Performance of direct seeded rice (*Oryza sativa.L.*) in relation to planting patterns, nitrogen levels and weed control methods

Thesis Submitted for the Award of the Degree of

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in

Agronomy

By

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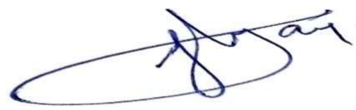
LOVELY PROFESSIONAL UNIVERSITY, PUNJAB

2024

DECLARATION

I, hereby declared that the presented work in the thesis entitled "**Performance of direct seeded rice (*Oryza sativa.L.*) in relation to planting patterns, nitrogen levels and weed control methods"** in fulfilment of degree of **Doctor of Philosophy (Ph. D.)** is outcome of research work carried out by me under the supervision of Dr Ujagar Singh Walia, working as Professor, in the Department of Agronomy 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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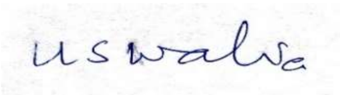
<u>CERTIFICATE</u>

This is to certify that the work reported in the Ph. D. thesis entitled **“Performance of direct seeded rice (*Oryza Sativa*.L.) in relation to planting patterns,Nitrogen levels and weed control methods”** submitted in fulfillment of the requirement for the award of degree of **Doctor of Philosophy (Ph.D.)** in the Department of Agronomy,School of Agriculture, is a research work carried out by **Burra Shyamsunder**,(**Registration No: 12106664**), is bonafide record of his/her 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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Abstract

Rice(*Oryza sativa.L.*) is the most important staple food of indian population. Compared to traditional puddled transplanting techniques, the new technique of direct seeded rice which is sown without puddling, is no dought environmental friendly but it is highly susceptible to weed pressure and iron deficiency. Due to huge infestation of all paddy and non paddy weeds in DSR, as well as poor knowledge of weed management, results in low yields in DSR. This was the major draw back resulting in poor adoption of this technology by farmers as uncontrolled weeds leads to more than 95 percent crop yield losses.Also soil texture is deteriorated with continous puddling.Considering the above-mentioned facts, an experiment entitled,**"Performance of direct seeded rice (*Oryza sativa.L.)* in relation to planting patterns, nitrogen levels and weed control methods"** was conducted at Lovely Professional University,Phagwara,Punjab(India).Two different field trials were designed in the Split Plot Design each during both years.**Experiment I** contained 4 main plots (planting patterns) and 4 sub plots (weed control treatments) and **Experiment II** had 4 main plots (Nitrogen levels) and 4 sub plots (weed control treatments) during kharif 2022 and 2023. Different planting patterns were kept in main plots were flat sowing, two rows per bed, three rows per bed and two rows per bed and one in furrow, and sub plots treatments were @ 0.75 kg/ha pendimethalin fb. bispyribac 25 g/ha,pendimethalin fb. metsulfuron 15 g/ha,weed free up to harvest and unweeded (control) were kept in first experiment. Different nitrogen levels viz., "0 kg/ ha, 120 kg/ha, 150 kg/ha and 175 kg/ha" in main plots and four weed management treatments in subplots viz., "pendimethalin fb. bispyribac, brown manuring with pre-em. application of pendimethalin fb. bispyribac, brown manuring fb. bispyribac ,and unweeded (control)" were kept in second experiment.

Among the planting patterns, three rows per bed produced significantly higher paddy yield than flat sowing.This treatment was followed by two rows on bed and one in furrow. Also weed density was lower in all bed planting treatments as compared to flat sowing technique due to deep burial of weed seeds.Among weed control treatments, unweeded (control) resulted in more than 95% yeild loss compared with herbicidal treated plots. Pre-emergence application of pendimethalin at 0.75 kg/ha fb. post-em. application of bispyribac at 25 g/ha showed better performance on typical non-paddy and paddy weeds i.e. grasses,sedges, and broad leafed weeds in DSR. Pendimethalin controlled all types of non-paddy weeds and post-em. application of bispyribac controlled all typical paddy weeds in DSR and resulted in higher

yields over other weed control treatments but weed free upto harvest treatment was found at par to this treatment during both years.. Bispyribac had an edge over metsulfuron for controlling weeds.It may be concluded that bed planted crop particularly three rows per bed treated with pendimethalin fb. bispyribac herbicides out yielded flat sown crop.Among , the nitrogen levels maximum paddy yield was observed by 175 kg N/ha which was found to be at par with 150 kg N/ha.and both these treatments holds superior over 125 kg N/ha and 0 kg N/ha.Among weed management treatments pre-em. application of pendimethalin fb. post-em. bispyribac recorded significantly higher yield than all other weed management treatments.Higher yield in pre-em.pendimethalin fb. post- em. bispyribac treatment may be due to better control of paddy and non paddy weeds.Also application of pre-emergence pendimethalin fb. bispyribac in brown manuring treatment significantly increased paddy yield than its no application of pendimethalin which may be due to better control of weeds in the former treatment.The negrigble (very low) yield in unweeded control may be due to the presence of paddy and non paddy weeds in abundance which smoothered rice crop plants resulting in their mortality as these (crop) plants were covered completely by weed plants.Losses due to weeds are more than 95 percent for paddy yield of direct seeded rice,which may be considered to highest among the field crops.

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Place: Phagwara, Date: 27/07/ 2024 **Burra Shyamsunder**

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List of symbols and abbreviations

N : nitrogen

% : Percent

@ : at the rate

I.e. : That is

M : meter

Cm : centimeter

Kg : kilogram

Gm : gram

RDN : Recommended dose of nitrogen

ha : hectare

P_2O_5 : Phosphorus

K_2O :Potassium

Kg N/ha : kilogram Nitrogen per Hectare

^0C :Degree

DAS : Days after sowing

SPD :Split Plot Design

T

:Treatment

dSm^{-1} :Deciseimen per meter

fig. :Figure

no.

:Number

RDF : Recommended dose of fertilizer

Tab :Table

P : Phosphorus

BM : Brown manuring

q/ha : quintal per hectare

sq.m : square meter

Pre.em. : Pre-emergence

Post-em. : post- emergence

Et.al : and others

Pendi : Pendimethalin

NUE : Nitrogen use efficiency

CD : Critical Difference

F.b. : Followed by

CHAPTER 1

INTRODUCTION

Rice (*Oryza sativa.L.*), often known as Asian rice, is widely farmed across the world. Between 13,500 and 8,200 years ago, it was initially domesticated in China's Yangtze River valley(Vaughan et al.2008). Since its proliferation, it has evolved into a worldwide primary food critical to nutritional requirements and culinary traditions throughout the globe. Over 40,000 distinct *Oryza sativa* L. cultivars of various types have been developed from local variations. The advent of distinct varieties, such as golden rice, which has been modified genetically, consisting of beta carotene, as well as other recent advances in agricultural practises and the adoption of enhanced breeding procedures, all led to the Green Revolution. Furthermore, output of this crop has expanded in recent decades as a result of advances in agronomic technology. Globally,rice has been the most edible cereal.

Rice is traditionally divided into three types: long, medium, and short grain. Long-grain rice which contains high amylose , after cooking the grains become intact, but medium-grain rice are rich in amylopectin ,turns more sticky, allowing rice to keep its form when cooked.Short-grained rice has plump and shorter grains that tend to stay together when cooked; it is used to produce sushi as well as rice puddlings due to its high starch content. Cooked white rice has 69% water, 29% carbs, and 2% protein, with little fat. Cooked white rice has 130 calories in a normal serving size of 100 grams (3.5 oz).Furthermore, it includes moderate quantities of manganese, which accounts for 18% of the Daily Value (DV), whereas other micronutrients are found in amounts less than 10% of the (DV).

Rice has been the majorly consumed food in several Asian nations, including India. The major food crop in India is rice . It is a *Kharif* season crop grown in hot ,humid and warmer climates in monsoon, which runs from the months of June and September. Rice seeds can be differentiated from paddy acquired by threshing the harvested crop. West Bengal,Punjab,Andhra Pradesh, Uttar Pradesh, Bihar, Chhattisgarh, Tamil Nadu and Odisha were the States with the highest rice production. About 3,000 rice types are farmed over the nation, with few maturing period of about 60 to 75 days after transplantation. The peninsular region of southern Asia ranks second place in rice consumption all over the world. Given that rice is consumed by more than half of the Indian population, this is not surprising. Rice cultivation in India occurs across diverse altitudes and climates, ranging from 8^0 to 350^0 N latitude and sea level to 3000 meters in elevation. The ideal conditions for rice crops involve a hot and humid climate, prolonged sunshine hours, and a reliable water supply are most suitable. The crop thrives at temperatures ranging from 21° to 37° C throughout its life cycle. During tillering, higher temperatures are required than during general growth. Blooming necessitates temperatures between 26.5° and 29.50° C, while ripening benefits from temperatures between 20° and 25° C. Rice is generally considered a short-day plant in terms of photoperiodicity, although there are varieties that exhibit non-sensitivity to photoperiodic conditions. Rice was the world's most productive crop following maize.

Rice cultivation in our country occurs across highly diverse soil conditions, encompassing both alkaline and acidic soils. Every soil type is conducive to rice growth in the country except exceptionaly very light and highly alkaline soils. However, the most favorable conditions for rice cultivation involve soils with excellent water retention capacity, rich in clay and organic matter. Particularly, clay or clay loams are considered optimal for rice farming due to their ability to retain water for extended periods, supporting sustained crop growth.Rice is a semi-aquatic crop, it thrives best when cultivated under submerged conditions. The majority of rice crops in India are cultivated in 'lowland' areas.While rice plants can tolerate diverse soil reactions, they tend to prefer acidic soils, showing optimal growth within a pH range of 5.5 to 6.5.

Rice production is an important aspect to the economy of India.The world's second most leading producer and exporter of rice is India , having the greatest rice cultivated area. Rice is among the most popular culinary crop consumed throughout India. Rice is one of the most important food crop in India, having the biggest acreage of any cereal crop, and the country is the top producer. Rice is a tropical plant that needs hot and humid conditions. Majorly,rice is cultivated in rain-fed locations with substantial yearly rainfall. This is why it is predominantly a *kharif* season crop in India. It needs a temperature of roughly 25 degrees Celsius or higher and rainfall of more than 100 cm. Rice is also grown in irrigated locations that experience less rain. Rice is a staple dish in eastern and southern India.

During 2021, global paddy rice output was 787.7 million metric tons, with China and India accounting for 51% of the total. Other notable manufacturers included Bangladesh, Indonesia and Vietnam. In 2021, the major five producers contributed about 72% of overall output,whereas the leading fifteen producers were responsible for 91% of worldwide output. Developing countries contribute approximately 95 percent of overall output.(FAO. 2023).

India ranked second in rice production globally with total production of over 178.31 million metric tons of paddy which is grown on 45 m ha and with average yield of 39.62 q/ha in financial year 2020(Faostat 2020). The highest production of rice globally was of China i.e. 213.61 million metric tonnes.In Punjab, the rice crop comprised of 31.49 lakh hectares, with a total paddy yield of 208.83 lakh tons in 2020-21.Paddy yields were 66.31

q/ha.The government's support for rice production, a good monsoon season, an increase in the number of rice processing companies, and rice-related exports all help the Indian rice industry. However, significant change in the climate had an influence on crop growing seasons, as have higher fertilizer costs, poor irrigation infrastructure, also difficulties in agricultural sectors, all of which discourage rice planting.

An essential staple food that ensures the food security of the rural people is rice. Small farmers cultivate it mostly on sites less than one hectare.Additionally, farm laborers are paid with rice, both as a cash crop and in non-agricultural industries. Many people in, the Caribbean,Latin America and Africa rely on rice for their sustenance. Rice covers the most land in India as a single crop, as well as the most land of any rice-growing country. India exports 7.5 million tons of non-basmati rice and 4.4 million metric tons of basmati rice.The primary producer and exporter of basmati rice is India. The states with the largest production of basmati rice are J&K, Himachal Pradesh, Punjab, Haryana, Delhi, Uttarakhand, and Uttar Pradesh.

Non-paddy annual weeds do not germinate or grow well in transplanted rice because of the unfavourable ecological conditions. Direct seeded rice (DSR) culture is more susceptible to weed competition than transplanted rice because both paddy and non-paddy weeds develop at the same time in this crop and compete with it from germination to harvest, resulting in a severe drop in rice seed production. Weeds grow quicker than crop plants, absorbing available nutrients early, resulting in nutritional deficiencies for agricultural plant development. Weeds compete with rice crops for resources such as nutrients, sunshine, water, and space. Crop development is weak in the early phases, and weeds may readily smooth out rice plants, resulting in significant crop yield losses.

Weed infestation is a key obstacle in the development of direct seeded rice (DSR), particularly in dry fields (Rao et al., 2007).Yield losses in DSR due to weeds is nearly 40 to 100% (Choubey et al., 2001). Weed growth reduced grain production in both wet-seeded and dry-seeded rice by up to 53% and 74%, respectively(Ramzan,2003). Remington and Posner (2000) conducted study on weed management in rice cultivation in Gambia and discovered that under direct cultivation, every day delay in weeding produces a 25 kg/ha drop in rice crop output.. Some important weeds of DSR are *Echinochloa colonum (L.)* Link, *E. cru-sgalli (L.) Beav, Oryza sativa L.* (volunteer/weedy rice)*, Hassk, Fimbristlis miliacea (L.), Ischaemum rugosum, Cyperus iria, Cyperus compressus, Digitaria sanguinalis, Eleusine aegyptiacum, Cyperus rotundus (L.), Cynodon dactylon (L.), Eleusine indica (L.), Leptochloa chinesis and Eragrostis spp) and few broadleafs* like *Ammania baccifera and Caesulia axillarism,Sphenoclea zeylanica, Eclipta alba (L.), Digiteria arvensis, and Amaranthus viridis etc.*

Nitrogen plays a key role of plant metabolism and performs very important functions in different metabolic pathway (Sangoi et al.,2008). Nitrogen is a vital macronutrient for plant activity and a fundamental component of amino acids, which serve as the building blocks for plant proteins and enzymes. Proteins are the structural ingredients of all living things, and enzymes help to improve a plant's biochemical processes widely. Nitrogen is also an element of the chlorophyll molecule, which permits the plant to absorb solar energy via photosynthesis, hence increasing plant growth and crop production. Nitrogen is an essential element in the plant because it ensures energy availability when and where it is required to increase production. These essential elements can also be present in the roots as enzymes and proteins that regulate water and nutrient uptake.

To increase rice productivity, it is critical to use the optimal planting techniques. In order to do this, research and development take initiatives on innovative rice crop establishment methods such as raised bed planting, direct sowing, and aerobic rice culture were launched in various areas of the world(Reddy and Reddy,2000). These technologies will be used in nations such as Pakistan due to the country's widespread water scarcity(Baloch et al., 2007)..DSR is often cultivated on flat beds, however raised beds may be used to save water and improve crop growth and development.Beds measuring 67.5 cm (37.5 cm bed top and 30 cm furrow) are made, and two to three rows of rice can be seeded in either dry or wet environments.

In present time, there is a lot of scarcity of water all over the world. Cultivation of transplanted rice not only require huge amount of water but also deteriorates soil texture due to repeated puddling which necessitated new techniques for rice cultivation.i.e. direct seeded rice,(DSR) and this technique is not new as it was practiced in back 50s.The percolation rate of water decreases with puddling which had a adverse effect on following wheat crop also. There is lot of water saving and physical conditions of soil are not deteriorated with cultivation of DSR as it is sown in unpuddled field. Some problems of DSR are that weeds are big problem as both rice and non rice weeds appears,crop stands may be poor due to lack of appropriate machinary,iron deficiency is more especially on light to medium soils.Moreover, laser land levelling is required for uniform crop stand and water saving.

Direct-seed rice (DSR) is an evolving agricultural technology in Asia due to certain advantages, i.e., there is labour saving, irrigation water saving, improved physical state of the soil for subsequent crops and reduced methane emissions, easy and faster planting, Less labor, early crop maturity in 7-10 days ,more tolerance for scarcity of water deficit, comparable yield and high benefit cost ratio (Dhillon and Mangat 2018, Kumar et al 2018). Various studies indicated that DSR provides saving of 12-60 per cent of irrigation water, 8-60 per cent in labour, reduction in global warming potential by 32-44 per cent, saving cost of cultivation by Rs. 6436-7950 ha-1 and results in better wheat yield (8-10%) than PTR (Basavalingaiah et al 2020). The saving of irrigation water in dry DSR is mainly achieved through omission of puddling (which requires 10-15 cm irrigation water) along with adoption of alternate wetting and drying conditions for regulating irrigation to the crop (Yadav et al 2011).Transplanted puddled rice crop deteriorates soil physical properties due to creation of hard pan at plough layer resulting in drastic reduction in percolation rates of water and it also adversely effects following wheat crop,this problem can be omitted by cultivating direct seeded rice(DSR).

Due to its reduced labor costs, enhanced nutrient management strategies, and accessibility to chemical weed control technologies, DSR has drawn a lot of farmers, it also give high total production and it is easy method for planting with minimum labor and hence most of farmers from the Philippines, Malaysia, Thailand and India adopt this technology. At present about 23% of total rice is under DSR world wide for DSR technology,short duration varieties are more suitable due to their quick initial growth as compared to long duration varieties. Cost of labor in rice cultivation is high as compared to all other crops so there is need to change from TPR to DSR immediately.

Therefore, present investigations entitled **"Performance of direct seeded rice (*Oryza sativa.L.*) in relation to planting patterns, nitrogen levels and weed control methods":** is being conducted with following objectives.

Objectives:

1. To study the role of planting patterns on crop and weed growth under direct seeding system.
2. To asses the crop under variable nitrogen levels and weed management practices on growth, and yield of direct seeded rice(DSR).
3. To study the interactive effects of nitrogen levels and planting patterns with weed management treatments.
4. To asses the quality and uptake of nitrogen by rice under variable treatments.

CHAPTER 2

REVIEW OF LITERATURE

The relevant work done on the problem entitled **"Performance of direct seeded rice (*Oryza sativa.L.*) in relation to planting patterns, nitrogen levels and weed control methods":** is reviewed with following sub heads:

1. Weed flora of direct seeded rice (DSR).
2. Losses caused by weeds in DSR.
3. Critical period of crop-weed competition and weed management in DSR.
4. Role of planting patterns on crop yield.
5. Role of planting patterns on weed growth
6. Impact of different levels of nitrogen on development of crop and weed growth.
7. Impact of different planting patterns,nitrogen levels and weed management strategies on crop quality and uptake of N

1. Weed flora of direct seeded rice (DSR)

In order to evaluate production losses in direct seeded rice (DSR) at various weeding timings, Singh (2022) performed an experiment at the National Rice Research Institute's research farm in Gerua, Assam, at the Regional Rainfed Lowland Rice Research Station, ICAR, during the course of two consecutive boro seasons, 2014–15 and 2015–16.He saw that the most common weed species in shallow lowlands were *Ludwigia octovalvis*, *Cyperus juncoides, Echinochloa colona, Cyperus difformis,* and *Cyperus iria*.

Kundu et al. (2020), observed that experimental plots were infested with mixed weed flora was dominated by broad leaves weeds (BLW), followed by grassy weeds and sedges.

According to Ghosh et al. (2017), *Commelina benghalensis (L.), Cyperus iria (L.), Bermuda grass* , *Barnyard grass* or *Jungle rice* and *cockspur* or *barnyard millet* were major common weed plants associated with rice. In contrast, *Quebra pedra* (*Bhue amala),False daisy ,* and *Physalis minima* comprise other weed flora in sandy clay loam soils of the Banaras Hindu University, Varanasi Agricultural Research Farm.

In a study conducted in Pant Nagar, Uttarakhand, Singh et al. (2016) found that rice ecosystems and establishing methods influence weed spectrum and infestation in rice fields. Around 350 different species of unwanted plants like weeds were identified in the rice field.Sedges,broad leaf weeds and narrow leaf weeds like grasses are major reasons for the losses in rice production, in the world.The two main weeds that effect the direct seeded rice are *Echinochloa colona* and *E. crus-galli* . The density of weeds in the direct seeded rice is mainly influenced by the wetness of the field.*E. colona* thrives in DSR due to its low water requirements.The major weeds in the direct seeded rice are *Paspalum spp.,Leptochloa chinensis*, *Dactyloctenium aegyptium,* Ischaemum *rugosum,Caesulia axillaris, Commelina spp,* and *Cyperus.*

Bajiya et al.in 2016 conducted an experiment of direct seeded rice in the Regional Research Station in Karnal reported that *Ammannia baccifera* (16. 9 was the broad leaf weed , *Cyprus rotundus* (19.2) was the sedge and *Echinochloa crus-galli* (18.9), *Eragrostis tenella* (13.0), and *Dactyloctinum aegyptium* were the grassy weeds observed in the field.

According to Jain et al. (2016), the major common weeds in direct-seeded rice at Birsa Agricultural University in Ranchi, Jharkhand were *Eleusine indica,Echinochloa colona, Bracharia milliformis, Ludwigia parviflora, Digitaria sanguinalis, Paspalum distichum, Sphellanthus acmella, Eclipta alba, Commelina benghalensis, Cyperus iria,Cyperus difformis,Fimbristylis milliaceae,* and *Kyllinga brevifolia.*

Mishra et al. (2016) performed an investigation on directly sown rice,in "University of Agriculture and Technology" in Bhubaneswar, Odisha, They found that broad-leaf weeds such as *Cleome viscosa, Ageratum conyzoides,, Celosia argentia, Ludwigia parviflora, Physalis minima,* and *Chrozoffera rottleri* dominated the floristic composition of the experimental site. *Cyperus rotundus* and *Cyperus irea* were the most prevalent sedges that were found. In sandy loams, lesser densities of *Panicum repens, Sporobolus diander, Alternanthera sessilis,* and *Eclipta alba* were also seen.

According to Saravanane et al. (2016), the dicot weeds in the sandy clay loam soils of "Pandit Jawaharlal Nehru College of Agriculture and Research Institute", Karaikal, Puducherry, were "*Commelina benghalensis L., Aeschynomene indica L., Trianthema portulacastrum L., Eclipta alba L., and Cleome viscosa L.*. The monocots observed in the DSR experimental field were *Echinochloa colona L., Leptochloa chinensis L., Panicum repens L., Dactyloctenium aegyptium Beauv., Cynodon dactylon L. Pers.,* and *Cyperus rotundus".*

According to Sharma et al. (2016), the primarly infested weed flora related to directly sown rice are *cockspur grass* (17.38%), *Cynodon dactylon* (18.72%), *Cyperus rotundus* (16.46%),*Commelina benghalensis* (12.50%),*Ammania baccifera* (13.03%) , and *Cyperus difformis* (15.94%) , with *Eclipta alba* and *Solanum nigrum*. Grassy weeds overtopped the weeds during development of crop in sandy clay loam soils of the Division of Agronomy's research farm at SKUAST in Jammu region .

Most common weeds noticed in clayey loam soils at the Research farm of the "Bangladesh Agricultural Research institute" (BARI) located in Jessore,Bangladesh are *Bermuda grass ,Digitaria ciliaris,Nut grass ,Celosia argentea L.,(Anagalis arvensis L.,Cleome rutidosperma,Echinochloa colona L,Fimbristylis miliacea*

*.L,Murdannia nudiflora L,Phyllanthus niruri L.*and *Galinsoga ciliata* was reported by Ahmed et al. (2015).

The most common weeds observed in the sandy loam soils of experimental farm which is located in Punjab Agricultural University,Ludhiana in the year 2015 were *Cyperus iria, C. compressus,* and *C. rotundus* which come under the group of sedges. *and jungle rice and Cockspur grass* were the weeds which were grassy in nature were stated by Kaur and Singh (2015) .

Joshi et al. (2015) noted that during the kharif season in the Crop Research Center of "G.B. Pant University of Agriculture and Technology", Pantnagar, the following priamry weed flora were found in rice field of calcareous soils: *Ecinochloa colona* (23.8%),*Echinochloa crus-galli* (15.8%), *Leptochloa chinensis* (18.4%), *Caesulia axillaris* (10.3%),*Ammania baccifera* (14.8%), *Cyperus rotundus* (8.9%) and other weeds (8.7%).

The majority of the weed flora at the experimental site, according to Prasuna and Rammohan (2015), was grasses ("89.96% and 98.32% at 30 and 70 DAS, respectively). Broad-leaved weeds (8.75% and 1.26% at 30 and 70 DAS, respectively) and sedges (1.29% and 0.42% at 30 and 70 DAS, respectively") were less common. *Aeschynomene indicia, Eclipta alba, Leptochloa chinensis, Cyperus rotundus, Cyperus iria, Cleome viscosa, Dactyloctenium aegyptium, and Digitaria sanguinalis* were the next most common weed species in direct-seeded rice, followed by *Echinochloa colona* and *E. cruss-galli*.

According to Ramesh et al. (2015), broad-leaved weeds such as *Euphorbia hirta, Ludwigia parviflora, Ammania baccifera,Paspalum conjugatum, Cynodon dactylon, Cyperus rotundus, Leptochloa chinensis* (grasses), and *Scirpus articulatus* (sedges) were mostly infested in the experimental plot of direct-seeded rice.

The experiment was conducted in the clayey loam soils of Chaudhary Charan Singh Haryana Agricultural University, Regional Research Station, Karnal, India by Ganie et al. (2014) revealed that the prominent weeds observed were "*Cyperus iria, Cyperus. difformis, Fimbristylis miliacea, Eclipta alba, Digera arvensis, Lindernia crustacean, and Mazus pumilus,Ammania baccifera, Echinochloa colona, E. glabrescens, Leptochloa chinensis, Dactyloctenium aegyptium".*

In a experiment conducted by Singh and Singh in the year 2014 , in the sandy loam soils of Agricultural institute of BHU,Varanasi reported that "*Caexulia auxillaries* was the broad leaf weed,sedges like *Cyperus rotundus* and *Cyperus iria* ,grassy weeds like *Echinochloa colona,E. crus-galli*, paspalum spp.,cynocon dactylon" were found in the field of directly sown rice.

According to Upasani and Barla (2014), "*Digitaria sanguinalis, Echinocloa colona, Echinocloa crus-galli, Paspalam indicum,* and *Panicum crusgali"* were among the narrow weeds present in the experimental plot at Birsa Agricultural University, Ranchi. When direct-seeded rice was established, broad-leaved weeds including "*Ludvigia parviflora, Sphellanthus acmella, Commelina benghalensis, Eclipta alba,* *and Marsillia quadrifolia"* were observed, along with sedges like *Cyperus iria, Fimbristlis milliaceae, Kyllinga sp.,* and *Cyperus difformis.*

According to Singh (2013), the main weeds infesting the experimental field 40 days after sowing were: *Caesulia axillaries* (4.5%),*Trianthema monogyna* (3.8%),*Ammannia baccifera* (1.9%), *Commelina benghalensis* (6.1%),*Phyllanthus niruri* (12.6%), *Physalis minima* (6.3%), *Eclipta alba* (3.3%), *Euphorbia hirta* (5.1%), *Cyperus difformis* (5.4%), and *Ludwigia spp*. (1.3%) among sedges in sandy clay loam at Agrricultural research farm in a Institute located in Varanasi of Uttar Pradesh state.

Naseeruddin and Subramanyam (2013), in sandy loam soils of Sri venkateshwara,college of Agriculture, Tirupati, Andhra Pradesh, observed that the most important weeds that are associated with drum-seeded rice were *Cyperus difformis* (40.0%), *Cyperus iria* (21.40%), and *Cyperus rotundus* (12.22%) which were sedges , also *Echinochloa colonum* (10.1%) which was a grassy weed and *Eclipta alba* (6.5%) and *Ammania bacifera* (4%) which were broad leaf weeds.

Walia et al. (2011) in sandy loam soils of Ludhiana, PAU, Ludhiana (Punjab),noted that most common weeds of the experiment field are (*Nut grass*, *Umbrella sedge* , and *hegehog sedge*) which were sedges, grasses (*Crab grass, Wild rice, Indian goose grass, red sprangletop, and lovegrass*.), and broad leaved weeds like (*monarch redstem and Pink node flower*).

At PAU, Punjab, Mahajan et al. (2009) discovered that the main weeds connected to aerobic direct seeded rice are broad-leaved weeds "*Sphenoclea spp., Euphorbia hirta, Eclipta prostrata, Trianthema portulacastrum, Ammania spp*., and *Ludwigia spp",* grasses *"Digitaria sanguinalis, Echinochloa colona*, and *Echinochloa crus-galli", sedges "Cyperus iria* and *Cyperus rotundus", and broad-leaved weeds "Cyperus iria* and *Cyperus rotundus".*

Ludwigia hyssopifolia and *Cynodon dactylon* were found to be the dominant weed species in the DSR at Bikramganj, Rohtas (Bihar) by Sinha et al. (2008). Other species found in the DSR included *Ischaemum rugosum*, *Cyperus spp, Ammania baccifera, Leptochloa adscendens, Echinocloa crusgalli, Marsilea minuta,Fimbristylis sp. Monochoria vaginalis,Commelina diffusa, Echinocloa colona,,* and *Dactyloctenium aegyptium.*

Mishra and Singh (2008) at Jabalpur (M.P.) reported that *Echinochloa colonum, Phyllanthus spp., Commelina communis, Cyperus iria, Alternanthera sessilis, Dinebra retrolexa, Physalis minima* and *Caesulia axillaris* were the main weeds related with dry-direct seeded rice.

Rajkhowa and Barua (2007) revealed that weed flora in DSR at Jorhat (Assam) consisted of grasses: *Axonopus compresus, Cynodon dactylon. Eluesine indica*; broad leaved weeds: *Alternanthera philaxeoides, Commelina diffusa and sedges: Cyperus iria and Cyperus rotundus.*

The primary weed flora in (DSR)directly sown rice was identified by Sharma et al. (2007) as follows: among the grasses*, "Echinochloa crus-galli (L.) P. Beauv., Dactyloctenium aegyptium (S) Richter, Setaria glauca (L.), and Cynodon dactylon (L.) Pers.; over the sedges, Cyperus rotundus (L.) and Cyperus iria (L.);* among the broad-leaf weeds, *Phyllanthus niruri (L.), Lindernia viscosa, and Amaranthus viridis"(L.)* were identified. In the sandy loam soils at "Bihar Agricultural College Farm, Sabour", the percentage of total weed flora that was composed of grasses, sedges, and broad-leafed weeds was 30.0, 44.3, and 25.7%, respectively.

Singh et al.in 2006 conducted an experiment regarding direct seeded rice in the clayey loam soils of research farm in the Agricultural sciences institute of BHU,Varanasi stated that *Cyperus rotundus (L.),Cynodon dactylon (L.), Eleusine indica (L.) Hassk,Echinochloa colonum (L.) Link, E. crus-galli (L.) Beav, Oryza sativa L. (volunteer/weedy rice),Fimbristlis miliacea (L.) and Eclipta alba (L.) Hassk* were observed.

2. Losses caused by weeds in DSR

The maximum yield losses caused because of weeds were observed in the treatment of 60 DAS (20.4%) which was followed by 45 DAS (15.8%) in direct seeded rice at "ICAR-National Rice Research Institute,Regional Rainfed Lowland Rice Research Station,Gerua,Kamrup,Assam".So it is concluded by Singh (2022) that weeding at the early stages of DSR was important in order to get maximum productivity of rice and also minimum yield loss because of weeds.

Shekhawat et.al (2020) has been claimed that unmanaged weeds in the field might affect yield losses in DDSR by up to 75%. Various weed-management techniques, such as cultural weed management using crop residue mulch and stale seedbed, can be used, as can cultivating cultivars that are crop-competitive and adjusting seed rate, row spacing, nutrient, and water management to improve crop competitiveness. Chemical weed control depending on needs, using herbicides, herbicide mixtures, and novel herbicides that are effective against a variety of weeds.

According to Saravanane et al. (2016), weeds constitute a major obstacle to aerobic rice production. The coastal ecology of Puducherry UT, India, produced rice with an aerobic yield loss of 86.3% because of uncontrolled weeds.

According to Kaur and Singh (2015), RCTs are also suggested in rice-wheat cropping systems; however, in direct seeded/RCT systems, paddy yield reduction by 35–100% in the absence of weed management.

Herbicides used alone were identical to both hand weeding and sequential treatment, according to Ramesh et al. (2015). The combined effects of less weed population, biomass of weeds, enhanced weed control efficiency(%), and higher number of panicle-having tillers per square meter and more filled grains per panicle may account for the higher yield in the treatments of herbicides. While compared with hand weeding, the unweeded yielded lowest grain output (1.89 t/ha), with a yield loss of 64%. This was because of intense competition between crop and weed, which impacted growth of crop as well as yield.

Raj et al. (2013) found that non-grassy weed density reduced grain yield in direct-seeding by 72%. They additionally observed that limited crop-weed competition at critical stages reduced grain yield decline.

According to Kumar et al. (2012), weeds in weedy check plots accumulated more dry matter and at a higher density, which resulted in a 67–70% reduced in rice grain yield in direct seeded paddy crops.

According to Daniel et al. (2012), uncontrolled weeds 90.3% decreased the aerobic rice production. The Pandit Jawaharlal Nehru Agriculture college,karaikal,Research institute, Puducherry experienced a significant decrease in the intensity of weeds because of majorly decrease of competition by weeds for different resources caused by all the weed control practices.

In direct seeded rice at Chata Farm SKUAST at Jammu in 2006 and also in 2007, Kachroo and Bazaya (2011) reported that the grain yield loss owing to uncontrolled weeds was 51.11%.

Naresh et al., (2011) reported that weed competition is so intense that failure to control weeds in DSR may result yield loss from 65 to 92 per cent.

According to research by Gopinath and Kundu (2008), unchecked weeds can cause a crop to fail entirely and reduce grain yield by up to 80%. The major cause for high weed infestation in DSR are limited canopy cover by the crop and also less smothering of weeds because of constant stagnant water in early stages of seedling development of crop.

According to Maity and Mukherjee (2008), weed-free conditions must be maintained mainly for the first 30-45 days after crop sowing. in order to prevent yield losses since the biomass of weeds in directly sown rice grows significantly after 30 DAS. Wet direct-seeded rice yields are reduced by weeds by 61%, while dry direct-seeded rice yields are reduced by weeds by 96%.

Maity and Mukerjee (2008a) found that uncontrolled weeds in Pundibari, West Bengal, decrease grain production by 61% in wet direct seeded system and 96% in dry direct seeded system.

According to Mishra and Singh (2007), weeds are the mainly one of the major obstacles to aerobic rice production because dry tillage, alternating wetting and drying conditions encourage weed germination and growth, which can result in 50–90% decrease in the production. Because of the severe competition between crop plants and weeds caused by weeds and rice seeds germinating at similar period, aerobic rice adoption is discouraged.

According to Rao et al. (2007), depending on the species of weed and the extent of its infestation in direct-seeded rice(DSR), weed infestation during the initial crop growth stages reduced production by 33–74%, sometimes even more.

In an experiment at the National Agriculture Science Center (NASC) in New Delhi, Rao et al. (2007a) found that weeds are the main factor preventing wet-seeded rice from yielding better yields, and that unchecked weed development can reduce yields by as much as 64%..

According to Singh et al. (2006), in dry direct seeded low land rice at Banaras Hindu University, Varanasi, weedy check indicated a mean yield of 53.8% reduction was noticed. This yield loss ranged between 10.1 to 28.8% in hand weeding treatment (25 and 50 DAS) and treatments using herbicides, respectively.

Subbaiah et al., (2005) reported that weeds in upland DSR pose substantial competition to the crop in its early stages, resulting in a significant drop in rice production. Weeds that are not controlled can reduce yield by by 80% in directly sown upland rice..

3. Critical crop-weed competition period and weed management practices of DSR

According to Singh (2022), weeding times had a substantial impact on both density of weeds and the accumulation of dry matter of specific weed varieties. When weeding at 15 DAS, weed density and biomass were substantially lower than when weeding at 45 and 60 DAS. Moreover, best yield and production of stover was obtained for early removal of weeds at 15 Days of sowing. Physical removal of weeds at 60 days (20.4%) resulted in higher losses from weeds than 45 Days after sowing (15.8%) in DSR. Therefore, initial hand weeding of Direct seeded rice is crucial to achieving improved rice productivity and minimizing yield loss from weeds.

Mubeena et al. (2014) reported that 15 to 30 was the most crucial time for competition between weeds and crop plants , so weeds can be controlled between 15-30 DAS which reduces the weed dry matter and the yield loss in DSR.

A selective herbicide which is pre-emergence, pendimethalin works well against most annual grassy weed species as well as some annual broad-leaved weeds. It works by inhibiting the development of microtubules, which stops cellular multiplication and disorients microfibrils. It is less potent for sedges and only kills unwanted plants that are just starting to germinate. According to Godara et al. (2012), "Pendimethalin applied at 1.0 kg/ha considerably reduced aerobic grassland weeds, yet it was least potent to sedges like *nut grass* as well as grass weeds like *Echinochloa crusgalli.*

In comparison to an unweeded , Walia et al. (2012) noticed that the combination of pendimethalin 0.75 kg ha-1, pretilachlor 0.5 kg ha-1, and thiobencarb 2.5 kg ha-1 which were pre emergence herbicides with bispyribac (25 or 30 g ha-1) or azimsulfuron (20 g ha-1) which were post germination herbicides effectively controlled weeds. Additionally, they reported that when applied in conjunction with applications of post-emergence herbicides like , azimsulfuron (20 g ha-1),bispyribac (25 kg for one hectare area) and 2, 4-D (0.5 kg for one hectare), pendimethalin applied at 0.75 kg ha-1 or oxadiargyl applied at 0.90 g ha-1 lowered the weed biomass in comparison with pendimethalin 0.75 kg ha-1 applied singlely. Pendimethalin at 0.75 kg ha-1, bispyribac 25 g ha-1, oxadiargyl (90 g ha-1) were applied at pre germination stage succeeded by bispyribac (25 g ha-1), oxadiargyl (90 g ha-1) succeeded by azimsulfuron (20 g ha-1), and pendimethalin at 0.75 kg ha-1 which was succeded by azimsulfuron 20 g ha-1 yielded the maximum yield of grain (5.3 t ha -1).

The key time for rice weed management as being around 18 and 52 DAS attained 95% of yield resulted in weed free conditions, which was computed by Chauhan and Johnson (2011) at Punjab Agricultural University, Ludhiana, India.

According to Sangeetha et al. (2009), at “Tamil Nadu Agricultural University, Coimbatore”, removal of weeds physically for about twice at 20 and 45 days after sowing increased crop growth parameters, yield traits, and grain yield of crop with lower weed count and weed dry matter.

According to Walia et al. (2009), application of pendimethalin at the pre emergence stage 0.75 kg ha-1 and also after about one month after sowing spraying of bispyribac 25 g ha-1 or azimsulfuron 20g for one hectare area can effectively reduce weeds in DSR. It was discovered that pendimethalin application alone was insufficient to control the complex weed flora of DSR. Pendimethalin 0.75 kg ha-1 applied pre-germination combined along either bispyribac 25 g for one hectare area or azimsulfuron 20 g ha-1 applied post-emergence resulted in a yield that was 61.7 and 42.1% greater, compared to pendimethalin 0.75 kg for one hectare area applied as alone.

According to Rao et al. (2008), at the RARS, Lam Farm, Guntur. Twice hand weeding resulted the lowest weed growth and the highest yield attributes and yield of direct seeded rice, which was identical to the pre-emergence spraying of pendimethalin (1.0 kg ha-1) succeeded along physical weeds removal of field around 30 days after sowing of seeds.

Walia et al. (2008) found that greater rice grain yields and efficient weed control were achieved by combining pre-emergence spraying of pendimethalin in the quantity 0.75 kg in the area of hectare combination of post-emergence herbicide,bispyribac which was applied in the quantity 25 g ha-1, azimsulfuron in the quantity of 20 for hectare area , or 2,4-D sprayed in the amount of 500 g ha-1. While bispyribac was sprayed post-emergence to control all usual dominant rice weeds, including all the species of Cyperus and Echinochloa colona , pendimethalin was applied before emergence to efficiently eliminate nonpredominant paddy weeds.As pendimethalin was sprayed at the rate of 0.75 kg per hectare as a pre-emergence herbicide and bispyribac was administered in quantity as 25 g ha-1 as post emergence herbicide , the rice grain production increased by 372% in comparison with the weedy check treatment.

According to Mukherjee and others in the year 2008, weed competition is crucial i after one month of rice that is directly sown. Additionally, they noticed that with direct-seeded rice, yield decreased as the length of the competition increased during the first phase.

Ranjit and Suwanketnikom (2005) reported that hand weeding twice gave the highest grain yield and yield attributes and lowest weed density compared to bispyribac sodium in directly sown rice field.

The administration of Pendimethalin in the quantity of 1 kg for the area of hectare within two days after sowing provided an effective control of *Setaria glauca,Echinochloa colonum,* and *Dactyloctenium aegypticum*, as well as obtained the highest grain yield. according to Bahar and Singh's (2004) research.

According to Malik et al. (2002), pendimethalin was exclusively efficient against *Commelina benghalensis, Cyperus iria,* and *Echinochloa species".* When pendimethalin was applied prior to the development of seedlings at the rate of 0.75 kg per hectare to direct-seeded rice, the pesticide effectively controlled grasses.

4. Role of planting patterns on crop yield

Four different transplanting geometries “single row rectangular system, single row triangular system, double row rectangular system, and double row triangular system” and three seedling hill-1 levels (3, 4, and 5 seedlings) were conducted by Bidahan et al. (2021). The findings demonstrated that the number of seedlings hill-1 or the individual transplanting geometry had a significant impact on yield parameters.Hence, the double row triangular arrangement had the highest grain production (5.6 t ha-1).

Various planting configurations are crucial for weed management, irrigation water conservation, and ultimately seed production. Variable planting patterns affect the growth and development of plants as well as their susceptibility to pests, diseases, and insects (Patel 2020).

The planting designs with two rows and one row yielded lower grain production than the triangle layout. Grain production was higher with the triangle pattern than with the one-row and two-row planting patterns, respectively, by 40.9% and 14.0%.(Purba 2018)

According to research by Kajonphol et al. (2018), spacing has no effect on rice development or yield; however, the number of seedlings per hill does. Furthermore, spacing and seedlings per hill do not interact. The maximum tillering was seen in the three seedling per hill condition (average 24.13 tillers per hill). The least amount of tillering was displayed by the single seedling per hill (average 16.24 tillers per hill).

According to Das et al. (2017), in regions where water is scarce, using raised beds instead of furrows can save crops' water use by 20–40%.

In comparison to bed sowing, Javaid et al. (2012) observed that the flat sowing method had resulted highest produce of rice. And also, flat planting yielded panicles with most empty spikelets along with greatest number of tillers..

Baloch and others (2011) investigated three different techniques of sowing in the direct weeded rice and in the transplanted rice : direct sowing of seeds on flat/ridges, transplanting on flat/ridges method , and parachute planting method . According to the study, direct seeding on flat resulted in a significantly maximum population of plants (30.5), followed by transplanting on flat (21) and direct seeding on ridges (22.5). The fact that the seed was dispersed across the ridges without preserving adequate spacing of plants is most likely what caused the increased plant population in the direct seeding area. All direct seeded treatments had the same seed rate, but because more net area was available for flat planting than for bed sowing, direct seeding on a flat produced a larger plant population.On the other hand, in both experimental years, the yield of the paddy planted on flat was greater (5.9 and 6.5 t ha^{-1}).

Roy and others in the year 2009 observed that DSR production can be improved with tillage which is conventional with square planting (20 cm), plant to plant (20 cm), while compared to "conventional tillage normal spacing (R × R) -18 cm], conventional tillage paired row treatment (9-27-9 cm), reduced tillage paired row treatment (9-27-9 cm), reduced tillage square planting (20 cm, P×P-20 cm)" during 2012 and 2013 at "Agricultural Research Farm,Banaras Hindu University, Varanasi" (Uttar Pradesh).

5. Role of planting patterns on weed growth

Yadav et al.,in 2018 conducted a study on different planting patterns and reported that in comparison to all other planting patterns ,the least weed biomass was observed in CT square planting succeded by "conventional tillage normal spacing [row to row (R × R) -18 cm], conventional tillage paired row (9-27-9 cm), reduced tillage paired row (9-27-9 cm), and reduced tillage square planting (R × R -20 cm, P×P20 cm)".

Das et al.(2017) stated that the crop weed competition in different rice varieties , beneficial characteristics like size of the seed,vigor of the seedlings,earlier and faster development ,plant height ,effective tillering capacity,root depth and both stress like biotic and abiotic ,early maturity and allelopathic effect on plants confine greater capabilities.Along with the crop weed competitive varieties,greater seed rate which in between 50 kg/ha and 60 kg per ha and also space of 15 to 25 cenimeters in rows was observed as the most recommended for reduction of weeds in DSR.

Rana et al. (2016) Rana found that the significantly lesser density of weeds and biomass was observed by two-handed weeding and also it was found to be significantly superior than all other weed management strategies when recorded for both years.

Joshi et al.,(2015a) stated that minimum accumulation of weed dry matter was recorded in the treatment with continuous digging at the depth of 20 cm which was significantly similar with the treatment containing spacing of 20 cm x 10 cm. This results in lesser space in narrow spacing which effects in the lesser biomass of weeds.

Joshi et al., (2015) demonstrated the 20 cm planting geometry had lower weed density than 20 cm x 10 cm and 25 cm x 25 cm due to mutual competition between grass species. Planting in narrow rows and higher crop density will shift the competitive balance in favor of the crop. . Broadleaf weeds had similar populations in all plantations, but C. iria sedum and E. colona were better managed in dense and uniform plantations .

Colbach et al., (2014) had used stochastic and 3 dimensional models for studying the suitable spacing of plants for various conditions and found that there was reduced competition of weeds along with the increased uniformity in the arrangement of plants which was either inter row spacing or intra row spacing.

Mahajan et al. (2014) stated that the treatment with one spraying of pendimethalin succeeded by spraying of bispyribac-sodium in paired row planting recorded the lowest accumulation of dry matter.

Paired row planting in DSR method ,with a spacing of 15-30 cm effected the weeds to a larger extent when compared to normal planting with the spacing of 23-cm as paired row planting pattern helps in the control of weeds which results in the dominance of rice up on weeds plants due to changes in its plant cover .This was reported by Mahajan and Chauhan (2011).

Nicholas et al.,(2009) reported that hybrid rice with lowest seed rate and spacing of 20 cm also produce the yield more effectively because of its effective tillers and greater vigor when the thickness of plants are similar.Maximum density of plants helps the crop to use all the resources in a larger amounts when compared to weeds which results in the effective consumption of all the available inputs.

Zhao et al., (2007) revealed that rice cultivated in the optimum conditions of water which has a crop thickness of 100 plants per meter square , has prominently reduced the thickness of weed cover which ultimately maximized the production of rice.

The relationship between the plant dry matter and thickness of the plants was maximum when there is maximum crop weed competition,so if the thickness of weeds is observed more, then there is maximum density of plants. This was reported by Mohler, (2001).And also this suggests that maximum plant thickness will result in the enhanced crop dry matter but not the yield or the production.

6. Effect of nitrogen levels on crop and weed growth

A study was organized in Kanchanpur, Nepal, from March 2021 to July 2021 on the impact of various doses of N on the production of seed and yield characteristics of variable cultivars of paddy in dry conditions .In this study 3 doses of nitrogen like 60 kg/ha, 120 kg/ha, and 180 kg/ ha are used as treatments. The stature of plant, panicles count and total number of tillers ,more effective tillers ,length regarding panicle,higher grain production and straw yield and grain filled per panicle were recorded maximum for the nitrogen level 180 kg N/ha revealed by Giri et.al. (2022).

In a study conducted by Singh and Pandey (2019), the greatest grain yield, biomass of straw , harvest index and grain: straw ratio was observed in the treatment in which 125% of RDF was administered and it was observed as similar with the treatment consisting of 100% RDF for when recorded for both the years .The two treatments are ultimately superior over 75% RDF treatment. Weed control strategies were also significantly affected the seed production,stover production, harvest index and seed: straw ratio of rice when recorded for both the years.The maximum yield of rice was noticed in the treatment where hand weeding had done two times and it was found to be statistically similar with spraying of of bispyribac-sodium + pyrazosulfuron treatment and these were found to be significantly superior than incorporation of brown manuring.

Dahipahle and Singh (2018) demonstrated that the highest plant height was observed by 180 kgN/ha which was observed as statistically similar with 150 kg N/ha.When data was recorded for yield and yield characteristics ,the largest amount of seed produced 150 kg Nitrogen per hectare compared to 120 kg Nitrogen per hectare and statistically similar along with 180 kg Nitrogen per hectare.

Singh et. al.(2015) revealed that highest production and yield characteristics like test weight,number of shoots,number of grains per panicle ,seed yield and stover yield had been recorded by 150 kg nitrogen per hectare at "Pantnagar University of Agriculture & Technology (GBPAUT) (Uttarakhand), India", yield attributing features were considerably greater when Nitrogen was given in 4 equal splits (basal + at active tillering + panicle initiation + at flowering) as different to variable nitrogen scheduling.

Azarpour et al.in the year 2014 examined a study with 4 different doses of N fertilizer like 0 kg N/ha,30,60 also 90 kg nitrogen per hectare along with 4 different rice varieties.The highest values of overall biomass of plant , biomass of leaves ,leaf area index (LAI), net absorption rate, total crop growth rate, relative growth rate, leaf area , leaf area ratio, biomass of leaves, total area of leaves, and seed production was observed by 90 kg N/ha.

According to Seema et al. in the year 2014, nitrogen doses between 75 and 100 kg/ha were similar and improved the DSR grain yield by a substantial 5% with an additional 125 kg/ha dose of nitrogen.

Puteh et al. (2014) used rice cultivars to examine three different nitrogen dosages (80, 120 kg , and 160 kg per hectare). Puteh et al., observed that highest plant height (119.5 cm), leaf area index, chlorophyll index, and total number of tillers per hill (15.33)was observed by 160 kg N/ha .

Four different nitrogen levels (control, 75%, 100%, and 125%) were tested by Gill and Walia (2013 a) in DSR. Half of the nitrogen was applied after two weeks, while the remaining half was applied five weeks after planting. According to the findings, compared to all other nitrogen dosages, 125% of the necessary amount resulted in noticeably taller plants, more leaf area, tillers, and CGR.

Gill and Walia (2013 b) in their study tested 4 different levels of nitrogen doses like control,75 %,100% and 125 % .They revealed that significantly highest grain yield was observed by the 125% nitrogen dose followed by 100% (88.44,) ,75% (25.81 and control 5.41%.They also stated the highest count of grains per panicle, 1000 seed mass or test weight , and spikelet length were observed by 125% of nitrogen.

Maiti and Bhattacharya (2012) performed experiments with three nitrogen levels (90, 120, and 150 kg ha-1) and three P2O5 values (40, 60, and 80 kg ha-1). They found that 150 kg nitrogen and 60 kg P2O5/ha produced the maximum grain production compared to other treatments.

The differences in the weed population due to increase in the nitrogen levels are observed as non-significant while the thickness of grasses and sedges were significantly increased due to the rise in the nitrogen levels from 120 kg nitrogen per hectare to 180 kg nitrogen per hectare. In addition, it was shown that applying 150 kg nitrogen per hectare, in comparison with 120 kg nitrogen per hectare, increased the overall weed density by 85%. However, according to Mahajan and Timsina (2011), applying more N than 150 kg ha-I would not significantly affect overall weed population.

Narayanaswamy *et al*. (2011) revealed that more usage of N:P:K with dose of 150:75:45 kg/ha has recorded significantly higher plant height in comparison with the dose of 90: 45: 45 kg NPK/ha.

In an experiment, Alagesan and Raja (2011) used equal four parts of nitrogen (seedling stage , active tillering stage , panicle initiation stage, and flower blooming stage) and five different nitrogen levels (40, 80, 120, 160, and 200 kg nitrogen per hectare). When nitrogen fertilizer was administered in the amount of 160 kg nitrogen per hectare, they reported more tillers/m^{-2} (529).

The highest uptake by crop (kg per hectare) of N, P and K was reported by Chaudhary et al. (2011) in four equal nitrogen splits: at early tillering stage, active tillering stage, panicle initiation stage , and panicle emergence stage. These splits were significantly better than different methods.

Kaushal et al. (2010) found that applying nitrogen in three splits—½ basal, ¼ at tillering, and ¼ at panicle initiation—resulted in greater growth characteristics and grain production (49.76 q ha-1). Up to 120 kg/ha, there were considerably more full grains per panicle.Additionally, direct-seeded rice that received nitrogen treatments of ½ basal application, one fourth (¼) during tillering stage, and ¼ during initiation of panicle produced a larger number of filled grains per panicle (124) .

Meena (2010) noted that the total prescribed N applied in three splits (40:40:40) yielded statistically similar outcomes to those of 20:50:50 and 60:60:0 ratios, but much larger spikes per meter row length, effective tillers plant-1, test weight, and seed and straw yields.

Jat *et al*. (2009) concluded that at all growth parameters, yield attributing characteristics enhanced with each increment in nutrient level from 50 to 100% (120: 60: 60 kg NPK/ha), 100% RDF recorded significantly higher values of all growth parameters. They also further came to know that with increase in dosage of RDF from 50% to 100% which resulted in the ultimate increment in the accumulation of dry matter .

Administration of 150 kg nitrogen per hectare in 4 splits in different stages like one by 6th percentage of nitrogen at 15 DAS, one third dose at tillering, 1/3 at PI, and one sixth at blooming stage leading to larger tiller count (361 m-2), stature of plant (77.0 cm), and crop biomass at blooming period (5.20 t ha-1) over a course of four doses of administering (one fifth at 15 DAS, another one fifth at tillering, and two fifth at PI, and also remaining at blooming),was stated by Sathiya and Ramesh (2009). The maximum count of panicles per meter square (322), highest figure of filled grains/panicle (94), highest test weight (21.4), and maximum grain and straw yields (2827 and 4919 kg ha-1) were recorded following the spraying of 150 kg nitrogen fertilizer for an hectare in 4 shares : on sixth share at 15 DAS, one third share at tillering, one third share at PI, and one sixth share at flowering.

Singh along with Singh (2007) performed a study with four schedules of nitrogen (0:25:40:35, 25:0:40:35, 50:0:25:25 and 0:40:30:30% N at 0, 25, 35, and 60 DAS) as treatments. The findings demonstrated that, in comparison to other N schedules for DSR, the weed spread and biomass at harvest were significantly reduced under the treatment 0:25:40:35%N at 0, 25, 35, and 60 DAS, respectively.

7. Effect of planting patterns,Nitrogen levels and weed management methods on crop quality weed management treatments on crop quality and uptake of N

Sheela et.al. (2021) studied performance of three nutrient levels i.e “100:50:40 kg/ha, 80:40:30,and 60:30:20 kg/ha. The researchers noticed that rice could absorb the maximum amounts of nitrogen, phosphorous, and potassium at a nutrient level of 100:50:40 kg/ha of N:P:K. in other words, 60.22, 12.98, and 75.21 kg/ha, which were, respectively, 116.9, 104.7, and 71.5% greater than 60:30:20 kg/ha of N:P:K.

Bavaji et.al (2017) reported the uptake of nitrogen in rice crop with maximum uptake of nutrient and grain yield was recorded in mulching using biodegradable polyethelene sheets. Minimum uptake of N, P and K was observed in unweeded check crop. The highest benefit: cost ratio were recorded in hand weeding on 15 DAT followed by azolla inoculation on the same day.

Singh et al. (2015) while working at N.E. Borlaug Crop Research Centre of G.B. Pant University of Agriculture & Technology, Pantnagar (Uttarakhand) India, reported that the NPK uptake by direct seeded rice was higher under 150 kg N ha^{-1} with nitrogen scheduling in 4 splits (basal + at active tillering + panicle initiation + at flowering) in silt loam soil.

Talla and Jena.(2014) reported that the nutrient content of grain and straw of rice in conoweeding was maximum, which was 1.33, 0.37 and 1.26% of N,P and K in grains respectively. The corresponding values for straw were 0.44, 0.10 and 1.82% respectively. The weedy check recorded the lower values of N, P and K content as compared with all weed management treatments.

Kaur and Mahal (2014) reported that the giving of nitrogen fertilizer in 3 or 4 parts which had failed to effect on yield and N, P and K uptake in the direct seeded basmati rice. It could also be inferred from the study that N application at sowing time can be skipped because it may not be immediately used by the emerging seedlings.

Raj et al. (2014) reported that the better uptake of N with minimum N losses and optimum N supply throughout the crop stage resulted in better growth and yield attributes. The highest grain yield was recorded in nitogen (urea) applied in four equal splits (3752 and 3872 kg ha^{-1}) during first and second year respectively. The study conclusively proved that physical blending of urea in four equal splits from 5-10 DAE to 60-65 DAE enhanced the N availability, N uptake and productivity in semi dry rice.

Ram et al.(2014) reported that an increase of 8.5–9.8% in total nutrient uptake with 25 cm × 25 cm spacing compared to 30 cm × 30 cm spacing.The increases in grain yield recorded under 25cm × 25 cm plant spacing. Similarly, significantly higher nutrient uptake (NPK) values by grain, straw and total uptake were recorded by 10 days old seedlings than 8 and 14 days old seedlings.

Singh et al in (2005) reported that the maximum amount of nitrogen mineral nutrient was absorbed with the use of rice bran at the rate if 2 tonne per hectare which is succeeded by physical weeding and removing of weeds three times with the help of cono weeder which impacted the absorption of potassium mineral.They also stated that intake of phosphorus was lowest when physical weeding was done two times and it was found to be statistically similar with the treatment in which there is application of rice bran at the rate of 2 tonnes per hectare along with one physical removal of weeds at the 5% significance.They also revealed that they observed very less losses of essential nutrients occured when there was efficient control of weeds.

CHAPTER 3

Materials and Methods

The study was conducted under the project **“Performance of direct seeded rice (Oryza sativa.L.) in relation to planting patterns, nitrogen levels, and weed control methods”** at the experimental farm of the Department of Agronomy, School of Agriculture, Lovely Professional University, Phagwara (punjab), during the Kharif seasons of 2022 and 2023. Two different field trials were designed in Split Plot Design. This chapter discusses the information of the things utilized and the practices pursued throughout the process of examination . For the following subheadings, you will find a brief overview of the experiment's location, soil characteristics, climate with meteorological data, experimental design, land preparation, and various agronomic practices.

3.1. Description of the experimental site.

3.1.1. Location of the experimental location

During *kharif* season of 2022 and 2023, the experiment was carried out at the Lovely Professional University's Agronomy Research Farm in Phagwara, District Kapurthala. The farm is situated at latitude 3122'31.81" North and longitude 7523'03.02" “East, with an average altitude of 252 m above mean sea level. It is situated in central Punjab and 360 km from Delhi, (The Indian capital). It is located in the central plain zone of the agroclimatic zones, which is a subtropical region.

3.1.2. Weather and climate conditions

This experimental site, located in a subtropical climate, has cold winters and hot summers, with the majority of its rainfall falling in July, August, and September due to the South-West monsoon. The highest temperature recorded in May and June throughout the summer was close to 46 degrees Celsius. If the South-West monsoon is not delayed, monsoon rains will begin in the second fortnight of July and extend until the end of month of September. Both the months of July and August get a lot of rain. The region receives approximately 650 mm of rain a year, with the majority of rains falling in July, August, and September. The majority of the year,the weather is hot and humid.Average temperature maximum, minimum, and rainfall data were collected during various stages of crop growth. Tables 3.1 and 3.2 contain these data. The cultivation of paddy requires a hot and humid environment. It performs best in regions with high humidity, constant sunlight, and an ongoing supply of water. Crops require an average temperature range of 21–37ºC throughout their life cycle. The crop will tolerate temperatures as high as 40 to 42 degrees Celsius.

Table 3.1. Meteorological data of experimental area through growing season of the rice for the year 2022

Months	Maximum temperate (^{0}C)	Minimum temperature (^{0}C)	Relative Humidity %	Rainfall (mm)
May	40.06	24.7	63.8	0.00
JUNE	41.2	30.8	60	1.42
JULY	34.75	27.5	63.5	7.73
AUGUST	34.25	25.8	64	1.03
SEPTEMBER	35.5	24.74	63.25	0.72
OCTOBER	33.5	21.42	47.75	0.00

Table 3.2. Meteorological data of experimental area during growing season of the rice for the year 2023

Months	Maximum temperature (^{0}C)	Minimum temperature (^{0}C)	Relative Humidity %	Rainfall (mm)
May	41.7	24.5	61.2	0.00
JUNE	42.8	27.6	62.5	0.98
JULY	37.9	27.3	62.8	5.58
AUGUST	35.8	25.3	59.5	1.25
SEPTEMBER	35.5	23.8	58.7	1.01
OCTOBER	34.9	21.3	49.54	0.00

3.2. Cropping history

The experiment during both years was conducted on typical rice soil (clay loam) with cropping history given in 3.3.

Table 3.3. Cropping History of the Experimental Field

Year	***Kharif***	***Rabi***
2020-2021	Rice	Wheat
2021-2022	Rice	Wheat
2022-2023	Experimental Rice	Wheat
2023-2024	Experimental Rice	Wheat

3.3 Collection of soil sample

Before beginning the research, random soil samples were taken from the field. After scraping the surface, a v-shaped incision was created 6 inches deep , and a 1-inch-thick slice of soil was extracted from one of the vertical cuts. Similarly, 10 to 12 samples were collected from the field in a zigzag pattern. Finally, approximately 500 g of soil were taken after the soil samples were completely mixed using the quartering technique.The specimens were exploited in finding out the physical and chemical characteristics of the soil. Tables 3.4 and 3.5 represent the experimental location's initial soil fertility level.Soil samples were collected and analyzed once more during harvest.The area where study was done ,was an area less in available N,medium P and K.

Table.3.4. Physical properties of soil at experimental site

Characteristics	Percentage (%)
Sand content	27
Silt content	41
Clay content	32
Soil texture	Clay Loam

Table.3.5. Chemical properties of soil of experimental site

S.no.	**Particulars**	**Result**	**Method Followed**
1	pH	7.6	pH meter
2	EC	0.31	EC meter
3	Organic carbon	0.45%	Walkley and Black` s method
4	Available Nitrogen	145kg/ha	Alkaline potassium permanganate method (Subbiah and Asija, 1956)
5	Available phosphorus	13.8 kg/ha	Olsen method (Olsen *et a*., 1954)
6	Available potassium	168 kg/ha	Flame photometery method (Black, 1965)

3.4. Nutrients sources utilized in the experiment

1. Nitrogen was given through Urea (46% nitrogen).

2. Phosphorus was given through DAP (46% phosphors)

3. Potash was given through MOP (60% potash)

3.5. Details of experiments (Technical programme)

Two different experiments were executed using a Split Plot Design.First experiment contained four main and four sub treatments, and second experiment also contained four main and four sub treatments with three replications of each experiment". Details about the treatments are presented below.

Expt-I "Role of Planting Patterns and weed control methods on growth and development of direct seeded rice"(DSR)

Main plots	Planting patterns
M_1	Flat sowing
M_2	Two rows per bed
M_3	Three rows per bed
M_4	Two rows per bed & one in furrow
Sub plots	**Weed control methods**
T_1	"Pendimethalin 30 EC 0.75 kg/ha,pre-em. fb. bispyribac 10 SC 25 g/ha,post-em.
T_2	Pendimethalin 30 EC 0.75 kg/ha,pre-em. fb. metsulfuron 20 WG 15 g/ha,post-em.
T_3	Weed free
T_4	Weedy check (control)

Note: Beds were made at 67.5 cm spacing with 37.5 cm bed top and 30.0 cm furrow.

Bispyribac and metsulfuron were applied 30-35 DAS.

Expt-II "Performance of nitrogen levels and weed control methods on growth and development of direct seeded rice"(DSR)

Main plots	Nitrogen levelss
N_1	0 kg N/ha
N_2	125 kg N/ha
N_3	150 kg N/ha
N_4	175 kg N/ha
Sub plots	**Weed control methods**
T_1	Pendimethalin 30 EC 0.75 kg/ha, fb. bispyribac 10 SC 25 g/ha
T_2	Brown manuring (sesbania), pendimethalin 30 EC 0.75 kg/ha fb. bispyribac 10 SC 25 g/ha
T_3	Brown manuring (sesbania) fb. bispyribac 10 SC 25 g/ha
T_4	Weedy check (control)

-Pendimethalin was applied as pre-emergence

- Bispyribac was applied 30 to 35 days after sowing.

-Sesbania was killed with the spray of 2,4-D when it was 25 days old.

3.6 Experiment layout details:

EXPT- I

Number of main plot treatments : 4

Number of sub plot treatments : 4

Numbers of replications:- 3

Numbers of plots : 4 x 4 x 3 = 48

EXPT- II

Number of main plot treatments : 4

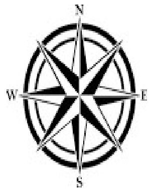
Number of sub plot treatments : 4

Numbers of replications:- 3

Numbers of plots : 4 x 4 x 3 = 48

Total no of plots for both expt-I & expt- II = 96

Layout experiment: I Role of Planting Patterns and weed control treatments on growth and development of direct seeded rice.(DSR)

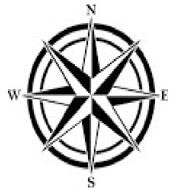


MAIN WATER CHANNEL

PATH	R1	WATER CHANNEL	R2	PATH	R3	WATER CHANNEL
	$M_3 T_2$		$M_1 T_4$		$M_4 T_3$	
	$M_3 T_3$		$M_1 T_2$		$M_4 T_1$	
	$M_3 T_1$		$M_1 T_3$		$M_4 T_4$	
	$M_3 T_4$		$M_1 T_1$		$M_4 T_2$	
	$M_1 T_2$		$M_3 T_4$		$M_3 T_3$	
	$M_1 T_4$		$M_3 T_2$		$M_3 T_2$	
	$M_1 T_3$		$M_3 T_1$		$M_3 T_1$	
	$M_1 T_1$		$M_3 T_3$		$M_3 T_4$	
	$M_4 T_3$		$M_2 T_1$		$M_1 T_2$	
	$M_4 T_1$		$M_2 T_3$		$M_1 T_4$	
	$M_4 T_4$		$M_2 T_2$		$M_1 T_3$	
	$M_4 T_2$		$M_2 T_4$		$M_1 T_1$	
	$M_2 T_3$		$M_4 T_2$		$M_2 T_3$	
	$M_2 T_2$		$M_4 T_4$		$M_2 T_2$	
	$M_2 T_4$		$M_4 T_1$		$M_2 T_4$	
	$M_2 T_1$		$M_4 T_3$		$M_2 T_1$	

Plot size – 6m x 3.5= 21 sq.m

Layout experiment: II Performance of nitrogen levels and weed control methods on growth and development of direct seeded rice(DSR)



MAIN WATER CHANNEL

	R1		R2		R3	
PATH	$N_3 T_2$	WATER CHANNEL	$N_1 T_4$	PATH	$N_4 T_3$	WATER CHANNEL
	$N_3 T_3$		$N_1 T_2$		$N_4 T_1$	
	$N_3 T_1$		$N_1 T_3$		$N_4 T_4$	
	$N_3 T_4$		$N_1 T_1$		$N_4 T_2$	
	$N_1 T_2$		$N_3 T_4$		$N_3 T_3$	
	$N_1 T_4$		$N_3 T_2$		$N_3 T_2$	
	$N_1 T_3$		$N_3 T_1$		$N_3 T_1$	
	$N_1 T_1$		$N_3 T_3$		$N_3 T_4$	
	$N_4 T_3$		$N_2 T_1$		$N_1 T_2$	
	$N_4 T_1$		$N_2 T_3$		$N_1 T_4$	
	$N_4 T_4$		$N_2 T_2$		$N_1 T_3$	
	$N_4 T_2$		$N_2 T_4$		$N_1 T_1$	
	$N_2 T_3$		$N_4 T_2$		$N_2 T_3$	
	$N_2 T_2$		$N_4 T_4$		$N_2 T_2$	
	$N_2 T_4$		N_4 T1		$N_2 T_4$	
	$N_2 T_1$		$N_4 T_3$		$N_2 T_1$	

Plot size – 6m x 3.5= 21 sq.m

3.7. Details of variety:

PR 126, a short-duration rice cultivar, was sown in both experiments. It's an early maturing rice variety. It has an average plant height of 102 cm and matures approximately 93 days after transplantation. PR 126 matures in 123 days if grown using the DSR method. It has long slender, clear translucent grains. It is resistant to seven of the 10 most common bacterial blight pathogens in Punjab State. The average paddy production is 75.0 quintals per hectare.Transplant 25-30 days old nursery. The Punjab Agricultural University (PAU) recommends cultivating PR 126 in 2017.

3.8. Agronomic practices

3.8.1. Preparation of land:

Preparation of field: Pre-sowing irrigation (rauni) was applied in the first week of May. The field was ploughed three times: once with a disc harrow and twice with a cultivator, followed by planking to make sure proper germination. The field was properly levelled to improve irrigation efficiency.

3.8.2 Seed rate and spacing :

The seeds were sown maintaining row to row distance of 22.5 cm. The seed rate is 20 kg/hectare. The sowing depth was 3-4 centimetres.

3.8.3. Sowing time:

A seed germination test was performed in the Agricultural Laboratory of Lovely Professional University. The germination ranged from 80-85%. Normally,the recommended sowing time of direct seeded rice is 25th May to 20th June for this variety. For the first and second experiment, sowing was done on 25th of may during both years,in the dry field followed by irrigation immediately.

3.8.4 Method of sowing:

In the first trial, sowing was done according to planting patterns of sowing i.e., (flat sowing,two rows/bed,three rows/bed and two rows/bed & one row in furrow.).by using constant seed rate.The beds of 67.5 cm (37.5 cm bed top and 30 cm furrow) were made manually, For second trail, the seeds were sown on flat bed by maintaining a distance of 22.5 cm row to row spacing, which is recommended when using the DSR technique to sow paddy.Seeds were sown approximately at the depth of about 3-4 cm .

Figure .3.1. Sowing of Direct Seeded Rice

3.8.5. Fertilizer application

Nutrient (kg/ha)		
Nitrogen (N)	**Phosphorus (P_2O_5)**	**Potassium (K_2O)**
150	**30**	**30**

During the sowing period, potassium and phosphorus were applied in a single split by broadcast method. The application of nitrogen was done in three split doses 20 DAS,tillering and before panicle intiation. Recommended nitogen was applied in first experiment where as in second experiment nitrogen was applied as per treatment.

3.8.6 Irrigation :

Irrigation was supplied as necessary by the crop.i.e. when lack of moisture was observed in soil due to break in monsoon rains,irrigations was applied.

3.9. Weed management:

Weed management practices was done as per treatments given in sub plots.

3.9.1 Brown manuring (sesbania) : Sesbania was sown in lines between the inter row spaces along with rice to smoother the weeds and the sesbania was killed by spraying 2-4 D sodium salt at 0.80kg a.i/ha, as post emergence i.e. between 25 to 30 DAS. When it started smoothering the rice plants.

3.9.2 Weed free

In weed free plot pre-emergence application of pendimethalin was done which was followed by post emergence application of bispyribac. Hand pulling of left over weeds was done manually to kept the crop free from weeds.

3.9.3 Weedy check

No efforts were made to control the weeds of weedy check (control) treatment and weeds were allowed to grow along with the crop up to harvest.

3.9.4 Weed flora

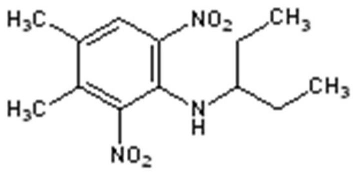
Echnochloa crusgalli, Echnochloa colona,Elusine indica, Cyperus rotundus,cyperus iria , Dactyloctenum aegypticum , Leptochloa chinenis, Caesulia axillaries,Commelina benghalensis,Physalis minima,Eclipta alba, Euphorbia hirta,Phyllanthus niruri, ,Ludwigia spp., Trianthema monogyna, Achyranthus aspera.Digiteria sanguinalis,Ammania baccifera,Fimbristylis miliaceae.

3.9.5 Herbicide application

The herbicides were calculated as per treatment and, using a knapsack sprayer, were sprayed in the required plot in accordance with the treatment, by using 500 lt/ha for pre-emergence herbicides and 250 lt/ha for post-emergence herbicides.

3.10. Herbicide details

Pendimethalin 30 EC



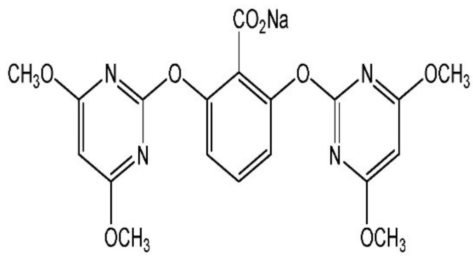
Common name **: Pendimethalin (Stomp)**

IUPAC **: N-(1-ethylpropyl)-2,6-dinitro-3,4-xylidine**

Formulation : 30 EC

Uses :	Used as pre-emergence applications to control annual grasses and certain broad leaf weeds
Mode of action : :	It inhibits cell division and cell elongation.

Bispyribac sodium 10 SC



Common name **:** Bispyribac sodium (**Nominee gold**)

IUPAC **: "Sodium 2,6-bis(4,6-dimethoxypyrimidin-2-yloxy)benzoate".**

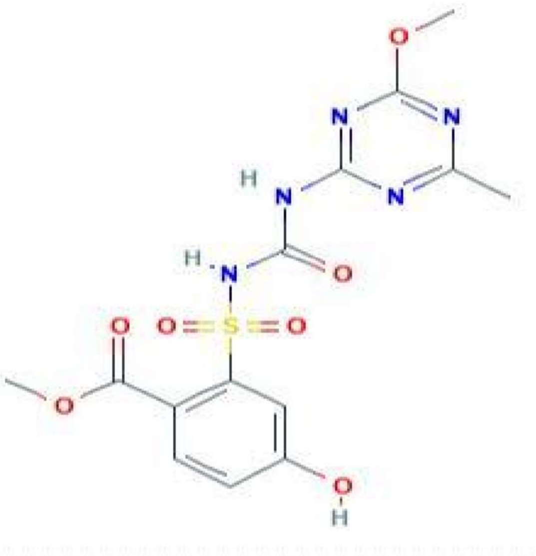
Formulation **:** 10-SC

Uses **:** Broad spectrum post-emergent herbicide: It efficiently suppresses grasses, broad leaf weeds, and sedges that infest rice crops, both direct-seeded and transplanted.

Mode of action **:** Bispyribac sodium is a systemic herbicide that travels throughout plant tissue and operates by inhibiting the formation of the enzyme acetolactate synthase (ALS), which is required for plant growth.

Metsulfuron

Common name **: Metsulfuron-methyl 20 WP (Algrip)**



IUPAC **: "**Methyl 2-[(4-methoxy-6-methyl-1,3,5-triazin-2yl) carbamoylsulfamoyl]benzoate".

Formulation **:** 20-WP

Uses **:** It is used as pre- emergent as well as post-emergent herbicide mainly for broad leaf weeds

Mode of action : It inhibits the division of cells in the plant's roots and shoots.

3.11. Insect management:

During entire growing season the paddy variety PR 126 was not infested by any disease or pest during both years.

3.12. Harvesting :

The crop was harvested when the plant started drying and reached up to 100% of the grain maturity in the panicles. A net plot area of 2 square metres from each subplot was harvested separately. Then after the proper sun drying,threshing was done by beating the plants on hard surface.

3.12.1. Biological yield (q/ha)

The bundles of paddy before threshing were weighed for recording biological yield which was converted to q/ha.

3.12.2 Threshing and winnowing :

The seeds were separated manually by beating the rice plants on the drum and winnowing was done to clean the seeds .Weighing for recording seed yield per plot was done with electronic balance.

3.12.3 Straw yield (q/ha)

The seeds were separated manually by beating the rice plants on the drum and winnowing was done to clean the seeds .Weighing for recording seed yield per plot was done with electronic balance.

3.12.4. Seed yield (q/ha)

After threshing,the seeds were cleaned thoroughly and dried in sun.After weighing on electronic balance seed yield per net plot (2.0 sq.m) was converted to q/ha for reporting.

3.13. Treatmental evaluation

3.13.1 Weed studies

Major weed flora of the experimental trail was observed during both years 2022 & 2023 of growing season of PR 126 paddy on the experimental field,The infesting weeds were *Echnochloa crusgalli, Echnochloa colona,Elusine indica, Cynodon dactylon , Dactyloctenum aegypticum , Leptochloa chinenis, Caesulia axillaries,Commelina benghalensis,Physalis minima,Eclipta alba,Euphorbia hirta,Phyllanthus niruri,Ludwigia spp., Trianthema monogyna,Achyranthus aspera.Digiteria sanguinalis,Ammania baccifera,Fimbristylis miliaceae*.

3.13.2 Weed count (weeds/m²)

Weed count was recorded at 30,60,90 DAS and at harvest with the help of 30 cm² quadrant. The quadrant was thrown twice randomly per plot and the number of weed plants present in the quadrat were counted and converted into sq.m basis.

3.13.3. Dry matter of weed (q/ha)

Weed plants were collected from one square feet quadrat which was thrown randomly at two spots/ plot from all experimental treatments which were cut from the soil surface at 30,60,90 DAS and at harvest. Sun drying of plants was done and dry weight of weeds was recorded after drying in the oven at 55 ± 5ºC on electronic weighing machine and dry weight accumulation was converted into q/ha.

3.13.4 Weed control efficiency (WCE):

The percentage reduction in dry weight of weeds under treated plots in comparision to untreated plot and was calculated in percentage with the help of following formula.

$$\text{WCE (\%)} = \frac{\text{(Weed dry matter in unweeded plot – Weed drymatter in treated plot)}}{\text{(Weed dry matter in unweeded plot)}} \times 100$$

3.14. Growth observations

All critical observations, such as crop growth factors, yield attributes, and yield, were recorded.Five sample plants of each treatment per plot were randomly picked and tagged to record growth and yield characteristics. The process for recording experimental observations is detailed below.

3.14.1 Plant height- (cm):

The height of five representative plants was measured at 30, 60, and 90 DAS as well as at harvest, from the base to the last fully opened leaf with using a meter scale,then the average height was then finally reported in centimetres

3.14.2 Number of tillers per sq.m.

The total number of tillers were counted at 30,60 ,90 and at harvest from all plots.In the first experiment,this observation was recorded from two random spots per plot by using 30cm x 30cm quadrate.In second experiment,it was recorded from 50cm running row length from two spots per experimental plot.

3.14.3. Number of effective tillers per sq.m

Tillers which have capability to produce ear filled with grains are considered to be a productive or effective tiller. In the first experiment,this observation was recorded from two random spots per plot by using 30cm X 30cm quadrate.In second experiment,it was recorded from 50cm running row length from two spots per plot.These observations were converted to number of effective tillers per sq.m. for presentation.

3.14.4. Dry matter accumulation by crop (q/ha):

Dry weight of crop was recorded at 30, 60, 90 days afer sowing, and at harvest. Before weighing the plants,they were sun dried and then transferred to an oven at $55 \pm 5^{o}C$ till complete dryness.

3.14.5. Chlorophyll index by SPAD meter:

Chlorophyll content of leaf per experimental plot have been analysed with the help of SPAD meter .Average was calibrated and recorded at 30, 60, and 90 DAS.

3.15. Yield and yield attributes :

3.15.1 Number of panicles m^{-2}

The number of panicles were counted at maturity with the help of quadrate of 30 cm X 30 cm and converted to sq.m basis for both experiments.

3.15.2 Number of grains per panicle :

Number of grains per panicle in five representative panicles and their average number of grains were expressed as grains/$panicle^{-1}$

3.15.3 Panicle length (cm) :

Five panicles from the tagged plants were taken individually, and their length in centimetres was measured from the node to the apex.and the average was done.

3.15.4 Test weight (gm) :

1000 grains were collected from each net plot and were counted at random with the help of automatic seed counter. The counted seeds were weighed and recorded subsequently in grams.

3.15.5. Biological yield (q/ha):

The weight was recorded after harvesting of the representative net area. This was reported as biological yield (q/ha).

3.15.6.Straw yield (q/ha):

The average straw yield was determined by subtracting the seed yield from the biological yield (total weight of rice plants – seed weight). and it was provided the q/ha report.

3.15.7.Seed yield (q/ha)

Crop harvested from representative net plot was threshed by beating on hard surface, cleaned carefully and seeds were weighed on electronic balance after drying, Then seed yield in q/ha was worked out.

3.15.8 Harvest Index (H.I.) :

The harvest index (%) was done with the help of using following formula :

Harvest Index (H.I.) = Seed yield/biological yield x 100

3.16. Quality analysis :

3.16.1 N content in seed and straw:

N content in seed and straw was evaluated by micro-Kjeldahl method as per procedure suggested by AOAC (1995).

3.16.2. N content in weeds:

N content in weeds was evaluated by micro-Kjeldahl method as per procedure suggested by AOAC (1995).

3.16.3 N uptake by seed :

N uptake by grain (kg ha^{-1})

$$= \frac{\text{N content in seed (\%) x seed yield (kg ha}^{-1}\text{)}}{100}$$

3.16.4. N uptake by straw (kg ha^{-1}) :

$$= \frac{\text{N content in straw (\%) x straw yield (kg ha}^{-1}\text{)}}{100}$$

3.16.5 N uptake by weeds (kg ha^{-1}) :

$$= \frac{\text{N content in weeds (\%) x Weed drymatter (kg ha}^{-1}\text{)}}{100}$$

3.16.6 Protein (%) content in seed:

Based on the assumption that nitrogen consists up to 16% of protein, the protein analysis of the seed was computed by multiplying the nitrogen content (%) by 6.25.

protein content percent (%) = nitrogen content percent (%) x 6.25

3.16.7 Nitrogen use efficiency (NUE):

The NUE components viz., recovery efficiency (REN) and agronomic efficiency (AEN) were calculated by below mentioned formulae.

$$\text{REN (\%)} = \frac{\text{Total N uptake in N fertilized plot – Total N uptake in no N plot}}{\text{Quantity of N fertilizer applied in N fertilized plot}} \times 100$$

$$\text{AEN (kg grain kg}^{-1}\text{ N applied)} = \frac{\text{Grain yield in N fertilized plot – Grain yield in no N plot}}{\text{Quantity of N fertilizer applied in N fertilized plot}}$$

3.16.8. Statistical analysis

The data recorded on different charecters of experimental crop was analyzed through OPSTAT as sugested by Fisher 1947 and all analysis work was done on computer at CD”(0.05).

Anova Tables (for both experiments)

Source of variation	Degree of freedom
Main	3
Replications	2
Error (a)	6
Sub	3
Main X sub	9
Error (b)	24
Total	47

Trianthema portulacastrum

Digera arvensis

Amaranthus viridis

Commelina benghalensis

Eleusine aegyptiaca

Eragrostis tenella

Cucumis trigonus

Tribulus terrestris

Brachiaria reptans

Figure 3.2: Important weeds in DSR (non-paddy weeds)

Echinochloa crusgalli

Ischaemum rugosum

Caesulia axillaris

Ammania baccifera

Cyperus iria

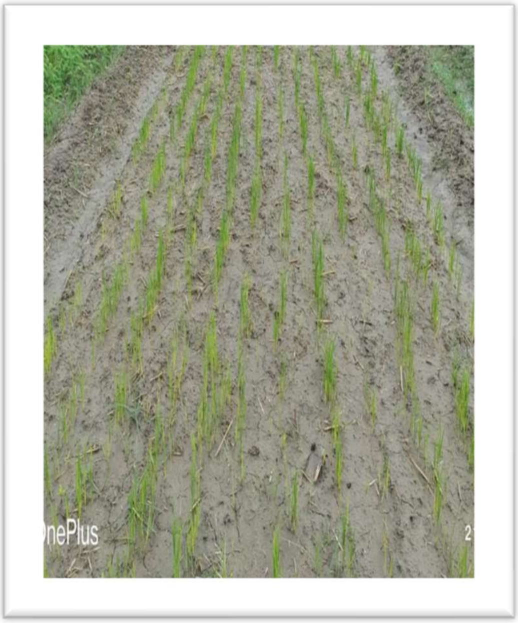
Cyperus difformis

Cyperus compressus

Sphenoclea zeylanica

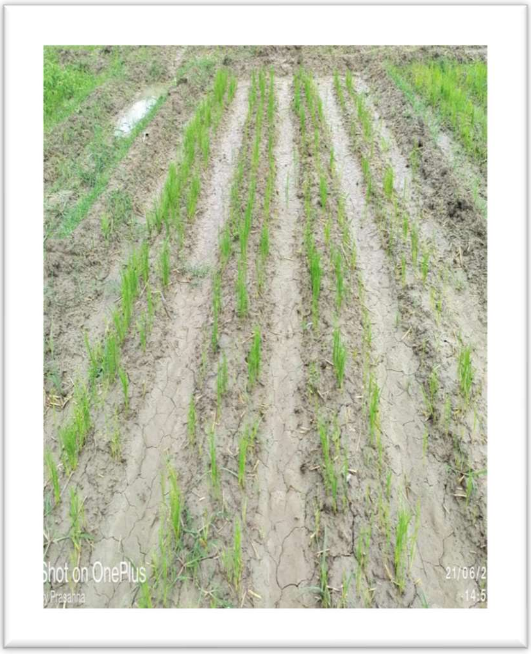
Fimbristylis miliacea

Figure 3.3: Important weeds in DSR (paddy weeds)

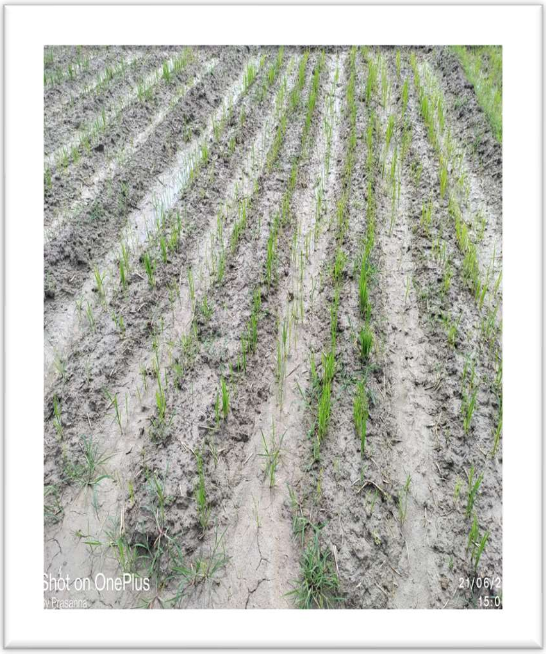


Flat sowing

Two rows/bed



Three rows/bed



Two rows/bed&1 in furrow

Figure .3.4: Experiment :1 planting patterns (15 DAS)

Pendi 0.75 kg/ha,pre.em. fb. bispyribac 25 g/ha 30 DAS

BM Sesbania,Pendimethalin 0.75 kg/ha,pre.em. fb. bispyribac 25 g/ha 30 DAS

BM Sesbania. fb. bispyribac 25 g/ha 30 DAS

unweeded (Control)

Figure 3.5. Experiment :2 Nitrogen levels (30 DAS)

Flat sowing

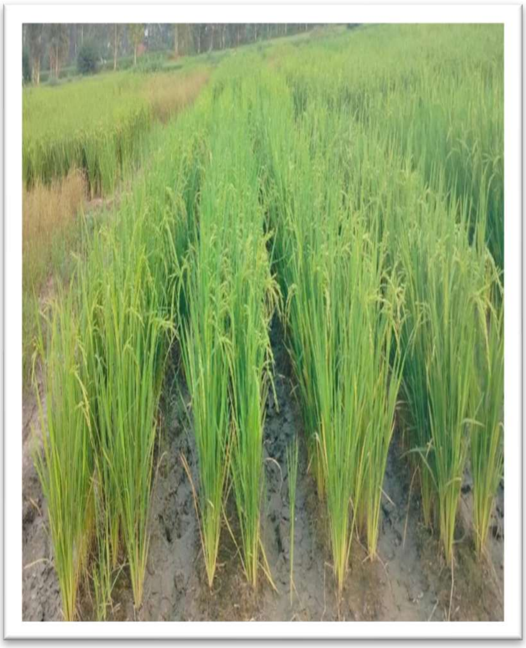
Two rows/bed

Three rows/bed

Two rows/bed one in furrow

Figure 3.6. Experiment:1 Planting Patterns (50 DAS)

Flat sowing



Two rows/bed

Three rows/bed

Two rows/bed & 1 in furrow

Figure 3.7. Experiment:1 Planting Patterns (85 DAS)

T1- Pendi. fb. bispyribac

T2-BM,Pendi,fb. bispyribac

T3- BM, . fb. bispyribac

T4- Unweeded (control)

Figure 3.8. N1- 0 kg N/ha

T1- Pendi. fb. bispyribac

T2-BM,Pendi,fb. bispyribac

T3- BM, . fb. bispyribac

T4- Unweeded (control)

Figure 3.9. N2- 125 kg N/ha

T1- Pendi. fb. bispyribac

T2-BM,Pendi,fb. bispyribac

T3- BM, . fb. bispyribac

T4- Unweeded (control)

Figure 3.10. N3- 150 kg N/ha

T1- Pendi. fb. bispyribac

T2-BM,Pendi,fb. bispyribac

T3- BM, . fb. bispyribac

T4- Unweeded (control)

Figure 3.11. N4- 175 kg N/ha

Before spraying

After 5 days of spray

Appearing plants after 10 days

Figure 3.12. Stages of sesbenia for brown manuring

CHAPTER 4

RESULTS AND DISCUSSION

The research trail was conducted in the *Kharif* season of 2022 and repeated in 2023, at the experimental farm of Department of Agronomy, School of Agriculture, Lovely Professional University, Phagwara (Punjab). The research project entitled**"Performance of direct seeded rice (*Oryza sativa.L.)* in relation to planting patterns, nitrogen levels and weed control methods"**.Two different field trials were designed in the Split Plot Design each during both years. The data on impact of different planting patterns, nitrogen levels and weed management treatments regarding weed parameters, crop growth parameters, yield and yield attributing characteristics, and crop quality had been subordinated to numerical evaluation with a view to test the level of significance of results. The results are being presented and discussed critically under the following sub- headings experiment wise.

Experiment: 1

"Role of planting patterns and weed management treatments on growth and development of direct seeded rice" (*Oryza sativa.L*).

4.1 Weed parameters

4.1. 1 Total weed count (per sq.m)

Weed count indicates intensity of weed plants as well as type of weed flora present in a particular treatment and this parameter also indicates extent of yield loss due to weeds.The data on total weed count per sq.m as influenced by different planting patterns and weed control methods were recorded periodically at 30 days after sowing interval,60 days after sowing interval,90 days after sowing interval and final interval at harvest and presented in Table 4.1.1a ,4.1.1b along with graphically depicted in Fig.4.1.1.Due to wide variations in data square root transformation was adopted after adding one to all the original values recorded for all periodic intervals.

There was no significance difference for total weed count per square meter recorded at 30 DAS as influenced by planting patterns for two consecutive years.(Table 4.1.1a) Out of the weed management methods ,the significantly higher weed count was recorded by unweeded (control) in comparison with another weed management practices for two consecutive years.The significantly less weed count was observed in weed free up to harvest compared to all other herbicidal treatments for both the years.Total weed count in pre-em.pendimethalin fb. bispyribac was significantly less than pendimethalin fb. metsulfuron during 2022 but during 2023 both these found treatments were at par with each other.

At 60 DAS,the differences in the weed count due to planting patterns were found to be non significant when recorded for the year 2022 but it was found significant for the year 2023.The significantly more weed count was recorded in flat sowing method as compared to three rows per bed (M3 & M4) planting patterns during 2023 and the latter planting methods were found at par. Also the differences for weed count in flat and two rows per bed were found to be non-significant. Among the weed management treatments,the significantly more weed count was recorded in unweeded (control) when compared with all other weed management treatments.The significantly less weed count was observed in weed free up to harvest when recorded for both the years in comparison with another weed management treatments.In the two years of study , pre-em. application of pendimethalin fb bispyribac recorded significantly less weed count per sq.m as compared to pendimethalin fb. metsulfuron treatment.

At 90 DAS,there is no significant differences in the weed count per sq.m. due to planting patterns for two consecutive years.(Table 4.1.1b). Amongst weed management practices,the significantly more weed count was recorded in unweeded (control) in comparison with additional weed management practices in the two consecutive years.The significantly less weed count was observed in weed free up to harvest as compared to all other treatments during both the years.Weed count in pendimethalin fb. metsulfuron was significantly higher than pendimethalin fb bispyribac during both years.

At harvest,the differences in the weed count due to planting patterns were observed as non significant in two consecutive years.(Table 4.1.1b)Among the weed management methods,the significantly more weed count was observed in unweeded in comparison with the further weed management treatments in two years of study .The lowest weed count was observed in weed free up to harvest when compared to all other weed management treatments during both the years.Also weed count per sq.m at harvest was significantly less in pendimethalin fb. bispyribac than pendimethalin fb. metsulfuron treatment during both years.

Generally weed count per square meter was high in flat sowing method when recorded at all periodic intervals during both years than bed sowing methods as weed seeds were burried deep in bed planting treatments. Total number of weeds/sq.m had significantly less in bispyribac treatment due to its broad spectrum weed control as compared to metsulfuron which controls sedges and broad leaf weeds in paddy and this holds good at all periodic intervals.Pendimethalin controlled all non paddy weeds where as bispyribac controlled all paddy weeds due to its broad spectrum nature and metsulfuron provided control on broad leaf weeds and sedges growing in rice. The weed population in unweeded (control) was significantly higher due to availibility of more space as initial growth of direct seeded rice is very slow.andits mortality rate was also high. Identical findings were observed by Pooja and. Saravanane 2021; Singh et al., 2016.

The interactive effect due to planting patterns and weed management treatments were observed as non-significant in all stages during both years.

Table. 4.1.1a. Effect of planting patterns and weed control treatments on weed count per square meter recorded at 30 DAS & 60 DAS during 2022 and 2023

	Weed count /m^{-2}			
Main plots – Planting patterns				
	30 DAS		60 DAS	
	2022	2023	2022	2023
M$_1$ – Flat sowing	8.3(69)	8.8(79)	9.2(85)	14.3(205)
M$_2$ – Two rows/bed	8.3(69)	8.3(69)	8.8(79)	13.6(185)
M$_3$ – Three rows/bed	7.9(63)	8.3(69)	9.3(88)	13.0(170)
M$_4$ –Two rows/bed & 1 in furrow	8.3(69)	8.4(71)	9.0(81)	13.4(181)
SE(m)	0.20	0.24	0.38	0.27
CD at P < 0.05%	NS	NS	NS	0.95
Sub plots - Weed control treatments				
T$_1$ -Pendi fb. bispyribac	6.7(46)	7.4(56)	7.6(58)	11.5(133)
T$_2$-Pendi fb. metsulfuron	7.9(63)	8.0(64)	8.5(73)	13.0(171)
T$_3$ -Weed free	1(0.0)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)
T$_4$ -Unweeded (control)	12.7((162)	12.9(168)	14.2(203)	20.9(438)
SE(m)	0.34	0.27	0.30	0.52
CD at P < 0.05%	0.99	0.85	0.76	1.66
CD for interaction	NS	NS	NS	NS

-Figures without paranthesis are statistically analysed square root transformed values.

-Figures in paranthesis are original values

-"Pendi stands for pre-em.application of Stomp 30 EC (pendimethalin) at 0.75 kg a.i/ha

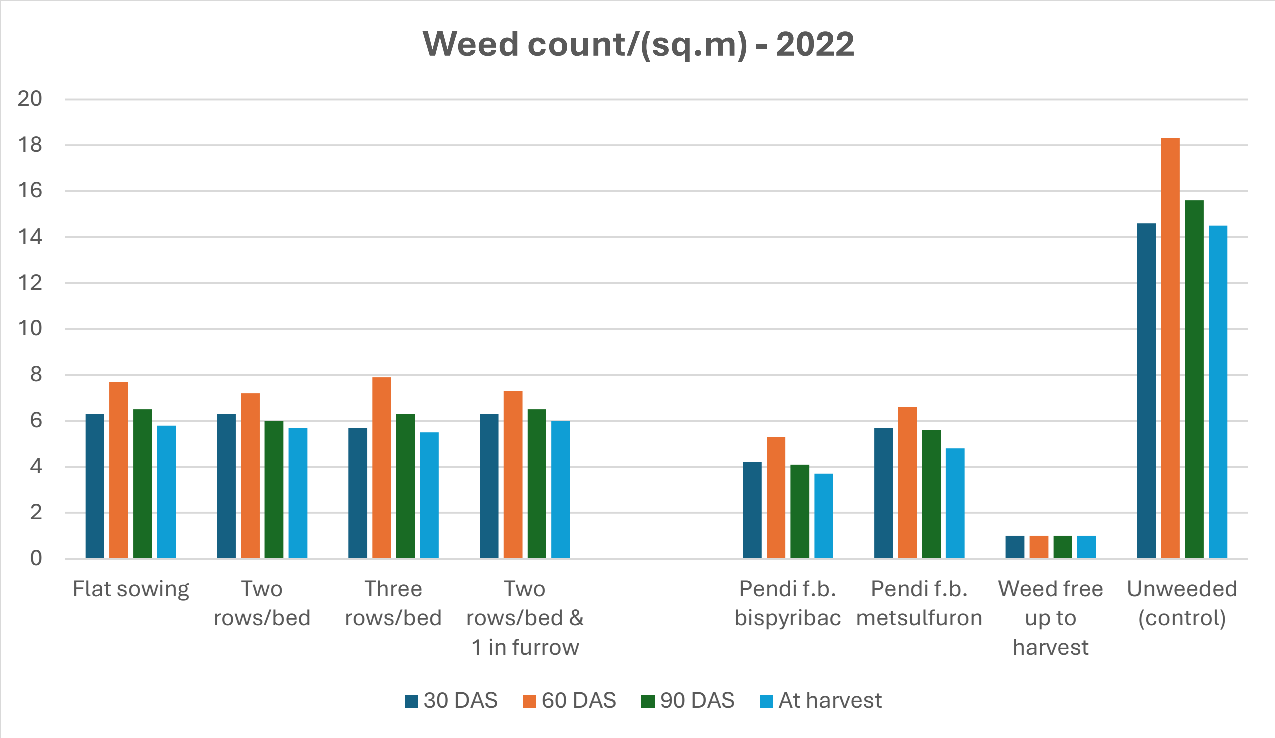
- Bispyribac was applied at 25 g/ha as post emergence & metsulfuron was applied at 15 g/ha as post em.(30 DAS)

Table. 4.1.1b. Effect of planting patterns and weed control treatments on weed count per square meter recorded at 90 DAS & at harvest during 2022 and 2023

	Weed count/m^{-2}			
Main plots – Planting patterns				
	90 DAS		At harvest	
	2022	2023	2022	2023
M_1 – Flat sowing	8.4(72)	9.6(94)	8.0(65)	9.2(85)
M_2 – Two rows/bed	8.1(67)	8.7(77)	7.9(63)	8.5(73)
M_3 – Three rows/bed	8.3(69)	9.0(81)	7.8(61)	8.7(77)
M_4 – Two rows/bed & 1 in furrow	8.4(72)	9.2(86)	8.1(67)	9.0(81)
SE(m)	0.55	0.32	0.18	0.22
CD at P < 0.05%	NS	NS	NS	NS
Sub plots - Weed control treatments				
T_1 -Pendi fb. bispyribac	6.7(45)	8.3(70)	6.4(42)	7.9(63)
T_2-Pendi fb. metsulfuron	7.8(62)	9.3(88)	7.2(53)	9.0(81)
T_3 -Weed free	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)
T_4 -Unweeded (control)	13.1(173)	13.4(180)	12.6(161)	13.1(172)
SE(m)	0.26	0.23	0.17	0.23
CD at P < 0.05%	0.67	0.87	0.38	0.59
CD for interaction	NS	NS	NS	NS

-Figures without paranthesis are statistically analysed square root transformed values.

-Figures in paranthesis are original values



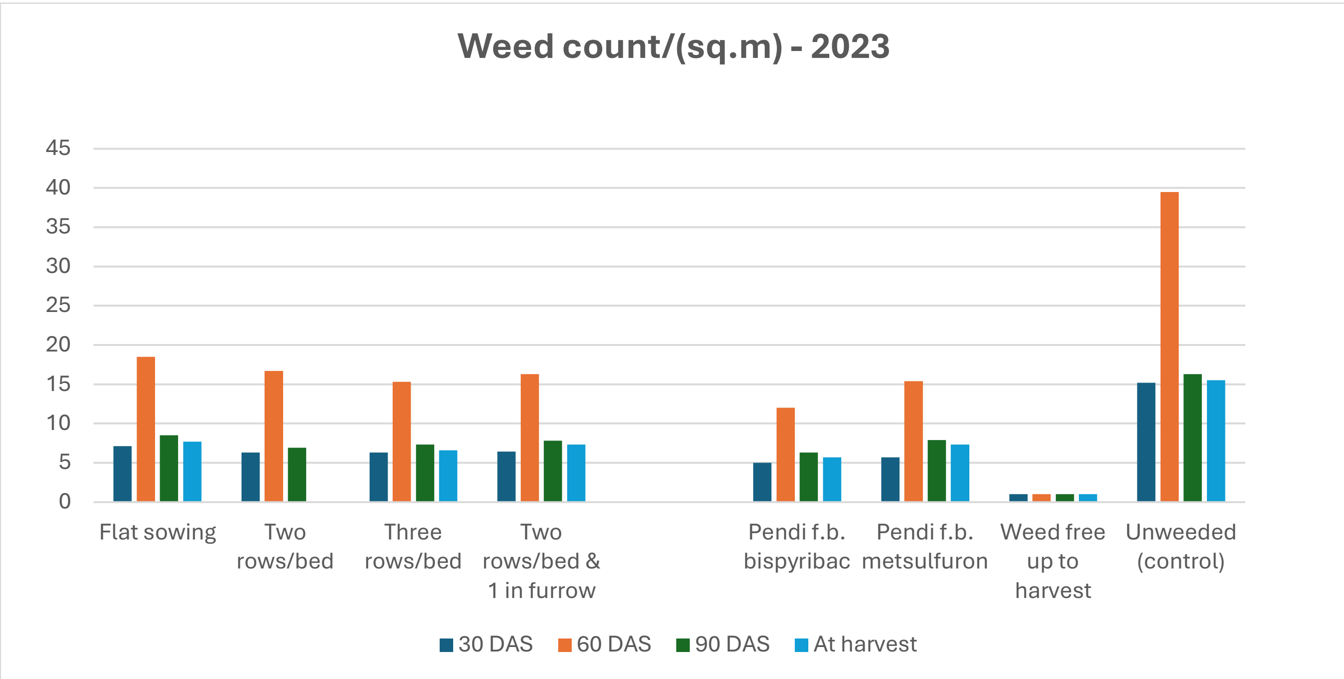


Fig. 4.1.1.Effect of planting patterns and weed control treatments on weed count per square meter recorded at 30,60,90 DAS & at harvest during 2022 and 2023

4.1.2 Dry matter of weeds (q/ha)

Recording dry matter accumulation by weeds is very important and valid indices for determining losses in crop yield due to weeds as compared to weed count per unit area,Hence the dry matter accumulation of weeds were recorded periodically and given in Table 4.1.2a, and 4.1.2b. and depicted graphically in Fig 4.1.2.

The accumulation of weed dry matter per (q/ha) was measured at 30 DAS, and there were significant differences among planting patterns and weed management treatments.(Table 4.1.2a). The significantly less dry matter accumulation was observed under two rows per bed and two rows per bed & one in furrow (M4) as compared to flat sowing and three rows per bed(M3).However during second year two rows per bed (M2) and three rows per bed (M3) being statistically similar. In the second year of study, significantly more dry matter of weeds was recorded in flat sowing compared to all other planting patterns. The dry matter accumulation by weeds exhibited a significant variation among weed management treatments.Among the weed management treatments, the unweeded (control) treatment recorded significantly more dry matter than all weed management treatments for both the years.(Table 4.1.2a).This underscores the effectiveness of weed management treatments in reducing weed dry matter accumulation compared to unmanaged conditions.The significantly lowest weed dry matter accumulation was observed in weed free up to harvest than all other treatments for both the years.This suggests that weed free up to harvest displayed effective weed control, resulting in the no accumulation of weed dry matter at the early growth stage.The dry matter accumulation in pendimethalin fb. bispyribac was found to at par with pendimethalin fb. metsulfuron in two consecutive years of study.

The dry matter of weeds (q/ha) had been measured at 60 DAS. At this stage, the differences in the weed dry matter accumulation due to planting patterns were found to be non significant(Table 4.1.2a).The dry matter accumulation by weeds exhibited a significant variation among weed management treatments .Among the weed management treatments, the unweeded (control) treatment recorded significantly more dry matter accumulation by weeds than all weed management treatments for both the years. This indicates the effectiveness of weed control methods in reducing weed dry matter accumulation compared to unmanaged conditions.The significantly less weed dry matter accumulation was observed in weed free treatment as compared to all other weed management treatments for both the years.Effective weed control, as demonstrated by weed free up to harvest ,because of periodic hand weeding .The differences in dry matter accumulation by weeds in pendimethalin fb. bispyribac and pendimethalin fb. metsulfuron were non-significant in two consecutive year of investigations.

The accumulation of dry matter of weeds (q/ha) observed at 90 DAS for two consecutive years. At this stage, the dry matter accumulation by weeds was not significantly influenced by planting patterns during both the years.(Table 4.1.2b). Among the weed management treatments, the unweeded (control) treatment recorded significantly more dry matter than all weed management treatments when recorded for both the years. This indicates the effectiveness of weed control methods in reducing weed dry matter accumulation compared to unmanaged conditions.Significantly lowest weed dry matter accumulation was recorded in weed free up to harvest than other weed management treatments for both the years.This suggests that weed free up to harvest provided effective weed control, resulting in no accumulation of weed dry matter.Pendimethalin fb. bispyribac recorded statistically at par weed dry matter accumulation with pendimethalin fb. metsulfuron treatment for both years.

The accumulation of weed dry matter per (q/ha) was also recorded at harvest. At this stage, the dry matter accumulation by weeds was not influenced significantly by the different planting patterns for both years.Among the planting patterns, overall more dry matter was observed in flat sowing technique than bed sowing as weed growth was comparatively less in bed sowing technique,may be due to burial of some weed seeds deep in soil. Among the weed management treatments, the unweeded (control) treatment recorded significantly more dry matter than all weed management treatments for both years.(Tab.4.1.2b) This indicates the effectiveness of weed control methods in reducing weed dry matter accumulation compared to unmanaged conditions.The significantly lowest weed dry matter accumulation was observed in weed free up to harvest as compared to all other weed control treatments.The dry matter accumulation by weeds in pendimethalin fb. bispyribac, pendimethalin fb. metsulfuron treatments was found at par with each other during both years.Effective control of weeds at all periodic intervals with bispyribac herbicide may be due to its broad weed control spectrum as compared to metsulfuron. The dry matter of weeds in unweeded (coontrol) was exceptionally high due to low smoothering effect of crop on weeds during initial stages. Identical outcomes are also revealed by Pooja along with Saravanane 2021; Singh et al., 2016.

The interactive effects due to planting patterns and weed control treatmets was found to be non-significant during both years at all periodic intervals for dry matter accumulation by weeds.

Table.4.1.2a. Effect of planting patterns and weed control treatments on weed dry matter accumulation(q/ha) recorded at 30 DAS & at 60 DAS during 2022 and 2023

	Weed dry matter accumulation(q/ha)			
Main plots – Planting patterns				
	30 DAS		60 DAS	
	2022	2023	2022	2023
M_1 – Flat sowing	2.5(6)	2.5(6)	4.1(17)	4.5(20)
M_2 – Two rows/bed	2.0(4)	2.1(5)	3.9(15)	4.3(18.9)
M_3 – Three rows/bed	2.5(6)	2.2(4)	3.9(15)	4.4(20)
M_4 – Two rows/bed & 1 in furrow	2.1(5)	2.3(5)	3.8(15)	4.3(19)
SE(m)	0.11	0.08	0.26	0.20
CD at P < 0.05%	0.25	0.18	NS	NS
Sub plots - Weed control treatments				
T_1 -Pendi fb. bispyribac	2.0(4)	2.0(5)	0.9(0.9)	2.7(7)
T_2-Pendi fb. metsulfuron	2.0(4)	2.0(4)	1.1(1)	3.0(9)
T_3 -Weed free	1.0 (0)	1.0(0)	1.0(0)	1.0(0)
T_4 -Unweeded (control)	3.6(13)	3.4(12)	7.7(60)	7.9(62)
SE(m)	0.245	0.188	0.541	0.303
CD at P < 0.05%	0.71	0.55	1.59	0.89
CD for interaction	NS	NS	NS	NS

-Figures without paranthesis are statistically analysed square root transformed values.

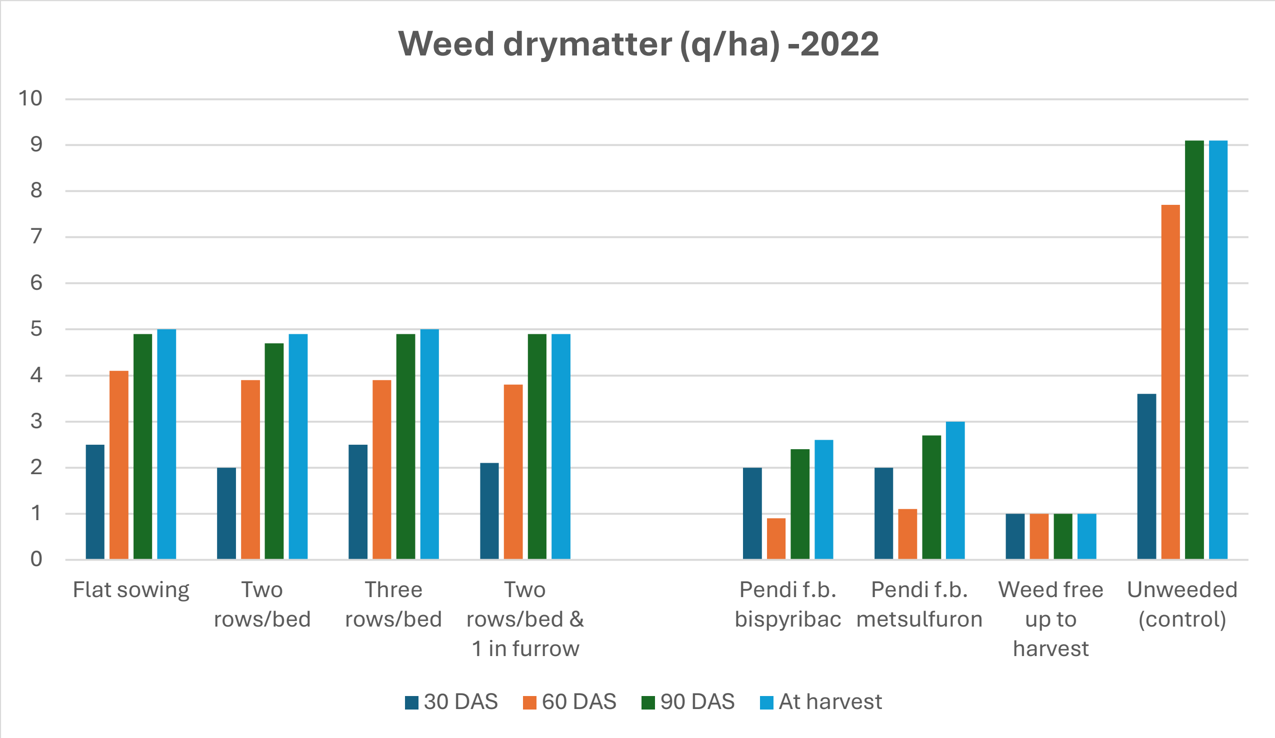
-Figures in paranthesis are original values

Table.4.1.2b. Effect of planting patterns and weed control treatments on weed dry matter accumulation (q/ha) recorded at 90 DAS and at harvest during 2022 and 2023

	Weed dry matter accumulation(q/ha)			
Main plots – Planting patterns				
	90 DAS		At harvest	
	2022	2023	2022	2023
M1 – Flat sowing	4.9(24)	4.9(24)	5.0(25)	5.4(29)
M2 – Two rows/bed	4.7(23)	4.7(22)	4.9(24)	5.2(27)
M3 – Three rows/bed	4.9(24)	4.7(22)	5.0(25)	5.3(28)
M4 – Two rows/bed & 1 in furrow	4.9(24)	4.8(23)	4.9(25)	5.3(28)
SE(m)	0.42	0.43	0.27	0.48
CD at P < 0.05%	NS	NS	NS	NS
Sub plots - Weed control treatments				
T1 -Pendi fb. bispyribac	2.4(6)	3.0(10)	2.6(7)	3.3(11)
T2 -Pendi fb. metsulfuron	2.7(7)	3.3(11)	3.0(9)	3.7(14)
T3 -Weed free	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0)
T4 -Unweeded (control)	9.1(82)	8.4(71)	9.1(83)	9.3(87)
SE(m)	0.82	0.04	0.26	0.38
CD at P < 0.05%	2.728	0.089	0.77	1.12
CD for interaction	NS	NS	NS	NS

-Figures without paranthesis are statistically analysed square root transformed values.

-Figures in paranthesis are original values



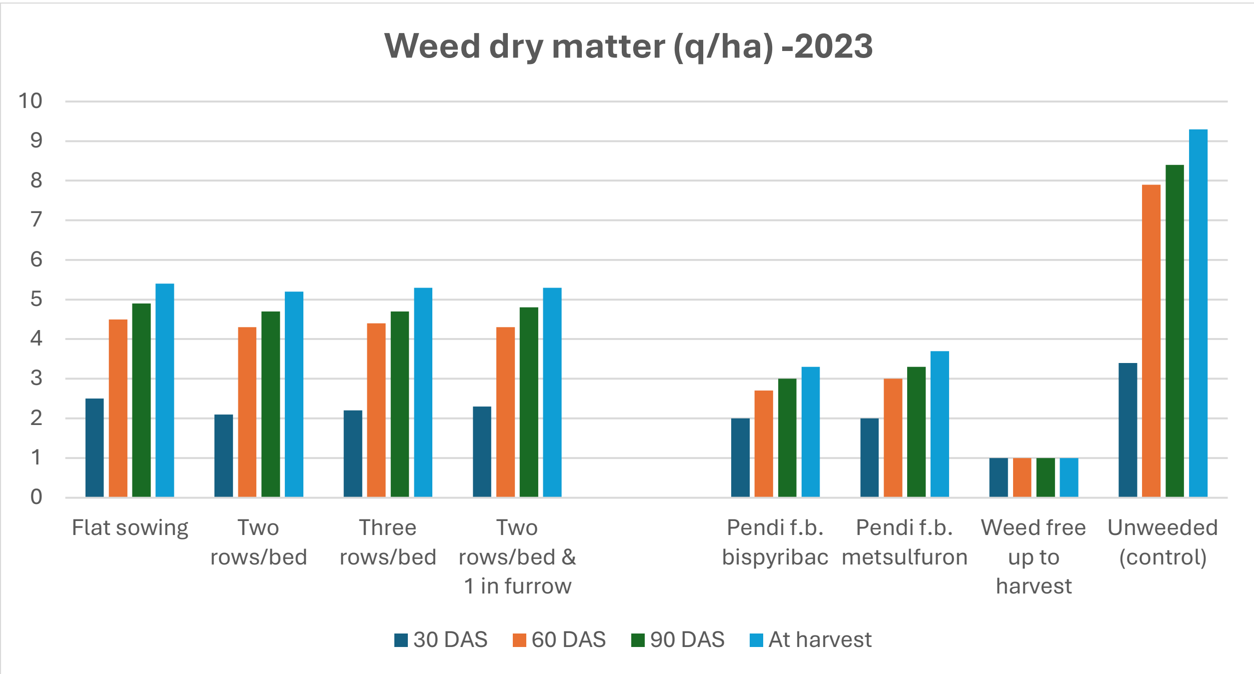


Fig.4.1.2. Effect of planting patterns and weed control treatments on weed dry matter accumulation (q/ha) recorded at 30, 60,90, and at harvest during 2022 and 2023

4.1.3. Weed control efficiency (%)

Weed control efficiency is the important indices for determining efficiency of a treatment and is calculated as below.

$$\text{WCE (\%)} = \frac{\text{Weed dry matter in control (q/ha)} - \text{Weed dry matter in the treatment(q/ha)}}{\text{Weed dry matter in control (q/ha)}} \times 100$$

The data recorded regarding weed control efficiency at harvest designated that there had been gradual rise in weed control efficiency percentage with different planting patterns during both the years which ranges in between 66.7 to 71.5 percent.The highest weed control efficiency (71.5 % and 69.4 %) was observed in two rows per bed (M2) followed by three rows per bed (M3) (70.2 & 67.8%) during respective years.Among the weed management treatments ,the highest weed control efficiency was observed in the weed free up to harvest(100%) followed by pendimethalin fb. bispyribac (91.6 and 87.2%) and pendimethalin fb. metsulfuron (89.4 And 84.3%) during 2022 and 2023 respectievely.

Table 4.1.3. Effect of planting patterns and weed control treatments on weed control efficiency (WCE)(%) at the time of harvest

	Weed control efficiancy (%)	
Main plots – Planting patterns		
	2022	2023
M_1 – Flat sowing	69.9	66.7
M_2 – Two rows/bed	71.5	69.4
M_3 – Three rows/bed	70.2	67.8
M_4 – Two rows/bed & 1 in furrow	69.4	67.6
Sub plots - Weed control treatments		
T_1 -Pendi fb. bispyribac	91.6	87.2
T2 -Pendi fb. metsulfuron	89.4	84.3
T_3 -Weed free	100	100
T_4 -Unweeded (control)	-	-

4.2 Crop growth parameters

4.2.1 Plant height (cm)

The most important parameter for governing crop yield is plant height. Data on periodic plant height recorded at 30 days after sowing interval ,60 days after sowing interval, 90 days after sowing interval and finally at harvest stage during 2022 and 2023 has been given in Table 4.2.1a, Table 4.2.1b and Fig 4.2.1.The non significant difference in plant height when recorded at 30 days after sowing interval, with regard to planting patterns had been found during 2023. But during 2022, plant height in flat sowing and three rows per bed (M3) was found at par among themselves and these treatments gave significantly higher plant height than two rows per bed and one row in furrow (M4) treatment. Among weed management treatments the significantly greater height of crop plants was registered with the spray of pendimethalin fb. metsulfuron in comparison with further weed management treatments for two consecutive years. Pre-em. application of pendimethalin fb. metsulfuron treatment was observed as statistically similar with pendimethalin fb. bispyribac during the year 2023.Crop height in unweeded (control) during both the years was observed as lowest as compared to all other weed management methods for two consecutive years.

During the 60 DAS interval ,the height of crop plants was influenced significantly by both the planting patterns and weed management treatments.(Table 4.2.1a) Among the planting patterns,the highest plant height was observed in two rows per bed and one row in furrow planting(M4) and it was found to be statistically at par with two rows per bed planting treatment and both these planting patterns had been observed as statistically higher to flat sowing and three rows per bed (M3) in two consecutive years.The significantly less height of the crop plants was registered in flat sowing treatment when compared with all other planting patterns in two consecutive years.Among weed management treatments,the significantly more plant height was observed in weed free treatment in comparison with further weed management methods in two consecutive years.Crop height in unweeded (control) treatment during both the years was observed as least in comparison with all other weed management methods.Pre-em. application of pendimethalin fb. post -em. application of metsulfuron registered significantly higher plant height than other herbicidal treatments in two consecutive years of study.

At the 90 DAS interval ,the height of crop plants had been significantly impacted by the planting patterns and weed management methods.(Table 4.2.1b) Among the planting patterns,the highest plant height was observed in two rows per bed and one row in furrow treatment and it was found to be statistically at par with two rows per bed and both the treatments had registered significantly greater plant height than flat sowing and three rows per bed in two consecutive years of study . Lesser height of plants had observed by flat sowing method which was found to be statistically at par with three rows per bed during both years.Amongst weed management methods,highest plant height was observed in weed free up to harvest which was found to be statistically at par with pendimethalin fb. bispyribac treatment when recorded for both the years and these two treatments registered significantly higher plant height when compared to pendimethalin fb. metsulfuron treatment.Crop height in unweeded (control) during both the years was found to be significantly less as compared to all other weed management treatments.

At harvest,the differences in the plant height due to planting patterns was found to be non-significant during 2022 and 2023 (Table 4.2.1b).Among the weed management treatments,the significantly highest plant height was observed in the weed free up to harvest than all other treatments when recorded for both years..Crop height in unweeded (control) during both the years was found to be significantly less as compared to all other weed management treatments.

Final plant height in pendimethalin fb. bispyribac treatment was found to be significantly higher than pendimethalin fb. metsulfuron treatment during both years.Alike outcomes had been by Awan et al., 2021 and Pooja along with. Saravanane 2021.

Overall it may be concluded that more plant height (cm) was recorded in bed sowing treatments may be due to better growth and development of crop as compared to flat sowing planting pattern. Also crop growth and development was better in weed free treatment due to absence of weed infestations.Pre-em. application of pendimethalin fb. bisptribac recorded more plant height than pendimethalin fb. metsulfuron treatment which was because of the fact that bispyribac regulates all the types of paddy weeds whereas metsulfuron controls only typical grassy weeds and sedges of paddy. The crop growth was very poor in weedycheck treatment because of high weed intensity in this treatment.which badly smoothered the crop.

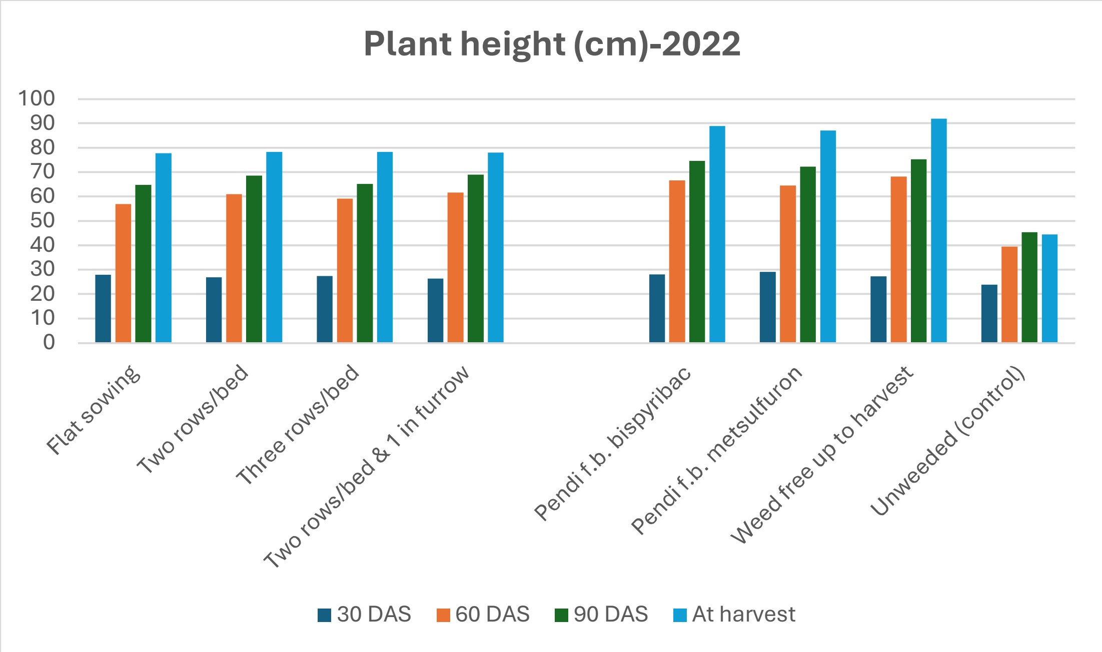
The interactive effects of planting patterns and weed management treatments for periodic plant height was observed as non-significant in two consecutive years of study.

Table 4.2.1a. Effect of various planting patterns and weed control treatments on plant height (cm) recorded at 30 & 60 DAS during 2022 and 2023

	Plant height (cm)			
Main plots – Planting patterns				
	30 DAS		60 DAS	
	2022	2023	2022	2023
M_1 – Flat sowing	27.9	24.0	56.9	55.4
M_2 – Two rows/bed	26.9	23.7	61.0	59.5
M_3 – Three rows/bed	27.4	23.8	59.1	57.6
M_4 – Two rows/bed & 1 in furrow	26.3	23.3	61.6	60.1
SE(m)	0.31	0.29	0.35	0.34
CD at P < 0.05%	1.02	NS	1.22	1.21
Sub plots - Weed control treatments				
T_1 -Pendi fb. bispyribac	28.1	25.1	66.6	65.1
T_2 -Pendi fb. metsulfuron	29.1	26.2	64.5	63.0
T_3 -Weed free	27.3	23.4	68.2	66.7
T_4 -Unweeded (control)	23.9	20.2	39.4	37.9
SE(m)	0.32	0.39	0.51	0.49
CD at P < 0.05%	0.91	1.22	1.49	1.50
CD for interaction	NS	NS	NS	NS

Table 4.2.1b. Effect of planting patterns and weed control treatments on plant height (cm) recorded at 90 and at harvest during 2022 and 2023

	Plant height (cm)			
Main plots – Planting patterns				
	90 DAS		At harvest	
	2022	2023	2022	2023
M_1 – Flat sowing	64.7	61.9	77.7	76.2
M_2 – Two rows/bed	68.5	65.3	78.3	77.1
M_3 – Three rows/bed	65.2	62.3	78.2	77.1
M_4 – Two rows/bed & 1 in furrow	69.0	65.8	78.0	76.6
SE(m)	0.32	0.38	0.39	0.35
CD at P < 0.05%	1.02	1.33	NS	NS
Sub plots - Weed control treatments				
T_1 -Pendi fb. bispyribac	74.6	71.8	88.9	87.4
T_2 - Pendi fb. metsulfuron	72.2	69.0	87.0	86.0
T_3 -Weed free	75.3	72.1	91.9	90.4
T_4 -Unweeded (control)	45.4	42.3	44.5	43.3
SE(m)	0.42	0.60	0.30	0.41
CD at P < 0.05%	1.23	1.74	0.89	1.19
CD for interaction	NS	NS	NS	NS



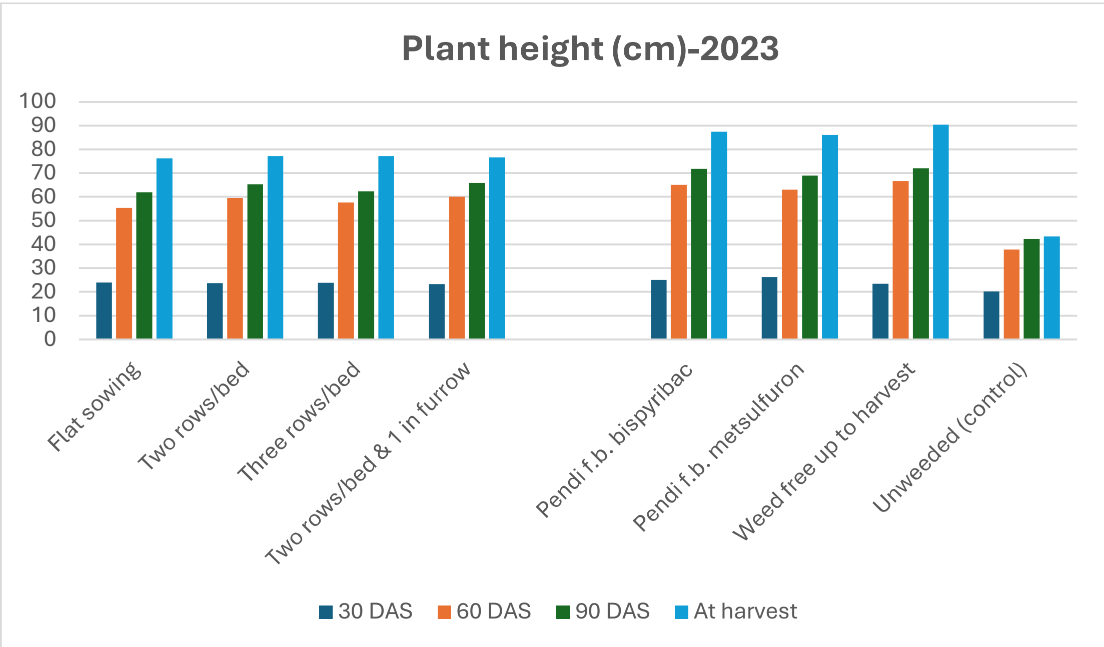


Fig 4.2.1. Effect of planting patterns and weed control treatments on plant height (cm) recorded at 30,60, 90 and at harvest during 2022 and 2023

4.2.2 Total no of tillers /sq. m

Total number of tillers per unit area are considered as major determinants for the crop growth and yield. The data pertaining to the number of tillers, recorded at 30, 60, 90 DAS and at harvest stage, are depicted in Table 4.2.2a and Table 4.2.2b as well as in Fig 4.2.2.The data recorded at 30 DAS showed that there was significant difference between planting patterns and different weed management treatments for both the years.There had been a prominent rise in the count of total tillers in three rows per bed as compared to all other planting patterns during both the years.(Table.4.2.2a) Significantly less number of tillers were observed in two rows per bed as compared to all other planting patterns.Also planting pattern of two rows per bed and one row in furrow recorded significantly higher total tillers than flat sowing and two rows per bed in two consecutive years.Out of all the weed management treatments,the highest number of tillers had been observed by pendimethalin fb. bispyribac treatment which had been observed as statistically at par with pendimethalin fb. metsulfuron and weed free up to harvest in two consecutive years.The significantly least count of tillers were found in weedycheck treatment in comparison with further weed management methods for both years.

At 60 DAS, there is significant difference in the number of tillers due to planting patterns and weed management treatments in two consecutive years (Table 4.2.2a).The significantly more number of tillers were observed in three rows per bed sowing in comparison with all other planting patterns during both years. The significantly less number of tillers were observed in the flat sowing method for both the years which were at par with two rows per bed and both these treatments were found significantly inferior to other planting patterns. Out of all the weed management treatments,weed free up to harvest registered significantly highest number of tillers which were at par with pendimethalin fb. bispyribac treatment and both these treatments were found to be significantly superior to pendimethalin fb. metsulfuron treatment for both years.Unweeded (control) recorded the significantly less number of tillers in two consecutive years in comparison with additional weed management methods.

The data recorded at 90 DAS interval, showed that there were significant differences in the number of tillers between planting patterns and various weed management methods in two consecutive years of study .(Table 4.2.2b) .There was significant increase in total tillers in three rows per bed as compared to all other planting patterns when recorded in two consecutive years. The significantly less number of tillers were observed in two rows per bed in comparison with further treatments in two consecutive years of study.Total tillers in flat sowing during both years were found to be significantly less than both the treatments of three rows per bed and two rows per bed and one row in furrow(M3 & M4).Among the weed management treatments,the significantly more number of tillers were observed in pendimethalin fb. bispyribac when compared to all other weed management treatments for both years.Total tillers in weed free treatment were found to be significantly higher than pendimethalin fb. metsulfuron treatment during both years.The significantly less number of tillers were observed in unweeded (control) treatments as compared to all weed management treatments when recorded for both the years.

The data recorded at harvest revealed that differences in total number of tillers for planting patterns and different weed management treatments were observed as significant in two consecutive years of study (Table 4.2.2b).There was significant increase in total tillers in three rows per bed as compared to all other planting patterns when recorded in two consecutive years . The significantly lowest tillers had been observed by two rows per bed in comparison to other treatments in two consecutive years of study. The planting pattern of two rows per bed and one row in furrow recorded significantly higher total tillers than flat sowing and two rows per bed treatment in comparison to other treatments in two consecutive years of study . Among the weed management treatments,the highest number of tillers were observed in pendimethalin fb, bispyribac which were at par with weed free upto harvest and both these treatments recorded significantly higher total tillers than pendimethalin fb. metsulfuron treatment. These findings conforms previous results of Pooja and. Saravanane 2021; Goswami et al.,2017).The significantly less number of tillers were observed in weedy check treatments as compared to all other weed management treatments in comparison to other treatments in two consecutive years of study.

Higher number of tillers in three rows per bed treatment may be due to more competition because of closer row to row spacings.Total tillers were also higher in pre-em. pendimethalin fb. bispyribac treartment due to the control of nearly all weeds of direct seeded rice which favoured better crop growth and development.Due to severe competition by weeds in unweeded (control) treatment, total tillers were reduced drastically in comparison to other treatments in two consecutive years of research.

The interactive impact on total tillers between planting patterns and weed management methods were observed as significant in 60 DAS interval during both years.Interaction data of total tillers are shown in Table 4.2.3.It was observed that during 2022, flat sown crop kept weed free up to harvest proved significantly inferior to two rows per bed and one in furrow planting pattern treated with pendimethalin fb bispyribac for total tillers of rice crop.Also total tillers were significantly less in flat sown crop treated with pendimethalin fb metsulfuron as compared to all other planting patterns sprayed with same herbicides.During 2023 flat sown and two rows per bed crop produced significantly less number of total tillers than three rows per bed (M3 & M4) planting pattern treated with pendimethalin fb. metsulfuron.Also three rows per bed treated with pendimethalin fb bispyribac treatment recorded significantly higher total tillers than all other planting patterns treated with same herbicides.

Table 4.2.2a. Effect of planting patterns and weed control treatments on total no of tillers/sq m recorded at 30 and 60 DAS during 2022 and 2023

	Total no of tillers/sq m			
Main plots - Planting patterns				
	30 DAS		60 DAS	
	2022	2023	2022	2023
M_1 – Flat sowing	408	387	421	432
M_2 – Two rows/bed	375	353	431	441
M_3 – Three rows/bed	538	574	620	636
M_4 – Two rows/bed & 1 in furrow	467	441	538	551
SE(m)	10.40	5.61	5.44	5.32
CD at P < 0.05%	33.0	17.8	17.2	16.6
Sub plots - Weed control treatments				
T_1 -Pendi fb. bispyribac	495	485	597	610
T_2 -Pendi fb. metsulfuron	486	470	540	553
T_3 -Weed free	469	484	605	618
T_4 -Unweeded (control)	337	314	266	279
SE(m)	6.10	5.42	12.3	13.3
CD at P < 0.05%	17.3	16.3	35.1	33.7
CD for interaction	NS	NS	63.3	63.1

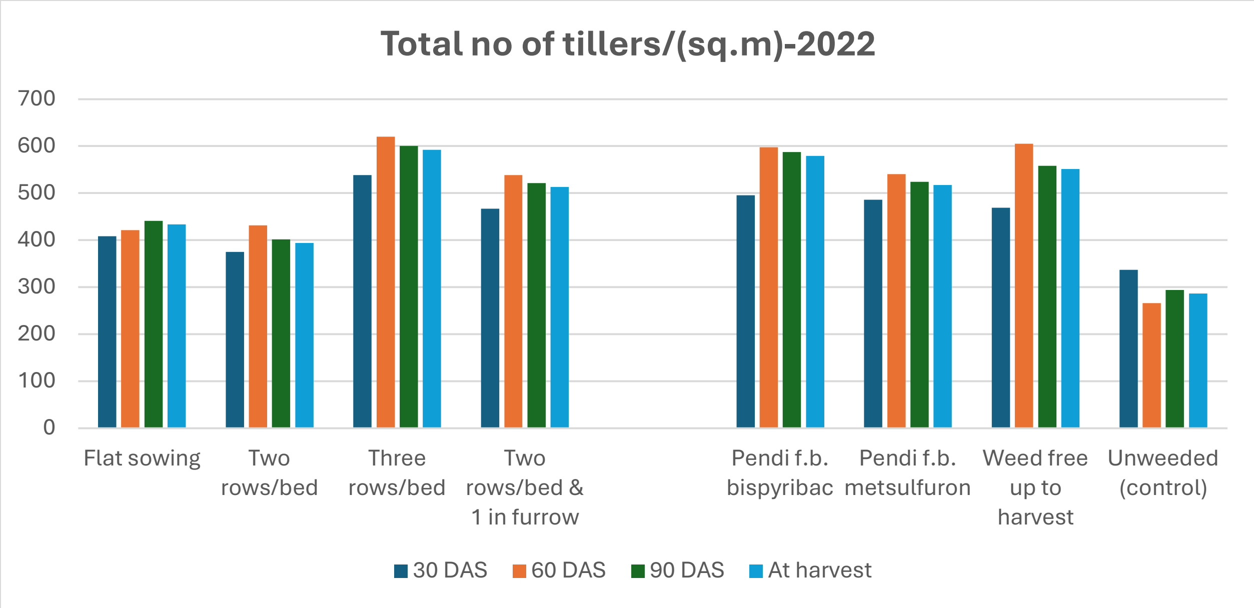
Table 4.2.2b. Effect of planting patterns and weed control treatments on total no of tillers/sq m recorded 90DAS and at harvest during 2022 and 2023

	Total no of tillers/sq m			
Main plots - Planting patterns				
	90 DAS		At harvest	
	2022	2023	2022	2023
M_1 – Flat sowing	441	424	433	416
M_2 – Two rows/bed	401	382	394	375
M_3 – Three rows/bed	600	574	592	566
M_4 – Two rows/bed & 1 in furrow	521	498	513	489
SE(m)	3.9	4.1	5.7	5.2
CD at P < 0.05%	13.5	16.7	17.1	16.6
Sub plots - Weed control treatments				
T_1 -Pendi fb. bispyribac	587	566	579	559
T_2 -Pendi fb. metsulfuron	524	504	517	495
T_3 -Weed free	558	537	551	529
T_4 -Unweeded (control)	294	271	286	265
SE(m)	4.1	4.2	11.8	12.2
CD at P < 0.05%	19.1	27.9	33.0	29.2
CD for interaction	NS	NS	NS	NS

Table 4.2.3. Interaction among planting patterns and weed control treatments on total no tillers/sq m recorded 60 DAS during 2022 and 2023

60 DAS (2022)					
Treatments	**Pendi fb. bispyribac**	**Pendi fb. metsulfuron**	**Weed free**	**Unweeded (control)**	**Mean**
Flat sowing	486	439	552	205	421
Two rows per bed	498	462	516	246	431
Three rows per bed	828	622	685	343	620
Two rows per bed & one in furrow	625	590	666	270	538
Mean	597	540	605	266	
CD at 5%	**63.3**				

60 DAS (2023)					
Treatments	**Pendi fb. bispyribac**	**Pendi fb. metsulfuron**	**Weed free**	**Unweeded (control)**	**Mean**
Flat sowing	497	450	563	216	432
Two rows per bed	509	473	527	257	441
Three rows per bed	844	639	702	360	636
Two rows per bed & one in furrow	639	603	680	284	551
Mean	610	553	618	279	
CD at 5%	**63.1**				



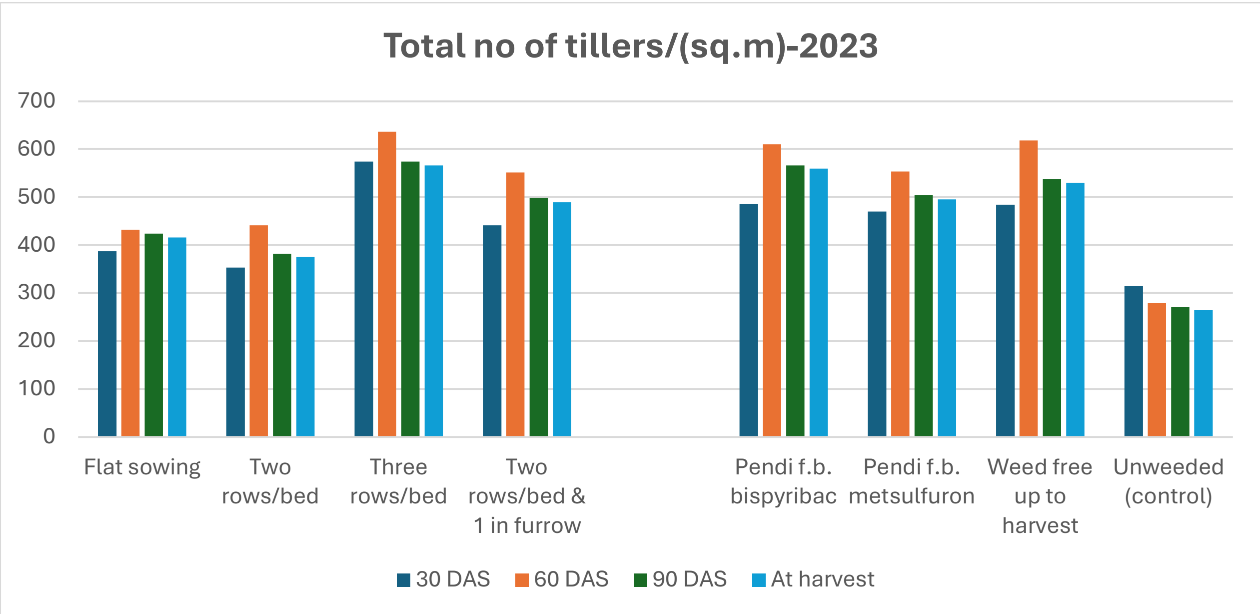


Fig 4.2.2. Effect of planting patterns and weed control treatments on total number of tillers per sq.m recorded at 30,60, 90 and at harvest during 2022 and 2023

4.2.3. Dry matter accumulation by the crop (q/ha)

Crop dry matter is also an important parameter which determines crop growth and hence yield.Crop dry matter was recorded 30,60,90 DAS and at harvest(Table 4.2.4a, 4.2.4b and Fig 4.2.3).The differences in the crop dry matter with respect to planting patterns had been observed as non significant at 30 days after sowing in two consecutive years of study. The differences in the crop dry matter were found to be significantly influenced by weed management treatments during both the years. Among weed management treatments,the highest dry matter of crops had been observed in treatment where spray of pendimethalin fb. bispyribac treatment which was found to be statistically similar to weed free up to harvest, and pendimethalin fb. metsulfuron treatments in two consecutive years.The significantly less crop dry matter was recorded in unweeded (control) in comparison with another weed management strategies in two consecutive years of research.

At 60 DAS,there is significant differences in the crop dry matter accumulation due to planting patterns and weed management methods during both the years (4.2.4a).Among the planting patterns,the highest crop dry matter accumulation (q/ha) was recorded in two rows per bed and one row in furrow method which was found to be statistically at par with two rows per bed and both these planting patterns were significantly superior to flat sowing and three rows per bed in two consecutive years of study. The significantly lowest accumulation of crop dry matter had been observed in flat sowing when compared to all other planting patterns for both the years.Out of the other weed management methods,the highest accumulation of crop dry matter was observed in pendimethalin fb. bispyribac which was found to be statistically similar to weed free up to harvest and both these treatments were significantly better as compared to pendimethalin fb. metsulfuron when recorded for both the years. The control treatment had been showed significantly less crop dry matter than all other weed management methods during both years.

At 90 DAS, the significant differences in the accumulation of crop dry matter were influenced by planting patterns along with weed management methods.(Table 4.2.4b) Among the planting patterns,the significantly higher crop dry matter accumulation was observed in three rows per bed which was significantly more than all other planting patterns. The minimum dry matter was recorded in flat sowing which was at par with two rows per bed treatments and both these treatments showed significantly less crop dry matter than three rows per bed (M3) and two rows per bed and one row in furrow (M4-except 2023). Among the weed management treatments,the highest crop dry matter accumulation was recorded in pendimethalin fb. bispyribac which was similar to weed free treatment and these two treatments showed significantly greater amount of crop dry matter when compared with pendimethalin fb. metsulfuron treatment. The unweeded (control) treatment recorded significantly less crop dry matter accumulation when compared to all other weed management treatments in two consecutive years of study.

At the harvest stage,the differences in the accumulation of dry matter of crop had been influenced significantly by both the planting patterns and weed management methods in two consecutive years of study.(4.2.4b)Among the planting patterns,the highest crop dry matter accumulation was recorded by three rows per bed which were found to be statistically at par with two rows per bed and one row in furrow when recorded in 2022 but it was not statistically similar in 2023.The lowest dry matter accumulation by crop was observed in two rows per bed which was found to be significantly less than all planting patterns during both the years. Out of other weed management methods,the highest dry matter accumulation by crop had been recorded in weed free up to harvest which was observed to be statistically similar to pendimethalin fb. bispyribac treatment and both these treatments registered significantly more accumulation of crop dry matter in comparison to pendimethalin fb. metsulfuron treatment for both the years. The significantly less crop dry matter accumulation was recorded by weedy check when compared to further weed management treatments in two consecutive years of study. Alike results were also presented by Pooja and. Saravanane 2021.

The crop dry matter accumulation had been observed to be higher in three rows per bed (M3 & M4) than flat sowing as well as two rows per bed which was because of improved growth and development of direct seeded rice in the former methods. Crop dry matter was higher in weed free and pendimethalin fb. bispyribac treatments due to better control of weeds as compared to pendimethalin fb. metsulfuron herbicides. On the other hand crop dry matter in unweeded (control) was drastically less due to poor crop growth as both non paddy and paddy weeds dominated the crop(Table 4.1.1 and 4.1.2).

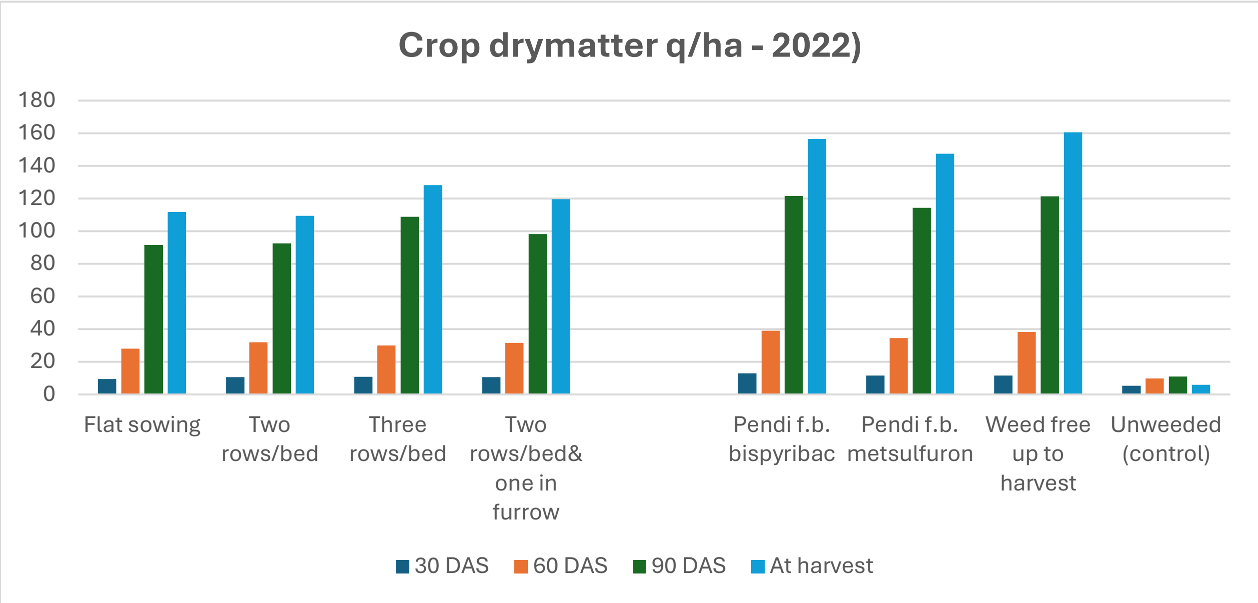
The interactive effect of crop dry matter between planting patterns and weed management treatments had been observed as non significant during both years.

Table 4.2.4a. Effect of planting patterns and weed control treatments on dry matter accumulation by crop (q/ha) recorded 30 and 60 DAS during 2022 and 2023

	Crop dry matter accumulation (q/ha)			
Main plots - Planting patterns				
	30 DAS		60 DAS	
	2022	2023	2022	2023
M_1 – Flat sowing	9.4	12.5	28.01	25.5
M_2 – Two rows/bed	10.6	12.3	31.9	29.0
M_3 – Three rows/bed	10.7	13.4	29.9	27.0
M_4 – Two rows/bed & 1 in furrow	10.5	11.4	31.5	29.0
SE(m)	0.42	0.42	0.35	0.41
CD at P < 0.05%	NS	NS	1.22	1.40
Sub plots - Weed control treatments				
T_1 -Pendi fb. bispyribac	12.9	14.7	39.0	36.0
T_2 -Pendi fb. metsulfuron	11.5	13.0	34.5	32.0
T_3 -Weed free	11.6	14.2	38.2	35.6
T_4 -Unweeded (control)	5.2	7.7	9.7	6.8
SE(m)	1.01	0.83	0.45	0.42
CD at P < 0.05%	2.97	2.42	1.30	1.24
CD for interaction	NS	NS	NS	NS

Table 4.2.4b. Effects of planting patterns and weed control treatments on dry matter accumulation by crop (q/ha) recorded 90 DAS and at harvest during 2022 and 2023

	Crop drymatter accumulation (q/ha)			
Main plots - Planting patterns				
	90 DAS		At harvest	
	2022	2023	2022	2023
M1 – Flat sowing	91.6	89.8	111.7	110.5
M2 – Two rows/bed	92.50	90.8	109.4	106.5
M3 – Three rows/bed	108.8	102.6	128.3	122.9
M4 – Two rows/bed & 1 in furrow	98.2	93.7	119.6	109.7
SE(m)	1.57	0.32	4.58	2.63
CD at P < 0.05%	5.52	4.13	16.17	9.29
Sub plots - Weed control treatments				
T_1 -Pendi fb. bispyribac	121.5	117.6	156.5	150.6
T_2 -Pendi fb. metsulfuron	114.3	109.9	147.5	140.4
T_3 -Weed free	121.4	117.7	160.6	152.2
T_4 -Unweeded (control)	10.94	7.2	5.9	4.9
SE(m)	0.84	0.82	2.69	1.47
CD at P < 0.05%	2.50	2.39	7.90	4.33
CD for interaction	NS	NS	NS	NS



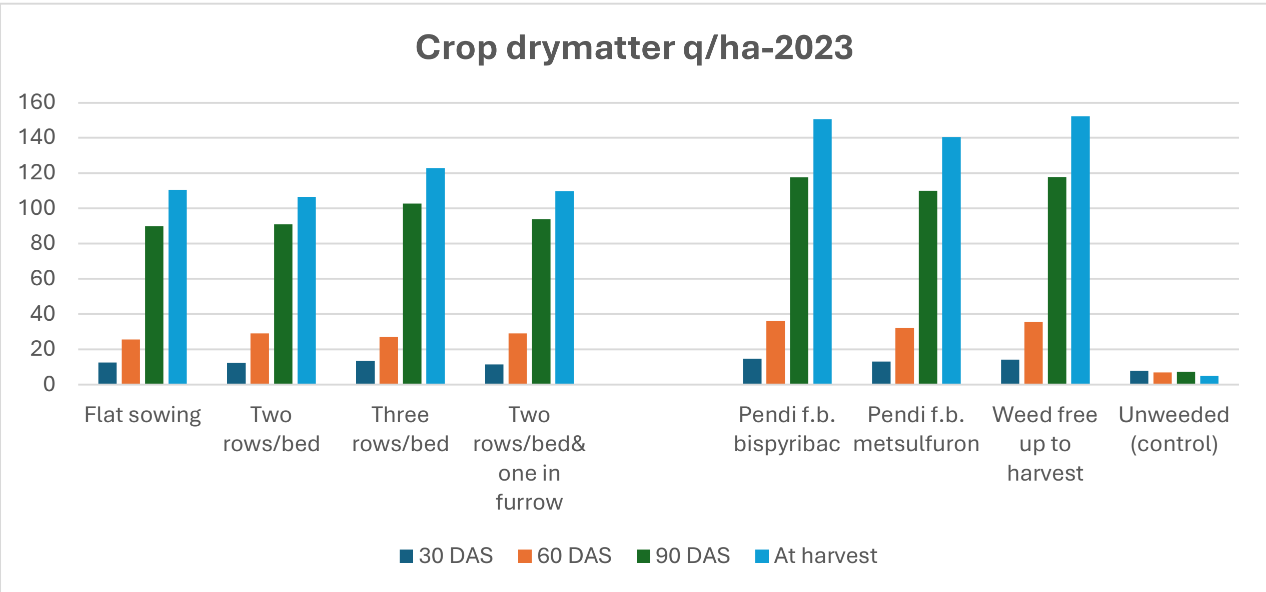


Fig 4.2.3. Effect of planting patterns and weed control treatments on crop dry matter accumulation q/ha recorded at 30,60, 90 and at harvest during 2022 and 2023

4.2.4 Chlorophyll index(%)

The data on periodic chlorophyll index had been registered at 30 DAS interval,60 DAS interval,and 90 DAS interval during 2022 and also 2023 and presented in Table 4.2.5a and 4.2.5b. The difference in chlorophyll index due to planting patterns was found to be non-significant in two consecutive years of study when recorded at 30 DAS interval.(Table 4.2.5a) Out of all the weed management methods,the greatest chlorophyll index had been observed by weed free up to harvest which had been observed as similar to pendimethalin fb. bispyribac and pendimethalin fb. metsulfuron during both years. The significantly less chlorophyll index had been noted in unweeded treatment in two consecutive years in comparison with other weed management methods.

At the 60 DAS interval ,the differences in the chlorophyll index due to planting patterns had been observed as non non-significant.(Table 4.2.5a).Out of all the weed management methods,the highest chlorophyll index had been observed by weed free up to harvest which had been observed as statistically similar to pendimethalin fb bispyribac and pendimethalin fb. metsulfuron during 2022.However,during 2023,pendimethalin fb. metsulfuron recorded significantly less chlorophyll index than weed free yet it was observed as similar to pendimethalin fb. bispyribac treatment.Unweeded (control) recorded the significantly less chlorophyll index in comparison to further weed management methods in two consecutive years of study.

At the 90 DAS stage,the differences in the chlorophyll index due to planting patterns were found to be non significant during 2022.During 2023,chlorophyll index was significantly more in two rows per bed which was at par with three rows per bed but significantly higher than flat sowing.(Table 4.2.5b). Out of all the weed management methods,the highest chlorophyll index was observed by weed free up to harvest which was found to be statistically at par with pendimethalin fb. bispyribac when recorded for both the years. The significantly lowest chlorophyll index was recorded by unweeded (control) when compared to all other treatments during both the years.Pendimethalin fb. metsulfuron recorded significantly less chlorophyll index than weed free during 2022 and weed free and pendimethalin fb. bispyribac during 2023. These data conforms previous reports by Pooja and. Saravanane 2021; Singh et al., 2016”.

The differences in chlorophyll index between planting patterns at all periodic intervals (except 90 DAS during 2023) was found to be non-significant indicating there by that greenness of crop was nearly same in all planting methods. Among weed management treatments, significantly less chlorophyll index was recorded in unweeded (control) than all other weed management methods because of severe competition of weeds with rice crop in the weedy check resulting in consumption of nitrogen by weeds.and hence crop lost its green color.

The interactive effect of planting patterns and weed management treatments for chlorophyll index at all periodic intervals had been observed as non-significant during both years.

Table 4.2.5a. Effect of planting patterns and weed control treatments on chlorophyll index(%) recorded at 30 DAS and 60 DAS during 2022 and 2023

	Chlorophyll Index (%)			
Main plots - Planting patterns				
	30 DAS		60 DAS	
	2022	2023	2022	2023
M_1 – Flat sowing	22.4	24.6	43.8	43.9
M_2 – Two rows/bed	23.1	23.0	45.2	46.4
M_3 – Three rows/bed	23.7	23.9	43.5	44.2
M_4 – Two rows/bed & 1 in furrow	24.4	22.9	46.8	44.5
SE(m)	0.58	0.51	0.87	0.71
CD at P < 0.05%	NS	NS	NS	NS
Sub plots - Weed control treatments				
T_1 -Pendi fb. bispyribac	24.5	25.8	47.0	47.6
T_2 -Pendi fb. metsulfuron	24.5	24.2	46.8	46.4
T_3 -Weed free	25.3	24.9	48.9	48.5
T_4 -Unweeded (control)	19.4	20.3	36.7	36.5
SE(m)	0.51	0.68	0.85	0.65
CD at P < 0.05%	1.48	2.31	2.50	1.93
CD for interaction	NS	NS	NS	NS

Table 4.2.5b. Effects of planting patterns and weed control treatments on chlorophyll index(%) recorded at 90 DAS during 2022 and 2023

	Chlorophyll Index (%)	
Main plots - Planting patterns		
	90 DAS	
	2022	2023
M_1 – Flat sowing	36.5	34.5
M_2 – Two rows/bed	36.1	36.8
M_3 – Three rows/bed	34.7	35.5
M_4 – Two rows/bed & 1 in furrow	33.2	35.1
SE(m)	0.53	0.40
CD at P < 0.05%	NS	1.39
Sub plots - Weed control treatments		
T_1 -Pendi fb. bispyribac	40.0	41.8
T_2 -Pendi fb. metsulfuron	38.8	39.5
T_3 -Weed free	41.7	42.3
T_4 -Unweeded (control)	19.9	18.3
SE(m)	0.97	0.65
CD at P < 0.05%	2.83	1.90
CD for interaction	NS	NS

4.3 Yield and yield attributing characteristics

4.3.1 Effective tillers /sq m

Effective tillers per square meter is the most important parameter as it is the yield determining factor for the cereal crops. Effective tillers per "square meter were recorded at harvest for both the years.(Table 4.3.1 and Fig 4.3.1) The differences in the effective tillers were significantly influenced by both planting patterns and weed management treatments when recorded for both the years.Among the planting patterns ,the significantly higher count of effective tillers per square meter were observed by three rows per bed (M3) as compared to all other planting patterns during both years.Also the planting pattern of two rows per bed and one row in furrow (M4) recorded significantly more effective tillers than two rows per bed and flat sowing technique during both years. Also flat sowing recorded significantly more effective tillers than two rows per bed during 2022 but these differences during 2023 were non-significant.Out of all other weed management treatments, the greatest number of effective tillers were observed in pendimethalin fb. bispyribac which were observed as statistically similar to weed free treatment and these two treatments observed significantly higher effective tillers as compared to pendimethalin fb. metsulfuron during both years.The significantly less number of effective tillers were recorded in unweeded(control) than all other weed management treatments for both the years. The data conforms previous findings by Pooja and. Saravanane 2021 and Singh et al., 2016.

Table 4.3.1. Effect of planting patterns and weed control treatments on effective tillers/row meter during 2022 and 2023

Main plots – Planting patterns		
	Effective tillers/sq meter	
	2022	2023
M_1 – Flat sowing	432.7	386.7
M_2 – Two rows/bed	408.7	378.2
M_3 – Three rows/bed	628.0	596.3
M_4 – Two rows/bed & 1 in furrow	540.7	501.3
SE(m)	5.91	6.01
CD at P < 0.05%	20.1	19.20
Sub plots - Weed control treatments		
T_1 -Pendi fb. bispyribac	609.6	569.2
T_2 -Pendi fb. metsulfuron	539.6	503.3
T_3 -Weed free	577.3	552.8
T_4 -Unweeded (control)	283.6	237.1
SE(m)	12.5	8.66
CD at P < 0.05%	36.7	27.3
CD for interaction	NS	NS

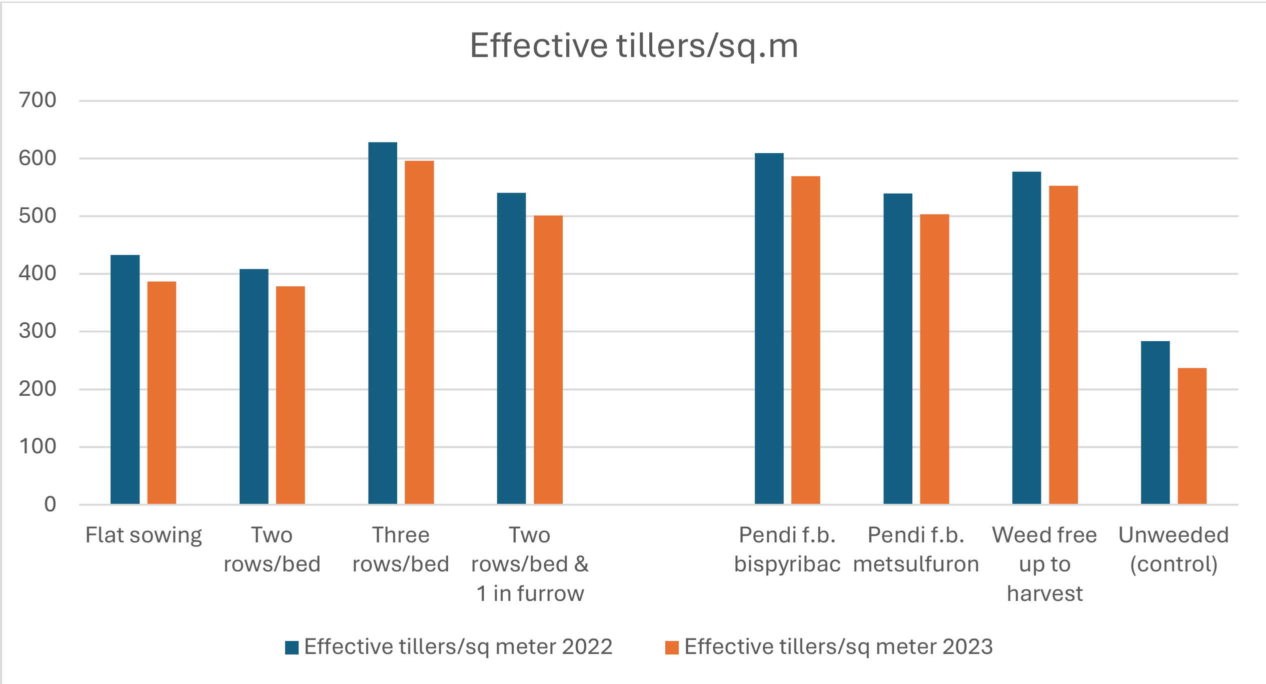


Fig.4.3.1. Effect of planting patterns and weed control treatments on effective tillers/sq.m during 2022 and 2023

4.3.2 Total number of grains per panicle

Total number of grains per panicle had been noted at harvest stage for both the years.The differences in the total number of grains per panicle had been significantly effected by both planting patterns and weed management treatments in two consecutive years of study(Table 4.3.2 and Fig 4.3.2).Amongst planting patterns,the significantly higher count of grains per panicle had been observed by two rows per bed than all other planting patterns when recorded during 2022.Also during 2023,significantly less count of grains per panicle were observed in two rows per bed as compared to all other planting patterns which being at par among themselves. Out of all other weed management methods,the significantly higher count of grains per panicle had been observed in weed free up to harvest in comparison with other treatments during the year 2023.During 2022 ,the greatest count of grains per panicle had been observed in weed free up to harvest which were found to be statistically at par with pendimethalin fb bispyribac treatment and both these treatments were significantly better than other weed management treatments.The significantly less number of grains per panicle were recorded in unweeded (control) in comparison with all other weed management methods in two consecutive years of study. The data conforms previous findings of Pooja and. Saravanane 2021 and Singh et al., 2016.

4.3.3 Panicle length (cms)

Panicle length was recorded at the harvest stage in the two consecutive years of study.The variations in panicle length had been significantly influenced by both planting patterns and weed management treatments in two consecutive years of study(Table 4.3.2 and Fig 4.3.2).Amongst all planting patterns,the largest panicle length had been recorded by two rows per bed during the year 2022,which was significantly higher than all other planting patterns.

but in the year 2023 ,the highest panicle length was observed in two rows per bed and one row in furrow which was statistically at par with two rows per bed but significantly more than three rows per bed and flat sowing. The significantly less panicle length was observed in flat sowing as compared to all other planting patterns in two years of study.Out of all the weed management treatments,the significantly higher panicle length was observed in weed free up to harvest which was statistically similar to pendimethalin fb. bispyribac treatment and these two treatments showed significantly greater panicle length than other weed management methods when recorded for both the years.The significantly less panicle length was recorded in unweeded(control) treatment in two consecutive years of study in comparison with further weed management methods.Same outcomes had been presented by Pooja and. Saravanane 2021 and Singh et al., 2016.

The interactive effect between planting patterns and weed management treatments for number of grains per panicle were found to be non-significant where as these differences for panicle length were observed as significant in two years of study and presented in Table 4.3.3.The panicle length(cm) of weed free flat sown crop was found to be significantly less than three rows per bed planting pattern but treated with pre-em. pendimethalin fb. bispyriac herbicide.This holds good for both the years.Flat sowing crop treated with pendimethalin fb. metsulfuron produced significantly less panicle length (cm) as compared to three rows per bed planting pattern treated with same herbicide combinations during 2022 and 2023.

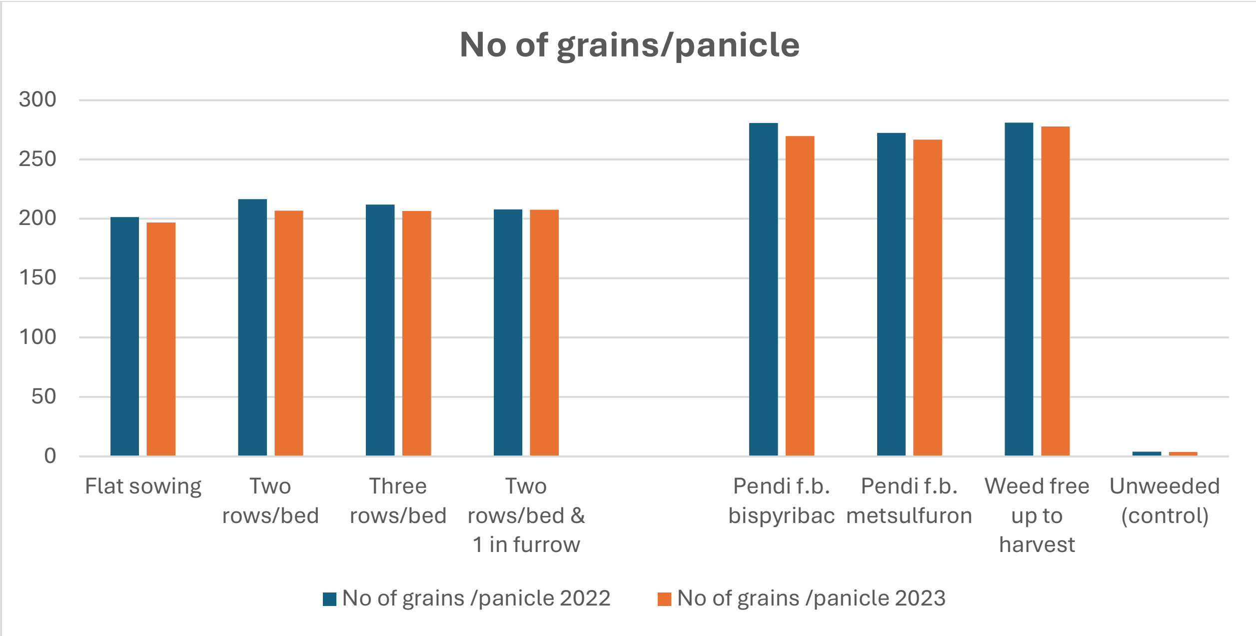
Table 4.3.2 Effects of planting patterns and weed control treatments on number of grains/panicle and panicle length (cm) during 2022 and 2023

Main plots – planting patterns				
	No of grains /panicle		Panicle length(cm)	
	2022	2023	2022	2023
M_1 – Flat sowing	201.3	196.8	18.5	18.1
M_2 – Two rows/bed	216.5	206.8	22.1	20.9
M_3 – Three rows/bed	211.9	206.6	21.2	20.4
M_4 – Two rows/bed & 1 in furrow	207.8	207.5	19.6	21.5
SE(m)	0.82	0.46	0.24	0.27
CD at P < 0.05%	2.87	1.63	0.72	0.91
Sub plots - Weed control treatments				
T_1 -Pendi fb. bispyribac	280.5	269.6	23.4	24.0
T_2 -Pendi fb. metsulfuron	272.2	266.7	22.0	22.7
T_3 -Weed free	281.0	277.7	24.3	24.7
T_4 -Unweeded (control)	3.8	3.7	11.7	9.5
SE(m)	1.10	0.62	0.28	0.15
CD at P < 0.05%	3.23	1.83	0.80	0.39
CD for interaction	NS	NS	1.57	0.88

Table 4.3.3. Interaction among planting patterns and weed control treatments for panicle length (cm) during 2022 and 2023

Panicle length (cm) (2022)					
Treatments	**Pendi fb. bispyribac**	**Pendi fb. metsulfuron**	**Weed free**	**Unweeded (control)**	**Mean**
Flat sowing	20.8	19.9	22.1	11.1	18.5
Two rows per bed	25.3	24.1	26.0	12.8	22.06
Three rows per bed	24.7	23.5	25.5	11.1	21.2
Two rows per bed & one in furrow	22.6	20.5	23.6	11.5	19.6
Mean	23.4	22.0	24.3	11.7	
CD at 5%	**1.66**				

Panicle length (cm) (2023)					
Treatments	**Pendi fb. bispyribac**	**Pendi fb. metsulfuron**	**Weed free**	**Unweeded (control)**	**Mean**
Flat sowing	21.7	19.9	22.4	8.3	18.1
Two rows per bed	25.0	24.5	25.1	9.2	20.9
Three rows per bed	24.2	22.9	25.4	9.0	20.4
Two rows per bed & one in furrow	25.2	23.6	25.8	11.4	21.5
Mean	24.0	22.7	24.7	9.5	
CD at 5%	**1.13**				



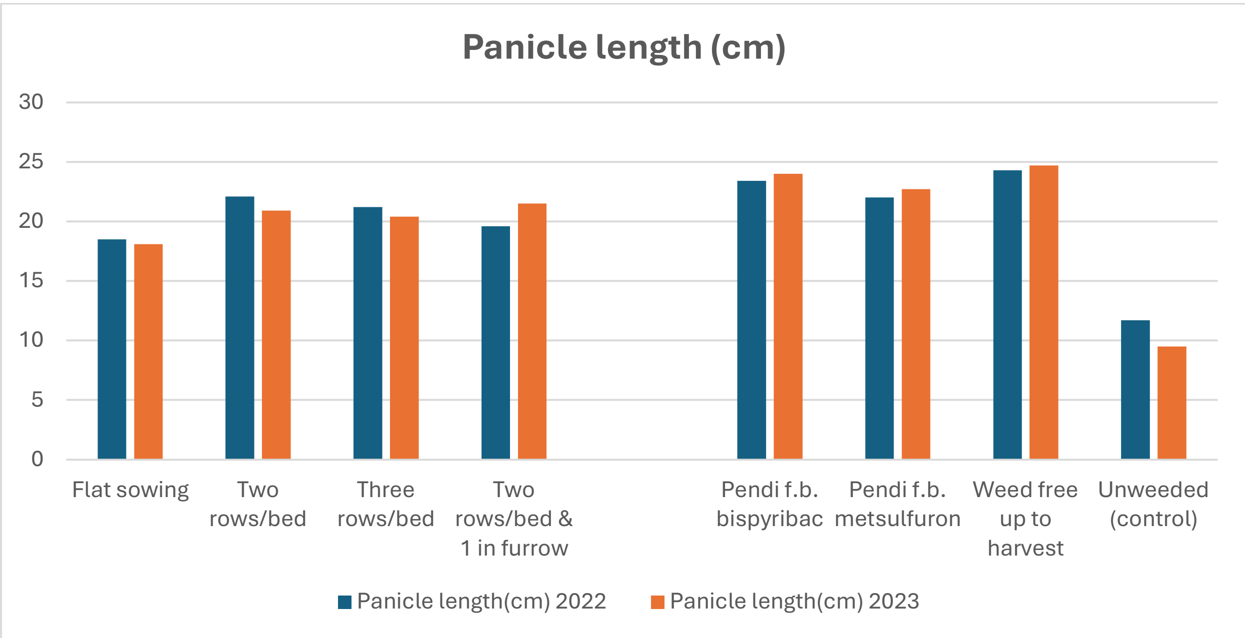


Fig. 4.3.2. Effect of planting patterns and weed control treatments for number of grains per panicle and panicle length (cm) during 2022 and 2023

4.3.4 Panicle weight (g)

Panicle weight was recorded at the harvest stage in two consecutive years of study and data presented in (Table 4.3.4 and Fig 4.3.3)The differences in panicle weight due to planting patterns was found to be non significant during 2022 but it was found to be significant for the year 2023.Among the planting patterns,the significantly higher panicle weight(g) was observed by two rows per bed as compared to three rows per bed and two rows per bed & one row in furrow and flat sowing method. But the differences of panicle weight between three rows per bed and two rows per bed & one row in furrow were found to be statistically at par with each other.The significantly lower panicle weight was observed in flat sowing as compared to all other planting patterns.The differences in the panicle weight was significantly influenced by weed management treatments. Among the weed management treatments, highest panicle weight was recorded in weed free up to harvest which was observed as similar with pendimethalin fb. bispyribac during both the years and both of these treatments were observed as significantly superior to other weed management treatments.The significantly less panicle weight was recorded in weedy check in two consecutive years of study as compared to all other herbicidal treatments.Also pendimethalin fb. metsulfuron produced significantly less panicle weight than pendimethalin fb. bispyribac and weed free treatments.Same results had been presented by Pooja and. Saravanane 2021 and Singh et al., 2016.

4.3.5 Test weight (g)

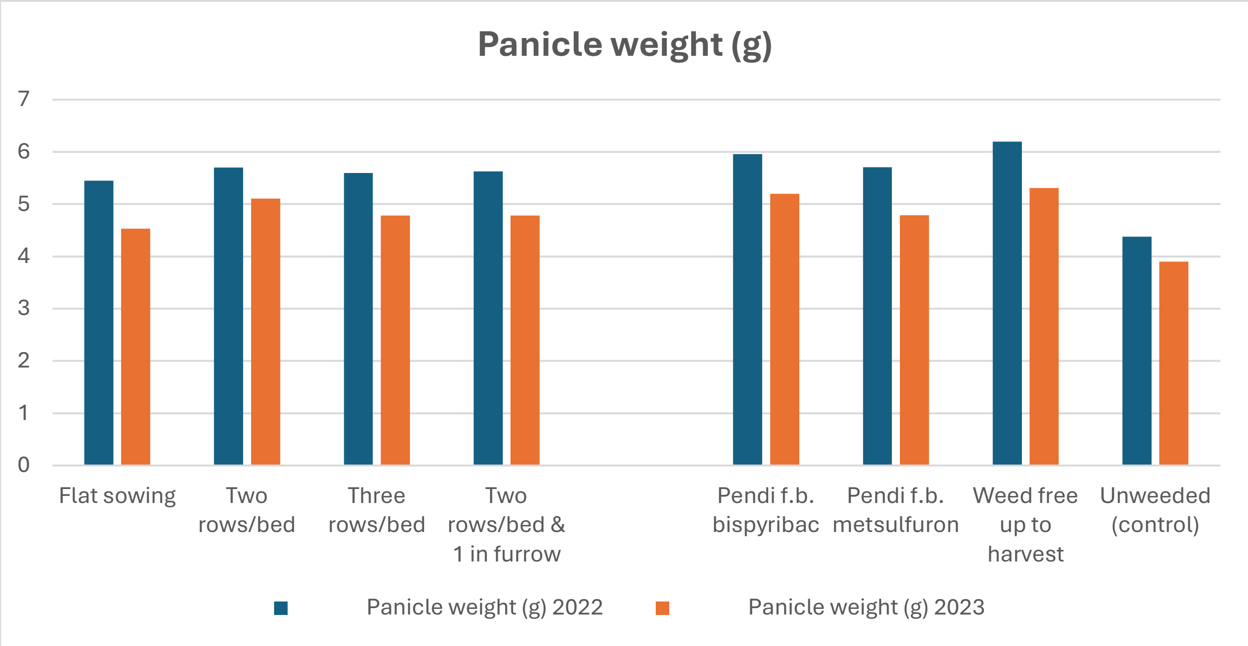
Test weight was recorded at the harvest stage in two consecutive years of study.The differences in test weight because of planting patterns had been observed as non significant in the year 2022 but it was found to be significant for the year 2023(Table 4.3.4 and Fig 4.3.3).Among the planting patterns,the significantly highest test weight during 2023 was observed in two rows per bed which was significantly superior to all other planting patterns.But three rows per bed recorded significantly less test weight than two rows per bed & one row in furrow and flat sowing methods.The differences in the panicle weight had been significantly impacted by weed management methods.Out of all the weed management treatments,the significantly highest test weight had been recorded by weed free up to harvest which had recorded significantly more test weight than all other weed management methods during 2022, but during 2023, it was found at par with pendimethalin fb. bispyribac and both these treatments were found to be significantly better than other weed management treatments. Pendimethalin fb. metsulfuron recorded significantly less test weight (g) than weed free and pendimethalin fb. bispyribac treatment during both years.The significantly lowest test weight was recorded in weedy check in two consecutive years of study, as compared to other treatments. Alike results had been noted by Pooja" along with Saravanane 2021 and Singh et al., 2016.

The interactive effects for panicle length and test weight between planting patterns and weed management methods had been observed as non-significant during both years.

The yield attributes were found to be superior in bed planted treatments compared to flat sown crop,which might be because of the improved crop growth and development when it is sown on beds as compared to flat sown crop. So,yield attributes were better on bed planted crop.

Table 4.3.4 Effect of planting patterns and weed control treatments on panicle weight (g) and test weight (g) during 2022 and 2023

Main plots – Planting patterns				
	Panicle weight (g)		Test weight (g)	
	2022	2023	2022	2023
M_1 – Flat sowing	5.45	4.53	21.36	20.63
M_2 – Two rows/bed	5.70	5.11	21.50	21.30
M_3 – Three rows/bed	5.60	4.78	21.24	19.61
M_4 – Two rows/bed & 1 in furrow	5.63	4.78	21.30	20.39
SE(m)	0.06	0.06	0.12	0.14
CD at P < 0.05%	NS	0.21	NS	0.48
Sub plots - Weed control treatments				
T_1 -Pendi fb. bispyribac	5.96	5.20	22.80	21.69
T_2 -Pendi fb. metsulfuron	5.71	4.79	20.50	19.84
T_3 -Weed free	6.2	5.31	23.35	22.15
T_4 -Unweeded (control)	4.38	3.90	18.75	18.25
SE(m)	0.04	0.06	0.13	0.20
CD at P < 0.05%	0.12	0.18	0.38	0.58
CD for interaction	NS	NS	NS	NS



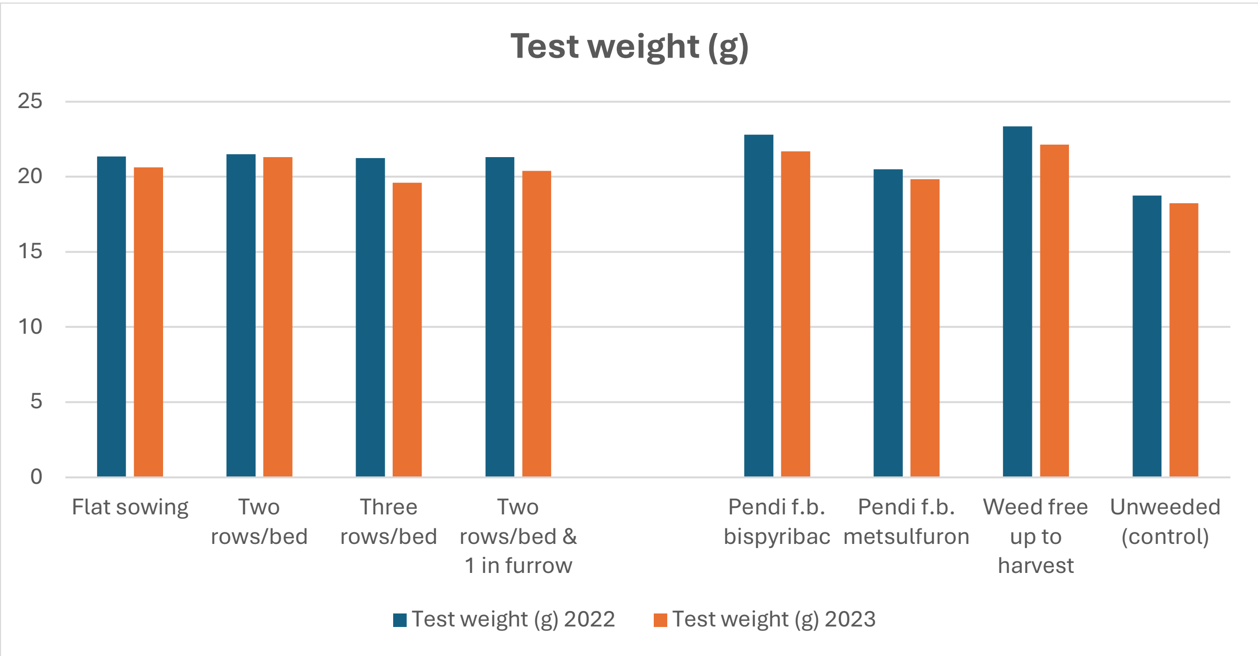


Fig. 4.3.3 Effect of planting patterns and weed control treatments on panicle weight (g) and test weight (g) during 2022 and 2023

4.3.6 Paddy yield (q/ha)

Paddy yield was recorded at harvest for both the years and given in (Table 4.3.5 and Fig 4.3.4).The statistics data of paddy yield of rice revealed that various planting patterns and weed management treatments exhibited significant disparity in paddy yield when recorded in two consecutive years of study . Among , planting patterns significantly higher yield was observed in three rows per bed than all other planting patterns when recorded for both the years.The significantly less yield was observed in two rows per bed than other planting patterns for both the years.Also planting pattern of two rows per bed and one in furrow (M4) recorded significantly more paddy yield than two rows per bed and flat sowing methods during both the years of investigations. More yield in three rows per bed might be because of less weed density (Table 4.1.1 and 4.1.2),higher growth attributes (Table 4.2.1 to 4.2.4) and more yield attributing characteristics (Table 4.3.1 to 4.3.4). Planting three rows per bed,two rows per bed and one in furrow and flat sowing increased paddy yield by 18.6 %,12.6%, and 3.5 % percent during 2022.and by 19.6 %,9.8 %, and 8.3 %, percent during 2023 than two rows per bed respectively. Among the weed management treatments, significantly higher seed yield was observed in weed free up to harvest treatment than another weed management methods in two consecutive years of study. The significantly low seed yield had been observed by unweeded (control)in two consecutive years . Pre-emergence application of pendimethalin fb. bispyribac recorded significantly higher yield than pendimethalin fb. metsulfuron during both years which was because of good management of weeds in the former treatment.The yield of weedy check had significantly lower among all weed management methods, which was very less due to more intensity of weeds during both years. The seed yield in all weed management treatments was significantly more than control during both years which was because of greater management of weeds (Table 4.1.1 and 4.1.2),improved attributes of growth(Table 4.2.1 to 4.2.4) and better yield attributes (Table 4.3.1 to 4.3.4) The unweeded (control) ,due to high weed intensity resulted in severe reduction in paddy yield to the tune of 96.9, 96.8,and 96.5%, during 2022 and 96.1,95.8, and 95.6%, during 2023 as compared to weed free,pendimethalin fb. bispyribac and pendimethalin fb. metsulfuron respectievely.Such drastic reduction in yield was because of greater infestation of weeds which smoothered the crops very effectively and resulted in more than 96 percent loss in yield,if weeds are not controlled in directly sown rice severe weed problem in directly sown rice is hindering the popularity of this technology among farmers.Same results had been ` reported by Singh et al., 2016.

4..3.7 Straw yield (q/ha)

The statistical data of straw yield revealed that various planting patterns and weed management treatments exhibited significant differences in straw yield of rice in two consecutive years of study(Table 4.3.5 and Fig 4.3.4). Among the planting patterns, significantly more straw yield was recorded in three rows per bed than all other planting patterns for both years .The straw yield in flat sowing,two rows per bed & one row in furrow and two rows per bed were found to be at par among themselves in two consecutive years.Out of all other weed management methods, significantly more yield of straw had been obtained in weed free upto harvest than all other herbicidal treatments except pendimethalin fb. bispyribac during 2023. However, the lowest straw yield of paddy crop was obtained under unweeded (control) which had been significantly least when compared to other weed management methods in two consecutive years. Straw yield in pendimethalin fb. metsulfuron was significantly less than pendimethalin fb. bispyribac treatment during both years. The data conforms previous findings by (Pooja and. Saravanane 2021 and Singh et al., 2016.

The interactive impact on planting patterns along with weed management methods on yield of straw yield had been observed as non significant in two consecutive years of study.

The interactive influence on paddy yield in between planting patterns and weed management treatments had been observed as significant in two consecutive years of study.(Table 4.3.6) During 2022,the yield of rice crop in three rows per bed planting pattern treated with pendimethalin fb. bispyribac was found at par with the weed free crop raised with two rows per bed and one in furrow planting pattern.The seed yield of weed free flat sown crop was significantly less than three rows per bed and two rows per bed & one in furrow(M3 & M4) crop treated with pendimethalin fb. bispyribac.During 2023,three rows/bed crop treated with pendimethalin fb. bispyribac produced at par seed yield than flat sown crop but kept weed free up to harvest.Also three rows per bed planting pattern treated with pendimethalin fb. metsulfuron produced.similar(at par) paddy yield than two rows per bed and one in furrow treated with pendimethalin fb. bispyribac.

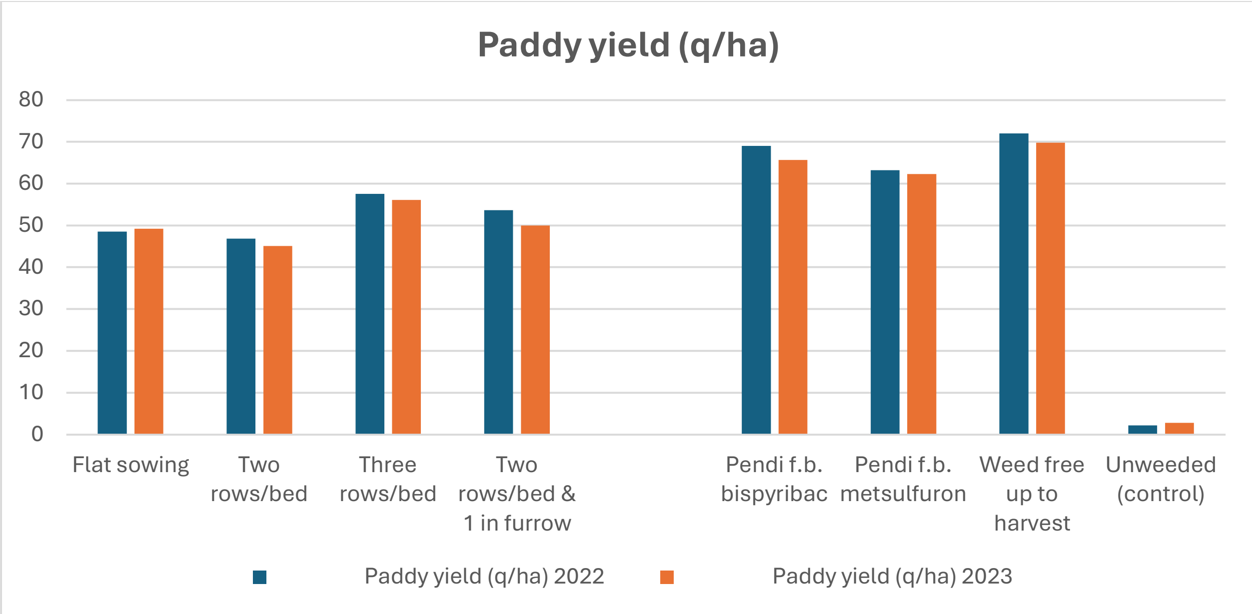
Table.4.3.5 Effect of planting patterns and weed control treatments on paddy yield and straw yield of direct seeded rice during 2022 and 2023

Main plots – Planting patterns				
	Paddy yield (q/ha)		Straw yield (q/ha)	
	2022	2023	2022	2023
M_1 – Flat sowing	48.5	49.2	62.7	61.6
M_2 – Two rows/bed	46.8	45.1	62.3	62.3
M_3 – Three rows/bed	57.5	56.1	71.5	66.7
M_4 – Two rows/bed & 1 in furrow	53.6	50.0	65.1	60.6
SE(m)	0.57	0.57	0.97	1.02
CD at P < 0.05%	1.84	1.87	3.43	3.59
Sub plots - Weed control treatments				
T_1 -Pendi fb. bispyribac	69.0	65.6	86.1	83.6
T_2 -Pendi fb. metsulfuron	63.2	62.3	83.3	78.6
T_3 -Weed free	72.0	69.8	89.4	85.0
T_4 -Unweeded (control)	2.2	2.8	2.9	4.0
SE(m)	0.51	0.46	0.91	1.00
CD at P < 0.05%	1.31	1.77	2.66	2.96
CD for interaction	2.42	3.57	NS	NS

Table.4.3.6. Interaction among planting patterns and weed control treatments on paddy yield of direct seeded rice during 2022 and 2023

Paddy yield (q/ha) (2022)					
Treatments	**Pendi fb. bispyribac**	**Pendi fb. metsulfuron**	**Weed free**	**Unweeded (control)**	**Mean**
Flat sowing	63.7	60.0	68.4	1.8	48.5
Two rows per bed	62.5	59.0	63.6	2.3	46.8
Three rows per bed	77.0	71.4	79.5	2.3	57.5
Two rows per bed & one in furrow	72.8	62.7	76.7	2.5	53.6
Mean	69.0	63.2	72.0	2.2	
CD at 5%	**2.42**				

Paddy yield (q/ha) (2023)					
Treatments	**Pendi fb. bispyribac**	**Pendi fb. metsulfuron**	**Weed free**	**Unweeded (control)**	**Mean**
Flat sowing	63.2	59.9	71.4	2.4	49.2
Two rows per bed	57.6	56.1	64.1	2.8	45.1
Three rows per bed	73.6	71.9	76.4	2.8	56.1
Two rows per bed & one in furrow	68.3	61.4	67.5	3.0	50.0
Mean	65.6	62.3	69.8	2.75	
CD at 5%	**3.57**				



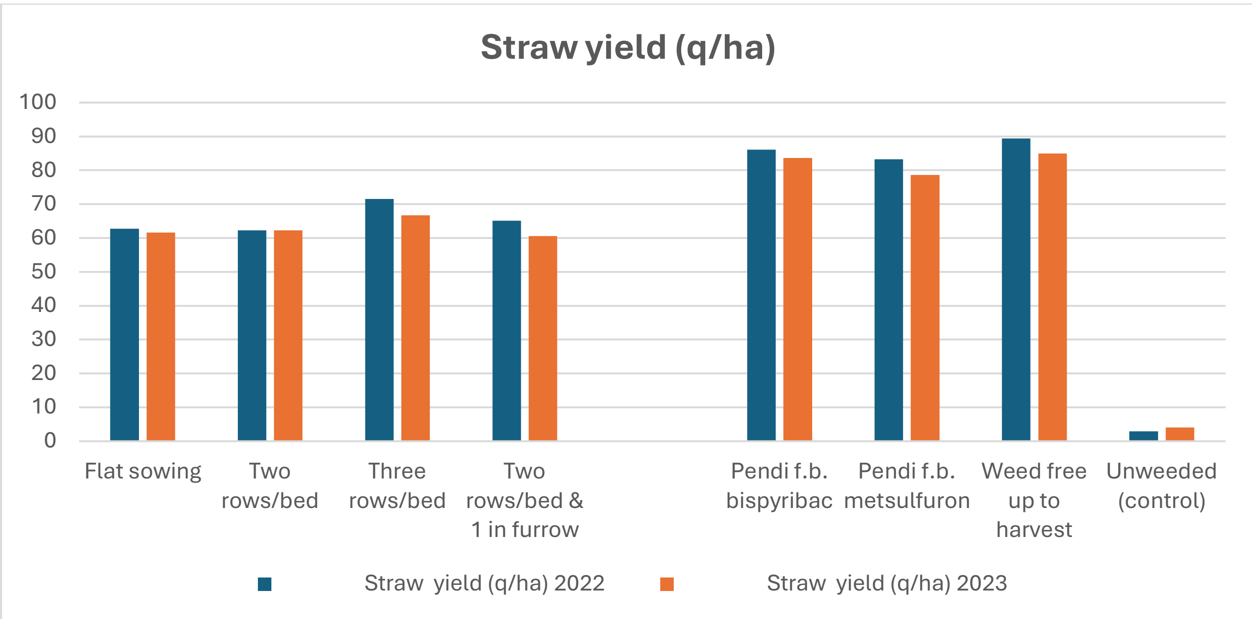


Fig.4.3.4 Effect of planting patterns and weed control treatments on paddy yield and straw yield of direct seeded rice during 2022 and 2023

4.3.8 Biological yield (q/ha)

The statistical data on biological yield revealed that different planting patterns exhibited significant variation in biological yield of rice when recorded for both the years.(Table 4.3.7) Among the different planting patterns, significantly more biological yield was recorded by three rows per bed planting pattern as compared to all other planting patterns during both years.The differences in biological yield among flat sowing, two rows per bed and three rows per bed were found to be non significant in two consecutive years of study.Out of all weed management methods maximum biological yield had been observed in treatment with weed free , also it was succeeded by pendimethalin fb. bispyribac and these two treatments yielded significantly greater biological yield compared to pendimethalin fb. metsulfuron and (unweeded) control treatment during 2023.During 2022, biological yield had been significantly higher in weed free when compared to other weed management methods.Significantly less biological yield had been recorded in the (control) in comparison with other weed management methods in two consecutive years of research.

The interactive effect on planting patterns and weed management treatments for biological yield had been observed as non significant in two consecutive years of research.

4.3.9 Harvest Index (%)

The statistical data on the harvest index was given in the Table 4.3.7.The data showed that differences in harvest index under different planting patterns were found in the range from 42.7 to 45.2 for the year 2022 and from 41.7 to 44.2 for the year 2023 . Out of all the weed management methods , the values of harvest index had found to vary from 43.1 to 44.5% for the year 2022 and 43.1 to 45.5% for the year 2023 .The highest value of harvest index had been recorded by weed free up to harvest succeeded by pendimethalin fb. bispyrbac and pendimethalin fb. metsulfuron treatments,The least harvest index had been observed by control in comparison with other weed management treatments in two consecutive years of study.

Table.4.3.7 Effect of planting patterns and weed control treatments on biological yield (q/ha) and harvest index (%) of direct seeded rice during 2022 and 2023

	Biological yield (q/ha)		Harvest Index(%)	
	2022	2023	2022	2023
Main plots – planting patterns				
M_1 – Flat sowing	111.2	110.9	43.5	44.1
M_2 – Two rows/bed	109.2	107.5	42.7	41.8
M_3 – Three rows/bed	129.0	122.9	45.3	44.0
M_4 – Two rows/bed & 1 in furrow	118.8	110.6	44.8	44.3
SE(m)	2.65	2.10	NA	NA
CD at P < 0.05%	8.44	7.58	NA	NA
Sub plots - Weed control treatments				
T_1 -Pendi fb. bispyribac	155.2	150.8	44.4	43.5
T_2 -Pendi fb. metsulfuron	146.6	140.9	43.2	44.1
T_3 -Weed free	161.5	153.5	44.6	45.5
T_4 -Unweeded (control)	5.0	6.8	44.1	41.0
SE(m)	1.91	1.75	NA	NA
CD at P < 0.05%	6.02	5.83	NA	NA
CD for interaction	NS	NS	NA	NA

4.4 Quality parameters

4.4.1. Nitrogen content present in seeds (%)

Data on the composition of nitrogen in seed pertaining to different planting patterns had been observed as non significant in two consecutive years of research and data it is given in the Table 4.4.1.Data on the nitrogen content in seed pertaining to various weed management methods had been observed as significant in two consecutive years of research. Among the weed management treatments , the significantly more nitrogen content in seeds was recorded in the weed free treatment than all other weed management treatments.The N content in weedy check had been observed as significantly lowestwhen compared with other weed management methods during both the years except pendimethalin fb. metsulfuron during 2023.

4.4.2 Nitrogen content in straw (%)

Data related to composition of nitrogen in rice straw pertaining to different planting patterns along with weed management treatments has been showed in the Table 4.4.1 and difference were significant for both the years . The significantly higher nitrogen content had been recorded by two rows per bed compared to all other planting patterns during 2022.However during 2023,N content in straw for two rows per bed was found similar to two rows per bed and one in furrow sowing method, further these two planting patterns produced significantly higher N content amongst all other planting patterns. The significantly low nitrogen content was recorded in flat sowing ,as compared to all other planting patterns for both the years.Among the weed management treatments , the significantly more nitrogen content in straw was observed in weed free treatment in comparison with other weed management methods.Pendimethalin fb. bispyribac recorded significantly more N content in straw than pendimethalin fb. metsulfuron during both years.The significantly low nitrogen content in straw was observed in weedy check (control) amongst all the other weed management methods in two consecutive years. The interactive effect related to planting patterns along with weed management treatments on N content in seeds along with nitrogen composition in straw had been observed as non- significant in two consecutive years of research.

Table.4.4.1. Impact of planting patterns and weed management methods on nitrogen content (%) in seeds and straw during 2022 along with 2023

Main plots – planting patterns				
	N content in seeds(%)		N content in straw(%)	
	2022	2023	2022	2023
M_1 – Flat sowing	0.80	0.84	0.65	0.64
M_2 – Two rows/bed	0.86	0.86	0.70	0.69
M_3 – Three rows/bed	0.85	0.86	0.65	0.66
M_4 – Two rows/bed & 1 in furrow	0.85	0.85	0.67	0.69
SE(m)	0.02	0.02	0.004	0.009
CD at P < 0.05%	NS	NS	0.021	0.032
Sub plots - Weed control treatments				
T_1 -Pendi fb. bispyribac	0.87	0.85	0.74	0.76
T_2 -Pendi fb. metsulfuron	0.80	0.79	0.68	0.69
T_3 -Weed free	1.05	1.04	0.83	0.82
T_4 -Unweeded (control)	0.64	0.74	0.43	0.40
SE(m)	0.02	0.03	0.006	0.007
CD at P < 0.05%	0.056	0.083	0.022	0.025
CD for interaction	NS	NS	NS	NS

4.4.3. Nitrogen uptake by seed (kg/ha)

The statistical data revealed that uptake of nitrogen by seeds was significantly influenced by planting patterns and weed management treatments during both the years (Table 4.4.2) Among the planting patterns, the significantly higher nitrogen uptake by seeds was observed in three rows per bed (M3) as compared to other planting patterns when recorded for both the years .The significantly low nitrogen uptake by seeds was observed in flat sowing compared to all other planting patterns for both the years.During 2022,flat sowing and two rows per bed were found at par and both these treatments recorded significantly more nitrogen uptake than three rows per bed treatment.During 2023 two rows per bed (M2) & two rows per bed and one in furrow (M4) were found at par and significantly better than flat sowing.Among the weed management treatments ,significantly higher nitrogen uptake by seeds was recorded in the weed free upto harvest as compared to all other weed management methods.Pendimethalin fb. bispyribac displayed significantly highest N uptake by seed compared to pendimethalin fb. metsulfuron during both years.The significantly low nitrogen uptake by seeds was observed in unweeded (control) in comparison to other weed management methods in two consecutive years of research.

4.3.4. Nitrogen uptake by straw

The statistical data revealed that the uptake of nitrogen by straw was significantly impacted by planting patterns along with weed management treatments (Table 4.4.2). Among the planting patterns, the highest nitrogen uptake by straw was observed in three rows per bed which was found to be at par with two rows per bed and these methods were significantly better than all other planting patterns for 2022. During 2023, significantly less N uptake by straw was recorded in flat sowing than two rows per bed and three rows per bed planting patterns.Out of other weed control methods, the significantly more nitrogen uptake by straw had been displayed by weed free treatment in comparison with other weed management treatment in two consecutive years of research.And also pendimethalin fb. bispyribac observed significantly higher N uptake by straw in comparison with pendimethalin fb. metsulfuron treatment during both years.The significantly less nitrogen uptake by straw was observed in weedy check (control)in comparison with all other weed management methods in two consecutive years of research. The interactive effects between planting patterns and weed management treatments for nitrogen uptake by seed & straw during both years had been observed as non significant.

Table.4.4.2. Influence of planting patterns and weed management methods on N uptake by seed and straw during 2022 and 2023

Main plots – planting patterns				
	N uptake by seeds(kg/ha)		N uptake by straw (kg/ha)	
	2022	2023	2022	2023
M_1 – Flat sowing	42.0	40.9	45.8	45.6
M_2 – Two rows/bed	43.3	44.1	49.2	48.2
M_3 – Three rows/bed	53.6	51.2	52.6	49.5
M_4 – Two rows/bed & 1 in furrow	49.5	44.5	49.0	47.2
SE(m)	0.41	0.64	1.14	0.79
CD at P < 0.05%	1.4	2.1	3.21	2.64
Sub plots - Weed control treatments				
T_1 -Pendi fb. bispyribac	60.1	55.8	63.7	65.0
T_2 -Pendi fb. metsulfuron	51.1	49.6	57.2	54.8
T_3 -Weed free	75.7	73.2	74.5	69.1
T_4 -Unweeded (control)	1.45	2.05	1.3	1.6
SE(m)	1.02	1.40	0.71	0.74
CD at P < 0.05%	3.38	4.32	2.32	2.28
CD for interaction	NS	NS	NS	NS

4.4.5. Total N uptake(seed+straw)(kg/ha)

The obtained data demonstrated that the total uptake of nitrogen (crop +straw) had been significantly affected by planting patterns along with weed management treatments in two consecutive years of research, in (Table 4.4.3 and Fig 4.4.1) Among the different planting patterns, significantly more total nitrogen uptake by crop was observed in three rows per bed (M3) than all other planting patterns during 2022 and 2023.The significantly low nitrogen uptake by crop was observed in flat sowing and two rows per bed than two rows per bed and one one in furrow (M4) during 2022. During 2023 flat sowing, two rows per bed and two rows per bed and one in furrow (M4) were at par. Among the weed management methods , the significantly highest uptake of nitrogen by crop had been observed by weed free up to harvest compared to all other weed control treatments during both years. The significantly less total nitrogen uptake by crop had been recorded by control ,out of all other weed management methods.Total uptake of nitrogen by rice was significantly higher in pendimethalin fb. bispyribac compared to pendimethalin fb. metsulfuron during both years.Uptake of nitrogen by crop in weed free,pendimethalin fb. bispyribac,pendimethalin fb. metsulfuron increased by 98.1%, 97.8%,and 97.4 percent during 2022 and 97.4%, 96.9 %,and 96.4% percent during 2023 over unweeded (control) respectievely.

4.4.6 Protein content (%)

Protein content of rice has been noted at the harvest stage . The obtained data regarding protein content revealed that planting patterns does not influenced significantly protein content in seeds for both the years(Table 4.4.3.The protein content in rice seeds was statistically influenced by weed management treatments.The significantly more protein content was observed in the weed free up to harvest treatment compared to all other weed management treatments. Also protein content of seed in pendimethalin fb. bispyribac was significantly higher than pendimethalin fb. metsulfuron treatment during both years. The protein content of weedy check (control) treatment was significantly lowest amongst other weed management methods in two consecutive years of research.

The interactive effect based on planting patterns and weed management treatments for total nitrogen uptake by rice crop,has been identified as significant and data presented in (Table 4.4.3).Total nitrogen uptake (seed and straw) by rice crop has been determined as significantly more in weed free up to harvest treatment consisting three rows per bed than all other planting patterns even applied with pendimethalin fb. bispyribac or metsulfuron.Application of pendimethalin fb. bispyribac on three rows per bed planting pattern resulted in significantly higher nitrogen uptake by crop than pendimethalin fb. metsulfuron sprayed on all other planting pattern treatments.These findings holds good for both years.

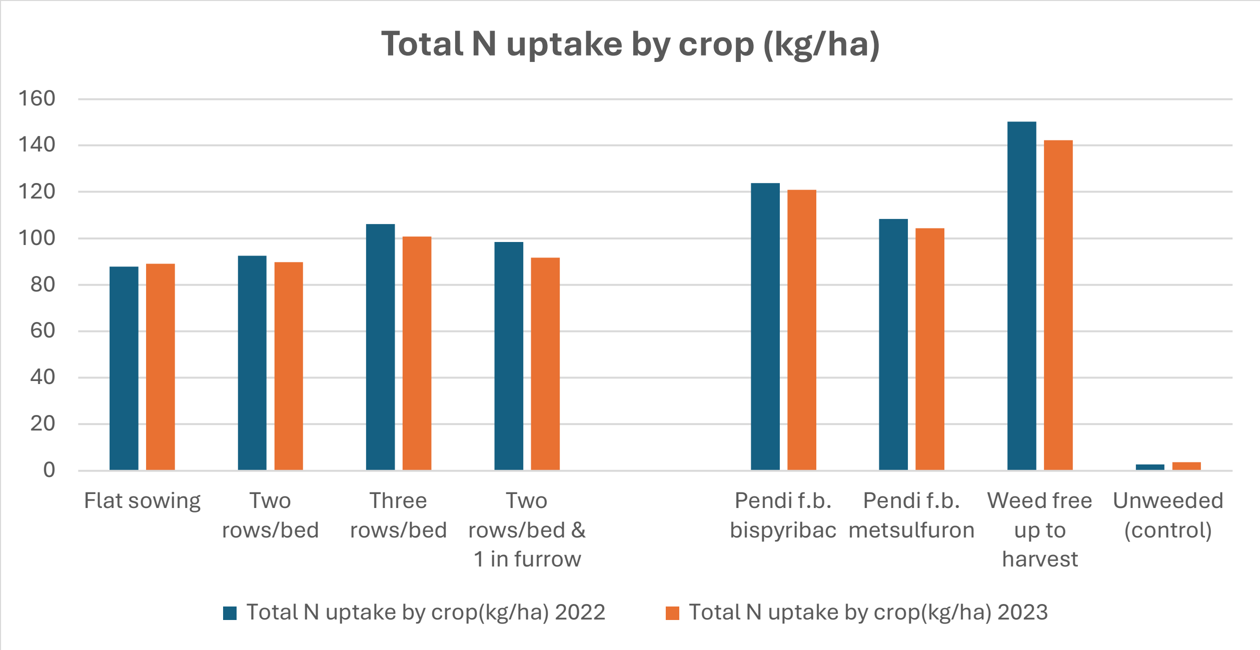
Table.4.4.3. Impact of planting patterns and weed management methods on total N uptake by crop (seed+straw)(kg/ha) and protein content during 2022 and 2023

Main plots – planting patterns				
	Total N uptake by crop(kg/ha)		Protein content (%)	
	2022	2023	2022	2023
M_1 – Flat sowing	87.8	89.1	5.00	5.25
M_2 – Two rows/bed	92.5	89.7	5.40	5.42
M_3 – Three rows/bed	106.2	100.7	5.35	5.43
M_4 – Two rows/bed & 1 in furrow	98.4	91.7	5.34	5.35
SE(m)	1.46	2.32	0.12	0.13
CD at P < 0.05%	5.13	7.58	NS	NS
Sub plots - Weed control treatments				
T_1 -Pendi fb. bispyribac	123.8	120.9	5.45	5.31
T_2 -Pendi fb. metsulfuron	108.3	104.3	5.04	4.97
T_3 -Weed free	150.2	142.3	6.56	6.53
T_4 -Unweeded (control)	2.71	3.68	4.04	4.63
SE(m)	1.08	1.24	1.20	0.09
CD at P < 0.05%	3.18	3.83	0.352	0.158
CD for interaction	6.85	8.40	NS	NS

Table.4.4.4. Interaction among planting patterns and weed management treatments on total N uptake by crop (seed+straw)(kg/ha) during 2022 and 2023

Total N uptake by crop (kg/ha) (2022)					
Treatments	**Pendi fb. bispyribac**	**Pendi fb. metsulfuron**	**Weed free**	**Unweeded (control)**	**Mean**
Flat sowing	116.8	96.0	136.3	2.1	87.8
Two rows per bed	119.1	104.6	143.1	3.0	92.5
Three rows per bed	131.5	121.5	169.4	2.5	106.2
Two rows per bed & one in furrow	127.8	110.9	152.0	3.0	98.4
Mean	123.8	108.3	150.2	2.7	
CD at 5%	**6.85**				

Total N uptake by crop (kg/ha) (2023)					
Treatments	**Pendi fb. bispyribac**	**Pendi fb. metsulfuron**	**Weed free**	**Unweeded (control)**	**Mean**
Flat sowing	117.1	96.4	142.5	2.7	89.1
Two rows per bed	114.3	101.3	136.9	3.8	89.7
Three rows per bed	130.6	114.0	154.2	3.9	100.7
Two rows per bed & one in furrow	121.4	105.5	135.8	4.1	91.7
Mean	120.9	104.3	142.3	3.68	
CD at 5%	**8.40**				



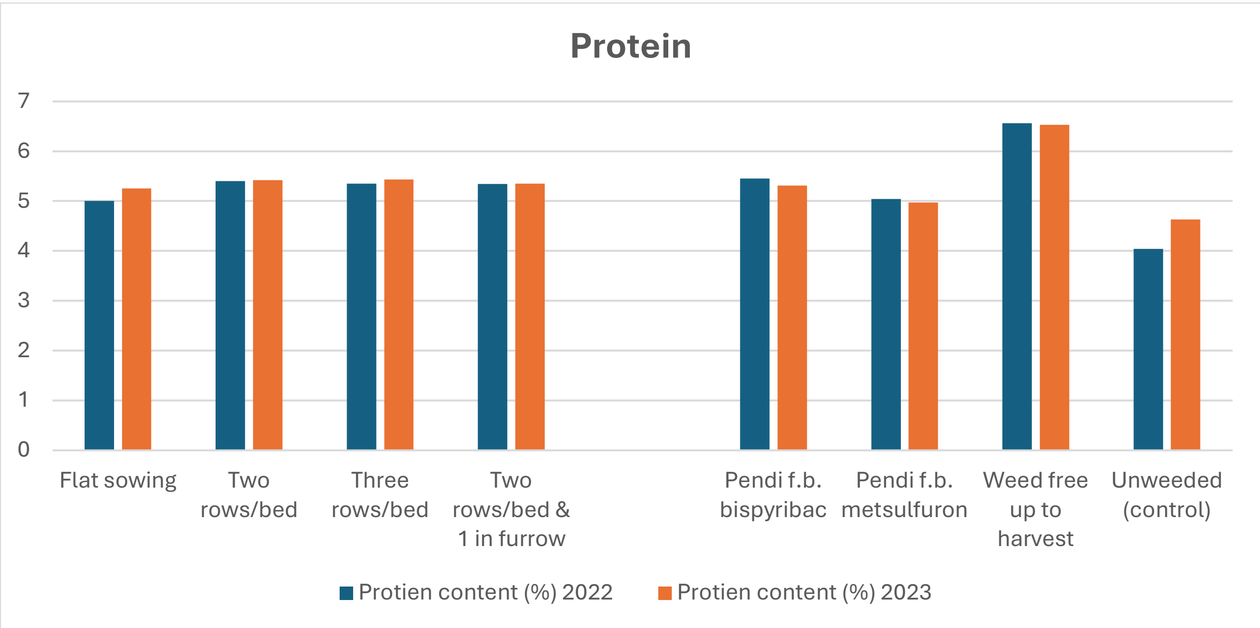


Fig.4.4.1. Effect of planting patterns along with weed management methods on total N uptake by crop (seed+straw)(kg/ha) and protein content during 2022 and 2023

4.4.7 Nitrogen content in weeds (%)

The differences in N % in weeds were significant due to planting patterns along with weed management methods in two consecutive years of study and depicted in Table 4.4.5. The highest composition of nitrogen in weeds had been recorded in two rows per bed and one in furrow which was found to be statistically similar with two rows per bed and both these planting patterns has been significantly greater compared to other planting patterns in two consecutive years.The nitrogen content in weeds under weed management treatments revealed that the significantly highest composition of nitrogen had been observed in unweeded (control) compared to other weed management methods in two consecutive years of research .The significantly less nitrogen content in weeds was observed in pendimethalin fb. bispyribac treatment when compared to pendimethalin fb. metsulfuron treatment for both the years.

4.4.8 Nitrogen uptake by weeds (kg/ha)

The differences in the uptake of N by weeds were found to be non-significant due to planting patterns in two consecutive years of research.(Table 4.4.5) The differences in the uptake of N by weeds has been observed as significantly affected by weed management methods in two consecutive years of research. The obtained data on nitrogen uptake by weeds under weed management treatments revealed that the significantly higher nitrogen uptake was observed in weedy check (control) than all other weed management treatments for both the years .The significantly less nitrogen uptake by weed was observed in pendimethalin fb. bispyribac treatment compared to pendimethalin fb. metsulfuron treatment during both years. Uptake of nitrogen by weeds in the weedy check treatment has observed to be very high i.e. 50.4 kg/ha and 61.7 kg/ha in the years 2022 and 2023 respectively which may be due to presence of high weed intensity in the experimental field.Both the herbicidal treatments resulted in huge reduction of nitrogen uptake by weeds ranging from (3.42 kg/ha to 8.62 kg/ha) during both years which may be due to excellent control of weeds by these herbicides in direct seeded rice.

The interactive effect between planting patterns and weed management treatments for N content and N uptake by weeds has been observed as non-significant during both years.

Table.4.4.5. Impact with regard to planting patterns along with weed management methods on N content (%) in weeds and also N uptake by weeds(kg/ha) during 2022 and 2023

Main plots – planting patterns				
	N content in weeds(%)		N uptake by weeds(kg/ha)	
	2022	2023	2022	2023
M_1 – Flat sowing	0.54	0.65	14.4	19.6
M_2 – Two rows/bed	0.59	0.68	14.1	18.7
M_3 – Three rows/bed	0.55	0.65	14.7	19.1
M_4 – Two rows/bed & 1 in furrow	0.59	0.69	15.3	19.5
SE(m)	0.008	0.008	0.410	0.546
CD at $P < 0.05\%$	0.013	0.021	NS	NS
Sub plots - Weed control treatments				
T_1 -Pendi fb. bispyribac	0.54	0.65	3.42	6.58
T_2 -Pendi fb. metsulfuron	0.61	0.69	4.91	8.62
T_3 -Weed free	-	-	-	-
T_4 -Unweeded (control)	0.66	0.78	50.4	61.7
SE(m)	0.005	0.008	0.403	0.601
CD at $P < 0.05\%$	0.016	0.026	1.024	1.56
CD for interaction	NS	NS	NS	NS

4.5 Soil studies

4.5.1 Organic carbon (%) and available N in soil (kg/ha)

The data pertaining to organic carbon and available N in soil after harvest of crop (Table 4.5.1) as affected by planting patterns and weed management methods were found to be non significant.Also organic carbon content (%) as well as available N in soil (kg/ha) were not influenced by weed management treatments in two consecutive years of research. Identical results had been determined by Goswami et al., 2017

The interactive effects between planting patterns along with weed management methods for organic carbon (%) and available nitrogen (kg/ha) was found to be non significant.

4.5.2 Available content of phosphorus & potassium in soil after the harvest stage

The differences in available phosphorus (kg/ha) and the potassium (kg/ha) under different planting patterns has been observed as non-significant.(Table 4.5.2). Also the differences for available phosphorus and potassium due to variable planting patterns were observed as non significant in two consecutive years of research.

The interactive effects between planting patterns and weed management treatments for available phosphorus and potassium has been observed as non significant in two consecutive years of research.

Table 4.5.1 Influence of planting patterns and weed management methods on organic carbon (%) , available nitrogen (kg/ha), in soil during 2022 & 2023

Main plots – planting patterns				
	Organic carbon (%)		Available nitrogen (kg/ha)	
	2022	2023	2022	2023
M_1 – Flat sowing	0.44	0.44	185.4	184.5
M_2 – Two rows/bed	0.43	0.45	186.1	185.7
M_3 – Three rows/bed	0.44	0.45	187.71	184.9
M_4 – Two rows/bed & 1 in furrow	0.43	0.45	185.2	185.4
CD at P < 0.05%	NS	NS	NS	NS
Sub plots - Weed control treatments				
T_1 -Pendi fb. bispyribac	0.45	0.45	187.0	186.7
T_2 -Pendi fb. metsulfuron	0.44	0.44	185.7	185.2
T_3 -Weed free	0.45	0.46	187.2	188.1
T_4 -Unweeded (control)	0.43	0.43	172.4	175.2
CD at P < 0.05%	NS	NS	NS	NS
CD for interaction	NS	NS	NS	NS

Table 4.5.2 Influence of planting patterns and weed management methods on available phosphorus (P) and available potassium (K) in soil during 2022 & 2023

Main plots – planting patterns				
	Available phosphorus (kg/ha)		Available potassium (kg/ha)	
	2022	2023	2022	2023
M_1 – Flat sowing	16.3	15.2	163.1	164.3
M_2 – Two rows/bed	16.6	16.5	165.3	167.8
M_3 – Three rows/bed	17.5	15.8	163.5	166.4
M_4 – Two rows/bed & 1 in furrow	17.2	16.2	164.7	167.2
CD at P < 0.05%	NS	NS	NS	NS
Sub plots - Weed control treatments				
T_1 -Pendi fb. bispyribac	17.2	16.4	167.2	171.8
T_2 -Pendi fb. metsulfuron	16.9	15.8	166.4	170.2
T_3 -Weed free	16.6	16.6	168.5	172.2
T_4 -Unweeded (control)	16.2	14.2	165.2	169.3
CD at P < 0.05%	NS	NS	NS	NS
CD for interaction	NS	NS	NS	NS

Experiment: 2 "Performance of nitrogen levels and weed management treatments on growth and development of direct seeded rice" (*Oryza sativa L.*)

4.1 Weed parameters

4.1. 1 Total weed count (per sq.m)

Weed count indicates intensity of weed plants as well as type of weed flora present in a particular treatment and this parameter also indicates extent of yield loss due to weeds.The data on total weed count per sq.m as influenced by different nitrogen levels and weed control methods were recorded periodically at 30 DAS interval,60 DAS interval,90 DAS interval along with the harvest stage and given in Table 4.1.1a ,4.1.1b and Fig 4.1.1.Due to wide variations in data ,square root transformation was adopted after adding one to all the original values recorded for periodic weed count at all periodic intervals.

The differences in total weed count per square meter recorded at 30 DAS as influenced by nitrogen levels had been observed as non significant in two consecutive years of study.(Table 4.1.1a) Out of all weed control methods, unweeded (control) produced significantly more weed count per sq.m than all other weed management treatments during both years.The variations in count of weeds between pendimethalin (stomp) applied as pre emergence herbicide fb. bispyribac (nominee gold) and brown manuring treatment along with application of pendimethalin (stomp) as pre emergence fb bispyribac (nominee gold) treatments were found to be at par with each other for both the years,and weed count was significantly less in these treatments compared to brown manuring treatment with alone application of bispyribac.

The variations in the weed count recorded at 60 DAS was found to be significantly in affected by both the nitrogen levels and weed management treatments during 2023 only.(Table 4.1.1a) However the variations in nitrogen levels,had been found to be non-significant during 2022.During 2023 significantly more weed count was found in 125 kg nitrogen/hectare which has been observed as statistically similar to 175 kg nitrogen /hectare.and the former N level (125 kg N/ha) recorded significantly more weed count then 0 kg N/ha and 150 kg N/ha. The significantly less weed count was found in 150 kg nitrogen/hectare which had been observed as statistically similar to 0 kg nitrogen /hectare.Out of all other weed management treatments, the significantly highest count of weed had been reported by weedy check (control) treatment contrary to further weed management treatments during both years. The significantly less weed count was observed in brown manuring rice treated with pendimethalin fb. bispyribac (T2) which was found to be at par with pendimethalin fb. bispyribac(T1) for both the years.Alone application of bispyribac to brown manuring treatment recorded significantly more weed count/sq.m. than pre-em. application of pendimethalin fb. bispyribac (T1 & T2) treatments. Effective weed control is evident in treatment with application of pre.em. pendimethalin, emphasizing their consistent performance while compared with no application of pendimethalin.

The weed count per square meter was also assessed at 90 DAS and presented in (Table 4.1.1b). Notably, there had been no significant variations in the weed count among the various nitrogen levels for both the years. The variations in weed count had been significantly affected by weed management methods (Table 4.1.1b).The significantly more weed count had been observed in weedy check compared with additional weed control methods in two consecutive years of research. Conversely, the lowest weed count in comparison to weedy check was observed in the pendimethalin fb. bispyribac treatment(T1), and it was statistically at par with the brown manuring crop treated with pre-em. pendimethalin fb. bispyribac treatment (T3) for both the years Effective weed control is evident in pendimethalin fb. bispyribac treatment and with brown manuring where pendimethalin as pre-em. was followed by bispyribac treatment, and these treatments recorded significantly less weed count than without application of pendimethalin(T3).

The total weed count per square meter recorded at harvest showed no significant differences among various nitrogen levels for both years.(Table 4.1.1b). The variations in weed count was significantly influenced by the weed management treatments at harvest. The significantly higher weed count was observed in unweeded (control) than all other weed management treatments. Among different herbicidal treatments lowest weed count was observed in the pendimethalin fb. bispyribac application, and it had been statistically similar to brown manuring method with pre-em. pendimethalin followed by bispyribac and these two methods had observed significantly lowest weed count compared to brown manured crop treated with alone bispyribac (T3) during both years.

Weed count was not significantly impacted by levels of nitrogen at all periodic intervals in two consecutive years of research except 60 DAS during 2023 only indicating there by that N application had no influence on weed emergence. Significantly less weed count in pre-em. pendimethalin fb. bispyribac treatments because of management of non paddy weeds by using pendimethalin and paddy weeds with bispyribac herbicide.The data conforms previous findings of Pooja and. Saravanane 2021; Singh et al., 2016; Mitra et al., 2022 along with Vijay singh et al., 2016.

The interactive effects between various levels of nitrogen along with different weed management methods on weed count in all the periodic intervals had been observed as non significant.

Table 4.1.1a. Impact of various levels of nitrogen and weed management methods on weed count per square meter (30 &60 DAS) during 2022 and 2023

Weed count per sq.m				
Main plots - Nitrogen levels	30 DAS		60 DAS	
	2022	2023	2022	2023
N_1 – 0 kg N /ha	9.5 (92)	12.6(159)	9.9(99)	16.9(287)
N_2 – 125 kg N /ha	10.2(105)	12.2(151)	9.8(98)	17.4(305)
N_3 – 150 kg N /ha	10.0(101)	12.0(145)	9.6(94)	16.7(280)
N_4 – 175 kg N /ha	10.4(109)	12.0(146)	9.8(97)	17.1(293)
SE(m)	0.42	0.55	2.91	5.84
CD at P < 0.05%	NS	NS	NS	1.51
Sub plots - Weed control treatments				
T_1 - Pendi fb. bispyribac	7.4(55)	8.1(67)	8.3(69)	9.0(81)
T_2 -BM,Pendi fb. bispyribac	7.5(57)	7.8(61)	8.5(73)	8.6(75)
T_3 – BM,bispyribac	10.5(111)	13.9((194)	11.6(135)	14.2(203)
T_4 -Unweeded (Control)	13.4(182.0)	16.1(260)	14.6(214)	16.3(267)
SE(m)	0.25	0.47	0.45	0.71
CD at P < 0.05%	0.73	1.32	1.51	2.23
CD for interaction	NS	NS	NS	NS

-"Pendi Stands for pre-em.application of Stomp 30 EC (pendimethalin) at 0.75 kg a.i/ha

-BM brown manuring of sesbania which was killed 25- 30 days after sowing with 2,4-D

-Post-em.application (30 DAS) of Nominie Gold (bispyribac 10 SC) at 25 g a.i /ha was made

-Figures without paranthesis are square root transformed values after adding one to orginal value.

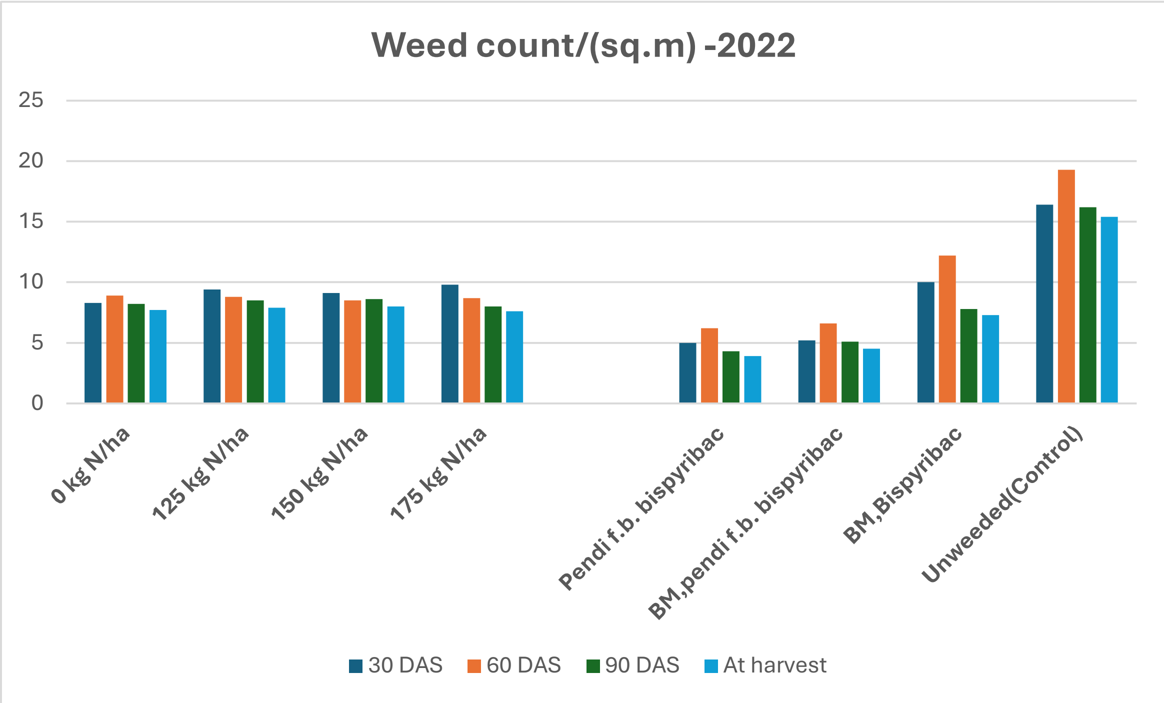
-Figures without parenthesis are original values without statistical analysis".

Table. 4.1.1b. Impact of various levels of nitrogen along with weed management methods against weed count per square meter (90 DAS & at harvest) during 2022 and 2023

	Weed count/sq.m			
Main plots - Nitrogen levels				
	90 DAS		At harvest	
	2022	2023	2022	2023
N_1 – 0 kg N /ha	9.5(90.6)	12.3(153)	9.2(85)	11.7(139)
N_2 – 125 kg N /ha	9.7(94.4)	12.4(155)	9.3(88)	12.1(147)
N_3 – 150 kg N /ha	9.7(95)	11.7(139)	9.4(89)	11.1(125)
N_4 – 175 kg N /ha	9.4(89)	11.7(139)	9.1(84)	11.3(128)
SE(m)	0.13	0.43	0.13	0.38
CD at P < 0.05%	NS	NS	NS	NS
Sub plots - Weed control treatments				
T_1 - Pendi fb. bispyribac	6.8(47)	7.4(55)	6.5(43)	7.0(50)
T_2 -BM,Pendi fb. bispyribac	7.4(56)	7.6(58)	7.0(50)	7.2(53)
T_3 – BM,bispyribac	9.3(87)	11.9(143)	9.0(81)	11.1(125)
T_4 -Unweeded (Control)	13.3(179)	18.2(332)	13.0(171)	17.4(305)
SE(m)	0.29	0.72	0.23	0.57
CD at P < 0.05%	0.92	1.77	0.64	1.68
CD for interaction	NS	NS	NS	NS

-Figures without paranthesis are square root transformed values after adding one to orginal value.

-Figures without parenthesis are original values without statistical analysis.



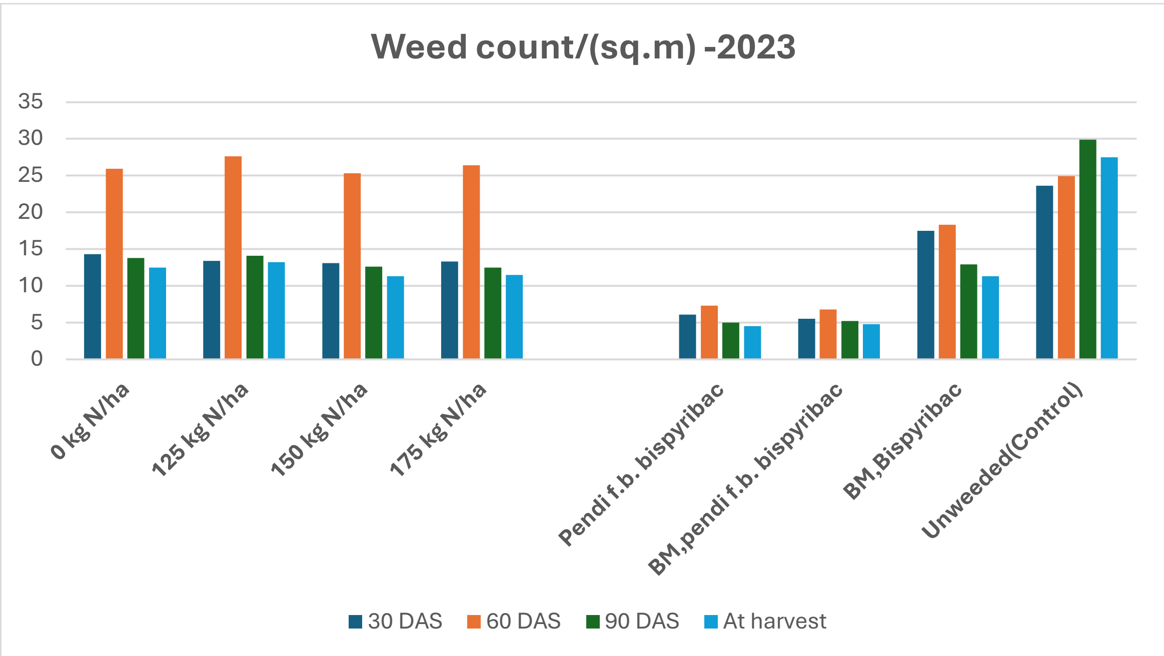


Fig.4.1.1. Impact of various levels of nitrogen along with weed management methods against weed count per square meter at 30,60,90 DAS & at harvest during 2022 and 2023

4.1.2 Dry matter of weeds (q/ha)

Recording dry matter accumulation by weeds is very important and valid indices for determining losses in crop yield due to weeds as compared to weed count per unit area,Hence the dry matter accumulation of weeds had been observed periodically at 30 DAS interval ,60 DAS interval,90 DAS interval and at the harvest stage which was given in Table 4.1.2a, and 4.1.2b. and its graphical depiction was in Fig 4.1.2.

The accumulation of dry matter by weeds(q/ha) was recorded at 30 DAS and data shown in Table 4.1.2.a. At this stage, the dry matter accumulation by weeds exhibited significant differences among nitrogen levels and weed management methods.The significantly greater dry matter accumulation by weeds during both years was observed under 175 kg Nitrogen/ha contrary to other levels of nitrogen. The dry matter accumulation in 0 kg, 125 kg of nitrogen and 150 kg Nitrogen per hectare was found to be at par among themselves in two consecutive years of research. Out of all management methods, weedy check (control) treatment registered significantly larger amount of dry matter contrary to all tried weed management methods in two consecutive years of study. This reason stipulated the effectiveness of weed control methods in reducing weed dry matter accumulation compared to unmanaged conditions. Among herbicidal treatments, weed dry matter accumulation in pendimethalin fb. bispyribac treatment (T1) was found at par with brown manuring rice applied with,pendimethalin fb. bispyribac (T2) treatment. Among brown manuring treatments, application of pendimethalin fb. bispyribac (T2) recorded significantly less weed drymatter than brown manuring treatment applied with only bispyribac (T3).This suggests that pre-em. application of pendimethalin fb. bispyribac, provided efficacious management of weeds, causing in minimal accumulation of dry matter by weeds because of management of paddy along with non paddy weeds effectively.

The accumulation of weed dry matter (q/ha) was also observed at the 60 DAS stage and at this stage, accumulation of dry matter by weeds exhibited significant differences among nitrogen levels and weed management methods.(Table 4.12a) Significantly greater dry matter accumulation by weeds had been observed by spraying of 175 kg of Nitrogen per hectare and 150 kg of Nitrogen per hectare contrary to 0 kg of Nitrogen per hectare and 125 kg Nitrogen per hectare in two consecutive years of research. Conversely, 0 kg of Nitrogen per hectare registered weed dry matter which had been found as statistically similar to 125 kg N/ha in two consecutive years of research.Also the differences for weed dry matter in 150 kg Nitrogen per hectare along with 175 kg Nitrogen per hectare had been observed as non significant in two consecutive years of study.Out of all other weed management methods, the weedy check (control) treatment noted significantly greater accumulation of dry matter by weeds contrary to other weed management methods for two consecutive years of research (Table 4.2.2a). This indicated the effectual control of weeds by reduction of weed dry matter accumulation compared to unmanaged conditions.The lowest weed dry matter accumulation was observed in pendimethalin fb. bispyribac(T1) in two consecutive years of study, and it had been observed as statistically similar to brown manuring treatment sprayed with pre.em. pendimethalin fb. bispyribac (T2) and brown manuring with post-em. bispyribac only(T3) during both years. Effective weed control, in pendimethalin fb, bispyribac because of the better management of non paddy weeds along with pendimethalin (stomp) and paddy weeds with bispyribac herbicide.

The accumulation of dry matter by weeds(q/ha) has been taken at 90 DAS interval. At this stage, the dry matter accumulation by weeds exhibited significant differences among nitrogen levels and weed management treatments.(Table 4.1.2b) Significantly greater dry matter accumulation by weeds has been observed by 175 kg Nitrogen per hectare than all other nitrogen levels for both the years except 150 kg N/ha during 2022. Conversely, 0 kg Nitrogen per hectare observed significantly less dry matter accumulation by weeds than 150 kg of nitrogen per hectare and 175 kg Nitrogen per hectare for both the years.However,the differences of accumulation of dry matter by weeds has been observed as non significant between 0 kg of Nitrogen per hectare and 125 kg of Nitrogen per hectare in two consecutive years of research. Out of all the weed management methods, the weedy check (control) treatment observed significantly greater amount of dry matter contrary to other weed management methods in two consecutive years of study . The significantly least accumulation of dry matter by weeds contrary to other weed management methods has been observed in pendimethalin fb. bispyribac treatment than all other weed management treatments. Brown manuring rice crop applied with pendimethalin fb. bispyribac treatment(T2) recorded significantly less weed dry matter than brown manuring crop applied with only post em. application of bispyribac treatment (T3)

The accumulation of weed dry matter (q/ha) was measured at harvest also.(Table 4.1.2b) At this stage, the dry matter accumulation by weeds exhibited significant differences among nitrogen levels and weed management treatments.At harvest, weed dry matter accumulation under 175 kg Nitrogen per hectare has been found similar to 125 kg and 150 kg of Nitrogen per hectare during 2022 and with 150 kg N/ha during 2023.Applying 0 kg Nitrogen per hectare has observed significantly less weed dry matter than 175 kg N/ha during 2022 and to 150 kg N/ha 175 kg N/ha during 2023. Among the weed management treatments, the unweeded (control) treatment recorded significantly more dry matter than all weed management treatments for both years. The lowest weed dry matter accumulation was observed in pendimethalin fb. bispyribac (T1), and it was found to be statistically at par with with brown manuring crop applied with pre-em. application of pendimethalin fb. bispyribac (T2) during both years due to the control of paddy and non paddy weeds.Both brown manuring treatments recorded statistically at par dry matter of weeds with this combination of herbicides.

Higher dry matter accumulation by weeds in higher doses of nitrogen 150 kg Nitrogen per hectare and 175 kg of Nitrogen per hectare was because of the reason as direct seeded rice crop had slow growth habits during initial stages which failed to smoother weed plants and hence weed plants enjoyed available resources including nitrogen and irrigation water for growth.Weed dry matter accumulation in 0 kg of Nitrogen per hectare and 125 kg of Nitrogen per hectare was less because of no/less availability of nitrogen for weed growth.Similar findings have been revealed by Goswami et al., 2017; along with Ravisankar et al., 2008.

Amongst all the weed management methods,applying of pre-em.pendimethalin controlled annual grassy and broad leaf non paddy weeds.Post em. applying of bispyribac regulated all the kinds of typical paddy weeds. The outcomes are in conformity with finding by Singh et al.2016 also Pooja along with Saravanane 2021). The smothering effect of brown manuring crop(sesbania) on weeds was less when observed in every stage of crop growth.The accumulation of dry matter by weeds in unweeded (control) treatment was exceptionally high (unlike other field crops) which may be due to very poor smothering effect of crop on weeds owing to very slow initial crop growth.

The interactive effect of various levels of nitrogen along with weed management methods on dry matter accumulation by weeds at all the intervals in two consecutive years of research had been observed as non-significant.

Table.4.1.2a. Effect of various levels of nitrogen along with weed management methods on accumulation of dry matter by weeds (30 DAS & at 60 DAS) during 2022 and 2023

	Dry matter accumulation by weeds (q/ha)			
Main plots - Nitrogen levels				
	30 DAS		60 DAS	
	2022	2023	2022	2023
N_1 – 0 kg N /ha	2.6(7)	2.7(7)	3.4(11)	3.2(10)
N_2 – 125 kg N /ha	2.7(8)	3.0(9)	3.6(13)	3.6(13)
N_3 – 150 kg N /ha	3.1(9)	3.3(11)	4.0(16)	4.0(16)
N_4 – 175 kg N /ha	4.0(16)	4.2(18)	4.0(16)	4.3(18)
SE(m)	0.72	0.77	0.79	0.54
CD at P < 0.05%	0.55	0.71	0.35	0.37
Sub plots - Weed control treatments				
T_1 - Pendi fb. bispyribac	2.4(6)	2.9(8)	1.6(2)	1.6(3)
T_2 -BM,pendi fb. Bispyribac	2.6(7)	3.3(11)	1.9(4)	2.0(4)
T_3 – BM,Bispyribac	3.3(11)	3.8(15)	2.2(5)	2.1(5)
T_4 -Unweeded (control)	5.9(35)	6.3(40)	6.8(46)	7.0(49)
CD at P < 0.05%	0.45	0.41	0.77	0.64
SE(m)	0.72	0.70	0.75	0.56
CD for interaction	NS	NS	NS	NS

-Figures without paranthesis are square root transformed values after adding one to orginal value.

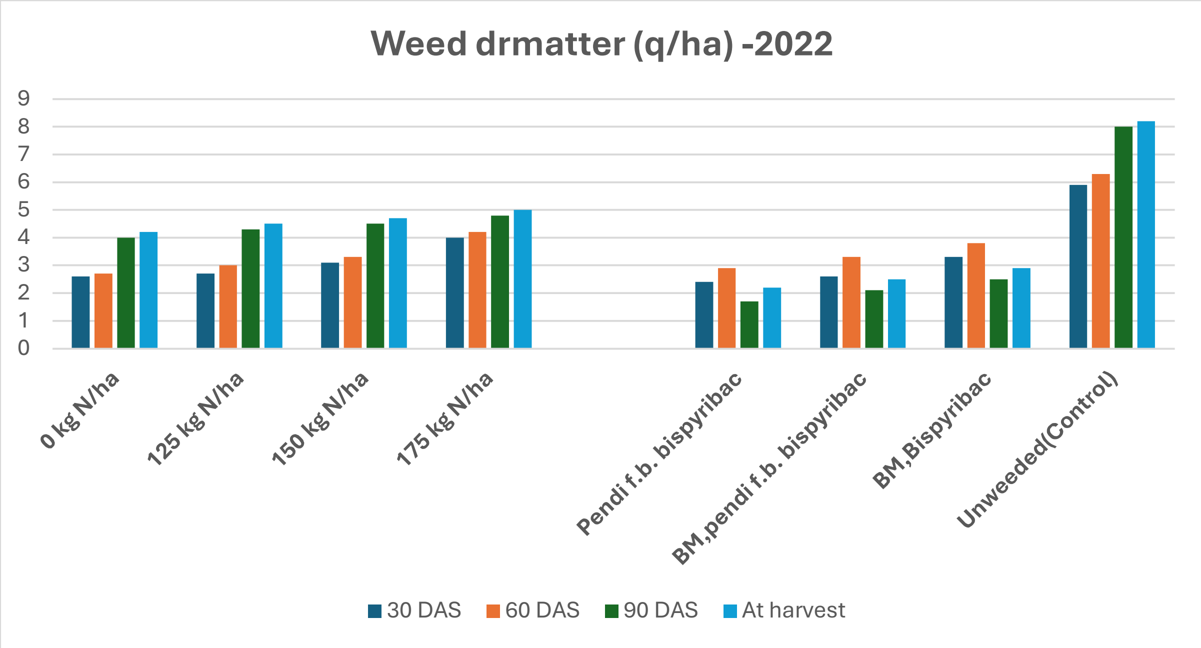
-Figures without parenthesis are original values without statistical analysis.

Table.4.1.2b. Effect of nitrogen levels and weed management treatments on weed dry matter accumulation (90 DAS & at harvest) during 2022 and 2023

	Dry matter accumulation by weeds (q/ha)			
Main plots - Nitrogen levels				
	90 DAS		At harvest	
	2022	2023	2022	2023
N_1 – 0 kg N /ha	4.0(16)	4.5(21)	4.2(18)	4.7(22)
N_2 – 125 kg N /ha	4.3(18)	4.9(24)	4.5(20)	4.9(24)
N_3 – 150 kg N /ha	4.5(21)	5.3(28)	4.7(23)	5.5(30)
N_4 – 175 kg N /ha	4.8(23)	5.9(35)	5.0(25)	6.1(37)
SE(m)	0.21	0.23	0.27	0.30
CD at P < 0.05%	0.35	0.44	0.60	0.55
Sub plots - Weed control treatments				
T_1 - Pendi fb. bispyribac	1.7(3)	2.6(7)	2.2(5)	2.9(9)
T_2 -BM,pendi fb. Bispyribac	2.1(5)	3.0(9)	2.5(7)	3.3(11)
T_3 – BM,Bispyribac	2.5(7)	3.4(11)	2.9(9)	3.5(12)
T_4 -Unweeded (control)	8.0(64)	9.6(93)	8.2(67)	9.9(97)
SE(m)	0.16	0.12	0.18	0.48
CD at P < 0.05%	0.39	0.36	0.57	1.65
CD for interaction	NS	NS	NS	NS

-Figures without paranthesis are square root transformed values after adding one to orginal value.

-Figures without parenthesis are original values without statistical analysis.



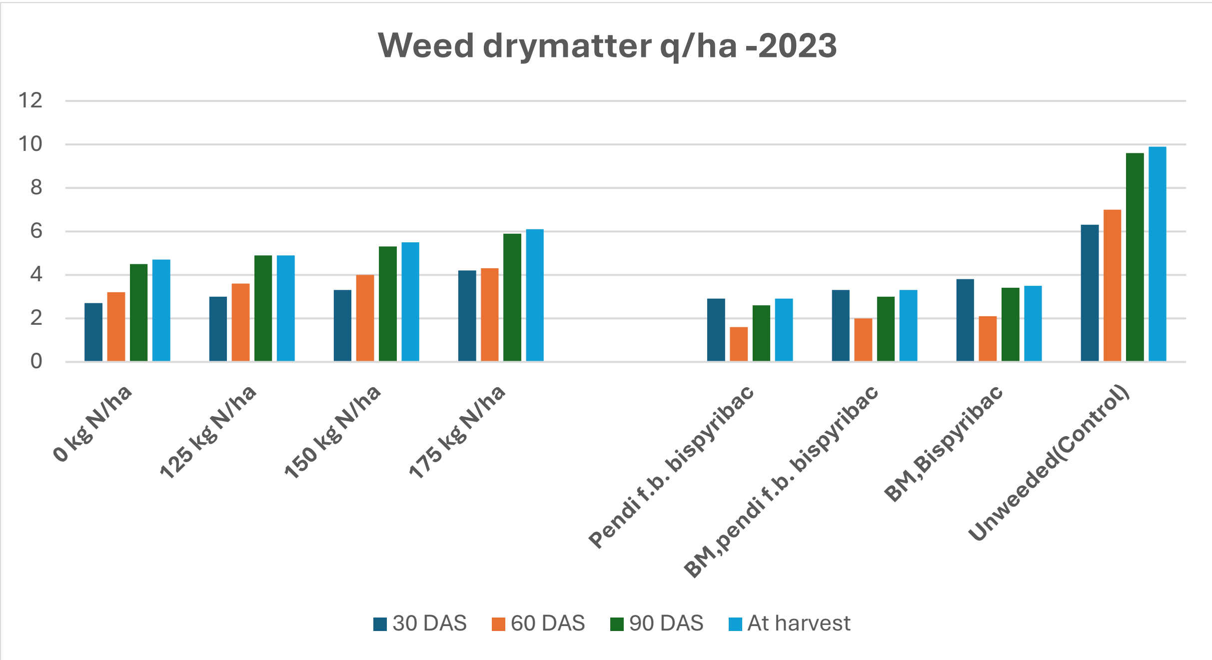


Fig.4.1.2. Effect of nitrogen levels along with weed management methods on dry matter accumulation by weeds at the stages of 30,60,90 DAS & at the harvest) during 2022 and 2023

4.1.3 Weed control efficiency (%)

Weed control efficiency is the important indices for determining efficiency of a treatment and is calculated as below.

$$\text{WCE (\%)} = \frac{\text{Weed dry matter in control plot(q/ha)} - \text{Weed dry matter in the treatment(q/ha)}}{\text{Weed dry matter in control plot(q/ha)}} \times 100$$

The data recorded regarding weed control efficiency at harvest demonstrated that there has been a gradual rise in the percentage of weed control efficiency with decrease in levels of nitrogen.(Table 4.1.3.)The maximum efficiency of weed control has been registered by 0 kg of Nitrogen per hectare,(73.2 % and 77.4 %) followed by 125 of kg Nitrogen per hectare , 150 kg of kg Nitrogen per hectare along with 175 kg of kg Nitrogen per hectare for both years. Out of all the weed management methods,the greatest weed control efficiency has been recorded in pendimethalin fb bispyribac and this treatment recorded highest WCE i.e. 92.8 % and 91.2 % respective for 2022 and 2023 which was followed by brown manuring treatment in rice applied with pendimethalin fb. bispyribac and alone application of bispyribac treatment during both years.

Table 4.1.3. "Impact of various levels of nitrogen along with weed management methods on weed control efficiency (WCE %)

Weed control efficiency (%)		
Main plots - Nitrogen levels		
	WCE(%)	
	2022	**2023**
N_1 – 0 kg N /ha	73.2	77.4
N_2 – 125 kg N /ha	69.7	74.9
N_3 – 150 kg N /ha	66.5	68.8
N_4 – 175 kg N /ha	62.5	62.1
CD at P < 0.05%	NA	NA
Sub plots - Weed control treatments		
T_1 - Pendi fb. bispyribac	92.8	91.2
T_2 -BM,Pendi fb. bispyribac	90.3	88.7
T_3 – BM,bispyribac	87.3	87.3
T_4 -Unweeded (control)	-	-
CD at P < 0.05%	NA	NA

NA – Not analyzed

4.2 Growth parameters

4.2.1. Plant height (cm)

The majorly important parameter for governing crop yield is plant height. Data on periodic plant height recorded at the intervals of 30,60,90 DAS and also at the harvest stage during 2022 and also 2023 were given in Table 4.2.1a and also Table 4.2.1b and depicted in Fig 4.2.1. The difference in plant height (cm) due to nitrogen levels was found to be non-significant in two consecutive years when noted at the 30 DAS interval 4.2.1a).Out of all weed management methods significant greater plant height has been observed in brown manuring rice applied with post-em. of bispyribac contrary to all other methods which uses herbicides in two consecutive years of studies.Crop height in unweeded (control) during both the years has been observed as significantly lower in comparison with other weed management methods.

At 60 DAS the height of plants has been significantly influenced by nitrogen levels (Table 4.2.1a) There had been a notable increase in the height of plants by applying of 175 kg of Nitrogen per hectare in comparison with other levels of nitrogen during both the years.The notably least height has been observed in 0 kg of Nitrogen per hectare contrary to other levels of nitrogen during both the years.However plant height under 125 kg of Nitrogen per hectare has been observed as significantly smaller in comparison with 150 kg of Nitrogen per hectare in two consecutive year of research.Among the weed management treatments more plant height (cm) recoreded with pendimethalin fb bispyribac treatment(T1) was statistically at par with brown manuring with rice applied with, pre.em.pendimethalin fb. bispyribac treatment(T2) and both these treatments improved plant height significantly than brown manuring with bispyribac treatment(T3) only during both the years. However significantly less height was observed in unweeded(control) during 2022 and 2023 contrary to additional weed management methods.

At 90 DAS the differences in plant height as influenced by nitrogen levels has been observed as significant (Table 4.2.1 b) More height of plants has been observed by applying 175 kg of Nitrogen per hectare but it was observed as statistically similar to 150 kg of N/ha and both these nitrogen levels produced significantly more plant height than 125 kg Nitrogen per hectare in two consecutive years of research.The significantly less height was observed in 0 kg of Nitrogen per hectare contrary to other levels of nitrogen in two consecutive years of research.Out of all other weed management methods, more height has been observed by pendimethalin fb bispyribac (T1) and it is statistically at par with brown manuring rice applied with, pre.em. pendimethalin fb. bispyribac (T2),and both these treatments produced significantly more plant height than all control methods pf weeds in two consecutive years of research . However significantly smallest height was observed in unweeded (control) during 2022 and 2023 contrary to additional weed management methods in two consecutive years of research.

At harvest variations in plant height as influenced by nitrogen levels were found to be significant.(Table 4.2.1b) It has been noticed that applying of 175 kg of Nitrogen/hectare revealed significantly greater height of plant than all other nitrogen levels during both years.Applying 150 kg of Nitrogen/hectare has been observed as statistically similar to 125 kg of Nitrogen/hectare in two consecutive years of research.The significantly least height of plant has been observed in 0 kg of Nitrogen/hectare contrary to additional levels of nitrogen during both the years.Similar findings was also confirmed by Goswami et al., 2017 & Ravisankar et al., 2008. Out of all the weed management treatments, more plant height was recorded with pendimethalin fb bispyribac (T1) and it is statistically at par with brown manuring with sunhemp,in rice applied with pre.em. pendimethalin fb. bispyribac(T2),and these two treatments produced significantly greater height of plants in comparison to brown manuring with only bispyribac (T3) treatment during both years.However significantly less plant height was observed by weedy check(control) contrary to additional treatments during 2022 along with 2023. Similar results also reported by Goswami et al., 2017.

More plant height in higher doses of nitrogen levels because of better utilization of nitrogen by the paddy crop in comparison with lowest nitrogen levels. crop height recorded at all periodic intervals during both years was significantly less in 0 kg of Nitrogen/hectare, because of poor growth of crop because of no / less availability of nitrogen. All weed management treatments improved growth of crop plants may be due to smothering effect on weeds with brown manuring in initial growth stages or because of excellent weed control with applied herbicides, that resulted in significant improvement in plant height in comparison with a weedy check. More height in all herbicidal treatments,because of the availability of weed free conditions in these treatments as compared to unweeded (control). The least plant height was recorded in weedy check due to the more density of weeds which covered the crop.

The interaction among the various nitrogen levels along with weed management treatments affected height of the plants at all the periodic intervals during both years and was observed as non-significant.

Table.4.2.1a. Effect of nitrogen levels and weed management treatments on periodic plant height (30 &60 DAS) during 2022 and 2023

	Plant height (cm)			
Main plots - Nitrogen levels				
	30 DAS		60 DAS	
	2022	2023	2022	2023
N_1 – 0 kg N /ha	23.2	21.6	54.3	51.8
N_2 – 125 kg N /ha	23.9	22.3	56.0	53.5
N_3 – 150 kg N /ha	24.6	22.8	59.9	57.4
N_4 – 175 kg N /ha	25.7	23.9	62.6	60.1
SE(m)	0.56	0.48	0.55	0.39
CD at P < 0.05%	NS	NS	1.94	1.25
Sub plots - Weed control treatments				
T_1 - Pendi fb. Bispyribac	24.5	22.8	64.2	62.1
T_2 -BM,Pendi fb. Bispyribac	24.4	22.7	64.6	61.7
T_3 – BM,bispyribac	25.5	23.8	61.4	59.0
T_4 -Unweeded (Control)	23.1	21.4	40.7	38.2
SE(m)	0.34	0.30	0.59	0.68
CD at P < 0.05%	0.99	0.72	1.75	2.20
CD for interaction	NS	NS	NS	NS

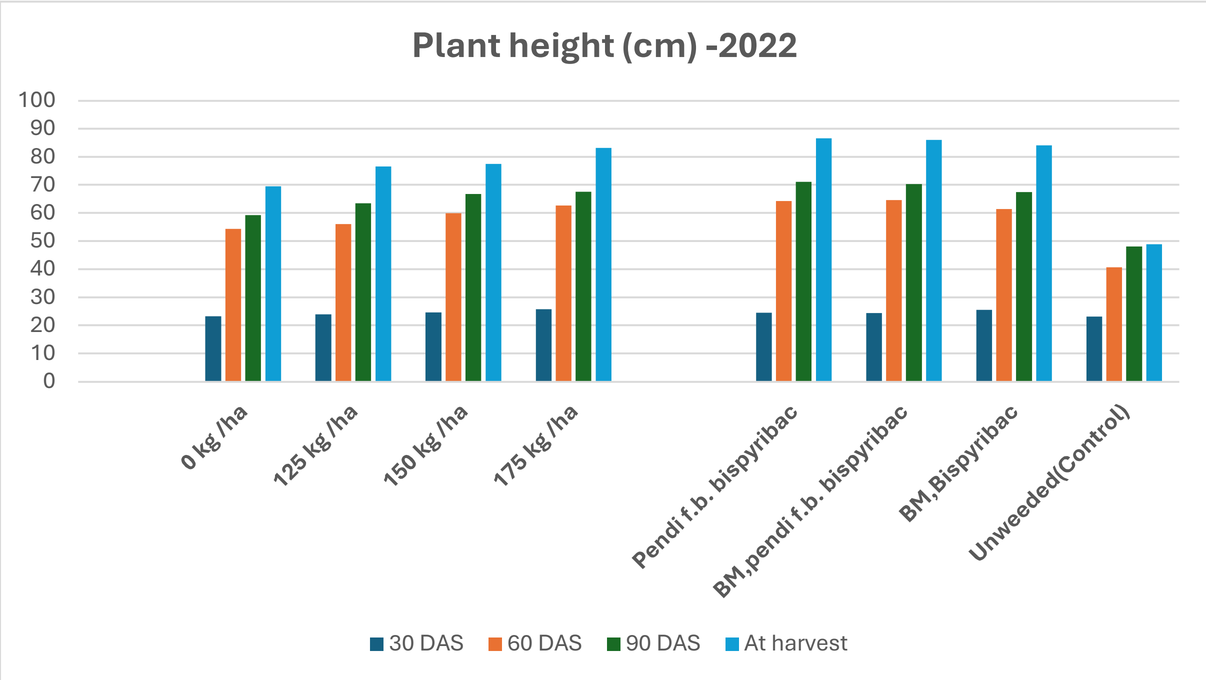
-Pendi stands for "pre-em.application of Stomp 30 EC (pendimethalin) at 0.75 kg a.i/ha".

-BM stands for brown manuring of sesbania which was killed 25- 30 days after sowing

-Post-em .application (30 DAS) of Nominie Gold (bispyribac sodium "10 SC at 25 g a.i /ha" was made.

Table.4.2.1b. Impact by levels of nitrogen along with various weed management methods on periodic plant height (90 DAS & at harvest) during 2022 and 2023

	Plant height (cm)			
Main plots - Nitrogen levels				
	90 DAS		At harvest	
	2022	2023	2022	2023
N_1 – 0 kg N /ha	59.2	57.5	69.5	67.8
N_2 – 125 kg N /ha	63.4	61.3	76.6	74.9
N_3 – 150 kg N /ha	66.7	64.8	77.5	75.8
N_4 – 175 kg N /ha	67.6	65.2	83.1	81.4
SE(m)	0.34	0.33	0.87	0.88
CD at P < 0.05%	1.19	1.35	3.08	2.51
Sub plots - Weed control treatments				
T_1 - Pendi fb. bispyribac	71.1	69.4	86.6	84.9
T_2 -BM,Pendi fb. bispyribac	70.3	68.2	86.0	84.4
T_3 – BM,bispyribac	67.4	65.4	84.1	81.4
T_4 -Unweeded (Control)	48.1	46.5	48.9	47.2
SE(m)	0.45	0.39	0.69	0.62
CD at P < 0.05%	1.32	1.85	2.03	1.72
CD for interaction	NS	NS	NS	NS



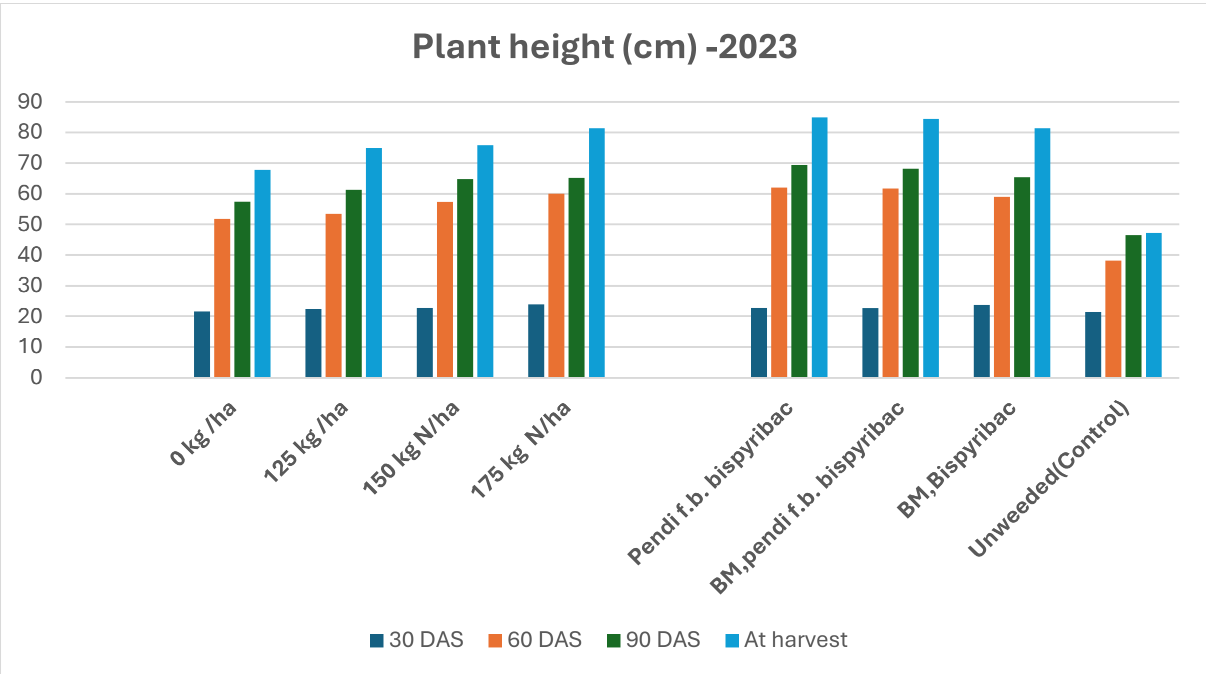


Fig.4.2.1. Effect of nitrogen levels and different weed management treatments on periodic plant height observed at 30 DAS ,60 DAS ,90 DAS and at the harvest stage during 2022 and 2023

4.2.2. Total tillers per meter row length

The number of tillers per unit area are considered as major determinants for the crop growth and yield. The data pertaining to the number of tillers, recorded at 30, 60, 90 DAS and at harvest stage, are presented in Table 4.2.2a and 4.2.2b.and presented in Fig 4.2.2 The statistical data recorded at 30 DAS showed that there has been no significant variations among nitrogen levels along with various weed management methods, indicating that neither main plots nor sub plot treatments showed any impact on the total number of tillers recorded per meter row length.

At 60 DAS stage, the total number of tillers recorded as per meter row length as influenced by nitrogen levels was found to be significant,(Table 4.2.2a) There has been significant rise in total number of tillers by applying 175 kg of Nitrogen per hectare in comparison to additional levels of nitrogen during 2023 however during 2022 it has been observed as similar to 150 kg of nitrogen per hectare.The significantly less number of tillers were observed by 0 kg of nitrogen per hectare contrary to additional levels of nitrogen in two consecutive years of study.Applying of 150 kg of Nitrogen per hectare produced significantly more total tillers in comparison with 125 kg N/ha during both years.With every rise in the level of nitrogen from 0 kg of Nitrogen per hectare to 175 kg of Nitrogen per hectare significantly increased total tillers per meter row length in two consecutive years of research except the levels of 150 and 175 kg N/ha during 2022.Out of all the weed management methods significantly greater number of tillers had been observed with the treatments of pendimethalin fb bispyribac(T1) in comparison to all other weed management methods in two consecutive years of study.Out of all the brown manuring treatments,application of pendimethalin treatment (T2) recorded significantly greater number of tillers per meter row length than without pendimethalin treatment (T3). However significantly less number of tillers per meter row length has been observed in unweeded (control) during 2022 and 2023 as compared to all herbicidal treatments.

At 90 DAS the total number of tillers per meter row length has been affected by nitrogen levels has been observed as significant (4.2.2b) Total number of tillers produced by applying 175 kg of Nitrogen per hectare has been observed as statistically similar to 150 kg of Nitrogen per hectare however it was significantly greater than 125 kg of Nitrogen per hectare and 0 kg of Nitrogen per hectare. Similarly the variations of 125 along with 150 kg of Nitrogen per hectare has been observed as non-significant. This holds good for both years.The significantly less count of tillers were observed in 0 kg of Nitrogen per hectare contrary to additional nitrogen levels in two consecutive years of research.Out of all the weed management methods significantly higher count of total tillers per meter row length has been recorded with pre-em. pendimethalin fb bispyribac (post-em.) treatments(T1) and it was statistically at par with brown manuring in rice sprayed with pre-em. pendimethalin fb. Bispyribac,in two consecutive years of study.Out of all the brown manuring applied treatments,pre-em. Applying pendimethalin(stomp) (T2) recorded significantly higher tiller count than without application of pendimethalin (T3). Significantly less tiller count in meter row length has been observed by unweeded(control) during 2022 and 2023 as compared to all other herbicidal treatments.

At the harvest stage, the count of tillers noted per meter row length as influenced by nitrogen levels were found to be significant (Table 4.2.2b) The total tillers produced by applying 175 kg of Nitrogen per hectare has been observed as statistically similar to 150 kg of Nitrogen per hectare and also these two treatments were found to be significantly better than 125 kg N/ha during both years. The significantly less count of total tillers were observed in 0 kg of Nitrogen per hectare contrary to additional levels of nitrogen during both the years.Identical outcomes has been observed by Ravisankar et al., 2008.Out of all these weed management methods, higher tillers count per meter row length were recorded by applying pendimethalin (stomp) fb bispyribac sodium (T1) and it has been observed as statistically similar to brown manuring in rice applied with pendimethalin fb. bispyribac, as compared to brown manuring with alone bispyribac (T3) treatment. This holds good for both years.Significantly least tillers count per meter row length has been observed in unweeded (control) during 2022 and 2023 as compared to all other herbicidal treatments.Alike outcomes has also been observed by Goswami et al., 2017.

Higher tillers count in higher level of nitrogen like 150 kg and 175 kg of Nitrogen per hectare because of improved crop growth contrary to control (0 kg of Nitrogen per hectare) and 125 kg of Nitrogen per hectare .Lowest tillers in weedycheck (control) is because of poor growth of crop (because of severe competition by weeds for growth factors) as compared to all other weed management treatments.Total tillers count per meter row length recorded 60 DAS interval,90 DAS interval,120 DAS interval and at the harvest stage,in the brown manuring treatments (T2 and T3) has been observed as significantly less in two consecutive years of research in comparison to the treatment without brown manuring(T1) treatment which may be due to the initial smoothering effect of sesbania on rice plants due to which intial crop growth was inhibited.

The interactive impact of various nitrogen levels along with weed management methods at all periodic intervals has been observed as non significant except 60 DAS in two consecutive years of study. Interaction data of total tillers are shown in Table 4.2.3.Total no of tillers recorded at 60 DAS indicated that brown manured crop applied with 175 kg N/ha and treated with pendimethalin fb. bispyribac was found at par with crop applied with 150 kg N/ha and sprayed with pendimethalin and bispyribac during 2022.Also brown manuring crop treated with bispyribac and supplied with 175 kg N/ha recorded at par total tillers as compared to crop applied by 125 kg of Nitrogen per hectare despite that sprayed with pendimethalin and bispyribac.During 2023 applying 150 kg of Nitrogen per hectare to rice crop treated with pendimethalin (stomp) fb. Bispyribac sodium (nominee gold) recorded significantly more total tillers than the brown manured crop supplied with 175 kg N/ha treated with bispyribac only.Similarly crop raised with 0 kg N/ha but sprayed with pendimethalin fb. bispyribac produced statistically at par total tillers than the crop treated with brown manuring by applying 125 kg of Nitrogen per hectare even so treated with pendimethalin only.

Table.4.2.2a. Effect of nitrogen levels and weed management treatments on total tillers per meter row length at 30 & 60 DAS during 2022 and 2023

	Total tillers per meter row length			
Main plots - Nitrogen levels				
	30 DAS		60 DAS	
	2022	2023	2022	2023
N_1 – 0 kg N /ha	82.8	83.1	95.0	101.0
N_2 – 125 kg N /ha	82.6	84.1	129.2	128.7
N_3 – 150 kg N /ha	83.9	83.4	155.8	161.3
N_4 – 175 kg N /ha	81.9	84.4	165.4	170.8
SE(m)	0.58	0.62	3.70	1.99
CD at P < 0.05%	NS	NS	12.3	7.03
Sub plots - Weed control methods				
T_1 - Pendi fb. bispyribac	87.3	85.4	179.2	185.3
T_2 -BM,pendi fb. bispyribac	86.5	86.6	157.9	162.2
T_3 – BM,bispyribac	86.6	86.9	145.8	148.3
T_4 -Unweeded (control)	76.7	77.0	62.5	66.1
SE(m)	0.48	0.64	2.40	1.69
CD at P < 0.05%	NS	NS	7.5	4.95
CD for interaction	NS	NS	16.3	10.5

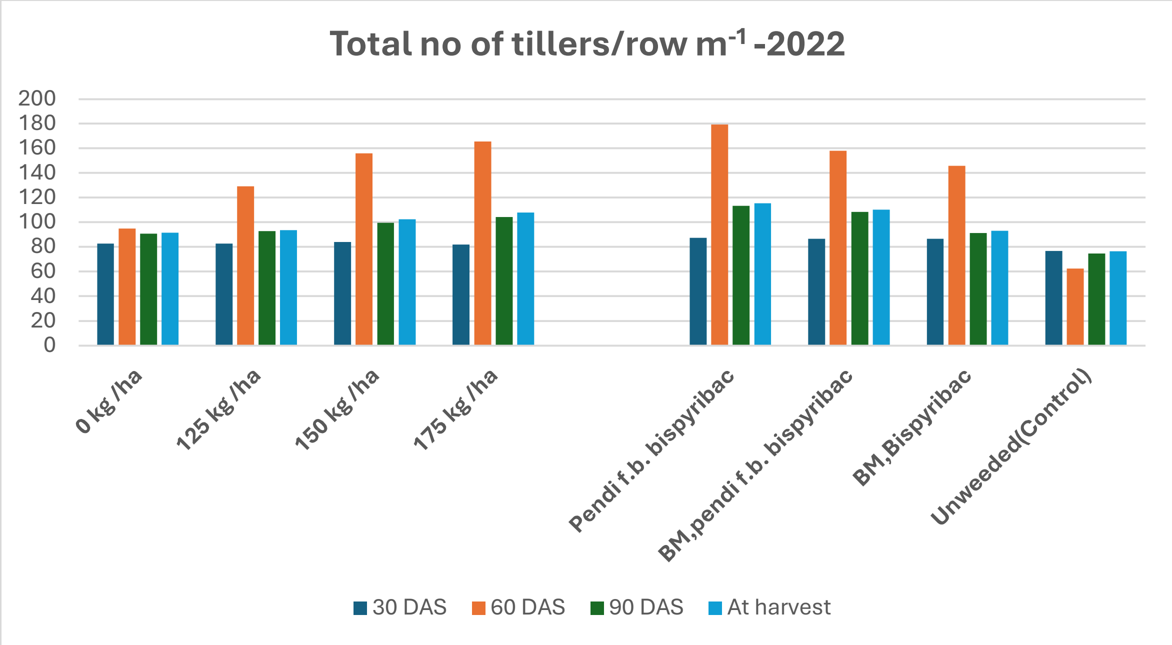
Table.4.2.2b. Effect of nitrogen levels and weed management treatments on total tillers per meter row length at 90 DAS & at harvest during 2022 and 2023

	Total tillers per meter row length			
Main plots - Nitrogen levels				
	90 DAS		At harvest	
	2022	2023	2022	2023
N_1 – 0 kg N /ha	90.8	96.5	91.5	88.8
N_2 – 125 kg N /ha	92.9	98.9	93.6	89.3
N_3 – 150 kg N /ha	99.6	105.7	102.3	96.6
N_4 – 175 kg N /ha	104.2	109.7	107.8	101.2
SE(m)	1.83	2.10	1.84	2.09
CD at P < 0.05%	7.39	7.40	5.39	5.98
Sub plots - Weed control treatments				
T_1 - Pendi fb. bispyribac	113.3	117.8	115.3	110.4
T_2 -BM,pendi fb. bispyribac	108.3	111.4	110.3	105.2
T_3 – BM,bispyribac	91.3	98.3	93.2	88.3
T_4 -Unweeded (control)	74.6	83.3	76.5	72.0
SE(m)	2.07	1.81	1.48	2.30
CD at P < 0.05%	7.27	5.31	5.27	6.34
CD for interaction	NS	NS	NS	NS

Table.4.2.3. Interaction among nitrogen levels and weed management treatments on total tillers per meter row length at 60 DAS during 2022 and 2023

Total tillers/m row(60 DAS -2022)					
Treatments	Pendi fb. bispyribac	BM,Pendi fb. bispyribac	BM,bispyribac	Unweeded (control)	Mean
N_1 – 0 kg N /ha	121.7	118.3	100.0	40.0	95.0
N_2 – 125 kg N/ha	173.3	143.3	130.0	70.0	129.2
N_3 – 150 kgN/ha	208.3	173.3	171.7	70.0	155.8
N_4 – 175 kg N/ha	213.3	196.7	181.7	70.0	165.4
Mean	179.2	157.9	145.8	62.5	
CD at 5%	16.3				

Total tillers/m row(60 DAS -2023)					
Treatments	Pendi fb. bispyribac	BM,Pendi fb. bispyribac	BM,bispyribac	Unweeded (control)	Mean
N_1 – 0 kg N/ha	126.3	127.7	104.3	45.7	101.0
N_2 –125 kg N/ha	172.0	145.3	129.3	68.0	128.7
N_3 – 150kg N/ha	223.7	172.7	172.3	76.3	161.3
N_4 –175 kg N/ha	219	203.0	187.0	74.3	170.8
Mean	185.3	162.3	148.25	66.1	
CD at 5%	10.5				



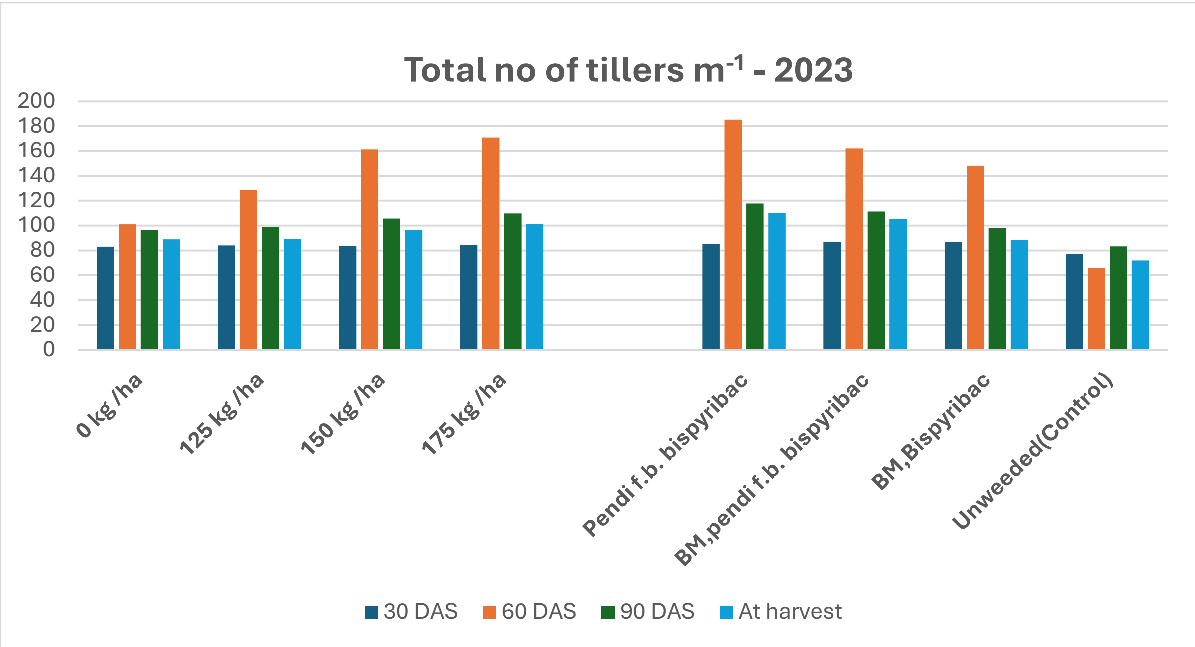


Fig 4.2.2. Effect of nitrogen levels and weed management treatments on total number of tillers per row meter length recorded at 30,60, 90" and at harvest during 2022 and 2023

4.2.3 Crop dry matter accumulation (q/ha)

The dry matter accumulation by crop is also the prominent parameter which determines crop growth and hence yield.Crop dry matter was recorded at 30,60,90 DAS and at harvest(Table 4.2.4a and 4.2.4b and Fig 4.2.3).The variations in the dry matter accumulation by crop because of various levels of nitrogen and weed management methods had been observed as non significant at 30 DAS in two consecutive years of study.(Table 4.2.4a).

At the 60 DAS stage,the dry matter accumulation by crop has been significantly affected by both nitrogen levels along with weed control methods in two consecutive years of study.(Table 4.2.4a) The significantly more crop dry matter has been observed by 175 kg of Nitrogen per hectare contrary to additional levels of nitrogen in two consecutive years of research. There has been continuous significant increment in accumulation of dry matter by crop with each increase of level of nitrogen from 0 to 175 kg of Nitrogen per hectare during both the years.The 0 kg of Nitrogen per hectare observed the significantly least accumulation of crop dry matter in both the years in comparison to additional nitrogen levels of nitrogen.The differences by crop dry matter between 125 kg of Nitrogen per hectare along with 150 kg of Nitrogen per hectare were found significant in two consecutive years of research. Out of all weed management methods,the significantly greater accumulation of dry matter by crop has been observed by pre-em.pendimethalin fb bispyribac(T1) in comparison with further weed management methods when recorded for two consecutive years.Among brown manuring treatments application of pendimethalin (T2) recorded significantly higher crop dry matter than the treatment where no application of pendimethalin was made (T3).The significantly less crop dry matter was recorded in unweeded (control) contrary to additional weed control methods in two consecutive years of research.

At the 90 DAS interval,the changes in the accumulation of dry matter by crop has been significantly effected by nitrogen levels along with different weed management treatments when recorded during both the years(4.2.4b).The significantly greatest accumulation of dry matter by crop has been observed by applying 175 of kg Nitrogen per hectare contrary to other nitrogen levels.There was progressive significant rise in crop dry matter for each increment in nitrogen dosage from 0 kg to 175 kg of Nitrogen per hectare in two consecutive years of research. The significantly less crop dry matter was observed in level of 0 kg of Nitrogen per hectare contrary to other nitrogen dosages in two consecutive years of research.Accumulation of dry matter by crop was observed significantly less by 125 kg of Nitrogen compared with 150 kg of Nitrogen in two consecutive years of research.Out of all other weed management methods significantly greater accumulation of dry matter by crop has been observed in pendimethalin fb bispyribac treatment compared to brown manuring treatment (T2 & T3) and unweeded (control) treatments when recorded in two consecutive years of research.The significantly lowest accumulation of dry matter by crop has been observed in unweeded contrary to further weed management methods in two consecutive years of research.Among brown manuring treatments,application of pendimethalin (T2) recorded significantly higher crop dry matter than without pendimethalin (T3) treatment in two consecutive years of research.

At the harvest stage,the variations in the accumulation of dry matter by crop has been significantly influenced by both levels of nitrogen along with weed management methods when recorded for two consecutive years of study.(Table 4.2.4b)The significantly higher accumulation of dry matter by crop has been observed by 175 kg of Nitrogen per hectare as compared to all other nitrogen levels during both the years.Application of 150 kg N/ha produced significantly higher crop dry matter than 125 kg of Nitrogen per hectare during both years. The significantly lowest accumulation of dry matter by crop has been inscribed by 0 kg of Nitrogen per hectare when compared with all other treatments in two consecutive years . There was significant continuous rise in accumulation of dry matter by crop with each increment in dose of nitrogen i.e. 0, 125, 150 and 175 kg N/ha during both years.Similar results has been observed by Goswami et al., 2017 along with Ravisankar et al., 2008.Out of all the weed management methods,the significantly greater dry matter accumulation by crop has been reported in pendimethalin (stomp) fb bispyribac sodium (nominee gold)in comparison with other weed management methods when observed in two consecutive years of research.The significantly lowest accumulation of crop dry matter has been observed in weedy check(control) contrary to other treatments applying herbicides, in both the years. Pooja and Saravanane 2021 and Singh et al.,2016 reported similar findings. Also the treatment of brown manuring with pendimethalin(T2) recorded significantly higher crop dry matter than without pendimethalin treatment(T3).This holds good for both years.

Higher crop dry matter in 175 kg N/ha has been observed because of improved growth and development of crop in comparison with other nitrogen levels.Crop growth was less in lower levels of nitrogen (0 kg and 125 kg of Nitrogen per hectare) resulting less crop dry matter due to poor crop growth as compared to higher nitrogen levels (150 & 175 kg N/ha).Brown manuring crop smothered weeds to some extent but showed smothering effect on crop which is indicated by lower crop dry matter as compared to without brown manuring treatment.More dry matter accumulation by rice crop in pre-em. application of pendimethalin fb. bispyribac may be due to excellent control of weeds in this treatment which provided good crop growth. On the other hand,brown manuring crop provided slight smoothering effect on rice crop resulting in less dry matter accumulation by the crop, even if treated with pendimethalin and bispyribac.Simiar results were also reported by Gaire et al ., 2013 and Rehman 2007.

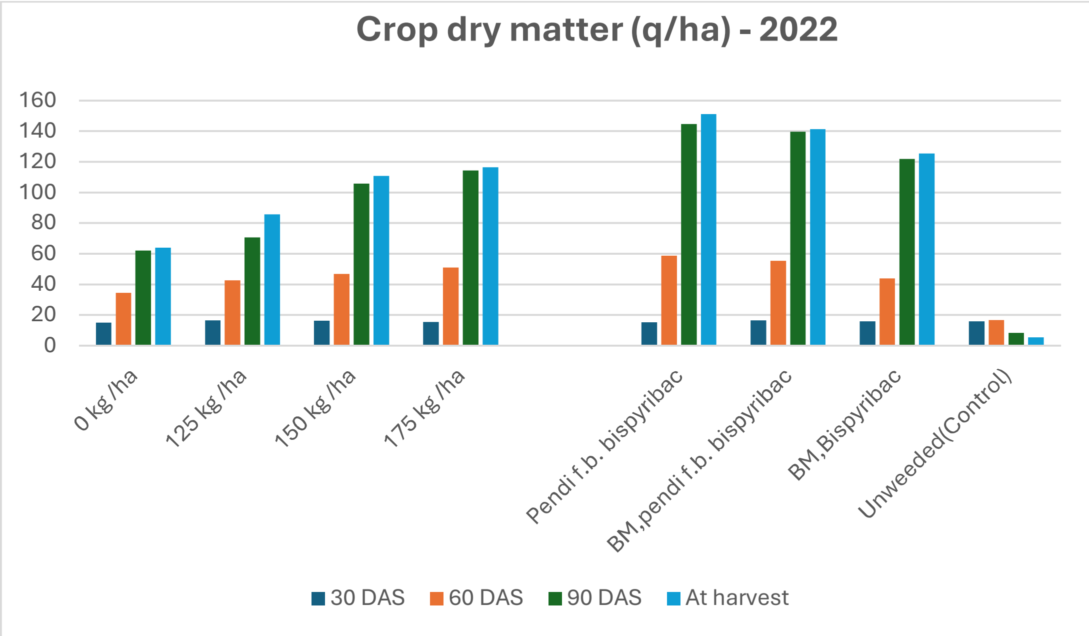
The interactive effect of nitrogen level and weed control treatment for accumulation of dry matter by crop has been observed as non-significant at 30 DAS interval,60 DAS interval,90 DAS interval and at harvest.

Table.4.2.4a. Effect of nitrogen levels and weed management treatments on crop drymatter accumulation q/ha at 30 & 60 DAS during 2022 and 2023

	Crop drymatter accumulation(q/ha)			
Main plots - Nitrogen levels				
	30 DAS		60 DAS	
	2022	2023	2022	2023
N_1 – 0 kg N /ha	15.1	13.6	34.4	30.3
N_2 – 125 kg N /ha	16.4	14.8	42.7	38.2
N_3 – 150 kg N /ha	16.3	14.7	46.9	43.5
N_4 – 175 kg N /ha	15.4	14.8	50.9	47.8
SE(m)	0.44	0.47	0.98	0.66
CD at P < 0.05%	NS	NS	3.55	2.34
Sub plots - Weed control treatments				
T_1 - Pendi fb. bispyribac	15.2	13.7	58.8	54.8
T_2 -BM,Pendi fb. bispyribac	16.4	15.0	55.4	51.5
T_3 – BM,bispyribac	15.9	14.3	43.9	40.7
T_4 -Unweeded (control)	15.8	14.8	16.7	12.7
SE(m)	0.38	0.44	0.81	0.63
CD at P < 0.05%	NS	NS	2.68	1.84
CD for interaction	NS	NS	NS	NS

Table.4.2.4b. Effect of nitrogen levels and weed management treatments on crop drymatter accumulation q/ha at 90 DAS & at harvest during 2022 and 2023

	Crop drymatter accumulation (q/ha)			
Main plots - Nitrogen levels				
	90 DAS		At harvest	
	2022	2023	2022	2023
N_1 – 0 kg N /ha	62.1	62.6	64.0	64.3
N_2 – 125 kg N /ha	70.6	87.3	85.7	90.6
N_3 – 150 kg N /ha	105.8	110.2	110.8	112.6
N_4 – 175 kg N /ha	114.4	119.9	116.5	123.7
SE(m)	1.91	2.11	1.43	1.68
CD at P < 0.05%	7.07	8.01	3.97	4.74
Sub plots - Weed control methods				
T_1 - Pendi fb. bispyribac	144.6	125.4	151.2	128.8
T_2 - BM,Pendi fb.bispyribac	139.6	114.4	141.4	118.2
T_3 - BM,bispyribac	121.8	101.6	125.5	105.4
T_4 -Unweeded (control)	8.25	5.75	5.50	3.82
SE(m)	1.47	1.32	0.97	0.91
CD at P < 0.05%	3.82	3.22	2.79	2.34
CD for interaction	NS	NS	NS	NS



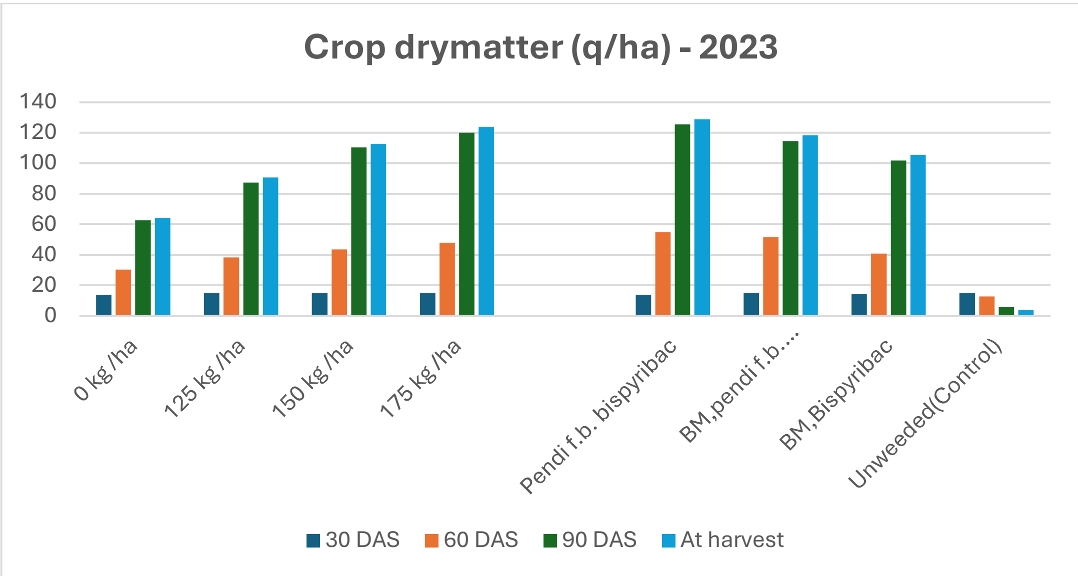


Fig 4.2.3. Effect of nitrogen levels and weed management treatments on crop dry matter accumulation q/ha recorded at 30,60, 90 and at harvest during 2022 and 2023

4.2.4. Chlorophyll Index

The statistical data on periodic chlorophyll index has been observed at 30 DAS interval,60 DAS interval,and 90 DAS interval during 2022 and 2023 and shown in (Table 4.2.5a and 4.2.5b). The difference in chlorophyll index was because of various Nitrogen levels and different weed management methods has been observed as non-significant in two consecutive years of research when recorded at the 30 DAS interval.

At 60 DAS,the difference in the chlorophyll index due to nitrogen levels has been observed as significant in two consecutive years of research.(Table 4.2.5a) The highest chlorophyll index was observed by 175 kg of Nitrogen per hectare which has been observed as statistically similar to 150 kg of Nitrogen per hectare and also significantly more in comparison with 0 kg of Nitrogen per hectare when recorded for both the years.The significantly less chlorophyll index has been observed in 0 kg of Nitrogen per hectare for 2023,but in the first year 0 kg of Nitrogen per hectare and 125 kg of Nitrogen per hectare has been observed as statistically similar to each other.During both years crop supplied with 125 kg of nitrogen per hectare along with 150 kg of Nitrogen per hectare has been observed as similar to each one but both these treatments resulted in significant less chlorophyll index as compared to 175 kg N/ha.The variations in the chlorophyll index because of weed management methods has been observed as significant in two consecutive years of research.During 2022,greater chlorophyll index was observed in brown manuring applied with pendimethalin fb. bispyribac treatment(T2) which was found to be statistically at par with brown manuring crop fb. bispyribac(T3) and pendimethalin fb. bispyribac treatment(T1).During the year 2023,pendimethalin fb bispyribac treatment recorded significantly highest chlorophyll index than both brown manuring treatments(T2 & T3).The significantly lowest chlorophyll index was observed in unweeded(control) treatment during both years as compared to all other weed management treatments.

At 90 DAS,the differences in the chlorophyll index has been significantly impacted by both the nitrogen levels and also weed management treatments when recorded for both the years(Table 4.2.5b).Out of all the nitrogen levels, the greater chlorophyll index has been recorded by 175 kg of Nitrogen per hectare which has been statistically at par with 150 kg of Nitrogen per hectare in two consecutive years of research yet both of these two treatments has been observed as significantly superior to 125 kg N/ha.The significantly low chlorophyll index has been recorded by 0 kg of Nitrogen per hectare for both the years as compared to other nitrogen levels. More chlorophyll index in 175 and 150 kg of Nitrogen per hectare because of increased greening in the crop by these treatments.Out of all weed management methods,the greater chlorophyll index has been observed in pendimethalin fb bispyribac (T1) treatment which was found to be statistically at par with brown manuring treatment applied with pendimethalin fb. bispyribac for both the years because of excellent management of weeds which stimulated growth of plants.The significantly less chlorophyll index was recorded in weedy check treatment for both the years as compared to all other weed management treatments.Lowest chlorophyll index in weedy check treatment which was because of increased competition between crops and weeds in weedy check treatment due to presence of abundance weed flora in the experimerntal field in two consecutive years of research. The lowest chlorophyll index has been associated with high weed interference resulting in yield decrease as reported by Pabitra 2016 and Anwar et al. 2010.

The impact of interaction between nitrogen levels along with different weed management methods for chlorophyll index has been observed as non-significant in two consecutive years of research when data was recorded in all the stages of crop growth.

Table.4.2.5a. Effect of nitrogen levels and weed control management on chlorophyll index at 30 & 60 DAS during 2022 and 2023

	Chlorophyll index (%)			
Main plots - Nitrogen levels				
	30 DAS		60 DAS	
	2022	2023	2022	2023
N_1 – 0 kg N /ha	27.3	25.6	40.4	38.6
N_2 – 125 kg N /ha	25.3	25.6	41.8	42.7
N_3 – 150 kg N /ha	26.9	26.3	43.9	43.8
N_4 – 175 kg N /ha	27.4	26.6	44.7	44.6
SE(m)	0.52	0.46	0.74	0.54
CD at P < 0.05%	NS	NS	2.62	1.88
Sub plots - Weed control treatments				
T_1 - Pendi fb. bispyribac	26.4	26.0	45.3	46.2
T_2-BM,Pendi fb.bispyribac	26.9	26.2	45.8	44.8
T_3 – BM,bispyribac	26.6	25.6	45.7	44.1
T_4 -Unweeded (control)	27.0	26.2	34.0	34.5
SE(m)	0.47	0.21	0.55	0.36
CD at P < 0.05%	NS	NS	1.61	1.05
CD for interaction	NS	NS	NS	NS

Table.4.2.5b. Effect of nitrogen levels and weed control management on chlorophyll index (%) at 90 DAS during 2022 and 2023

Chlorophyll Index(%)		
Main plots - Nitrogen levels		
	90 DAS	
	2022	2023
N_1 – 0 kg N /ha	29.4	27.2
N_2 – 125 kg N /ha	32.9	32.1
N_3 – 150 kg N /ha	36.4	35.2
N_4 – 175 kg N /ha	37.0	36.5
SE(m)	0.75	0.57
CD at P < 0.05%	1.94	1.65
Sub plots - Weed control treatments		
T_1 - Pendi fb. bispyribac	38.8	38.9
T_2 -BM,Pendi fb. bispyribac	38.9	37.8
T_3 – BM,bispyribac	37.0	36.4
T_4 -Unweeded (control)	21.0	17.9
SE(m)	1.18	0.52
CD at P < 0.05%	3.76	1.53
CD for interaction	NS	NS

4.3 Yield and yield attributing charecters

4.3.1 Effective tillers /meter row length

Effective tillers per meter row length are the most important parameter as it is the yield determining factor for cereal crops.Effective tilers per meter row length were recorded at harvest stage in two consecutive years of research.The variations in the count of effective tillers recorded per meter row length has been significantly effected by both nitrogen levels along with weed management methods when recorded in two consecutive years (Table 4.3.1 and in Fig 4.3.1).Among the nitrogen levels,the significantly greater number of effective tillers recorded per meter row length by 175 kg of Nitrogen/ha over 150 kg of Nitrogen/ha during 2022 but in the year 2023,the differences were non-significant among these nitrogen levels i.e. 150 and 175 kg N/ha.The significantly least number of effective tillers has been recorded by 0 kg of Nitrogen/ha and it has been observed to be statistically similar to 125 kg of Nitrogen/ha both years.The number of effective tillers per meter row length were significantly more in 150 kg of Nitrogen/ha in comparison with 125 kg of Nitrogen/ha during both years of experimentation. More effective tillers in 175 and 150 kg of Nitrogen/ha possibly because of excellent growth of crop while compared to other nitrogen levels.These findings were also confirmed by Jahan et al., 2022,Giri et al., 2022 and Singh et.al., 2018.Out of all weed management methods,the significantly more effective tillers count has been observed in pendimethalin fb bispyribac contrary to other weed management treatments.These results were also concluded by Pooja and P. Saravanane 2021 and Singh et al.,2016.The significantly least effective tillers has been observed in weedy check (control) than all other treatments for both the years.Among brown manuring treatment,application of pendimethalin(T2) recorded significantly more effective tillers than without application of pendimethalin treatment (T3).These results agree with the finding of Goswami et al., 2017.Significantly higher effective tillers in without brown manuring treatment (T1) may be due to no initial smoothering of rice crop as compared to brown manuring treatments (T2 &T3).

Table.4.3.1. Effect of nitrogen levels and weed control treatments on effective tillers during 2022-2023

Main plots - Nitrogen levels		
	Effective tillers /m row length	
	2022	2023
N_1 – 0 kg N /ha	72.4	71.1
N_2 – 125 kg N /ha	76.6	71.8
N_3 – 150 kg N /ha	87.4	80.8
N_4 – 175 kg N /ha	96.8	88.1
SE(m)	1.42	2.15
CD at P < 0.05%	4.98	7.58
Sub plots - Weed control treatments		
T_1 - Pendi fb. bispyribac	106.3	99.3
T_2 -BM,Pendi fb. bispyribac	95.4	92.5
T_3 – BM,bispyribac	84.3	78.8
T_4 -Unweeded (control)	47.3	41.1
SE(m)	1.26	1.92
CD at P < 0.05%	3.72	5.64
CD for interaction	NS	NS

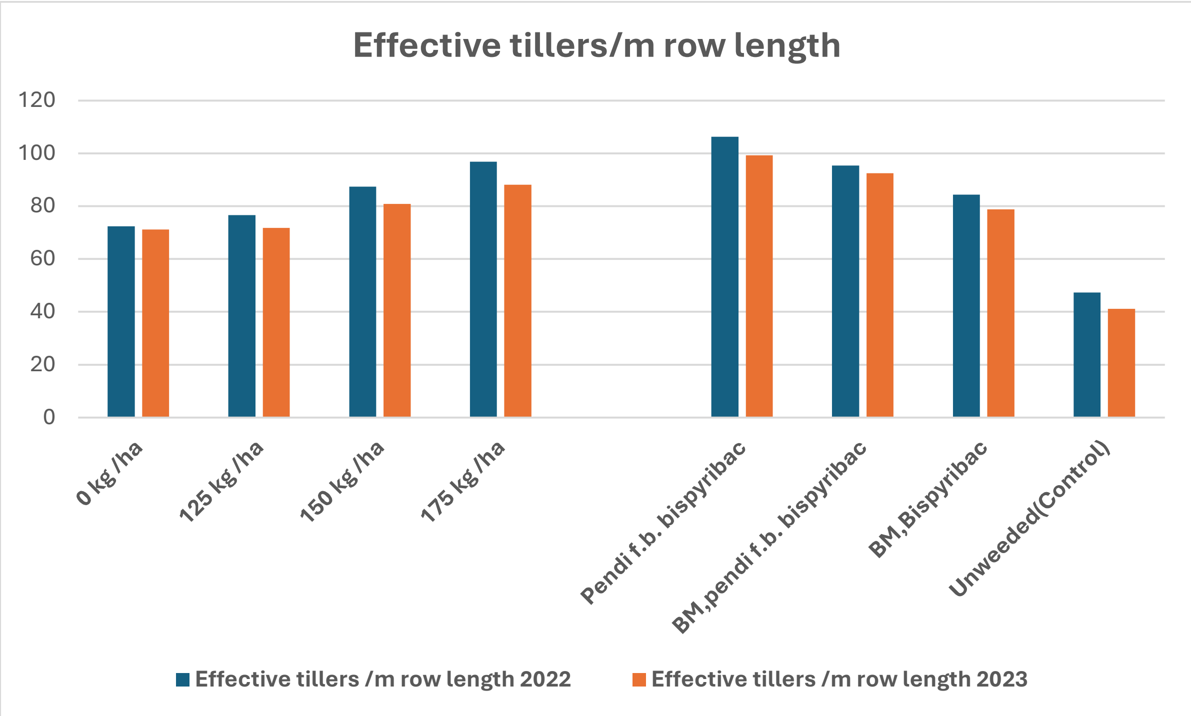


Fig.4.3.1. Effect of nitrogen levels and weed control treatments on effective tillers/row meter during 2022 and 2023

4.3.2 Number of grains per panicle

Number of grains per panicle were recorded at harvest for both the years.The differences in the number of grains per panicle has been significantly influenced by different levels of nitrogen along with weed management methods when recorded in two consecutive years of experimentation(Table 4.3.2 and Fig 4.3.2).Among the nitrogen levels,the significantly higher number of grains per panicle were observed in 175 kg N/ha than all other nitrogen levels when recorded in two consecutive years.The number of grains/panicle has been observed significantly greater in 150 kg of Nitrogen/ha over 125 kg of Nitrogen/ha in two consecutive years of experimentation.The significantly least count of grains per panicle were observed by 0 kg of Nitrogen/ha than other nitrogen levels in two consecutive years.Out of all weed management methods,the significantly more number of grains per panicle were observed in pendimethalin fb bispyribac treatment contrary to other weed management treatmentsAmongst the brown manuring treated plots, applying pendimethalin (T2) significantly increased number of grains/panicle than alone application of bispyribac (T3) treatment.The significantly less number of grains per panicle were recorded in unweeded(control) as compared to all other weed management treatments in two consecutive years of experimentation.

4.3.3 Panicle length (cm)

Panicle length was recorded at harvest stage in two consecutive years of experimentation.The variations in panicle length has been observed as significantly effected by various nitrogen levels along with different weed management treatments when recorded in two consecutive years(Table 4.3.2 and Fig 4.3.2).As influenced by nitrogen levels,the highest panicle length was observed by 175 kg N/ha and it has been noticed statistically similar to 150 kg N/ha but significantly more than 125 kg N/ha when recorded for both the years.The significantly lowest panicle length was observed by 0 kg of Nitrogen/ha contrary to other nitrogen levels in two consecutive years of experimentation.Amongst weed management methods,the significantly greater panicle length has been recorded in pendimethalin(stomp) fb bispyribac treatment (T1) which was found to be statistically at par with brown manuring teatment applied with pendimethalin fb. bispyribac (T2) and these two treatments produced significantly greater panicle length over brown manuring applied with bispyribac treatment only i.e. without pre-em. application of pendimethalin (T3) for both the years.The significantly less panicle length was recorded in unweeded(control) treatment for both the years as compared to all other weed management treatments.

The interactive effect on number of grains per panicle between nitrogen levels and weed management methods has been observed as significant during both years. Interaction data of number of grains per panicle are shown in (Table 4.3.3). During both years of experimentation when the crop has been supplied with 150 kg of Nitrogen/ha but treated with pendimethalin fb. bispyribac produced statistically at par number of grains per panicle than the brown manured crop supplied with 175 kg N/ha and sprayed with only bispyribac. Also during 2022, application of pendimethalin fb. bispyribac to the crop receiving 0 kg N/ha produced statistically at par number of grains per paicle than the brown manured crop receiving 125 kg N/ha and post-em. application of bispyribac during 2023.

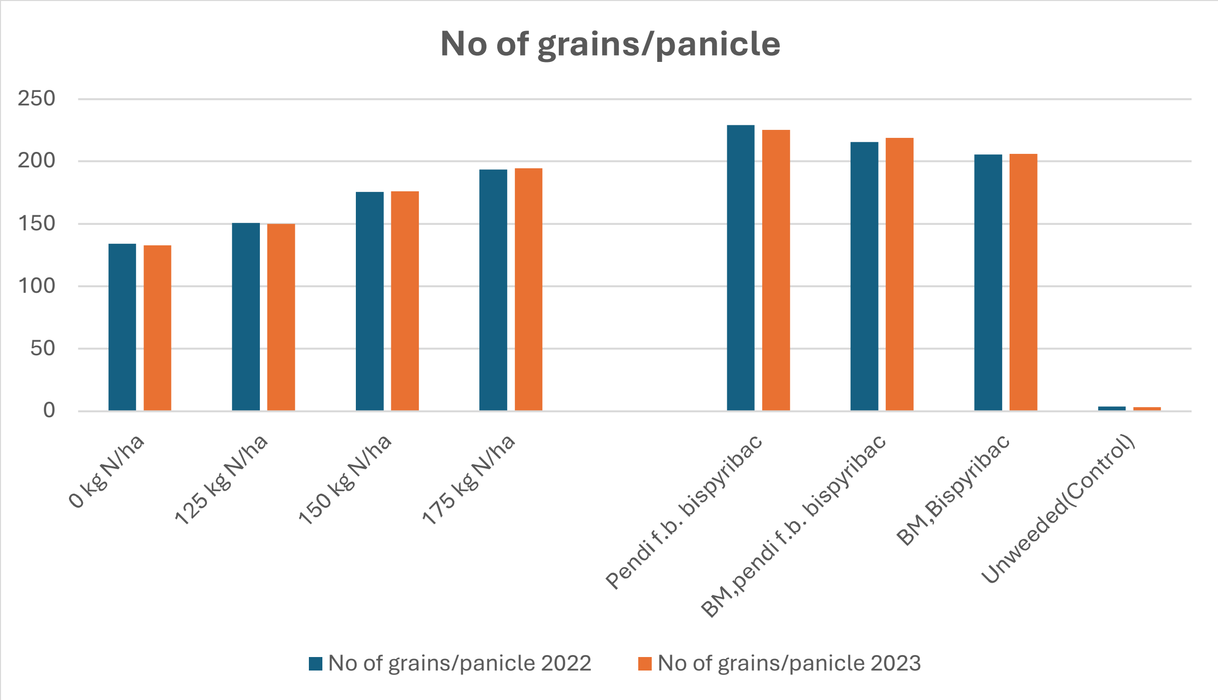
Table.4.3.2. Effect of nitrogen levels and weed control treatments on number of grains/panicle and panicle length (cm) during 2022 and 2023

Main plots - Nitrogen levels				
	No of grains/panicle		Panicle length(cm)	
	2022	2023	2022	2023
N_1 – 0 kg N /ha	134.1	132.7	17.6	16.2
N_2 – 125 kg N /ha	150.7	149.8	19.0	17.3
N_3 – 150 kg N /ha	175.5	176.0	20.6	20.8
N_4 – 175 kg N /ha	193.3	194.5	21.1	21.1
SE(m)	0.66	0.96	0.19	0.15
CD at P < 0.05%	2.32	3.37	0.67	0.53
Sub plots - Weed control treatments				
T_1 - Pendi fb. bispyribac	229.1	225.1	23.4	22.8
T_2 - BM,Pendi fb.bispyribac	215.5	218.8	22.6	22.5
T_3 – BM,bispyribac	205.4	205.9	21.6	21.9
T_4 -Unweeded (control)	3.58	3.25	10.6	8.1
SE(m)	1.16	0.84	0.31	0.19
CD at P < 0.05%	3.39	2.46	0.89	0.44
CD for interaction	NS	NS	NS	NS

Table.4.3.3. Interaction among nitrogen levels and weed control treatments for number of grains/panicle during 2022 and 2023

No of grains/panicle (2022)					
Treatments	Pendi fb. bispyribac	BM,Pendi fb. bispyribac	BM,bispyribac	Unweeded (control)	Mean
N_1 – 0 kg N /ha	192.0	175.7	167.0	2.0	134.1
N_2 – 125 kg N/ha	208.3	198.3	193.3	3.0	150.7
N_3 – 150 kgN/ha	246.7	231.3	220.0	4.0	175.5
N_4 – 175 kg N/ha	269.7	257.0	241.3	5.3	193.3
Mean	229.1	215.5	205.4	3.58	
CD at 5%	6.30				

No of grains/panicle (2023)					
Treatments	Pendi fb. bispyribac	BM,Pendi fb. bispyribac	BM,bispyribac	Unweeded (control)	Mean
N1 – 0 kg N/ha	184.7	179.7	165.0	1.7	132.7
N_2 – 125 kgN/ha	206.7	196.0	194.0	2.7	149.8
N_3 – 150 kgN/ha	245.0	238.0	218.3	3.0	176.0
N_4 – 175 kg N/ha	264.3	261.7	246.3	5.7	194.5
Mean	225.1	218.8	205.9	3.25	
CD at 5%	5.23				



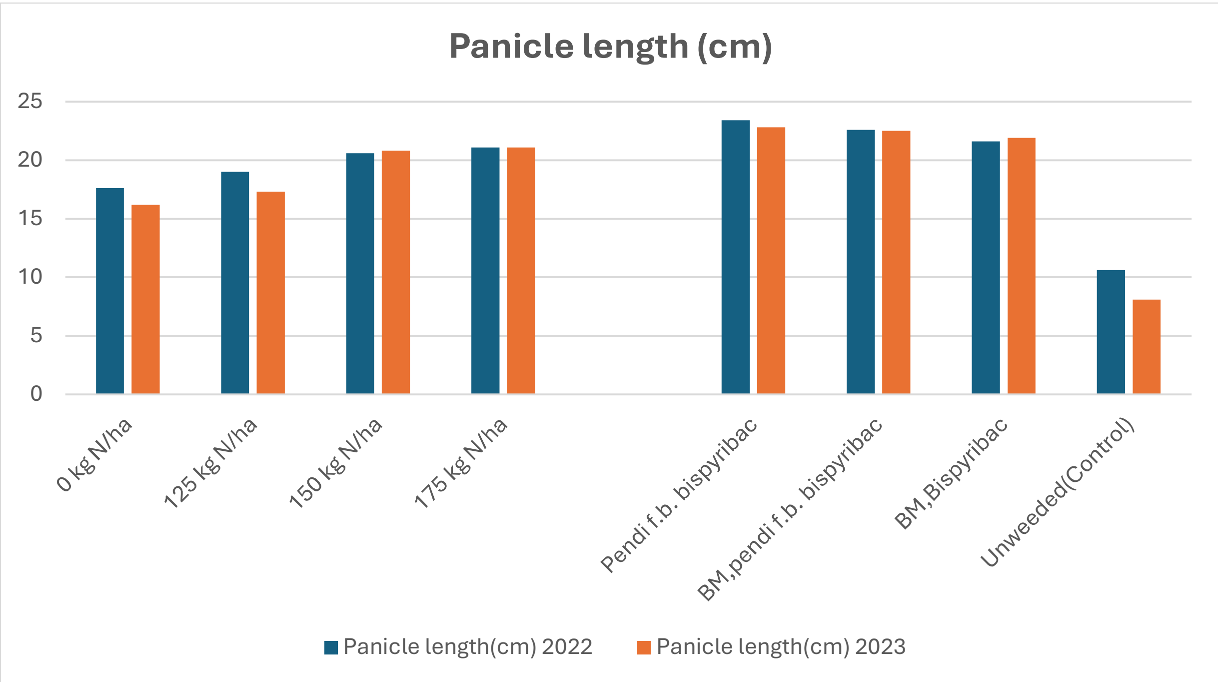


Fig. 4.3.2. Effect of nitrogen levels and weed control treatments for number of grains per panicle and panicle length (cm) during 2022 and 2023

4.3.4. Panicle weight (g)

Panicle weight was recorded at harvest stage in two consecutive years of experimentation(Table 4.3.4 and Fig 4.3.3).Panicle weight was recorded in grams at harvest.The differences in panicle weight has been significantly effected by various levels of nitrogen along with weed management treatments when recorded for both the years(Table 4.3.5).Amongst various nitrogen levels,the greatest panicle weight has been found by 175 kg of Nitrogen/ha and it was statistically similar to 150 kg of Nitrogen/ha during 2023 but differed significantly during 2022.The significantly lower panicle weight was observed by 0 kg of Nitrogen/ha in two consecutive years. Applicaion of 125 kg of Nitrogen/ha recorded significantly less panicle weight over 150 and 175 kg of Nitrogen/ha in two consecutive years of experimentation. Amongst out of all the weed management methods,the significantly greater weight of panicles has been observed by pendimethalin fb bispyribac contrary to other weed management method. The significantly least weight of panicle was recorded in unweeded(control) treatment in two consecutive years over other herbicide applied treatments.Amongst the brown manuring treatments,application of pendimethalin (T2) produced significantly more panicle weight than its no application(T3).

4.3.5 Test weight (g)

Test weight was recorded at harvest for both the years.Test weight was recorded in grams at harvest.The differences in test weight was significantly influenced by both nitrogen levels and weed management treatments when recorded for both the years(Table 4.3.4 and Fig 4.3.3).Among the nitrogen levels,the highest test weight was observed with the application of 175 kg N/ha which was statistically at par with 150 kg N/ha when recorded for both the years, and both these treatments gave significantly more test weight than 125 kg N/ha.The significantly lowest test weight was observed by 0 kg N/ha which was found to be statistically at par with 125 kg N/ha for both the years.Among the weed management treatments,the significantly highest test weight was observed in pendimethalin fb bispyribac treatment (T1) which was found to be statistically at par with brown manuring with sesbania applied with pendimethalin fb. bispyribac treatment (T2) during 2023 and during first year these differences were found to be significant.Among brown manuring treatments, “pre-em. application of pendimethalin (T2)significantly increased test weight of rice as compared to the treatment where pendimethalin was not applied.The significantly lowest test weight was recorded in unweeded(control) treatment for both the years as compared to all other weed management treatments.

Table.4.3.4. Effect of nitrogen levels and weed control treatments on panicle weight (g) and test weight (g) during 2022 and 2023

Main plots - Nitrogen levels				
	Panicle weight (g)		Test weight (g)	
	2022	2023	2022	2023
N_1 – 0 kg N /ha	4.09	4.01	20.03	19.54
N_2 – 125 kg N /ha	4.39	4.35	20.29	19.96
N_3 – 150 kg N /ha	5.10	5.17	21.13	21.04
N_4 – 175 kg N /ha	5.36	5.20	21.29	21.53
SE(m)	0.06	0.06	0.18	0.19
CD at P < 0.05%	0.21	0.21	0.63	0.67
Sub plots - Weed control treatments				
T_1 - Pendi fb. bispyribac	5.36	5.31	22.09	22.31
T_2 - BM,Pendi fb.bispyribac	5.16	5.13	21.82	22.03
T_3 – BM,bispyribac	4.658	4.56	20.23	20.23
T_4 -Unweeded (control)	3.77	3.73	18.60	17.47
SE(m)	0.04	0.04	0.11	0.18
CD at P < 0.05%	0.14	0.13	0.34	0.53
CD for interaction	NS	NS	NS	NS

All yeid attributing parameters viz. effective tillers/m row length,number of panciles/m row length,number of grains/panicle,panicle length (cm),panicle weight (g) and test weight (g),were higher in 175 and 150 kg N/ha due to good vegetative and hence reproductive growth of rice crop under these treatments as compared to 0 kg N/ha and 125 kg N/ha due to poor crop growth under these treatments. Similar findings were reported by Jahan et al., 2022,Giri et al., 2022 and Singh et al., 2018.Among sub plot treatments, all these yeild attributes were higher in pre-em. pendimethalin fb. bispyribac treatment(T1) due to good vegetative and hence reproductive growth as compared to all other weed management treatments.On the other hand these yield parameters were less in brown manuring treatments which may be due to the smoothering effect of sesbania on rice crop seedlings during initial growth stages resulting in poor growth and development of crop under these treatments. Similar findings were reported by Gaire et al., 2013 and Rehman et al., 2007.The data pertaining to yield attributes is being depicted in Fig 4.3.1,4.3.2,& 4.3.3.

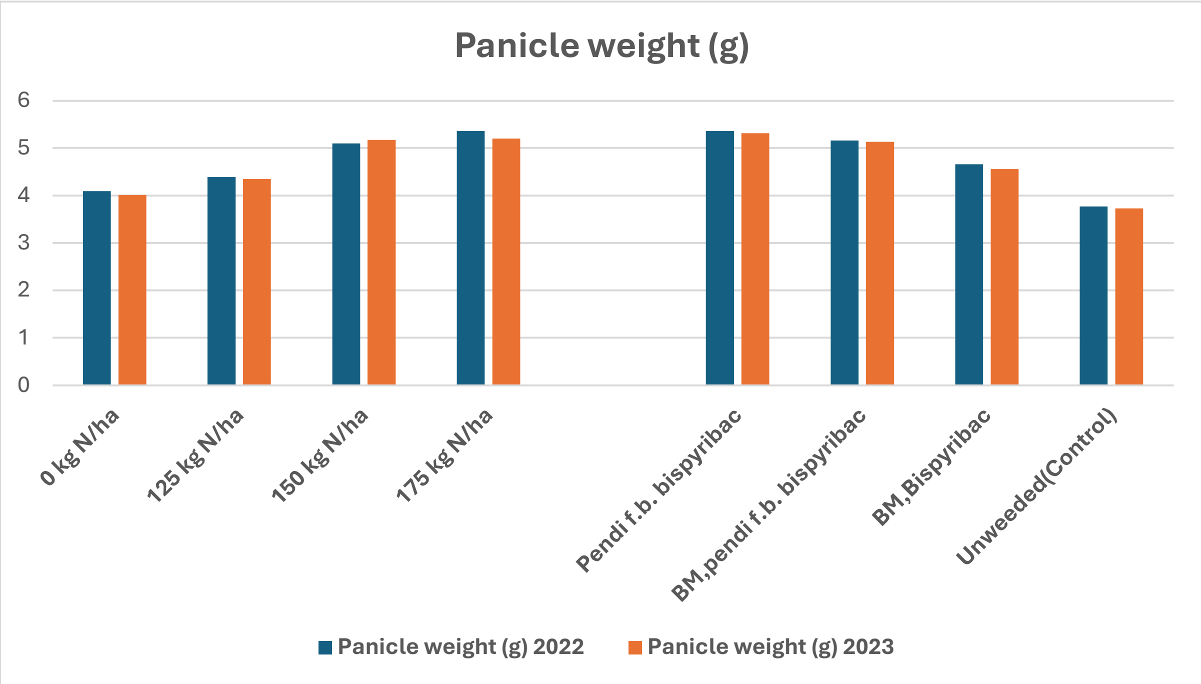


Fig. 4.3.3 Effect of nitrogen levels and weed control treatments on panicle weight (g) and test weight (g) during 2022 and 2023

4.3.6. Paddy yield (q/ha)

Grain yield is the most important parameter which governs net profit of the farmer which was recorded at harvest for both the years.and data presented in Table 4.3.5. and Fig 4.3.4. The data on paddy yield of rice revealed that different nitrogen levels and weed management treatments exhibited significant variation in paddy yield when recorded for both the years . Among , the nitrogen levels maximum paddy yield was observed by 175 kg N/ha which was found to be at par with 150 kg N/ha when recorded for both the years.and both these nitrogen levels produced significantly higher paddy yield than 0 kg and 125 kg N/ha.Application of 125 kg N/ha during both years recorded significantly less paddy yield than 150 kg N/ha.The nitrogen level of 0 kg N/ha recorded significantly less yield than other nitrogen levels during both years.The significantly more yield in 175 kg N/ha and 150 kg N/ha than 125 kg N/ha during both years.may be due to better crop growth parameters (Table 4.2.1 to 4.2.4) better yield attributes (Table 4.3.1 to 4.3.5) It was also observed that application of 175 kg N/ha,150 kg Nha, and 125 kg N/ha increased paddy yield by 53.1 %,48.5 %,and 38.2 % during 2022 and 56.7 %,51.3 %,and 40.9 % during 2023 respectievely.

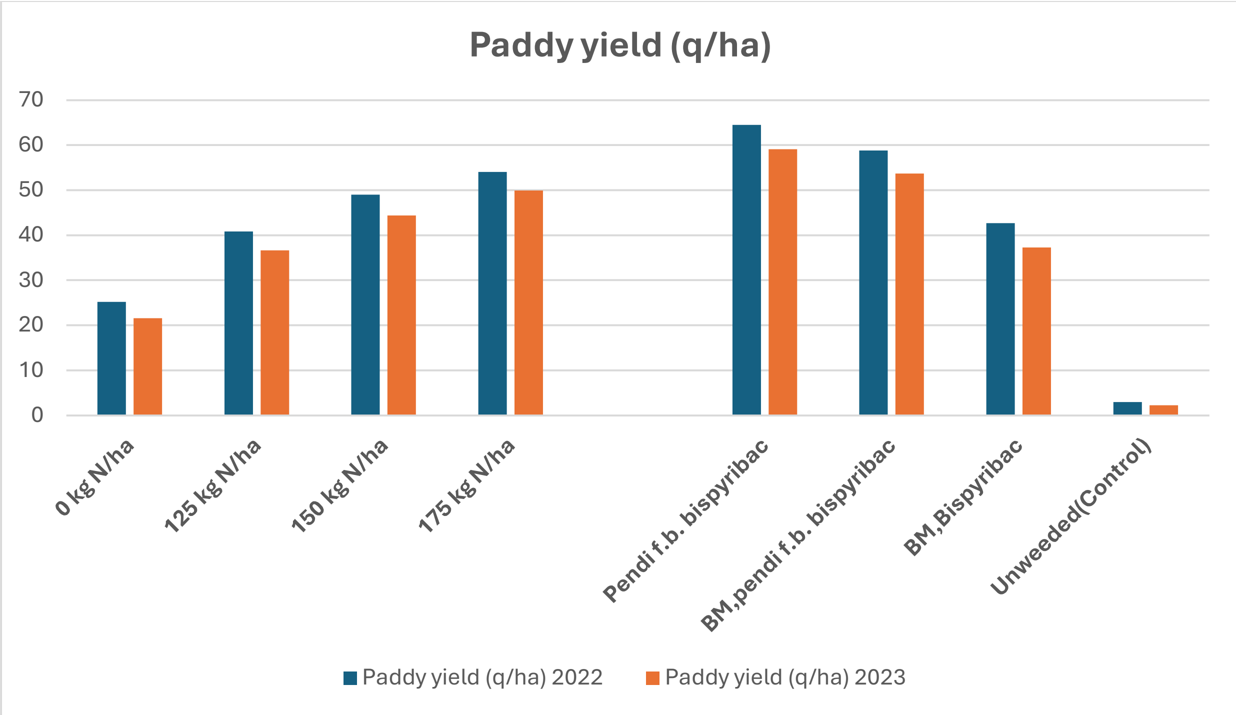
Among weed management treatments pre-em. application of pendimethalin fb. post-em. bispyribac recorded significantly higher yield than all other weed management treatments.However application of pendimethalin to brown manuring treatment (T2) recorded significantly higher yield than its no application of pendimethalin (T3) during both years.Significantly less yield was observed in unweeded (control) as compared to all other weed management treatments during both years.Higher yield in pre-em.pendimethalin fb. post-em. bispyribac treatment (T1) may be due to better control of paddy and non paddy weeds (Table 4.1.1 and Table 4.1.2) improved growth and yield attributes,(Table 4.2.1 to 4..3.5).Also application of pre-emergence pendimethalin in brown manuring treatment (T2) significantly increased paddy yield than its no application (T3) which may be due to better control of weeds (Table 4.1.1 and Table 4.1.2) and crop growth and yield attributes (4.2.1 to 4.3.5).The negrigble (very low) yield in unweeded control may be due to the presence of paddy and non paddy weeds in abundance which smoothered rice plants resulting in their mortality as these (crop) plants were covered completely by weed plants. Application of pendimethalin fb. bispyribac,brown manuring treatment sprayed with pre-em. pendimethalin fb. bispyribac and brown manuring with post-em, application of bispyribac only increased paddy yield by 95.3 %,94.8 % ,and 92.9 % during 2022 and 96.1 %,94.6 %, and 94.1 % during 2023 over unweeded (control) tretment respectievely,indicating thereby that failure of direct seeding technology is mainly due to uncontrolled weed problem in this crop.

4.3.7 Straw yield (q/ha)

The data on straw yield revealed that different nitrogen levels and weed management treatments exhibited significant variation in straw yield of rice for both the years(Table 4.3.5 and Fig 4.3.4) . Among the nitrogen levels, maximum straw yield was recorded with the application of 175 kg N/ha ,which was found to be statistically at par with 150 kg N/ha during both years and these nitrogen levels were found to be significantly superior to 125 kg N/ha with respect to straw yield. It can be concluded that each increment in dose of nitrogen from 0 to 175 kg/ha resulted in significant increase in straw yield for both the years. However all the nitrogen levels has significantly increased straw yield than 0 kg N/ ha during both years.Higher paddy straw yield in 175 and 150 kg N /ha may be due to good vegetative growth of rice as compared to 125 and 0 kg N/ha.Among the weed management treatments, more straw yield was obtained in pendimethalin fb bispyribac treatment and it was statistically at par with brown manuring with sesbania fb. bispyribac as well as brown manuring rice crop with pre-em. pendimethalin fb. bispyribac treatments(T2 & T3) for both the years . However, the lowest straw yield of paddy was obtained under weedy check (control) which was significantly less than all other weed management treatments for both years.More straw yield in the herbicidal treatments may be due to better crop growth due to the excellent control of weeds in these treatments.In unweeded (control) crop failed to grow due to the presence of abundance of weeds in direct seeded rice.

Table.4.3.5. Effect of nitrogen levels and weed control treatments on paddy yield (q/ha) and straw yield of DSR (q/ha) during 2022 and 2023

Paddy Yield (q/ha)				
Main plots - Nitrogen levels				
	Paddy yield (q/ha)		Straw yield (q/ha)	
	2022	2023	2022	2023
N_1 – 0 kg N /ha	25.2	21.6	38.5	43.3
N_2 – 125 kg N /ha	40.8	36.6	45.4	54.0
N_3 – 150 kg N /ha	49.0	44.4	60	69.2
N_4 – 175 kg N /ha	54.0	49.9	62.4	73.2
SE(m)	1.71	1.84	1.92	1.68
CD at P < 0.05%	5.26	5.91	8.14	5.06
Sub plots - Weed control treatments				
T_1 - Pendi fb.bispyribac	64.5	59.1	85.6	69.1
T_2 -BM,pendi fb.bispyribac	58.8	53.7	80.8	65.7
T_3 – BM,bispyribac	42.7	37.3	81.0	66.6
T_4 -Unweeded (control)	3.01	2.25	3.46	2.50
SE(m)	1.21	1.57	1.81	1.24
CD at P < 0.05%	4.20	4.86	5.48	3.75
CD for interaction	NS	NS	NS	NS



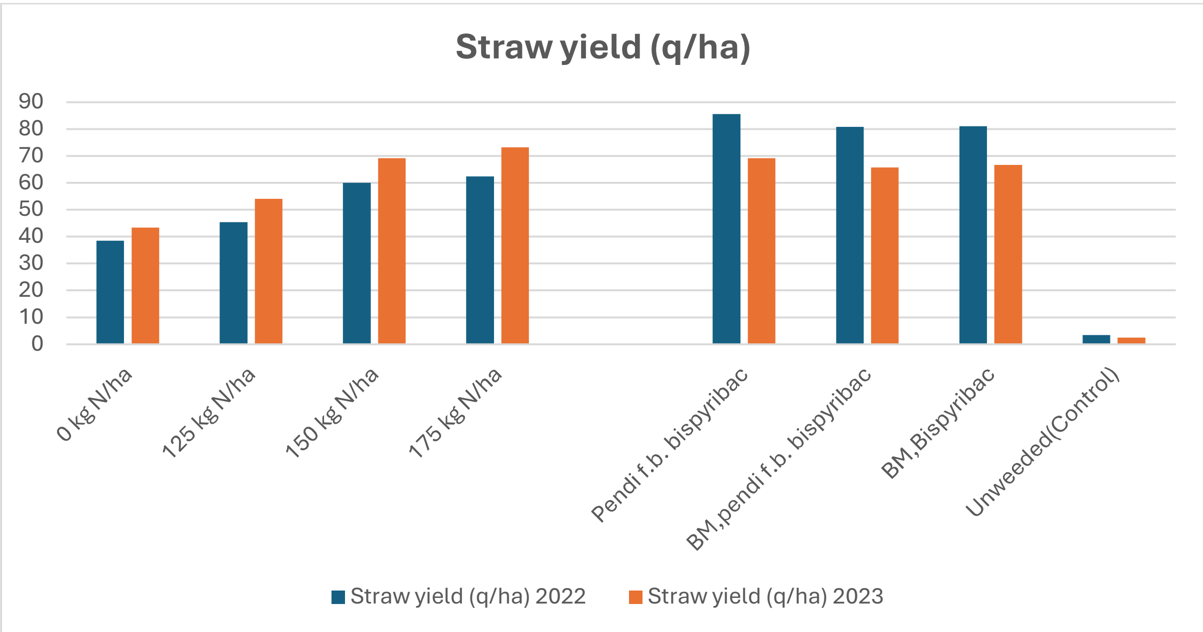


Fig.4.3.4 Effect of nitrogen levels and weed control treatments on paddy and straw yield of direct seeded rice during 2022 and 2023

4.3.8. Biological yield (q/ha)

The data on biological yield revealed that different nitrogen levels and weed management treatments exhibited significant variation in biological yield of rice during both the years(Table 4.3.6) . Among the nitrogen levels, the maximum biological yield was recorded with application of 175 kg N/ha ,followed by 150 kg N/ha and 125 kg N/ha which was significantly higher than 0 kg N/ha for both the years. However all the nitrogen level treatments have significantly increased biological yield over 0 kg N/ha for both the years. The biological yield increased significantly with each increment of nitrogen dose i.e. 0 kg-125 kg- 150 kg, and 175 kg/ha . Among the weed control treatments, more biological yield was obtained in pendimethalin fb. bispyribac which was significantly superior to the rest of the treatments when recorded for both the years. Biological yield in brown manuring crop applied with pre-em pendimethalin fb bispyribac (T2), was significantly more than brown manuring,fb bispyribac (T3). However, the lowest biological yield was obtained under weedy check (control)which was significantly less than all weed management treatments for both the years. The interactive effect of nitrogen levels and weed management treatments for biological yield were non significant during both years.

4.3.9 Harvest Index (%)

The persual of data on the harvest index was presented in the Table 4.3.6. The data revealed that differences in harvest index under different levels of nitrogen varied from 43.2 to 49.4 for the year 2022 and 41.1 to 46.8 for the year 2023 . Among the different weed management treatments, the values of harvest index were found to vary from 38.8 to 56.3% for the year 2022 and 34.7 to 53.4% for the year 2023. The highest value of harvest index was observed in unweeded (control) treatment due to very less biological and more grain yield .The lowest harvest index was recorded in the brown manuring,fb bispyribac (T3) compared to all other weed management treatments.

Table.4.3.6. Effect of nitrogen levels and weed control treatments on biological yield(q/ha) and harvest index(%) of DSR (q/ha) during 2022 and 2023

Main plots – Nitrogen levels				
	Biological yield (q/ha)		Harvest Index(%)	
	2022	2023	2022	2023
N_1 – 0 kg N /ha	63.7	64.7	39.5	33.3
N_2 – 125 kg N /ha	86.2	90.6	47.3	40.3
N_3 – 150 kg N /ha	109	113.6	44.9	39.0
N_4 – 175 kg N /ha	116.4	123.1	46.3	40.5
SE(m)	1.86	0.55	NA	NA
CD at P < 0.05%	6.56	1.93	NA	NA
Sub plots - Weed control methods				
T_1 - Pendi fb. bispyribac	150.1	128.2	42.9	46.0
T_2 - BM, pendi fb. bispyribac	139.6	119.4	42.1	44.9
T_3 – BM,Bispyribac	123.7	103.9	34.5	35.8
T_4 -Unweeded (control)	6.47	4.75	46.5	47.3
SE(m)	1.42	1.04	NA	NA
CD at P < 0.05%	4.17	2.79	NA	NA
CD for interaction	NS	NS	NA	NA

4.4 Quality parameters

4.4.1. Nitrogen content in seeds (%)

Data on the nitrogen content in seed pertaining to different nitrogen levels and weed management treatments was found to be significant for both the years and presented in the (Table 4.4.1.) A close examination of the data showed that there was progressive increase in the nitrogen content of the seeds with the successive increase of nitrogen level from 0 kg N/ha to 175 kg N/ha during 2022.During 2023, nitrogen content in 175 kg N/ha and 150 kg N/ha was found to be statistically at par with each other and both these levels were found significantly superior to 125 kg N/ha and 0 kg N/ha.Among the weed management treatments , the significantly highest nitrogen content in seeds was recorded in the pendimethalin fb. bispyribac than all other weed management treatments during both years.Among the brown manuring treatments,application of pendimethalin (T2) to rice crop significantly improved N content in seed than without application of pendimethalin (T3). The N content in unweeded (control) was significantly less than all other weed management treatments during both the years

4.4.2. Nitrogen content in straw (%)

Data on the nitrogen content in straw of rice pertaining to different nitrogen levels and weed management treatments are presented in the (Table 4.4.1) and difference were significant for both the years . A close examination of the data showed a progressive significant increase in the nitrogen content of straw was observed with the successive increase in nitrogen level from 0 to 125 to 150 to 175 kg/ha when recorded for both the years. The significantly highest nitrogen content was observed in 175 kg N/ha than all other nitrogen levels. The significantly low nitrogen content was recorded in 0 kg N/ha,as compared to all other nitrogen levels for both the years.Among the weed management treatments , the significantly more nitrogen content in straw was recorded in pendimethalin fb. bispyribac treatment when compared to all other weed management treatments.Among the brown manuring treatments, significantly more nitrogen content in straw was recorded where pendimethalin was applied (T2) to rice crop as compared to its without application treatment (T3).The significantly low nitrogen content in straw was observed in weedy check (control) compared to all other weed management treatments during both the years. The interactive effect of nitrogen levels and weed management treatments for nitrogen content in seeds and nitrogen content in straw was found to be non-significant for both the years.

Table.4.4.1. Effect of nitrogen levels and weed management treatments on N content in seeds and N content in straw(%) during 2022 and 2023

Main plots – Nitrogen levels				
	N content in seeds (%)		N content in straw (%)	
	2022	2023	2022	2023
N_1 – 0 kg N /ha	0.68	0.78	0.31	0.28
N_2 – 125 kg N /ha	0.76	0.88	0.48	0.48
N_3 – 150 kg N /ha	0.82	0.96	0.65	0.54
N_4 – 175 kg N /ha	0.86	1.00	0.70	0.60
SE(m)	0.01	0.03	0.02	0.01
CD at P < 0.05%	0.04	0.11	0.03	0.04
Sub plots - Weed control treatments				
T_1 - Pendi fb. bispyribac	0.95	1.09	0.69	0.61
T_2 -BM,pendi fb.bispyribac	0.80	0.98	0.58	0.54
T_3 – BM,bispyribac	0.73	0.80	0.53	0.47
T_4 -Unweeded (control)	0.63	0.74	0.36	0.29
SE(m)	0.02	0.02	0.01	0.01
CD at P < 0.05%	0.065	0.06	0.03	0.03
CD for interaction	NS	NS	NS	NS

4.4.3. Nitrogen uptake by seed (kg/ha)

The data revealed that the nitrogen uptake by seeds of rice was significantly influenced by nitrogen levels and weed management treatments during both the years (Table 4.4.2) Among the different nitrogen levels, significantly highest nitrogen uptake by seeds was observed in 175 kg N/ha as compared to 150 kg N/ha ,125 kg N/ha and 0 kg N/ha when recorded for both the years. There was progressive and significant increase in nitrogen uptake by seeds during both years with the subsequent increase in nitrogen level from 0 kg to 125 kg to 150kg to 175 kg/ha to rice crop. The significantly low nitrogen uptake by seeds was observed in 0 kg N/ha compared to all other nitrogen levels for both the years. Application of 175,150 and 125 kg N/ha increased N uptake by 64.2%,57.9%,and 46.5% during 2022 and 65.7%,61.2%,and 48.1% during 2023 over 0 kg N/ha respectievely. Among the weed management treatments ,significantly highest nitrogen uptake by seeds was recorded in the pendimethalin fb. bispyribac than all other weed management treatments when recorded for both the years.The significantly low nitrogen uptake by seeds was observed in unweeded (control) compared to all other weed management treatments during both the years.Application of pendmethalin fb. bispyribac with brown manuring treatment resulted in significant increase in N uptake by paddy seeds than alone application of bispyribac to brown manuring treatment during both years.Pre-em. application of pendimethalin fb. bispyribac,brown manuring,to rice applied with pendimethalin fb. bispyribac and brown manuring with only,bispyribac treatments increased nitrogen uptake by 96.9%,96.0 % and 94 % during 2022 and 97.4%,96.8%,and 94.5 % during 2023 over unweeded (control) respectively.

4.4.4. Nitrogen uptake by straw

The data revealed that the nitrogen uptake by straw was significantly influenced by nitrogen levels and weed management treatments (Table 4.4.2.). Among the different nitrogen levels, the highest nitrogen uptake by straw was observed in 175 kg N/ha which was significantly more than all other nitrogen levels during both years.The lowest nitrogen uptake by straw was observed in 0 kg N/ha which was significantly less than all other nitrogen levels. Nitrogen uptake by straw increased significantly with the corresponding increase of nitrogen levels from 0 to 175 kg N/ha for both the years.Among the weed management treatments , the highest nitrogen uptake by straw was recorded in pendimethalin fb. bispyribac than all other weed management treatments during both the years.The significantly low nitrogen uptake by straw was observed in weedy check (control) compared to all other weed management treatments for both the years.Among the brown manuring treatments, application of pendimethalin increase N uptake by straw than without pendimethalin treatment (T3) during 2023 but these differences were found to be non-significant during 2022.

The interactive effects between nitrogen nitrogen levels and weed management treatments for nitrogen uptake by seed and straw was found to be non-significant.

Table.4.4.2. Effect of nitrogen levels and weed management treatments on N uptake by seed and straw (kg/ha) during 2022 and 2023

Main plots – Nitrogen levels				
	N uptake by seeds (kg/ha)		N uptake by straw(kg/ha)	
	2022	2023	2022	2023
N_1 – 0 kg N /ha	18.0	18.1	11.9	10.6
N_2 – 125 kg N /ha	33.7	34.9	19.9	20.6
N_3 – 150 kg N /ha	42.8	46.7	36.5	30.9
N_4 – 175 kg N /ha	50.3	52.9	40.9	36.2
SE(m)	0.58	1.19	1.29	0.66
CD at P < 0.05%	2.29	4.21	4.38	2.31
Sub plots - Weed control treatments				
T_1 - Pendi fb. bispyribac	62.6	66.0	43.0	37.8
T_2 -BM,pendi fb. bispyribac	48.4	53.5	33.4	31.6
T_3 – BM,bispyribac	32.0	31.2	30.9	27.4
T_4 -Unweeded (control)	1.9	1.7	0.9	0.6
SE(m)	0.93	0.81	1.07	0.689
CD at P < 0.05%	3.30	2.68	3.15	2.02
CD for interaction	NS	NS	NS	NS

4.4.5. Total N uptake by seed+straw (kg/ha)

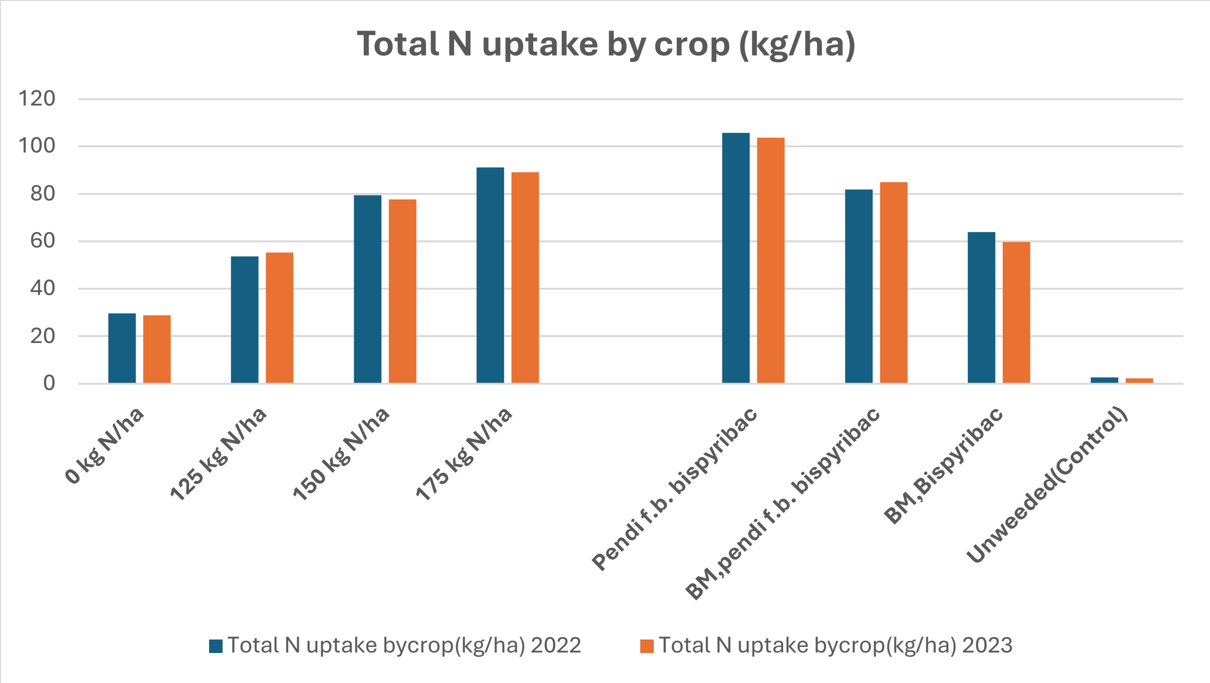
The data revealed that the total nitrogen uptake (crop + straw) by crop was significantly influenced by nitrogen levels and weed management treatments during both the years in (Table 4.4.3 and Fig 4.4.1) Among the different nitrogen levels, significantly highest nitrogen uptake by crop and straw was observed in 175 kg N/ha than all other nitrogen levels during both years. The significantly low nitrogen uptake by crop was observed in 0 kg N/ha compared to all other nitrogen levels. Total nitrogen uptake increased significantly with the successive increase of nitrogen levels from 0 kg to 125 kg to 150 kg to 175 kg N/ha.Total uptake of nitrogen by crop in 175 kg,150 kg and 125 kg was 67.4%, 62.5%,and 44.5 % higher during 2022 and 67.6%,62.8%,and 44.3% higher during 2023 than unweeded (control) respectively.Similar results were obtained by Jahan et al., 2022.Among the weed management treatments , the significantly highest nitrogen uptake by crop was recorded in pre-em. pendimethalin fb. bispyribac than all weed control treatments. The significantly low total nitrogen uptake by crop was observed in weedy check (control) compared to all other weed management treatments. Among the brown manuring treatments, application of pendimethalin (T2) significantly increased nitrogen uptake by crop than its without application (T3) treatment during both years.Pre.em. application of pendimethalin fb. bispyribac,brown manuring in rice sprayed with,pendimethalin fb. bispyribac, brown manuring bispyribac treatments increased total uptake of nitrogen by crop to the tune of 97.4%,96.6%, and 95.7% during 2022 and 97.7%,97.2 %,and 96.1% during 2023 over unweeded (control) respectievely. Total N uptake in herbicidal treatments was very high due to the control of non paddy weeds by pendimethalin and paddy weeds by bispyribac herbicide.Similar results were reported by Pooja and Saravanane 2021.

4.4.6 Protein content (%)

Protein content of rice was recorded at harvest . The data pursued regarding protein content revealed that nitrogen levels significantly influenced the protein content in seeds for both the years(Table 4.4.3 and Fig 4.4.1) The significantly higher protein content in the seed was observed in the 175 kg N/ha than other nitrogen levels during 2022, but for the year 2023 , the significantly more protein content was observed in 175 kg N/ha than 125 kg and 0 kg N/ha. The values of protein content in 150 kg N/ha and 125 kg N/ha were statistically at par with each other for both the years.The protein content in 0 kg N/ha was significantly less than all other all other nitrogen levels during both the years. The protein content in rice was statistically influenced by weed management treatments during both years.The significantly higher protein content was observed in the pendimethalin fb. bispyribac treatment than all other weed management treatments. The protein content of weedy check (control) treatment was significantly less when compared to all other weed management treatments for both the years.Protein content among brown manuring treatments was significantly high in pendimethalin treatment (T2) as compared to its without application (T3).The interactive effect of nitrogen levels and weed management treatments for nitrogen uptake by (seed & straw) and protein content was found to be non-significant.

Table.4.4.3. Effect of nitrogen levels and weed control treatments on total N uptake by crop (seed+straw)(kg/ha) & protein conternt (%) during 2022 and 2023

Main plots – Nitrogen levels				
	Total N uptake bycrop(kg/ha)		Protein content (%)	
	2022	2023	2022	2023
N_1 – 0 kg N /ha	29.7	28.8	4.27	4.84
N_2 – 125 kg N /ha	53.6	55.3	4.78	5.50
N_3 – 150 kg N /ha	79.4	77.6	5.00	5.97
N_4 – 175 kg N /ha	91.2	89.1	5.40	6.23
SE(m)	1.50	1.34	0.07	0.19
CD at P < 0.05%	5.28	4.73	0.25	0.68
Sub plots - Weed control methods				
T_1 - Pendi fb.bispyribac	105.7	103.7	5.94	6.79
T_2 -BM,pendi fb.bispyribac	81.8	85.0	5.00	6.10
T_3 – BM,bispyribac	62.9	58.6	4.57	5.20
T_4 -Unweeded (control)	2.8	2.3	3.94	4.64
SE(m)	1.5	0.95	0.14	0.12
CD at P < 0.05%	4.8	2.79	0.40	0.36
CD for interaction	NS	NS	NS	NS



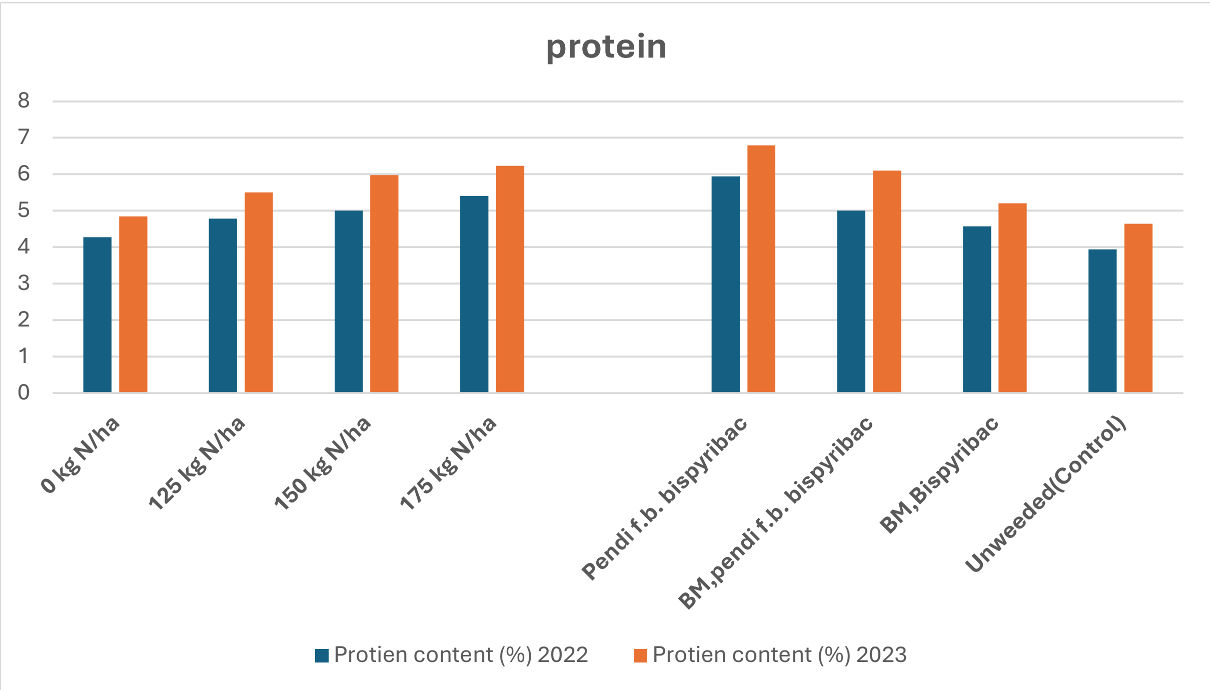


Fig.4.4.1. Effect of nitrogen levels and weed control treatments on total N uptake by crop (seed+straw)(kg/ha) and protein content during 2022 and 2023

4.4.7 Nitrogen content in weeds

The differences in N % in weeds was significant due to nitrogen levels and weed management treatments during both the years and presented in (Table 4.4.4.) the data on nitrogen content in weeds revealed that with 175 kg/ha nitrogen levels there was significant increase in the nitrogen content of weeds over other nitrogen levels during both years except during 2023 150 and 175 Kg N/ha were at par.The lowest nitrogen content was observed in 0 kg N/ha which was significantly less than all other nitrogen levels for both years.The nitrogen content in weeds under weed management treatments revealed that the significantly highest nitrogen content was observed in weedy check (control) than all other weed management treatments for both the years except brown manuring fb. bispyribac during 2022 only.The significantly less nitrogen content was observed in pendimethalin fb. bispyribac treatment when compared to all other weed management treatments for both the years.

4.4.8 Nitrogen uptake by weeds

Nitrogen uptake by weeds was significantly influenced by the nitrogen levels and weed management treatments for both the years and presented in(Table 4.4.4) The data on nitrogen uptake by weeds revealed that with the successive increase in the nitrogen levels with each increment in nitrogen levels from 0 kg to 175 kg N/ha.The highest nitrogen uptake by weeds was observed in 175 kg N/ha which was significantly more than all other nitrogen levels for both the years.. The lowest nitrogen uptake by weeds was observed in 0 kg N/ha which was significantly less than all other nitrogen levels during both the years. The data on nitrogen uptake by weeds under weed management treatments revealed that significantly more nitrogen uptake by weeds was recorded in weedy check (control) treatment than all other weed management treatments for both the years .The significantly low nitrogen uptake by weed was observed in pendimethalin fb. bispyribac treatments when compared with all other weed management treatments for both the years.

The interactive effect between nitrogen levels and weed management treatments for N contents(%) and uptake by weeds was found to be non-significant.

Table.4.4.4. Effect of nitrogen levels and weed control treatments on N content (%) in weeds and N uptake in weeds(kg/ha) during 2022 and 2023

Main plots – Nitrogen levels				
	N content in weeds (%)		N uptake in weeds(kg/ha)	
	2022	2023	2022	2023
N_1 – 0 kg N /ha	0.46	0.45	11.61	11.30
N_2 – 125 kg N /ha	0.54	0.51	15.68	13.77
N_3 – 150 kg N /ha	0.54	0.54	16.74	15.83
N_4 – 175 kg N /ha	0.61	0.59	19.03	18.49
SE(m)	0.01	0.01	0.06	0.36
CD at P < 0.05%	0.04	0.06	2.12	1.27
Sub plots - Weed control treatments				
T_1 - Pendi fb. bispyribac	0.425	0.42	1.59	1.89
T_2 - BM,pendi fb.bispyribac	0.50	0.50	2.66	3.07
T_3 – BM,bispyribac	0.58	0.53	4.14	4.22
T_4 -Unweeded (control)	0.65	0.64	54.67	50.21
SE(m)	0.02	0.01	0.50	0.50
CD at P < 0.05%	0.07	0.04	1.46	1.32
CD for interaction	NS	NS	NS	NS

4.4.9 Nitrogen use efficiency

Nitrogen use efficiency was calculated as below:

NUE (kg grain per kg N applied) = <u>(grain yield in N fertilized plot – grain yield in no N plot</u>
(quantity of N fertilizer applied in N fertilized plot)

Nitrogen use efficiency in paddy was recorded at harvest. As per the persual of data regarding nitrogen use efficiency ,the nitrogen levels influenced the nitrogen use efficiency by the crop. The highest nitrogen use efficiency was observed in the 175 kg N/ha (0.165 & 0.162 %) followed by 150 kg N/ha (0.151 & 0.152 %) , 125 kg N/ha (0.120 & 0.121 %) and 0 kg N/ha during 2022 and 2023 respectievely.Application of 150 and 175 kg N/ha recorded significantly more NUE than 125 kg N/ha where as the former treatments (150 & 175 Kg N/ha) were found at par during both years.

The nitrogen use efficiency also varied with different weed control treatments.The highest nitrogen use efficiency was obseved in the pendimethalin fb. bispyribac (0.165 & 0.169 %) followed by brown manuring(sesbania) with pre.em pendimethalin fb. bispyribac (0.163 & 0.157 %) , brownmanuring (sesbania) with bispyribac (0.095 & 0.101 %) and weedy check (control)(0.013 & 0.007%) respectievely during 2022 and 2023.Nitrogen use efficiency was significantly less in unweeded (control) than all other treatments.Also the treatment of pendimethalin fb. bispyribac(T1 & T2) recorded significantly higher NUE as compared to alone application of bispyribac.

Table 4.4.5 Influence of nitrogen levels and weed control treatments on nitrogen use efficiency NUE(%)

Main plots - Nitrogen levels		
	Nitrogen use efficiency (%)	
	2022	2023
N_1 – 0 kg N /ha	-	-
N_2 – 125 kg N /ha	0.120	0.121
N_3 – 150 kg N /ha	0.151	0.152
N_4 – 175 kg N /ha	0.165	0.162
SE(m)	0.005	0.002
CD at P < 0.05%	0.018	0.007
Sub plots - Weed control treatments		
T_1 - Pendi fb. Bispyribac	0.165	0.169
T_2 -BM,Pendi fb. Bispyribac	0.163	0.157
T_3 – BM,bispyribac	0.095	0.101
T_4 -Unweeded (control)	0.013	0.007
SE(m)	0.002	0.002
CD at P < 0.05%	0.005	0.005
CD for interaction	NA	NA

4.5 Soil parameters

4.5.1 Organic carbon (%) in soil

The data pertaining to organic carbon in soil after harvest of crop (Table 4.5.1) as influenced by nitrogen levels and weed management practices was not influence significantly.Among weed management treatments, maximum and minimum organic carbon content in soil after crop harvest were recorded with pendimethalin @ 1 kg ha^{1} fb bispyribac- sodium @ 25 g ha^{1} and weedy check during both the years, respectively. However, the variation among them was found to be non-significant.Similar findings were also reported by Goswami et al., 2017.

4.5.2 Available Nitrogen (kg ha^{1}) in soil

The data relevant to available nitrogen in soil (Table 4.5.1) indicated that, nitrogen levels and weed management practices did not influence it significantly in both the years of investigation.These findings also agreed with Goswami et al., 2017.

The interactive effect between nitrogen levels and weed management treatments was found non-significant for organic carbon (%) and available nitrogen (kg/ha).

4.5.3 Available phosphorus (kg ha^{1}) in soil

It is evident after the analysis of data (Table 4.5.2) that nitrogen levels and weed management practices had no significant effect on available phosphorus in soil after harvest. Similar findings were also reported by Goswami et al., 2017.

4.5.4 Available potassium (kg ha^{1}) in soil

A thorough analysis of the data pertaining to available potassium in soil after crop harvest (Table 4.5.2) revealed that it was not significantly influenced by nitrogen levels and weed management practices.The variation due to different weed management practices was found to be non significant in both the years of experimentation.However, numerical higher values of available potassium in soil after crop harvest was registered with pendimethalin @ 1 kg ha^{1} fb. bispyribac- sodium @ 25 g ha^{1} amongst all weed management practices during both the years. Similar findings also reported by Goswami et al., 2017".

The interactive effect of nitrogen levels and weed management treatments for available phosphorus and potassium was found to be non-significant.

Table 4.5.1 Effect of nitrogen levels and weed control treatments on organic carbon (%), available nitrogen (kg/ha), in soil during 2022 & 2023

Main plots – Nitrogen levels				
	Organic carbon (%)		Available nitrogen (kg/ha)	
	2022	2023	2022	2023
N_1 – 0 kg N /ha	0.42	0.43	184.80	184.60
N_2 – 125 kg N /ha	0.43	0.43	185.61	185.71
N_3 – 150 kg N /ha	0.43	0.43	185.82	185.98
N_4 – 175 kg N /ha	0.43	0.43	185.89	186.10
CD at P < 0.05%	NS	NS	NS	NS
Sub plots - Weed control treatments				
T_1 - Pendi fb. Bispyribac	0.44	0.45	185.83	184.92
T_2 -BM,pendi fb.bispyribac	0.43	0.44	185.71	184.63
T_3 – BM,bispyribac	0.43	0.44	185.69	184.21
T_4 -Unweeded (control)	0.43	0.43	185.05	183.78
CD at P < 0.05%	NS	NS	NS	NS
CD for interaction	NS	NS	NS	NS

Table 4.5.2 Effect of nitrogen levels and weed control treatments on available phosphorus and available potassium (kg/ha) in soil during 2022 & 2023

Main plots – Nitrogen levels				
	Available phosphorus (kg/ha)		Available potassium (kg/ha)	
	2022	2023	2022	2023
N_1 – 0 kg N /ha	16.75	15.21	165.20	166.04
N_2 – 125 kg N /ha	16.82	15.86	167.18	168.15
N_3 – 150 kg N /ha	16.91	16.24	168.25	168.50
N_4 – 175 kg N /ha	17.2	16.39	168.85	168.91
CD at P < 0.05%	NS	NS	NS	NS
Sub plots - Weed control treatments				
T_1 - Pendi fb. bispyribac	17.24	16.58	165.05	166.28
T_2 -BM,pendi fb. bispyribac	16.85	16.21	164.68	165.12
T_3 – BM,bispyribac	16.62	15.85	164.21	165.08
T_4 -Unweeded (control)	16.23	15.61	163.85	164.59
CD at P < 0.05%	NS	NS	NS	NS
CD for interaction	NS	NS	NS	NS

CHAPTER 5

SUMMARY AND CONCLUSION

The field experiment entitled "Performance of direct seeded rice (*Oryza sativa.L.*) in relation to planting patterns,nitrogen levels and weed control methods" was conducted during *kharif* 2022 and 2023 on the experimental farm of School of Agriculture, Lovely Professional University, Phagwara (Punjab). The experimental field was fairly uniform and leveled..Sixteen treatment combinations each for both the experiments were kept.

Experiment :- I "Role of planting patterns and weed management treatments on growth and development of direct seeded rice"(DSR)

Four main plot treatments viz., "flat sowing, two rows per bed, three rows per and two rows per bed and one in furrow. and four weed management treatments in subplots viz., pendimethalin fb. bispyribac, pendimethalin fb metsulfuron,weed free up to harvest,and unweeded (control).The experiment was laid out in Split-Plot Design with three replications.The important findings are summarized below.

5.1.1 – Weed studies

5.1.1.1 Weed count /sq.m

Weed count per quare meter was numerically high in flat sowing method when recorded at all periodic intervals than bed sowing methods.Number of weeds per square meter were significantly less in pendimethalin fb. bispyribac treatment due to its broad spectrum weed control as compared to pendimethalin fb. metsulfuron at all periodic intervals.Pendimethalin controlled all non paddy weeds where as bispyribac controlled all paddy weeds due to its broad spectrum nature and metsulfuron provided control on broad leaved weeds and sedges growing in "direct seeded rice"(DSR). The weed population in unweeded control were significantly higher due to the availibility of more space as initial growth of direct seeded rice is very slow.

5.1.1.2 Weed dry matter (q/ha)

Among the planting patterns, overall more dry matter of weeds was observed in flat sowing technique than bed sowing as weed growth was comparatively less in bed sowing technique,may be due to burial of some weed seeds deep in soil. Among the weed management treatments, the unweeded (control) treatment recorded significantly more dry matter accumulation by weeds than all other weed management treatments for both years.The significantly less weed dry matter accumulation was observed in weed free up to harvest treatment as contrary to all other herbicidal treatments.The dry matter of weeds was significantly less in pendimethalin fb. bispyribac than pendimethalin fb. metsulfuron during both years.

5.1.1.3 Weed control efficiency (%)

The highest weed control efficiency (71.5 % and 69.4 %) was observed in two rows per bed followed by three rows per bed (70.2 & 67.8%) during respective years.Among the weed management treatments ,the highest weed control efficiency was observed in the weed free up to harvest(100%) followed by pendimethalin fb. bispyribac (91.6 and 87.2%) and pendimethalin fb. metsulfuron (89.4 And 84.3%) during 2022 and 2023 respectievely.

5.1.2 Effect on crop parameters

5.1.2.1 Plant height (cm)

The differences in crop height (cm) as influenced by planting patterns was observed to be non-significant in two years of experimentation. Among the weed management treatments,the significantly more crop height was observed in the weed free up to harvest than all other herbicidal treatments in two years of experimentation.Plant height in unweeded (control) during both the years was observed to be significantly less as contrary to all other weed management treatments.

5.1.2.2 Total tillers

There was significant increase in total tillers in three rows per bed as compared to all other planting patterns when recorded for both years of 2022 and 2023. The significantly less total number of tillers were observed in two rows per bed when compared to all planting patterns for two consecutive years. The planting pattern of two rows per bed and one row in furrow recorded significantly higher total tillers than flat sowing and two rows per bed treatment during both years.Among the weed management treatments,the higher number of tillers were observed in pendimethalin fb, bispyribac which were at par statistically with weed free upto harvest and both these treatments recorded significantly higher total tillers than pendimethalin fb. metsulfuron treatment.The unweeded (control) treatment recorded significantly less total number of tillers than all other weed management treatments for both years.

5.1.2.3 Dry matter accumulation by crop

Dry matter accumulation by crop was observed to be higher in three rows per bed, two rows per bed and one in furrow than flat sowing as well as two rows per bed planting patterns. Crop dry matter was higher in weed free and pendimethalin fb. bispyribac treatment due to broad spectrum weed control as compared to pendimethalin fb. metsulfuron herbicides.On the other hand, the unweeded (control) was produced significantly less crop dry matter in comparison with other weed management treatments, possibly because of poor crop growth as both non-paddy and paddy weeds dominated the crop.

5.1.2.4 Chlorophyll Index

The differences for chlorophyll index between planting patterns at all periodic intervals (except 90 DAS during 2023) were found to be non-significant indicating there by that greenness of crop was nearly same in all planting methods. Among weed management treatments, significantly less chlorophyll index was recorded in unweeded (control) conditions than all other weed management treatments,possibly because of severe competition of weeds with rice crop in unmanaged or unweeded (control) conditions resulting in depletion of nitrogen by weeds.

5.1.3 Effect on yield and yield attributes

5.1.3.1 Yield attributes

All yeid attributing parameters viz. “effective tillers/m row length, number of grains/panicle,panicle length (cm),panicle weight (g) and test weight (g)”,were significantly higher in bed planting of three rows per bed,two rows per bed & one in furrow and two rows per bed planting patterns than flat sowing technique during both years.Among the weed management treatments the higher yield attributes were observed in pendimethalin fb. bispyribac which were statistically similar with weed free up to harvest treatment and both these treatments found significantly superior in all yield attributes when compared with other weed management treatments during both years.The significantly lowest yield attributes were recorded in unweeded(control) than all other weed management treatments for both the years.

5.1.3.2 Effect on yield (q/ha)

All yield parameters viz.paddy yield,straw yield,biological yield (q/ha) were recorded.Amongst , the planting patterns significantly Maximum paddy yield,straw,and biological yield was observed in three rows per bed than all other planting patterns when recorded for both the years.The significantly less yield was observed in two rows per bed than other planting patterns for both the years.Planting of three rows per bed, two rows per bed and one in furrow and flat sowing increased paddy yield by18.6%,12.6%, and 3.5% during 2022 and 19.6%,9.8% and 8.3% during 2023 than two rows per bed respectievely.Among the weed management treatments, significantly highest paddy yield,straw,and biological yield was observed in weed free upto harvest treatment than all other herbicidal treatments for two years of study. The significantly less paddy yield,straw,and biological yield was observed in unweeded(control) treatment, when compared with other weed management treatments for both the years.Pre-emergence application of (stomp) pendimethalin fb. (Nominie gold) bispyribac sodium recorded significantly higher paddy yield than pendimethalin fb. metsulfuron during both years which possibly because of better control of all weeds of DSR in the former treatment.The yield of unweeded (control) treatment was signficantly less than all weed management treatments”, which was very less due to more intensity of weeds during both years.

The unweeded (control) due to high weed intensity resulted in drastic or extreme reduction in paddy yield to the tune of 96.9%,96.8% and 96.5% during 2022 and 96.1%,95.8% and 95.6% during 2023 as compared to weed free,pendinethalin fb. bispyribac,and pendimethalin fb. metsulfuron respectievely.

5.1.4 N content and uptake of N by crop and weeds.

5.1.4.1 N content and uptake of N by crop

N content in seed was not influenced by planting patterns.weed free recorded significantly more N content in seed than other weed management treatments.

Uptake of N by crop was significantly more (106.2 and 100.7 kg/ha during 2022 and 2023 respectievely) in three rows per bed than other planting patterns.Also uptake of N in weed free up to harvest treatment was significantly more than other herbicidal treatments.

5.1.4.2 N content and uptake of N by weeds

The unweeded (control)treatment, resulted in significantly more nitrogen content by weeds than all other weed control treatments.

The unweeded (control)treatment, resulted in significantly more nitrogen uptake by weeds than all other weed control treatments.Uptake of nitrogen in unweeded (control) was 50.4 kg N/ha during 2022 and 61.7 kg N/ha during 2023 against 3.42 and 6.58 kg N/ha during 2022 and 2023 respectively in the best treatment i.e. pre-em. pendimethalin and post-em. bispyribac.

Experiment :-2 "Performance of nitrogen levels and weed management treatments on growth and devvelopment of direct seeded rice"(DSR)

Four nitrogen levels viz., "0 kg/ ha, 120 kg/ha, 150 kg/ha and 175 kg/ha" in main plots and four weed management treatments in subplots viz., "pendimethalin fb. bispyribac, brown manuring with pre-em. application of pendimethalin fb. bispyribac, brown manuring fb. bispyribac ,and unweeded (control)" in sub plots and the experiment was set up in a "split-plot design with three replications. The important findings are listed as below.

5.2.1 Effect on weed parameters

5.2.1.1 Weed count/sq.m.

Weed count was not influenced significantly by nitrogen levels at all periodic intervals in two consecutive years of study, except 60 DAS during 2023 only indicating there by that N application had no influence on weed emergence. Total weed count in unweeded (control) treatment at latter stages of crop growth was significantly more as compared to other weed management treatments . However pendimethalin fb. bispyribac treatment, resulted in significantly less weed count than all other weed control treatments. and it was statistically at par with the brown manuring treatment applied with pre-em. pendimethalin fb. bispyribac and both of these treatments resulted in significantly lower weed count over brown manured crop treated with alone bispyribac treatment during both years.

5.2.1.2 Dry matter accumulation by weeds

Higher dry matter accumulation by weeds in higher doses of nitrogen 150 kg N/ha and 175 kg N/ha produced significantly more weed dry matter than other nitrogen levels during both years.Weed dry matter accumulation in 0kg N/ha and 125 kg N/ha was less due to no/less availibilitty of nitrogen. Pre-em. pendimethalin fb. bispyribac recorded significantly less dry matter of weeds than all other treatments. The weed drymatter accumulation in unweeded (control) treatment was significantly and exceptionally high (unlike other field crops) than all other weed management treatments which may be due to very poor smoothering effect of crop on weeds owing to very slow initial crop growth.

5.2.1.3 Weed control efficiency (%)

The data recorded weed control efficiency at harvest indicated that there was progressive increase in the percentage of weed control efficiency with decrease in levels of nitrogen from 175 kg N /ha to 0 kg N/ha.The highest weed control efficiency was observed in 0 kg N/ha,(73.2 % and 77.4 %) followed by 125 kg N/ha , 150 kg N/ha and 175 kg N/ha for both years respectievely. Among the weed management treatments,the highest weed control efficiency was observed in pendimethalin fb bispyribac which was 92.8 % and 91.2 % during 2022 and 2023 respectievely,which was followed by brown manuring crop applied with pendimethalin fb. bispyribac for both years .

5.2.2 Effect on crop parameters

5.2.2.1 Plant height (cm)

It was observed that application of 175 kg N/ha recorded sigtnificantly more plant height than all other nitrogen levels during both years. The significantly less plant height was observed in 0 kg N/ha than all other nitrogen levels during both the years. Among the weed control treatments, more plant height was recoreded with pendimethalin fb bispyribac and it is statistically at par with brown manuring crop applied with pendimethalin fb. bispyribac,and both these treatments produced significantly higher plant height than brown manuring with only bispyribac treatment during both years.However significantly less plant height was observed in unweeded(control) as compared to all other treatments during 2022 and 2023.

5.2.2.2 Total tillers /meter row length

Significantly higher number of total tillers were obtained in higher level of nitrogen i.e. 150 and 175 kg N/ha than lower levels which may be due to better crop growth as compared to 0 kg N/ha and 125 kg N/ha.Lowest tillers in unweeded (control) may be due to poor growth of crop (because of severe competition by weeds for growth factors) as compared to all other weed control treatments.Total number of tillers per meter row length recorded 60,90,120 DAS and at harvest,in the brown manuring treatments were significantly less during both the years of study as compared to without brown manuring treatment which may be due to the initial smoothering effect of sesbania on rice plants due to which initial crop growth was inhibited.

5.2.2.3 Crop dry matter (q/ha)

Crop dry matter was significantly less in low levels of nitrogen (0 and 125 kg N/ha) as compared to higher nitrogen levels (150 & 175 kg N/ha). Pre-em. application of pendimethalin fb. bispyribac produced significantly more crop dry matter than all other weed control treatments.On the other hand,brown manuring crop provided slight smoothering effect on rice crop resulting in less dry matter accumulation by the crop, even if treated with pendimethalin and bispyribac as compared to its similar treatment without brown manuring.

5.2.2.4 Chlorophyll Index

The highest chlorophyll index was observed in 175 kg N/ha which was found to be statistically at par with 150 kg N/ha in both the years.and both these treatments were found to be significantly superior to 125 kg N/ha.The significantly low chlorophyll index was observed in 0 kg N/ha for both the years as compared to other nitrogen levels.In the weed control treatments,the highest chlorophyll index was observed in pendimethalin fb bispyribac treatment which was found to be statistically at par with brown manuring crop in rice applied with pendimethalin fb. bispyribac treatment for both the years.The significantly lowest chlorophyll index was recorded in unweeded (control) treatment for both the years as compared to all other weed control treatments.

5.2.3 Effect on yield and yield attributes

5.2.3.1 yield attributes

All yield attributing parameters viz. effective tillers/m row length, number of grains/panicle,panicle length (cm),panicle weight (g) and test weight (g) were higher in 175 and 150 kg N/ha due to good vegetative and hence reproductive growth of rice crop,under these treatments as compared to 0 kg N/ha and 125 kg N/ha due to poor crop growth. Among sub plot treatments, all these yeild attributes were higher in pre-em. pendimethalin fb. bispyribac treatment due to good vegetative and hence reproductive growth as compared to all other weed control treatments.On the other hand these yield parameters were less in brown manuring treatments which may be due to the smoothering effect of sesbania on rice crop seedlings during initial growth stages resulting in poor growth and development of crop under these treatments.

5.2.3.2 Paddy yield (q/ha)

All yeid parameters viz.paddy yield,straw yield,biological yield (q/ha) were significantly higher in 175 and 150 kg N/ha than other nitrogen levels,may be due to better crop growth parameters, and better yield attributes. It was also observed that application of 175 kg N/ha,150 kg Nha, and 125 kg N/ha increased paddy yield by 53.1 %,48.5 %,and 38.2 % during 2022 and 56.7 %,51.3 %,and 40.9 % during 2023 respectievely than 0 kg N/ha.Among weed control treatments pre-em. application of pendimethalin fb. post-em. bispyribac recorded significantly higher paddy yield,straw yield and biological yield than all other weed control treatments.However application of pendimethalin to brown manuring treatment recorded significantly higher yield than no application of pendimethalin during both years.Significantly less yield was observed in unweeded (control) as compared to all other weed control treatments during both years.Higher yield in pre-em.pendimethalin fb. post- em. bispyribac treatment may be due to better control of paddy and non paddy weeds,and improved growth and yield attributes.Also application of pre-emergence pendimethalin in brown manuring treatment significantly increased paddy yield,straw yield and biological yield than its no application of pendimethalin which may be due to better control of weeds and good crop growth and yield attributes.Application of pre-em. pendimethalin fb. post-em. bispyribac,brown manuring in rice with pre-em. pendimethalin fb. bispyribac,Brown manuring in rice with post-em. bispyribac increased paddy yield by 95.3%,94.8% and 92.9 % during 2022 and 96.1%,94.6% and 94.1% during 2023" over unweeded (control) respectievely.

5.2.4 Quality parameters

5.2.4.1. Nitrogen content in seeds and straw (%)

There was successive and significant increase in nitrogen content of the seed and straw with the successive increase of nitrogen level from "0 kg N/ha to 175 kg N/ha.Among the weed control treatments , the significantly highest nitrogen content in seeds and straw was recorded in the pendimethalin fb. bispyribac than all other weed control treatments during both years.Among the brown manuring treatments,application of pendimethalin significantly improved N content in seed than without application of pendimethalin. The N content in unweeded (control) was significantly less than all other weed control treatments during both the years.

5.2.4.2. Nitrogen uptake by seed,straw,and total N uptake by crop (kg/ha)

Among the different nitrogen levels, significantly highest nitrogen uptake by seeds was observed in 175 kg N/ha as compared to other nitrogen levels.when recorded for both the years. There was progressive and significant increase in nitrogen uptake by seeds during both years with the subsequent increase in nitrogen level from 0 kg to 125 kg to 150kg to 175 kg/ha. The significantly low nitrogen uptake by seeds was observed in 0 kg N/ha compared to all other nitrogen levels for both the years. Among the weed control treatments ,significantly highest nitrogen uptake by seeds was recorded in the pendimethalin fb. bispyribac than all other weed control treatments when recorded for both the years.The significantly low nitrogen uptake by seeds was observed in unweeded (control) compared to all other weed control treatments during both the years.Application of pendmethalin fb. bispyribac with brown manuring treatment resulted in significant increase in N uptake by paddy seeds than alone application of bispyribac to brown manuring treatment during both years.

5.2.4.3 Nitrogen content and uptake by weeds

The data on nitrogen content and uptake by weeds revealed that with the successive increase in the nitrogen uptake by weeds with the increase in nitrogen levels from 0 kg to 175 kg N/ha.The highest nitrogen content and uptake by weeds was observed in 175 kg N/ha which was significantly more than all other nitrogen levels for both the years.. The lowest nitrogen uptake by weeds was observed in 0 kg N/ha which was significantly less than all other nitrogen levels during both the years. Among weed control treatments significantly more nitrogen uptake by weeds was observed in weedy check (control) treatment (52.44 kg N/ha) than all other weed control treatments for both the years .The lowest nitrogen uptake by weeds was observed in pendimethalin fb. bispyribac treatment (1.8 kg" N/ha) when compared with all other weed control treatments for both the years.

Salient findings:

• More weed count/sq.m and more weed biomass (q/ha) was observed in flat sowing technique than bed sowing as weed growth was comparatively less in bed sowing technique.

• Planting pattern of three rows per bed was found significantly better than other planting patterns with respect to paddy yield.

• Nitrogen level of 175 kg N/ha and 150 kg N/ha were found significantly superior over 125 kg N/ha and 0-kg N/ha for yield and yield yield attributes.

• Herbicide pendimethalin 0.75 kg/ha fb. bispyribac 25 g/ha was found as better weed control option than other treatments in both experiments.

• Brown manuring sesbania with application of pendimethalin 0.75 kg/ha fb. bispyribac 25 g/ha was found better option for weed control but brown manuring sesbania was not able to smoother weeds very effectievely.

• The yield reduction due to uncontrolled weeds in DSR is more than 96 percent indicating complete crop failure withhout proper control of weeds.

Recommendations:

- The planting pattern of three rows per bed along with the application of pendimethalin 0.75 kg/ha fb. bispyribac 25 g/ha, is beneficial to farmers in direct seeded rice.
- Nitrogen level of 175 kg N/ha and 150 kg N/ha along with the application of pendimethalin 0.75 kg/ha fb. bispyribac 25 g/ha, is beneficial to farmers in direct seeded rice.

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