(Rs)**				**87232**
13	Rental Value of land	(Rs)	Months	2	5000	10000
14	**COST "B"(Items 12-13)**	**(Rs)**				**97232**