

**“Effect of plant morphology and chlorophyll content
on weed dynamics, germination, growth, yield and
quality parameters of wheat (*Triticum aestivum* L.)”**



**Thesis submitted in partial fulfillment of the
requirements for the award of**

**Master of Science (Agriculture)
in
Agronomy**

Supervisor

Prof. Ram Kumar Singh

Submitted By

Alka Verma

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Through: The Head, Department of Agronomy, Institute of Agricultural Sciences,
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Sir,

I have great pleasure in forwarding the thesis entitled, topic **“Effect of plant morphology and chlorophyll content on weed dynamics, germination, growth, yield and quality parameters of wheat (*Triticum aestivum* L.)”** submitted by **Ms. Alka Verma, Examination I.D. No. 20412AGR001; Enrolment no. 383052** in partial fulfillment of the requirements for the degree of **Master of Science (Agriculture) in Agronomy** of the Banaras Hindu University and placing on record that she has completed the requisite requirements as contained in the statutes of the University.

I certify that the entire scheme of investigation reported herein was planned, and carried out solely by the candidate under my guidance and supervision. The data presented in the thesis, to the best of my knowledge and belief, are genuine and have not been utilized for the award of other degree or distinction.

Thanking you,

Yours faithfully,

Forwarded by

(Prof. Ram Kumar Singh)
Supervisor

Head

**Effect of plant morphology and chlorophyll content on weed dynamics,
germination, yield and quality parameters of wheat**



ESTABLISHED BY PARLIAMENT BY NOTIFICATION NO. 225 OF 1916

By
Alka Verma

**Thesis submitted in partial fulfillment of the
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**DEPARTMENT OF AGRONOMY
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ID. No. 20412AGR001

2022

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Date:

(Alka Verma)

Place: Varanasi

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LIST OF ABBREVIATIONS

%	-	Percentage
°C	-	Degree centigrade
/ha	-	Per hectare
@	-	At the rate of
CD	-	Critical Difference
cm	-	Centimetre
DAS	-	Days after sowing
dS/m	-	Deci Siemen per meter
e.g.	-	For example (<i>exempli gratia</i>)
B: C		Benefit –cost ratio
<i>et al.</i>	-	And others (<i>et alibi</i>)
<i>etc.</i>	-	And so forth (<i>et cetera</i>)
g	-	Gram
ha	-	Hectare
i.e.	-	That is (<i>id est</i>)
K	-	Potassium (<i>Kallium</i>)
kg	-	Kilogram
mg	-	Milligram
mm	-	Millimeter
MSL	-	Mean Sea Level
N	-	Nitrogen
No.	-	Number
NS	-	Non-significant
P	-	Phosphorus
ppm	-	Parts per million
Rs.	-	Rupees
SEm±	-	Standard Error of Mean
t	-	Tonnes
viz.	-	Namely(<i>videlicet</i>)
ANOVA	-	Analysis of Variance
Mt	-	Metric tonnes
LAI	-	Leaf Area Index

SLA	- Specific leaf area
LDM	- Leaf dry matter
LNC	- Leaf nitrogen content
RVI	- Ratio Vegetation Index
NDVI	- Normalized Difference Vegetation Index

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INTRODUCTION

Concerns over food security have prompted a rise in agricultural productivity, owing to the world's ever-increasing population, which is expected to reach 9.6 billion by 2050 (Ray *et al.*, 2012). Since the early 1980s, climatic constraints have resulted in decrease in global/capita cereal production but the rate of world population growth has outpaced food supply (Hafner *et al.*, 2003). Therefore, a new green revolution is required to address the global food security crisis by increasing the productivity of all key food and energy crops (G. Bai *et al.*, 2016).

Wheat is one of the oldest and most widely planted grain crops today. Bread wheat (*Triticum aestivum* L.) is an important staple crop that feeds 36 *per cent* (%) of the world's population (Maulana *et al.*, 2018). Wheat grain is a good source of carbohydrates, protein, and minerals for people (Shewry *et al.*, 2015). It provides 20 % of the calories consumed by humans. Its straw is also utilized in animal feed and other manufacturing processes (Tufail *et al.*, 2021).

Wheat was cultivated in an area of 215.90 million hectares (Mha) globally and contributed 778.6 million tonnes (Mt) to the global food basket in the year 2021. India rank 2nd both in context to area and productions in world next to China with productions of 110.00 Mt from an area of 31.60 Mha in 2021 (Anonymous, 2021).

Wheat output has barely increased by 0.5 % / year in recent years, significantly less than the required 1.4 % to meet the demands of an ever-growing human population (Reynolds *et al.*, 2009). In order to boost wheat output, increased grain productivity is required.

Grain yield is a complex metric that results from a multiplicative interplay of factors (Slafer *et al.*, 2014), they define wheat yield components as two key parameters: grain productivity and grain yield/spike. Grain yield/unit area comprises the number of

spikelets/spike, the number of grains/spike, and the grain size/spike and/or spikelet, whereas grain yield/spike includes the number of spikelets/spike, the number of grains/spike, and the number of spikelets/unit area. There are multiple interactions and compensation processes between the various yield components depending on genotype x environment x agronomy interactions (Slafer *et al.*, 2014). Increased assimilate partitioning to developing spikes and grains had the most impact on boosting wheat yield potential in the past, resulting in a higher harvest index but less biomass gain (M.J Foulkes *et al.*, 2011).

The sacrifice of some of the carbon in vegetative tissue and the transfer of that proportion to the grain has resulted in improvements in harvest index. An increase in above ground biomass on the other hand, must be accompanied by an increase in carbon capture, either through increased radiation interception or increased radiation usage efficiency (RUE). Shearman *et al.*, 2005).

Chlorophyll metre readings have been increasingly popular in recent years, particularly for controlling nitrogen (N) nutrition in cereals. Leaf colour is a major phenotypic trait of a crop that is influenced by crop growth conditions. SPAD is used to measure leaf colour that indirectly indicates N and chlorophyll content of leaf, thus reflecting the crop growth state and act as guide for crop management (Islam *et al.*, 2014).

In view of this context, a research entitled “**Effect of plant morphology and chlorophyll content on weed dynamics, yield and quality parameters of wheat**” was carried out at the Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi during the *Rabi* season of the year 2020-2021 and 2021-2022 with the following main objectives:

1. To find out the effects of wheat morphology on growth, yield, and quality in wheat.
2. To find out the effects of chlorophyll content on growth, yield, and quality in wheat.

3. To find out the effects of wheat morphology and chlorophyll content on weed dynamics.
4. To study the economics of treatments.



REVIEW OF LITERATURE

Inherent morphology and chlorophyll content play an instrumental role in deciding the potential yield and quality of wheat crop. The review of literature for the topic "**Effect of plant morphology and chlorophyll content on weed dynamics, germination, growth, yield, and quality parameters of wheat (*Triticum aestivum* L.)**" has been done in this chapter. Here it has been attempted to review the literature on the effects of chlorophyll content and morphology of wheat on crop-weed competition, quality, and yield attributes under the following headings:

2.1 Weed population dominance in wheat crop

2.2 Critical duration of crop weed competition in wheat crop.

2.3 Crop architecture and the ability to suppress weeds.

2.4 Effect of morphology on yield attributes and quality parameters.

2.5 Relationship between chlorophyll content, yield, and quality parameters.

2.6 Economics.

2.1 DOMINANT WEED POPULATION IN WHEAT CROP

Punia *et al.* (2018) reported the following broadleaf weeds *Rumex dentatus*, *Convolvulus arvensis*, *Anagallis arvensis*, *Chenopodium album*, *Lathyrus aphaca* and *Medicago denticulata* in their weedy check plot in an experiment on herbicides.

Labar *et al.* (2017) conducted an experiment at Regional Research Station, Bidhan Chandra Krishi Viswavidyalaya (BCKV), Chakdaha and they found weeds such as *Anagallis arvensis*, *Avena fatua*, *Phalaris minor*, *Cynodon dactylon*, *Cyperus rotundus*, *Cyperus iria*, *Chenopodium album*, *Cirsium arvense*, *Fumaria parviflora* in their experimental site.

Khokhar *et al.* (2010) conducted an experiment at the Agronomy farm, Rajasthan College of Agriculture, Udaipur and reported grassy weeds such as *Phalaris minor* and broadleaf weeds in wheat crop as *Chenopodium album*, *Chenopodium murale*, *Coronopus didymus*, *Convolvulus arvensis*, and *Melilotus indica*.

2.2 CRITICAL DURATION OF CROP WEED COMPETITION IN WHEAT CROP.

Weeds and crop plants compete for limited resources such as moisture, light, nutrients, and space, among other things. As a result, crop-weed competition is a critical factor limiting crop production. This happens when weeds and crops grow in the same field in close proximity, with a high likelihood of root and shoot overlap.

Paswan *et al.* (2017) suggested that when weeds come on the soil surface earlier than crops, they show a smothering effect on crops resulting in poor growth.

Martin and Field (1988) did a study and found the critical period for crop weed competition to be 30-45 DAS in wheat.

2.3 CROP ARCHITECTURE AND WEED SUPPRESSION ABILITY

Gail A. Wicks *et al.* (2017) did a study to find the characteristics of winter wheat cultivars that help in annual weed suppression and found that weed density showed a negative association with the number of winter wheat stems/m², mature winter wheat height, and lodging. After wheat harvest, total weed density was positively associated with the delayed sowing date of wheat and was negatively related to precipitation upto 30 days after winter wheat seeding, during tillering, tillering to boot stage, and heading to maturity stage.

K.M. Murphy *et al.* (2008) did a study on 63 landraces of wheat and found that yield showed a negative association with coleoptile length and a positive correlation with plant height, juvenile growth habit, thousand kernel weight, and LAI. Negative relations were found between weed weight and plant height and weed weight and

coleoptile length. Also, LAI did not show a direct effect on weed weight, plant height, thousand kernel weight (TKW), but LAI accounted for 38% of the variation in yield.

R. K. Vandeleur and G. S. Gill (2004) did a study to find the effect of crop breeding on competitive ability with weeds and found that leaf length, width, light interception, and flag leaf length, and mainly plant height, contributed to the better competitive ability of weed tolerant cultivars and the high weed suppressing ability of cultivars.

G.P. Seavers and K.J. Wright (2002) did a study on several winter cereals and weed suppression characteristics and found that cultivar competitive ability was related to more leaf area, the ability to not lose tillers under competitive pressure, more height, canopy structure and development.

2.4 EFFECT OF MORPHOLOGY ON YIELD ATTRIBUTES AND QUALITY PARAMETERS

2.4.1 Various morphological traits

Rameez Iftikhar *et al.* (2012) did a study to find inter-relationships among yield and yield related traits and found that grain yield has a positive correlation with peduncle length, spike length, grains/spike and TKW.

Mahmooda buriro *et al.* (2011) did a study and found that within same temperature range different varieties show different germination %.

Lauro Akio Okuyama *et al.* (2005) conducted an experiment to find an inter-relation between yield/spike and plant traits and found that yield/spike showed a positive direct effect and a positive correlation with spike length and culm diameter under irrigated conditions.

2.4.2 Spike and its effect on yield

Muhammad Irfan Ullah *et al.* (2021) did a study on 33 wheat lines to find relations between morphological traits and yield and found significant positive relationships at genotypic and phenotypic levels between grain yield and related traits, including spike length, number of spikelets/spike, grains/spike and TKW.

Gizaw M. Wolde *et al.* (2019) in an experiment on wheat spike architecture found that increased spikelets/spike and increased sink size led to more grain yield without affecting the thousand kernel weight.

Tobias Wurschum *et al.* (2018) did a study to find spike and kernel characteristics and their relation to grain yield and found that while the number of kernels/spike and spikelet fertility were significantly positively correlated, both traits showed a significant negative correlation with thousand-kernel weight and breeding success was mainly due to spikelet fertility.

Norman Philip *et al.* (2018) did a study on two winter wheat population to investigate how grain number and grain distribution along the spike are associated with yield attributing traits and changed over years in the breeding process and found that breeding improvement was due to an increase in grains and yield/spike in addition to grains and yield/spikelet. Breeding increased grain number and yield uniformly along the spike without changing the relative yield input of individual spikelets, it was concluded.

Zifeng Guo *et al.* (2018) showed on 12 wheat varieties that spike morphology can be changed by removal of tillers which results due to a change in carbon partitioning, this prediction and potentiality of altered spike morphology (was based on 44 traits and total and fertile spikelet number, spike length) displayed high prediction abilities.

A. J. Khan *et al.* (2010) did a study on 16 recombinant inbred lines of wheat under moisture stress condition for relationship among morphological traits and yield

and found that peduncle length had the highest direct effect on grain yield followed by tillers/m², grains/spike, spike length and days to maturity whereas peduncle extrusion, sheath length, TKW and plant height had a negative direct effect on the same parameter.

2.4.3 Height of wheat plant and association with yield attributes

Alex G. Ogg Jr. and Steven S. Seefeldt (2017) did a study to find the traits that affect the goat grass population most and concluded that cultivars with a higher growth rate will be competitive with goat grass in both drier and wet conditions.

Khalil Ahmed Laghari *et al.* (2010) compared fourteen new advanced lines of wheat (*Triticum aestivum* L.) to two local check varieties in yield performance experiments. The researchers looked at certain morphological (grain yield, plant height, 1000-grain weight, spike length, number of spikelets/spike, number of grains/spike, main spike yield) and phenological (days to ear emergence, maturity time and grain filling duration) data and found a negative correlation between plant height and yield.

Rameez Iftikhar *et al.* (2012) did a study to find inter-relationships among yield and yield-related traits and found that plant height had a negative direct effect on yield.

2.4.4 Effective tillers and its association with yield.

Quan Xie, *et al.* (2016) reported that more fertile tillers increased plant production and grain number without lowering individual shoot yield and grain set.

Elhani *et al.* (2007) reported that more tillers lead to more production/ha.

2.4.6 Leaf number per plant

Anil Kumar Rai *et al.* (2018), carried out an experiment at RVSKVV, College of Agriculture, Gwalior, Madhya Pradesh and found that the treatment that showed more leaf count/plant recorded maximum yield.

2.4.7 Leaf area index and yield

In a study of 63 wheat landraces, K.M. Murphy *et al.* (2008) discovered that yield was negatively correlated with coleoptile length and positively correlated with plant height, juvenile development behaviour, thousand kernel weight and Leaf Area Index (LAI).

2.4.8 Awns

L. Maydup *et al.* (2014) in a study found that awns can have both positive (increased photosynthetic area and activity, drought resistance) and negative (increased ear temperature) impacts on grain filling, and the final influence on yield will depend on how these effects interact with the surrounding environment.

2.4.9 Leaf inclination and its association with yield

Richards *et al.* (2019) did a study on a 4-way MAGIC population and on 8-way MAGIC population in New South Wales in both irrigated and dryland regions on several wheat genotypes to find a relation between leaf canopy architecture and yield and found that most erectophile MAGIC populations yielded 24% more than most planophilic MAGIC populations. Also, erectophile populations showed 13% more above ground mass than planophiles.

Monneveux *et al.* (2004) did a study on 167 lines of bread wheat cultivars to find the effect of leaf angle, leaf rolling, glaucousness, on yield and found that yield was not affected significantly by leaf angle, leaf rolling, but cultivars having higher grain yield had droopy leaves, whereas carbon isotopes and ash content were significantly related to higher grain yield.

Arous *et al.* (1993) did a study on wheat cultivars to find the effect of leaf posture on grain yield in Mexico for two years and found that droopy leaf lines had more yield than erect leaf lines but later had 5% to 16% more kernels/unit ground area.

2.4.10 Quality of wheat grains –

Azad *et al.* (2021) did a study on wheat variety BARI Gom 26 in the "North Eastern Barind Tract Soils" at Kushadaha, Nawabganj, Dinajpur, Bangladesh, to find relations between micro and macro nutrients on yield and yield attributing character and uptake by wheat crop and found that T₂: NPK + S showed the highest uptake by grain and straw of NPK and S.

Kairovin Lakra and Karam Husain (2020) found an increase in nutrient uptake by wheat crops due to the lower dry weight of weeds under these treatments, which aids in the improved usage of NPK as well as other elements. More yields, higher dry matter production, and higher nutrient content in various sections of plants all contributed to higher nutrient uptake.

Kumari *et al.* (2019) did a study to find the nutrient content of wheat grain and straw under moisture stress conditions and concluded that under control and moisture stress conditions, K, Zn, Fe and Mn concentrations were more in straw than in grain, and drought tolerant cultivars showed less uptake of nutrients in comparison to susceptible cultivars under moisture stress conditions.

Dong *et al.* (2015) did a study to assess wheat growth, morphological characteristics, biomass yield and quality parameters in different environments and found that environments with CO₂ on the higher side were good for non-edible biomass. Grain protein is inversely related to grain yield.

Sheoran *et al.* (2015) did a study and found that NPK uptake by grains and straw increased with an increase in concentration up to 200 mg of N/Kg of soil. They also found that NPK uptake increased significantly over 1% for vermicompost application over control. Also, they noticed a significant reduction in the uptake of NPK by grain and straw on application of Clodinafop propargyl at 60 and 90 g a.i./ha.

Weeds, according to Singh *et al.* (2013), have a greater propensity to deplete nutrients than wheat.

2.5 ASSOCIATION OF CHLOROPHYLL CONTENT WITH YIELD AND QUALITY ATTRIBUTES

Jiayi Zhang *et al.* (2019) conducted a study to find the usability of Green Seeker in monitoring growth status and predicting grain yield of winter wheat (*Triticum aestivum* L.) using multiple wheat cultivars and N treatments during 2013–2015. Duration models based on NDVI (Normalized Difference Vegetation Index) and RVI (Ratio Vegetation Index) were developed, which indicated that NDVI and RVI explained 80%, 68–70%, 10–12%, and 67–73% of the variability in LAI, LDM (leaf dry matter), LNC (leaf nitrogen concentration), and LNA (leaf nitrogen accumulation), respectively.

Ali *et al.* (2019) conducted a field experiment at two locations in Egypt in two consecutive years and found that measurements with Green Seeker were related with N uptake and yield of wheat through exponential function and could explain 68.50 % and 60.60 % of the variation in N uptake and grain yield, respectively.

Monostori *et al.* (2016) conducted a field experiment between 2012 and 2015, on forty winter wheat varieties in Hungary over three consecutive cropping seasons on two different nitrogen levels. Strong significant positive correlation was found between grain yield and SPAD values, but it was highly influenced by cultivars.

Yldrm *et al.* (2014) conducted an experiment on twenty-five durum wheat (*Triticum turgidum* L. var. *durum*) under irrigated and rain-fed conditions at two experimental sites in Diyarbakir, Turkey during 2005 and 2006. The study aimed to evaluate the genetic variation in SPAD readings and to determine relationships among SPAD readings, grain yield, grain quality and yield parameters. SPAD readings showed greater genotypic variance compared with grain yield and protein content and found a positive correlation between SPAD readings and grain yield.

Islam *et al.* (2014) did a study to determine the association between leaf chlorophyll and its association with yield and found that plants that received full doses of inorganic fertilizers had consistently greater SPAD readings than those that received

reduced doses of inorganic and/or organic fertilizers, resulting in increased grain yield. At various growth phases, the SPAD levels were favourably linked with grain yield.

Debaeke *et al.* (2007) conducted a three-year experiment on five *durum* wheat cultivars in Toulouse (in Southwest France) and discovered that the SPAD index cannot be used to predict nitrogen nutrition index when wheat is over-fertilized.

Franc Bavek and Martina Bavek (2006) conducted an experiment on thirteen wheat cultivars seeking a relationship between chlorophyll metre reading and grain yield and found that chlorophyll reading at EC 45/50 could only explain 37% of the impact of chlorophyll reading on grain yield.

Giunta *et al.* (2002) conducted an experiment on 17 cultivars of *durum* wheat, 8 triticale and 18 barley at two locations in Sardinia, Italy to find the association between SPAD readings, area/leaf blade, specific leaf area (SLA), LNC and leaf N/unit leaf surface and concluded that in *durum* wheat and triticale, SPAD readings were genetically correlated with SLA.

2.6 ECONOMICS-

D'ixon *et al.* (2005) concluded that wheat genetic advancement has contributed to a constant rise in yields of wheat and thus increased the benefit-cost ratio.

Islam *et al.* (2014) found that the levels of SPAD were positively correlated with grain yield; thus, cultivars with high SPAD readings are high in economic importance.



MATERIALS AND METHODS

The field experiment "**Effect of plant morphology and chlorophyll content on weed dynamics, germination, growth, yield and quality parameters of wheat (*Triticum aestivum* L.)**" was conducted during the *Rabi* season of the year 2020–21 and 2021-2022 at the Agriculture Research Farm, Banaras Hindu University, Varanasi, to better understand the effect of morphology and chlorophyll content on wheat. This chapter attempts to detail the numerous methods and materials employed, as well as the procedures followed, during the experimentation phase.

3.1 EXPERIMENTAL SITE

The research was carried out at the Agriculture Research Farm, Banaras Hindu University, Varanasi, which is located at 25 18 'N latitude and 83 30' E longitude at a height of 128.93 m above mean sea level. The area is part of Uttar Pradesh's Eastern Plain Zone (Zone-8).

3.2 CLIMATE AND WEATHER CONDITION

Varanasi's climate is typically sub-tropical, with hot and dry summers and bitterly cold winters. The region receives an average of 1081.5 mm of precipitation/year, with the South West Monsoon accounting for the vast majority (87%) (June-September). In this area, potential evapotranspiration is at 1525 mm with a moisture deficit of 425 mm. Maximum and minimum temperatures ranged from 17.5 to 40.7 °C (degree centigrade) and 7.5 to 22.1 °C , respectively, during the *Rabi* season 2020–2021. The maximum and minimum temperatures in *Rabi* season 2021–2022 ranged from 18.5–40.0°C, and 6.7–21.9°C respectively. The total amount of rain that fell during the *Rabi* season 2020–2021 was 4.2 mm and 69.2 mm during the *Rabi* season 2021–22. During *Rabi* season 2020–2021, the average weekly humidity was 45.10% in the evening and 82.95% in the morning, During *Rabi* season 2021–2022, the average

weekly humidity was 52.76% in the evening and 88.52% in the morning. Table 3.1, 3.2 and Fig 3.1, 3.2 show the mean weekly weather data for the cropping season.

3.3 PHYSICO-CHEMICAL PROPERTIES OF SOIL AT EXPERIMENTAL SITE

Soil samples from different spots of the experimental field at 0–15 cm depth were collected at random for studying the physical and chemical properties of soil, and after proper drying, mixing, and sieving, a composite sample was formulated, which was then analyzed for different physico-chemical characteristics of soil. The physico-chemical parameters of the soil in the experimental field are shown in Table 3.3 and 3.4. The soil texture of the experimental site was alluvial and sandy clay loam, and the soil pH was neutral. It had low organic C and available N content, medium P content, and medium available K content.

3.4 CROPPING HISTORY

Prior to the present study following crops were grown at the experimental site.

Year	<i>Kharif</i>	<i>Rabi</i>
2017	Paddy	Wheat
2018	Paddy	Wheat
2019	Maize	Wheat

3.5 DETAILS OF EXPERIMENT

During the *Rabi* season of 2020-21 and 2021-2022, a study titled “**Effect of plant morphology and chlorophyll content on weed dynamics, germination, growth, yield and quality parameters of wheat (*Triticum aestivum* L.)**” was conducted, the experiment was set up in a Randomized Block Design with five treatments and four replications. Table 3.5, 3.6 provide detailed information on the treatments used in this investigation.

3.5.1 Field preparation

In order to achieve a fine tilth for wheat cultivation, the experimental field was ploughed twice with a cultivator and then harrowed twice with a rotary cultivator. The plots were marked out, as were the routes. Bundles and irrigation ditches were built to separate the plots according to the layout plan. (Fig. 3.3 and 3.4)

3.5.2 Fertilizer

Urea, DAP (Diammonium phosphate) and MOP (Muriate of Potash) were used to provide the recommended dose of fertilizer for wheat, which was 150-60-40 Kg NPK.

3.5.3 Seed sowing and treatment

5 wheat varieties were used, each was given different treatment name. The treatment name was kept same for particular variety for both the years of trials. In order to avoid any biasness variety names were not disclosed (Table 3.9). The seeds were sown at 20 cm row spacing and 10 cm plant-to-plant spacing using a seed rate of 100 Kg/ha. (Seed rate may vary in actual practice from variety to variety, but in order to maintain homogeneity same seed rate was used for all the treatments.)

Table 3.9 Details of treatment for *Rabi* 2020-2021 and 2021-2022.

Variety number	Treatment name
1	Treatment 1 (T ₁)
2	Treatment 2 (T ₂)
3	Treatment 3 (T ₃)
4	Treatment 4 (T ₄)
5	Treatment 5 (T ₅)

3.5.4 Irrigation

Irrigation was applied to the crop during important growth stages (Table 3.7 and 3.8).

3.5.5 Harvesting and threshing

When the crop reached maturity, it was harvested. Plants from the border area were picked and preserved in a separate location. The net area plants were harvested, and the produce was tied and tagged in bundles. After sufficient sun drying, the bundles were weighed to determine the biological yield plot by plot. A thresher was used to thresh the grain. To record grain yield/plot, the output was winnowed, cleaned, and weighed individually.

3.6 TREATMENT EVALUATION

3.6.1 OBSERVATION ON WEEDS

3.6.1.1 Weed density

Individual weed species were counted by placing a 0.25 m² quadrat at a randomly selected place, which was devoid of weeding, in each plot at 30, 60, and 90 DAS. No./m² was used to represent the ultimate weed count. Major broad-leaved weeds and narrow-leaved weeds were counted separately in the experimental field. To standardize the distribution of the data, the square root transformation $x+0.5$ was applied (Gomez and Gomez, 1984).

3.6.2 OBSERVATIONS ON WHEAT

3.6.2.1 Growth parameters

3.6.2.1.1 Germination %

The plant population was counted at 8–10 DAS in order to assess the germination %. In each plot, the three centre rows were used to count the number of plants/m of row length. The ratio of no. of plants that emerged to the seed sown was calculated and used to find germination %.

3.6.2.1.2 Plant height

The plant height of five randomly selected plants from each treatment plot was measured at various growth phases and an average was calculated to express the plant height in centimeters (cm).

3.6.2.1.3 Number of tillers

At 30, 60 and 90 DAS, as well as at the harvest, the number of tillers was counted/plant from the randomly selected plants that were tagged. Plants were selected excluding border rows.

3.6.2.1.4 Leaf count

At 30, 60 and 90 DAS, the number of leaf was counted/plant from the randomly selected plants that were tagged. Plants were selected excluding border rows.

3.6.2.1.5 Awn length

In order to represent the average awn length, length of awns in middle region of spike was measured in cm.

3.6.2.1.6 Flowering per cent

In order to find flowering % treatments were observed visually for 50%, 75% and 100% flowering.

3.6.2.1.7 LAI (Leaf Area Index)

At 30, 60 and 90 days after sowing, leaf area and leaf area index were measured using leaf area meter from the tagged plants, and then leaf area index was computed.

The following formula, was used to calculate LAI

$$\text{LAI} = [\text{Leaf area (m}^2\text{)} / \text{Ground cover (m}^2\text{)}]$$

3.6.2.1.8 Leaf orientation

Leaf orientation value was measured in the field using a ruler and protractor and calculated according to Pepper (1977) as follows:

$$\text{LOV} = \sum_{i=1}^n [\theta (l_f / l)]_i / n$$

where θ is the leaf angle from horizontal at the stalk, l_f is the length from the leaf collar to "flagging point" (cm), l is the total leaf blade length (cm), and n is the measured leaf number ($n = 30$).

3.6.2.2 SPAD reading

At 30, 60 and 90 DAS, SPAD reading was taken using SPAD meter from the randomly selected plants that were tagged. Plants were selected excluding border rows.

3.6.2.3 Yield and yield attributes

3.6.2.3.1 Spike length

Five different plants' spike lengths were measured from the neck to the tip of the spike and expressed in cm.

3.6.2.3.2 Grain number/spike

The number of grains in each spike was counted after each spike was threshed independently. The number of grain no./spike was computed as a mean.

3.6.2.3.3 Test weight

A thousand seeds were counted at random from the representative grain sample, and their weight was determined in grams.

3.6.2.3.4 Grain yield

Each net plot's yield was threshed and collected separately, and its weight was calculated and translated to a hectare basis.

3.6.2.3.5 Straw yield

The straw yield was calculated by subtracting the grain yield from each net plot's biological yield. Then it was converted to a hectare basis.

3.6.2.3.6 Biological yield

Biological yield is defined as the sum of grain and straw yields. Before threshing, the weight of the whole output was measured and expressed in Kg/ha

3.6.2.3.7 Harvest index

Donald (1976) formulated an expression for determining the harvest index which took into account the economic yield (grain yield) and biological yield.

$$\text{Harvest Index} = \frac{\text{Economic Yield}}{\text{Biological yield}}$$

3.6.3 NUTRIENT UPTAKE BY CROP

At the harvest stage, the nutrient content depleted by the crop was calculated. The N content of crops was calculated using the Kjeldahl method, as recommended by Jackson, on a % dry weight basis (1967). Similarly, the Vandomolybdate phosphate yellow colour method (Johnson and Ulrich, 1969) and Flame photometry (Jackson, 1967) was used to calculate P and K. The following formulae were used to calculate nutrient uptake.

$$\text{Nutrient uptake by crop (Kg/ha)} = \text{Nutrient Content (\%)} \times \text{Total yield (straw + grain) (Kg/ha)}$$

3.6.4 ECONOMICS

3.6.4.1 Cost of cultivation

In order to determine the most remunerative treatment for crop production, the cost incurred in carrying out all the cultural operations from land preparation to harvesting and threshing of crop was worked out including the cost of all inputs *i.e.*, seeds, fertilizers, irrigation, etc.

3.6.4.2 Gross returns

The gross returns were calculated out by taking into consideration the mean grain and straw yield obtained on per hectare basis and estimating the monetary returns based on the current Minimum Support Price (MSP) prevailing in the market.

3.6.4.3 Net returns

The net returns were computed by deducting the cost of cultivation from the gross returns.

3.6.4.4 Benefit-cost ratio

The Benefit: cost was estimated by the following formulae

$$\text{B: C Ratio} = \frac{\text{Net Return}}{\text{Cost of Cultivation}}$$

3.7 STATISTICAL ANALYSIS

The data from the experimental study's numerous characters were statistically analyzed using analysis of variance in accordance with Randomized Block Design (RBD) in field experiments and the F test was used to determine the relevance of the treatment (Gomez and Gomez, 1984).

The critical difference for each significant data point was calculated and provided below the data at a 5% level of significance for field experiment studies and a 1% level of significance for laboratory estimation.

Table 3.1: Standard week-wise meteorological observation during the crop season 2020-2021, Meteorological Observatory, Institute of Agricultural Sciences, BHU, Varanasi

Week No.	Month & Date	Rainfall mm	Temperature °C		R.H. %		Wind Speed km/hr	Sunshine hours	Evaporation mm
			MAX	MIN	Morn.	Even			
49	Dec 03-09	0.0	27.7	12	93	53	0.9	3.5	1.2
50	10-16	3.6	23.9	14.8	93	64	1.8	2.1	1.4
51	17-23	0.0	20.5	7.5	91	59		5.6	1.3
52	24-31	0.0	22.3	7.8	94	49		5.2	1.2
1	Jan 1-7	0.0	25.4	12.3	90	54		3.3	1.1
2	8-14	0.0	21.7	13.0	92	59		2.3	1.6
3	15-21	0.0	19.4	8.1	95	65		0.2	1.0
4	22-28	0.0	17.5	9.2	95	71		2.2	1.0
5	29-04	0.0	22.3	7.3	96	46		4.5	1.25
6	Feb 05-11	0.6	24.6	10.8	91	50		6.5	1.7
7	12-18	0.0	28.4	12.4	90	37		7.6	1.9
8	19-25	0.0	29.0	13.7	85	41		7.3	2.6
9	26-04	0.0	30.7	15.4	79	34		9.1	3.8
10	March 05-11	0.0	32.7	17.0	88	36		6.5	4.5
11	12-18	0.0	32.3	17.7	87	39		4.7	6.3
12	19-25	0.0	34.5	20.7	64	40		4.4	5.1
13	26-01	0.0	36.0	17.8	73	23		5.6	5.6
14	April 02-08	0.0	38.8	18.9	74	20		6.5	6.3
15	09-15	0.0	35.3	20.2	60	25		2.9	6.9
16	16-22	0.0	37.3	22.1	58	38		6.0	6.4
17	23-29	0.0	40.7	20.7	-	-		9.8	4.9
18	30-06	0.0	38.9	23.7	54	46		5.2	6.7

Table 3.2: Standard week-wise meteorological observation during the crop season 2021-2022, Meteorological Observatory, Institute of Agricultural Sciences, BHU, Varanasi

Week No.	Month & Date	Rainfall mm	Temperature °C		R.H. %		Wind Speed km/hr	Sunshine hours	Evaporation mm
			MAX	MIN	Morn.	Even			
49	Dec 03-09	0.0	26.8	12.8	97	54	0.6	4.2	1.2
50	10-16	0.0	24.6	8.6	94	44	0.5	5.4	1.2
51	17-23	0.0	22.3	7.2	91	53	1.1	6.0	1.3
52	24-31	8.6	21.9	10.0	97	72	1.0	3.1	0.8
1	Jan 1-7	1.2	19.2	8.8	98	75	0.9	3.3	0.6
2	8-14	5.4	22.1	11.8	96	74	1.4	1.6	0.9
3	15-21	0.0	18.5	6.7	93	70	1.6	2.2	1.2
4	22-28	49.0	20.0	9.8	94	68	3.1	3.4	1.7
5	29-04	4.3	22.7	8.6	94	61	3.7	7.2	1.9
6	Feb 05-11	0.0	22.6	9.6	94	57	2.9	5.7	2.0
7	12-18	0.0	25.0	7.9	92	47	2.6	9.6	2.7
8	19-25	0.3	26.7	12.3	90	59	3.7	8.7	3.2
9	26-04	0.4	28.6	12.5	95	53	1.9	8.4	2.9
10	March 05-11	0.0	29.7	13.5	89	54	2.4	9.4	3.5
11	12-18	0.0	32.9	16.6	89	53	2.4	8.9	4.1
12	19-25	0.0	36.5	19.3	85	49	2.3	8.7	4.6
13	26-01	0.0	38.0	18.6	79	39	3.1	9.4	5.9
14	April 02-08	0.0	40.2	18.1	76	31	2.6	9.7	6.5
15	09-15	0.0	40.5	21.6	78	33	3.1	9.4	6.2
16	16-22	0.0	40.9	21.9	73	32	3.4	9.8	7.5
17	23-29	0.0	42.0	20.9	65	30	3.8	10.1	8.6

Table 3.3: Physicochemical properties of the soil for the year 2020-2021.

A. Mechanical Composition			
1. Coarse sand (%)	52.87	-	Bouyoucos hydrometer method (Bouyoucos, 1962)
2. Silt (%)	23.67	-	
3. Clay (%)	25.07	-	
Soil textural class	Sandy clay loam		
B. Chemical properties			
pH (1:2.5)	7.15	Neutral	Potentiometric method (Jackson, 1973)
EC (1:2.5) (d/Sm)	0.25	Low	Conductometric method (Jackson, 1973)
Organic carbon (%)	0.37	Low	Modified Walkley and Black method (Black, 1965)
Available N (Kg/ha)	217	Low	Alkaline potassium permanganate method (Subbaiah and Asija, 1956)
Available P ₂ O ₅ (Kg/ha)	17	Medium	Olsen’s Method (Olsen <i>et al.</i> 1954)
Available K ₂ O (Kg/ha)	196	Medium	Flame photometric method (Jackson, 1967)

Table 3.4: Physicochemical properties of the soil for the year 2021-2022.

Particulars	Values	Status	Methods
A. Mechanical Composition			
1. Coarse sand (%)	52.87	-	Bouyoucos hydrometer method (Bouyoucos, 1962)
2. Silt (%)	23.67	-	
3. Clay (%)	25.07	-	
Soil textural class	Sandy clay loam		
B. Chemical properties			
pH (1:2.5)	7.25	Neutral	Potentiometric method (Jackson, 1973)
EC (1:2.5) (d/Sm)	0.2	Low	Conductometric method (Jackson, 1973)
Organic carbon (%)	0.35	Low	Modified Walkley and Black method (Black, 1965)
Available N (Kg/ha)	214	Low	Alkaline potassium permanganate method (Subbaiah and Asija, 1956)
Available P ₂ O ₅ (Kg/ha)	16	Medium	Olsen’s Method (Olsen <i>et al.</i> 1954)
Available K ₂ O (Kg/ha)	198	Medium	Flame photometric method (Jackson, 1967)

Table 3.5 Details of experiment carried out during the Rabi 2020-2021

Experimental Design	RBD
Treatments	5
Replications	4
Total number of plots	5 x 4 = 20
Gross plot size	5.0 m x 4.3 m = 21.5 m ²
Net plot size	4.3 m x 3.3 m = 8 m ²
Row spacing	20.0 cm
Plant to plant spacing	10.0 cm
Seed rate (Conventional tillage)	100 Kg/ha
Irrigation channel	1.5 m
Fertilizer dose	150 Kg/ha N, 60 Kg/ha P ₂ O ₅ , 60 Kg/ha K ₂ O
Fertilizer source	N(urea), P ₂ O ₅ (DAP), K ₂ O (MOP)

NOTE – Seed rate may vary according to varieties, but here taken same for experimental purpose.

Table 3.6: Details of experiment carried out during the Rabi 2021-2022.

Experimental Design	RBD
Treatments	5
Replications	4
Total number of plots	5 x 4 = 20
Gross plot size	5.0 m x 4.3 m = 21.5 m ²
Net plot size	4.3 m x 3.3 m = 8 m ²
Row spacing	20.0 cm
Plant to plant spacing	10.0 cm
Seed rate (Conventional tillage)	100 Kg/ha
Irrigation channel	1.5 m
Fertilizer dose	150 Kg/ha N, 60 Kg/ha P ₂ O ₅ , 60 Kg/ha K ₂ O
Fertilizer source	N(urea), P ₂ O ₅ (DAP), K ₂ O (MOP)

NOTE – Seed rate may vary according to varieties, but here taken same for experimental purpose.

Table 3.7: Schedule of cultural operations for *Rabi* 2020-2021 trial.

Sl. No.	Operation	Date of Operation	Methods/Implements used
1.	Ploughing	12.12.2020	Tractor drawn cultivator
2.	Harrowing	13.12.2020	Tractor drawn rotary cultivator
3.	Layout	14.12.2020	Manually
4.	Sowing	15.12.2020	Manually
5.	Fertilizer application	07.01.2021 14.02.2021	Manually
7.	Irrigation I II III	06.01.2021 02.02.2021 01.03.2021	Check basin method
8.	Weeding	17/01/2021	Manually
8.	Harvesting	24/04/2021	Manually by sickle
9.	Threshing	28/04/2021	Thresher

Table 3.8: Schedule of cultural operations for Rabi 2021-2022 trial.

Sl. No.	Operation	Date of Operation	Methods/Implements used
1.	Ploughing	12.12.2020	Tractor drawn cultivator
2.	Harrowing	13.12.2020	Tractor drawn rotary cultivator
3.	Layout	14.12.2020	Manually
4.	Sowing	15.12.2020	Manually
5.	Fertilizer application	07.01.2021 14.02.2021	Manually
7.	Irrigation I II III	06.01.2021 02.02.2021 01.03.2021	Check basin method
8.	Weeding	17/01/2021	Manually
8.	Harvesting	24/04/2021	Manually by sickle
9.	Threshing	28/04/2021	Thresher

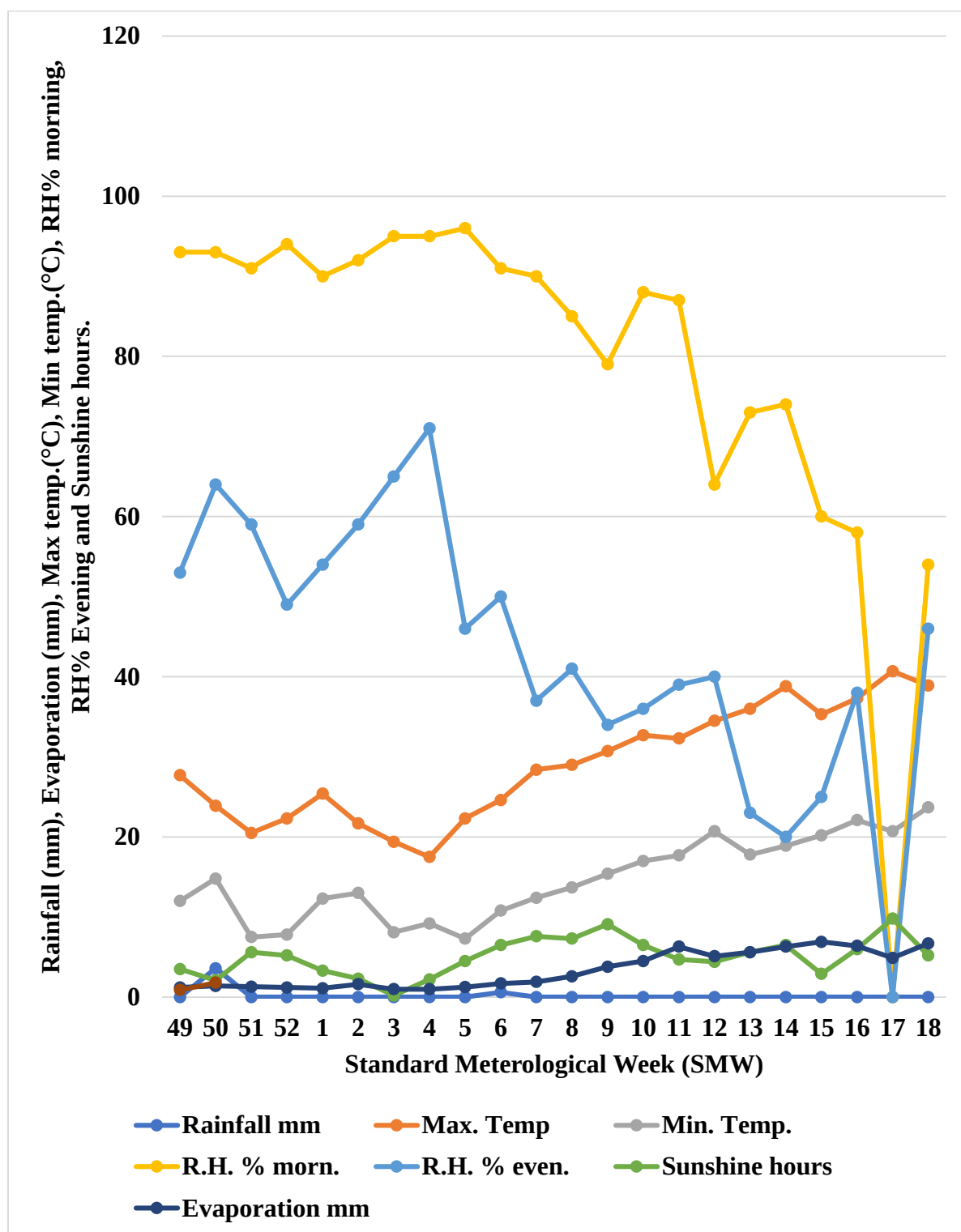


Fig. 3.1: Standard week-wise meteorological observation during the crop season 2020-2021, Meteorological Observatory, Institute of Agricultural Sciences, BHU, Varanasi

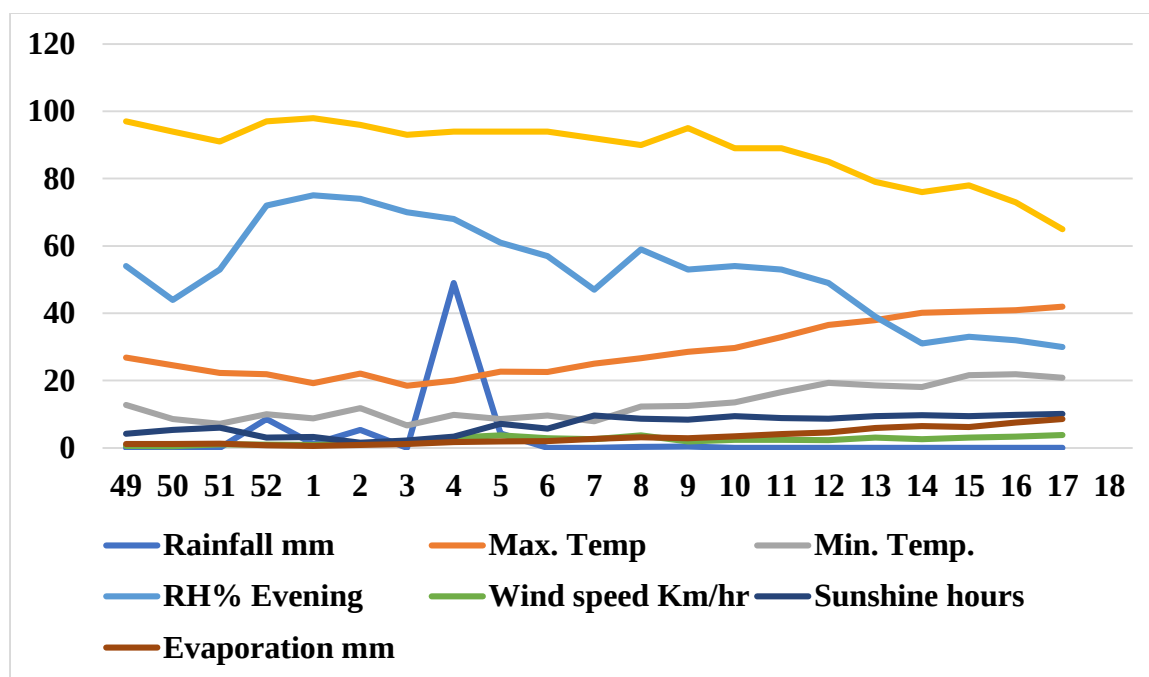


Fig: 3.2: Standard week-wise meteorological observation during the crop season 2020-2021, Meteorological Observatory, Institute of Agricultural Sciences, BHU, Varanasi.

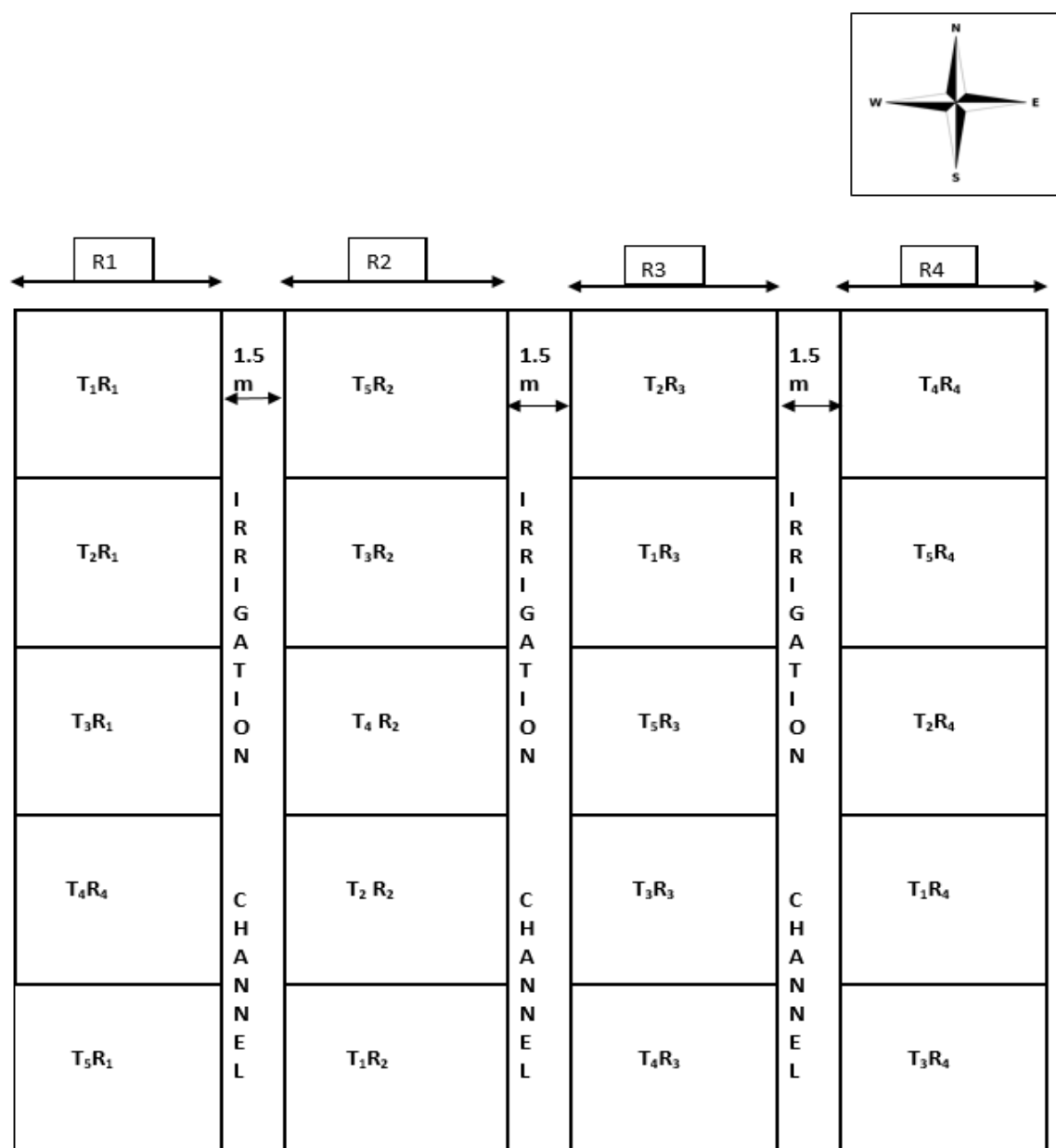
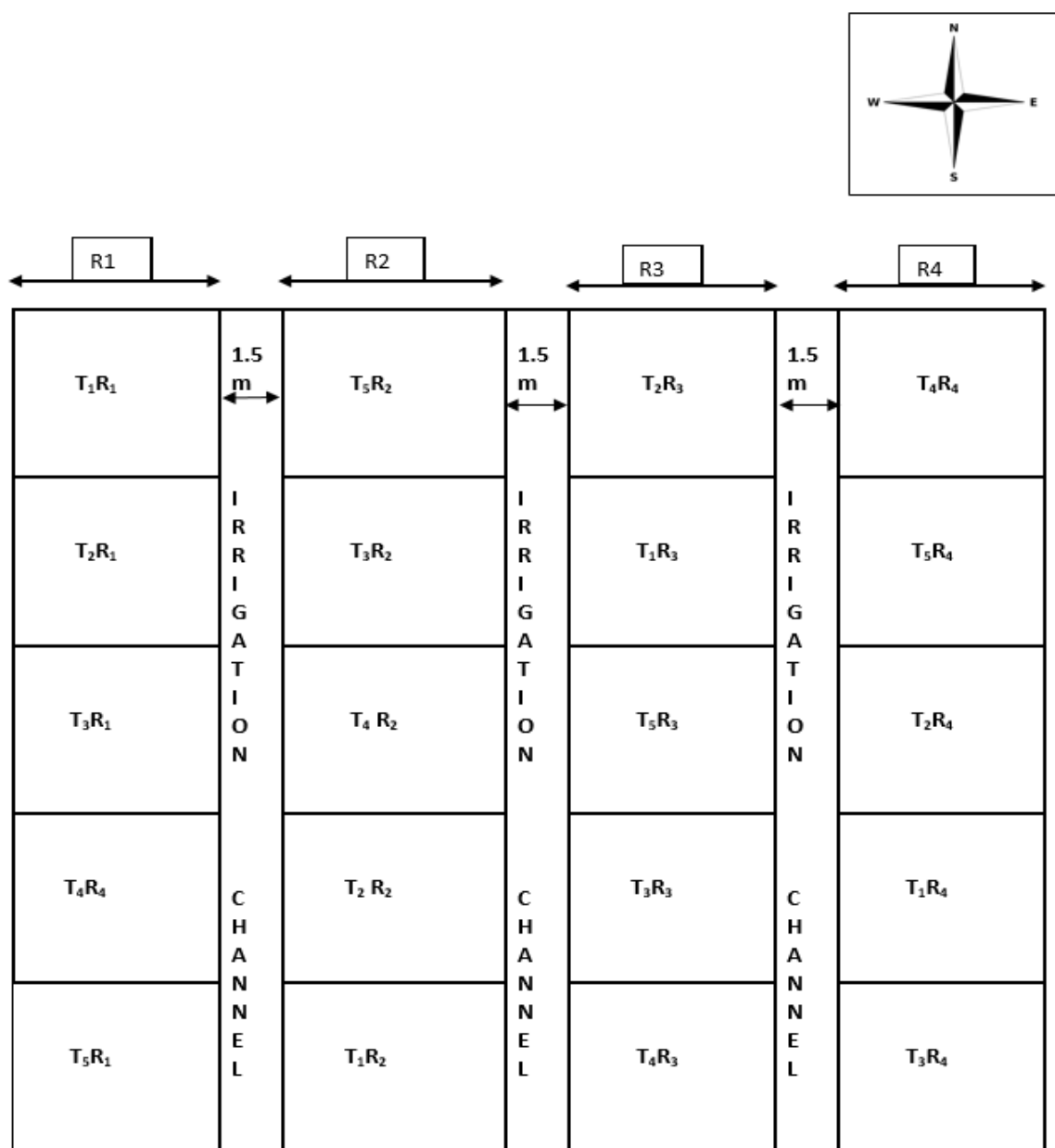
Fig. 3.3: Layout plan of the experimental site during *Rabi* 2020-2021

Fig. 3.4: Layout plan of the experimental site during *Rabi* 2021-2022

EXPERIMENTAL FINDINGS

This chapter includes detailed tables, graphs, and statistical inferences from a field experiment titled "**Effect of plant morphology and chlorophyll content on weed dynamics, germination, yield, and quality parameters of wheat**" that was conducted at the Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi during the *Rabi* seasons 2020-2021 and 2021-2022.

4.1 WEED STUDY

4.1.1 Weed flora

The field where the experimental study was undertaken was infested with weeds. These weeds can be broadly categorised into narrowleaf weeds and broadleaf weeds based on leaf morphology. Broad-leaved weeds found in the field included *Chenopodium album* L., *Anagallis arvensis* L., *Parthenium hysterophorus* L., and narrow-leaved weeds such as *Cynodon dactylon* Pers., *Phalaris minor* Retz., (Tables 4.1 and 4.2) in both the years.

4.1.2 Weed density

4.1.2.1 Broad-leaved weeds

4.1.2.1.1 *Chenopodium album*

A careful examination of (Table 4.3 and Fig. 4.1) reveals that the highest weed density was observed in T₅ at 30 DAS, 60 DAS and 90 DAS (14.0, 35.0 and 52.0/m², respectively in the *Rabi* 2020–2021 and 12, 31.75 and 51.50/m² in the *Rabi* 2021–2022 and least in T₁(0, 0, 12/m² at 30 DAS, 60 DAS and 90 DAS respectively in the *Rabi* 2020–2021 and 0, 0, 11.50/m² in the *Rabi* 2021–2022 at 30 DAS, 60 DAS and 90 DAS respectively due to T₁s' superior crop growth over T₅. In both the years at 30 DAS and 60 DAS, *Chenopodium album* weed density was observed at par in T₁, T₂, T₃ and T₄. In

both the years at 30 DAS, T₅ was significantly higher than the rest of the treatments. In the rest of the treatments, weed density was negligible at 30 DAS. In both years at 60 DAS, T₅ was found to have significantly higher weed density than the rest of the treatments. In years 2020–2021, at 60 DAS, T₂, T₃ and T₄ were found to be at par with each other with very minimal weed count, and in years 2021–2022, T₁, T₂, T₃ and T₄ were at par with each other. At 90 DAS, T₁, T₂, T₃ and T₄ were on par with each other. T₅ reported the highest weed density. T₄ and T₅ were found to be comparable in the years 2020–2021 but significantly different in the years 2021–2022. (Table 4.4 and Fig.4.2)

4.1.2.1.2 *Anagallis arvensis*

A perusal of data pertaining to *Anagallis arvensis* recorded under Table 4.5 and Fig. 4.3 (2020-2021) implies that all the treatments were at par with each other at 30 DAS and at 60 DAS. The highest weed density was found in T₅ (134/m²) and the lowest in T₁ (38.25/m²) at 90 DAS due to more plant height in T₁ in comparison to T₅ and thus suppressing weed growth. However, at 90 DAS, T₁ and T₂ were found at par with each other and T₃, T₄ and T₅ were at par with each other but T₅ was significantly different than the rest of the treatments.

A perusal of data pertaining to *Anagallis arvensis* recorded under Table 4.6 and Fig. 4.4 implies that in year 2021-2022 all the treatments showed non-significant result for *Anagallis arvensis* density at 30 DAS and 60 DAS. At 90 DAS, T₁ and T₂ were found at par with each other; T₁ recorded least weed density (36.50/m²) and T₃, T₄, and T₅ were at par with each other but T₅ was significantly higher than the rest of the treatments.

4.1.2.1.3 *Parthenium hysterophorus*

A perusal of data pertaining to Congress grass weed density (2020–2021) as recorded under Table 4.7 and Fig. 4.5 implies that all the treatments were at par with each other at 30 DAS. The highest weed density was found in T₅ at 60 DAS and 90 DAS (56.00/m², 111.90/m² in 2020-2021), and the lowest weed density was found in T₁ (1.00 and 60.00/m² at 60 DAS and 90 DAS respectively). T₁ and T₂ were found to be

on par with each other at 60 and 90 DAS. At 90 DAS, T₁, T₂ and T₃ were at par with each other but significantly different than T₄ and T₅, while T₄ and T₅ treatments were found at par with each other. It could be because T₁ and T₂ have a higher competitive ability than others due to more height, better tillering and LAI.

An experimental trial conducted in *Rabi* 2021–2022 yielded similar results, with T₅ reporting the highest weed density (55.00/m²; 110.08/m² at 60 and 90 DAS, respectively; and T₁ reporting the lowest weed density (1,13.35/m²); (Table 4.8 and Fig. 4.6)

4.1.2.2 Narrow-leaved weed density

4.1.2.2.1 *Phalaris minor*

A perusal of data pertaining to weed density (2020–2021) as recorded under Table 4.9 showed no significant effect of treatments on *Phalaris minor*, however, T₁ recorded the least weed density at 30 DAS, 60 DAS and 90 DAS, whereas T₅ recorded the maximum weed density in all the treatments were reported at 60 DAS, and later on declined owing to completion of life cycle. Similar results were obtained in an experimental trial conducted in *Rabi* 2021–2022 with T₅ reporting the highest weed density and T₁ reporting the least weed density but with no significant difference in weed density (Table 4.10)

4.1.2.2.2 *Cyanodon dactylon*

A perusal of data pertaining to weed density (2020–2021) as recorded under Table 4.11 and Fig. 4.7 reveals that T₁ recorded the least weed density at 30 DAS (4.00/m²) whereas T₅ recorded the maximum (27.00/m²) at 30 DAS, T₁ and T₂ were at par with each other, but T₁ was significantly different than the rest of the treatments. T₅ was at par with T₄ but significantly different than the rest of the treatments. At 60 DAS and 90 DAS all treatments were on par with each other.

Similar results were obtained in an experimental trial conducted in *Rabi* 2021–2022 with T₅ reporting the highest weed density and T₁ reporting the least weed density (26.50/m² and 3.30/m², respectively), at 30 DAS (Table 4.12 and Fig. 4.8). It could be

because T₁ and T₂ have a higher competitive ability than others owing to good height and better tillering.

4.2 STUDIES ON WHEAT CROP

4.2.1 GROWTH PARAMETERS

Growth is an irreversible process in which one's size, dry weight, or volume increases. At various stages of crop growth, plant growth features such as germination %, plant height, tiller count, leaf count, and LAI were assessed.

4.2.1.1 Germination *per cent*

A perusal of data pertaining to germination % (2020-2021) in Table 4.13 and Fig. 4.9 revealed that T₁ showed the highest germination rate (82.47 %) and T₅ showed the least with 69.07% germination. T₁ and T₂ were at par with each other; T₄ and T₅ were at par with each other. Similar results were obtained in an experimental trial conducted in *Rabi* 2021–2022 with T₁ reporting the highest germination (84.48%) and T₅ reporting the least (71.08%). (Table 4.14 and Fig. 4.10).

4.2.1.2 Plant height

A review of the data (Table 4.15 and Fig. 4.11) for plant height (2020–2021) revealed that the treatments had no discernible influence on plant height at 60 DAS. At all other stages of crop development, the T₁ had the highest plant height (23.43 cm, 73.85 cm, and 95.65 cm at 30, 60, 90 DAS and harvest, respectively). The shortest plant height was reported from T₅ at 30, 90 DAS, and at harvest. The results were obtained due to the genetic superiority of T₁ and T₂ compared to the rest of the treatments. Similar results were obtained in an experimental trial conducted in *Rabi* 2021–2022 where T₁ showed the greatest height (27.63, 98.65, and 105.75 cm at 30 DAS, 90 DAS, and harvest, respectively) and T₅ showed the least. (Table 4.16 and Fig. 4.12)

4.2.1.3 Tiller count

A perusal of data pertaining to tiller count (2020–2021) as recorded under Table 4.17 and Fig. 4.13 reveals that the tiller count (number/plant) increased until 90 DAS, after which it began to fall as the crop approached harvest stage. At the 60 DAS, 90 DAS, and harvest stages of the crop, all treatments had a substantial impact on the tiller count.

The T₁ treatment had the highest tiller count (2.75, 4.75, 4.75/plant at 60, 90 DAS and at harvest stages, respectively), which was significantly higher than treatments T₂, T₃, T₄ and T₅.

T₃ had the lowest tiller count at all stages of crop development. The results were obtained due to the genetic constitution of T₁ and T₂ compared to the rest of the treatments. Similar results were obtained in an experimental trial conducted in *Rabi* 2021–2022 where T₁ showed the greatest tiller count/plant (4.25, 5.25 and 4.50 at 60 DAS, 90 DAS and harvest, respectively) and T₃ showed the least (2.91, 3.75 and 2.83 at 60 DAS, 90 DAS and at harvest, respectively). Table 4.18 and Fig. 4.14.

4.2.1.4 Leaf count

A perusal of data pertaining to leaf count (2020-2021) as recorded under Table 4.19 and Fig. 4.15 revealed significant differences in leaf count at 30, 60 and 90 DAS. T₁ had the highest leaf count (4.00, 10.00 and 15.75/plant at 30 DAS, 60 DAS and 90 DAS, respectively), and T₃ showed the least leaf count (2.25, 5.25 and 12.00 at 30 DAS, 60 DAS and 90 DAS, respectively). At 30 DAS, T₁ and T₂ had the highest leaf counts, followed by T₅. T₁, T₂ and T₄ were found to be on par with each other at 60 and 90 DAS, T₁ was on par with T₂ at 60 DAS. The results were obtained due to the genetic constitution of T₁ and T₂ treatments. Similar results were obtained in an experimental trial conducted in *Rabi* 2021-2022 where T₁ showed the greatest leaf count (4.33, 10.25 and 16.75/plant at 30 DAS, 60 DAS and 90 DAS respectively) and T₅ showed the least (3.50, 8.58 and 13.25 at 30 DAS, 60 DAS and 90 DAS, respectively) Table 4.20 and Fig. 4.16.

4.2.1.5 Leaf area index

A perusal of data pertaining to LAI (2020–2021) as recorded under Table 4.21 and Fig. 4.17 reveals that at all the stages of growth significant difference for LAI was observed, T₁ showed the highest LAI (1.33, 2.81 and 4.99 at 30 DAS, 60 DAS and 90 DAS, respectively). At 30 and 60 DAS T₁ and T₂ are at par with each other. T₅ showed the lowest LAI reading at all growth stages. At 30 DAS and 60 DAS, T₅ is at par with T₄. The results were obtained due to the genetic superiority of T₁ and T₂ compared to the rest of the treatments. Similar results were obtained in an experimental trial conducted in *Rabi* 2021–2022, where T₁ showed the highest LAI (1.45, 2.98 and 5.15 at 30 DAS, 60 DAS and 90 DAS, respectively). T₅ showed the least (1.35, 2.69 and 4.06 at 30 DAS, 60 DAS and 90 DAS, respectively) (Table 4.22 Fig. 4.18)

4.2.1.6 Days to flowering

A perusal of data pertaining to days to flowering (2020–2021) as recorded under Table 4.23 and Fig. 4.19 reveals that T₃ achieved 50% flowering first, which is comparable to T₂. T₄ was the last to reach 50% flowering, which is comparable to T₁ and T₅. All the treatments failed to show a significant difference for 75% and 100% flowering. Similar results were obtained in an experimental trial conducted in *Rabi* 2021–2022, 50% flowering was first achieved in T₃ (73.50 DAS) and last in T₅ (76.25). Table 4.24 and Fig. 4.20

4.2.1.7 Awn length

The data in Table 4.25 and Fig. 4.21 show that there are significant differences in awn length between treatments, with T₁ having the longest, followed by T₂. The smallest awn length was found in T₅. However, T₁, T₂, T₃ and T₄ were found to be at par with each other. The results were obtained due to the genetic superiority of T₁ and T₂ compared to the rest of the treatments. Similar results were obtained in an experimental trial conducted in *Rabi* 2021–2022, where T₁ showed the longest awns (7.95 cm) and T₅ showed the shortest (6.63 cm). Table 4.26 and Fig. 4.22

4.2.1.8 Days to maturity

A perusal of data pertaining to days to maturity (2020-2021) as recorded under Table 4.27 and Fig. 4.23 revealed that the treatment T₄ took the longest time to mature (126 DAS), followed by T₅ with 125 DAS. Also, it showed that T₁, T₂, T₄ and T₅ are at par in terms of days to maturity. Similar results were obtained in an experimental trial conducted in *Rabi* 2021-2022 where T₄ showed the longest time to attain maturity (127.75), and T₃ showed the least (108.50 DAS), while T₁, T₂, T₄ and T₅ were at par with each other. (Table 4.28 and Fig. 4.24)

4.2.1.9 Effect of treatments on leaf orientation

T₁, T₂, and T₃ were found to have erectophile leaf orientation while T₄ and T₅ were found to have planophile leaf orientation (Table 4.29) during *Rabi* 2020-202. Similar results were obtained in an experimental trial conducted in 2021-2022, where T₁, T₂, and T₃ were found to have erectophile leaf orientation while T₄ and T₅ were found to have planophile leaf orientation. (Table 4.30)

4.2.2 SPAD READING

A perusal of data pertaining to SPAD reading (2020–2021) as recorded under Table 4.31 and Fig. 4.25 reveals that the treatments showed a significant difference for SPAD reading at all the stages of growth; T₁ showed the highest SPAD readings (43.30, 55.48 and 36.90 at 30 DAS, 60 DAS and 90 DAS respectively) and T₅ showed the lowest SPAD reading. At 60 DAS and 90 DAS, T₁ and T₂ are at par with each other. The results were obtained due to the genetic constitution of T₁ and T₂. Similar results were obtained in an experimental trial conducted in *Rabi* 2021–2022, where T₁ showed the greatest SPAD reading (39.78, 49.58 and 37.90 at 30 DAS, 60 DAS and 90 DAS, respectively) and T₅ showed the least (34.90, 36.78 and 30.88 at 30 DAS, 60 DAS and 90 DAS, respectively) Table 4.32 and Fig. 4.26.

4.2.3 YIELD ATTRIBUTES

4.2.3.1 Spike length

A perusal of data pertaining to spike length (2020–2021) as recorded under Table 4.33 reveals that all the treatments were statistically found to be non-significant for spike length. T₃ showed the longest spike with a 22.34 cm length, while T₅ showed the shortest spike length with a 16.44 cm spike length. Similar results were obtained in an experimental trial conducted in *Rabi* 2021–2022, where all the treatments were statistically found to be non-significant for spike length. (Table 4.34)

4.2.3.2 Grain number/spike

A perusal of data pertaining to grain no./spike (2020–2021) as recorded under Table 4.33 reveals that all the treatments were statistically found to be non-significant for grains/spike. T₁ recorded the highest grain number/spike while T₅ showed the least grain number/spike. Similar results were obtained in an experimental trial conducted in *Rabi* 2021–2022, where all the treatments were statistically found to be non-significant for spike length. (Table 4.34)

4.2.3.3 Test weight

A perusal of data pertaining to test weight (2020–2021) as recorded under Table 4.33 and Fig. 4.27 reveals that all the treatments were statistically significant for the test weight. T₃ had the greatest test weight (50.83 g) and T₅ had the lowest (34.63 g) due to better photosynthate distribution in T₃ as it has fewer fertile tillers and better leaf orientation. Similar results were obtained in an experimental trial conducted in *Rabi* 2021–2022 where T₃ showed the greatest test weight of 53.60 and T₅ showed the least (37.80 g). In both the trials T₁ and T₂ were found to be at par with each other. (Table 4.34 and Fig. 4.28)

4.2.3.4 Spikelet/spike

A perusal of data pertaining to spikelet/spike (2020–2021) as recorded under Table 4.35 and Fig. 4.29 reveals that treatments were significant for spikelet/spike. It

was found highest in T₁, which was at par with T₂. It was the lowest in T₅ owing to genetics. Similar results were obtained in an experimental trial conducted in *Rabi* 2021–2022 where T₁ showed the greatest spikelet/spike (20.50) and T₅ showed the least (16.63). Table 4.36 and Fig. 4.30.

4.2.4 YIELD

4.2.4.1 Grain yield

A perusal of data pertaining to grain yield (2020–2021) as recorded under (Table 4.37 and Fig. 4.31) reveals that the T₁ (43.44 q/ha) treatment produced the highest grain yield because of superior morphology, good chlorophyll content, and good weed suppression ability, followed by T₂ (41.46 q/ha). T₁ and T₂ were found to be at par with each other. T₅ had the lowest grain production (31.81 q/ha) because it was extensively infested with weeds, had inferior morphological traits, and poor chlorophyll content, resulting in a decrease in wheat yield. T₃ and T₄ were statistically equivalent, though both treatments were superior to T₅. Similar results were obtained in an experimental trial conducted in *Rabi* 2021–2022, where T₁ showed the greatest yield (45.94 q/ha) and T₅ showed the least (34.31 q/ha). Table 4.38 and Fig.4.32.

4.2.4.2 Straw yield

A perusal of data pertaining to straw yield (2020–2021) as recorded under Table 4.37 and Fig.4.31 indicates that all the treatments are non-significant. The highest straw yield was found in treatment T₁ with a 56.32 q/ha, followed by treatment T₂ with 54.00 q/ha straw yield. The least straw yield was recorded in treatment T₅ with 43.06 q/ha because it was extensively infested with weeds, had inferior morphological traits, and poor chlorophyll content, resulting in a decrease in straw yield. Similar results were obtained in an experimental trial conducted in *Rabi* in 2021–2022, where all the treatments were found to be non-significant (Table 4.38 and Fig.4.32).

4.2.4.3 Biological yield

A perusal of data pertaining to biological yield (2020–2021) as recorded under Table 4.37 and Fig.4.31 reveals that the largest biological yield was recorded in the T₁

(103.51 q/ha) which was statistically comparable to the T₂ treatment. The T₁ and T₂ treatments were found to be significantly superior to all other treatments. The least biological yield was recorded in T₅ (78.79 q/ha) because it was extensively infested with weeds, had inferior morphological traits, and poor chlorophyll content, resulting in a decrease in biological yield. Similar results were obtained in an experimental trial conducted in *Rabi* 2021–2022, where T₁ showed the greatest biological yield (103.51 q/ha) and T₅ showed the least (78.78 q/ha). Table 4.38 and Fig. 4.32.

4.2.5 NUTRIENT UPTAKE BY CROP

4.2.5.1 Nitrogen

A perusal of data pertaining to nitrogen (N) uptake (2020–2021) as recorded under Table 4.39 and Fig. 4.33 demonstrates that varied treatments had a considerable impact on N uptake by crop plants. T₁ had the highest N uptake in grain, straw and total uptake (89.40 Kg/ha, 47.2 Kg/ha and 136.60 Kg/ha, respectively). In T₅, minimum N uptake in grain, straw and total uptake was (76.68, 31.25 and 107.93 Kg/ha, respectively) was noticed because it was extensively infested with weeds, had inferior morphological traits, resulting in a decrease in nutrient uptake. Similar results were obtained in an experimental trial conducted in *Rabi* 2021–2022, where T₁ showed the highest N uptake in grain, straw and total uptake (94.40 Kg/ha, 50.20 Kg/ha and 144.60 Kg/ha, respectively). And T₅ showed least (81.65 Kg/ha, 34.25 Kg/ha and 115.90 Kg/ha in grain, straw and total uptake respectively). Table 4.40 and Fig. 4.34.

4.2.5.2 Phosphorus

A review of the data on phosphorus (P) uptake (2020–2021) presented in Table 4.39 and Fig. 4.35 reveals that there was a significant effect of various treatments on P uptake by crop plants in grain and total uptake. The maximum uptake of P in grain and total uptake (17.28 Kg/ha and 26.98 Kg/ha, respectively) were noticed in T₁. T₁ and T₂ were found at par in both grain and total uptake. T₅ had the lowest P uptake in grain and the lowest total uptake (11.17 and 17.96 Kg/ha) because it was extensively infested with weeds, and had inferior morphological traits, resulting in a decrease. Similar results were obtained in an experimental trial conducted in *Rabi* 2021–2022, where T₁ showed

the highest P uptake in grain, and total uptake (18.75 Kg/ha, 40.53 Kg/ha respectively) and T₅ showed least (12.30 Kg/ha, and 19.69 Kg/ha in grain, and total uptake respectively). Table 4.40 and Fig. 4.36.

4.2.5.3 Potassium

A perusal of data pertaining to potassium (K) uptake (2020–2021) as recorded under Table 4.39 and reveals that K uptake was found to be significant only for total uptake, with the highest reported in treatment T₁ with 166.70 Kg/ha. T₁ and T₂ were found to be at par for total uptake. A minimum uptake of K of (146.45 Kg/ ha) was witnessed in T₅ because it was extensively infested with weeds, and had inferior morphological traits, resulting in a decrease in resource use efficiency. Similar results were obtained in an experimental trial conducted in *Rabi* 2021–2022, where T₁ showed the highest total K uptake and T₅ lowest (175.70 Kg/ha and 155.45 Kg/ha, respectively). Table 4.40.

4.3 ECONOMICS

4.3.1 Cost of cultivation

When the economics of the cost incurred by various treatments were calculated (Appendix I. a, and Appendix I. b, Appendix II a, and Appendix II b.), it was noted that all the treatments had the same cost for *Rabi* 2020-2021 (₹ 36,714) due to the same cultivation practices followed in all the treatments and ₹ 40,680 for the year 2021-2022. (Note – Cost of cultivation may vary due to price difference in varieties' seed.)

4.3.2 Gross returns

The maximum gross return (₹ 99,868.75) was found in treatment T₁ due to the higher yield, followed by T₂ (₹ 95,378.56). Treatment T₅ showed the lowest gross returns of ₹ 7,359.09 among all the treatments in year 2020-2021. Similar results were obtained in years 2021-2022, the highest gross return of ₹1,07,702 was obtained in treatment T₁ followed by T₂ (₹ 1,01,705.96) and the least recorded in T₅ (due to lower grain and straw yields (Appendix III a, Appendix III b).

4.3.3 Net returns

The appraisal of data produced under (Appendix III a) revealed that the maximum net return was obtained from the T₁ plot (₹ 63,154.75). The lowest net return was observed under T₅ (₹ 3,680.09) during trial of 2020-2021, similarly in trial during *Rabi* 2021-2022 the maximum net return was obtained from the T₁ plot (₹ 67,022.57 q/ha) and least in T₅ due to lower grain and straw yield in later. (Appendix III. b)

4.3.4 B-C Ratio

The highest benefit-cost ratio incurred in the T₁ plot (1.75) followed by T₂ (1.59). The lowest B-C ratio was observed under T₅ (1.00) during 2020-2021 experimental trial. Similarly during 2021-2022 the highest benefit-cost ratio incurred in the T₁ (1.64) followed by T₂ and least in T₅ due to lower grain and straw yield in T₅ in comparison to T₁. (Appendix III. a and Appendix III. b)

Table 4.1: Weed flora infesting the crop field of experimental site during Rabi 2020-2021.

BOTANICAL NAME	ENGLISH NAME	COMMON NAME
1. BROAD LEAF WEEDS		
<i>Chenopodium album</i> L.	Common Lambsquarter	Bathua
<i>Anagallis arvensis</i> L.	Scarlet pimpernel	Krishnaneel
<i>Parthenium hysterophorus</i> L.	Congress grass	Gajar Ghas
2. NARROW LEAF WEEDS		
<i>Cynodon dactylon</i> Pers.	Bermuda grass	Doob ghas
<i>Phalris minor</i> Retz.	Little seed canary grass	Guli danda

Table 4.2: Weed flora infesting the crop field of experimental site during Rabi 2021-2022.

BOTANICAL NAME	ENGLISH NAME	COMMON NAME
1. BROAD LEAF WEEDS		
<i>Chenopodium album</i> L.	Common Lambsquarter	Bathua
<i>Anagallis arvensis</i> L.	Scarlet pimpernel	Krishnaneel
<i>Parthenium hysterophorus</i> L.	Congress grass	Gajar Ghas
2. NARROW LEAF WEEDS		
<i>Cynodon dactylon</i> Pers.	Bermuda grass	Doob ghas
<i>Phalris minor</i> Retz.	Little seed canary grass	Guli danda

Table 4.3: Effect of treatments on *Chenopodium album* weed density (No./m²) in the crop field at different growth stages during Rabi 2020-2021.

Treatment	30 DAS	60 DAS	90 DAS
T1	1.000 (0)	1.000 (0)	3.485 (12)
T2	1.000 (0)	1.309 (1)	3.896 (15)
T3	1.000 (0)	1.309 (1)	4.096 (17)
T4	1.000 (0)	1.309 (1)	5.400 (32)
T5	3.741 (14)	5.801 (35)	7.076 (52)
SEm±	0.259	0.448	0.562
CD (at 5%)	0.806	1.396	1.751

Values in the parenthesis are original values that were subjected to square root transformation ($\sqrt{X + 0.5}$).

Table 4.4: Effect of treatments on *Chenopodium album* weed density (No./m²) in the crop field at different growth stages during Rabi 2021-2022.

Treatment	30 DAS	60 DAS	90 DAS
T1	1.000 (0)	1.000 (0)	3.430 (11.5)
T2	1.000 (0)	1.309 (1)	3.791 (14)
T3	1.000 (0)	1.309 (1)	4.096 (17)
T4	1.000 (0)	1.309 (1)	5.339 (21)
T5	3.509 (12)	5.562 (31.75)	7.047 (51.5)
SEm±	0.214	0.409	0.540
CD (at 5%)	0.668	1.275	1.681

Table 4.5: Effect of treatments on *Anagallis arvensis* weed density (No./m²) in the crop field of experimental site during Rabi 2020-2021.

Treatments	30 DAS	60 DAS	90 DAS
T ₁	1.309 (0.998)	5.088 (32)	6.189 (38.25)
T ₂	1.000 (0)	6.459 (43.75)	7.229 (57)
T ₃	1.000 (0)	6.697 (55.1)	8.651(78.5)
T ₄	1.000(0)	8.668 (76.5)	8.956 (82.75)
T ₅	1.000(0)	9.993 (104.75)	11.237 (134)
SEm±	0.138	1.563	0.762
CD (at 5%)	NS	NS	2.373

Values in the parenthesis are original values that were subjected to square root transformation ($\sqrt{X + 0.5}$).

Table 4.6: Effect of treatments on *Anagallis arvensis* weed density (No./m²) infesting the crop field of experimental site during Rabi 2021-2022.

Treatments	30 DAS	60 DAS	90 DAS
T ₁	1.309 (1)	5.025 (31)	6.073 (36.5)
T ₂	1.000 (0)	6.394 (42.75)	7.192 (56.25)
T ₃	1.000 (0)	6.635 (54.1)	8.613 (77.75)
T ₄	1.000 (0)	8.618 (75.5)	8.913 (82)
T ₅	1.362 (1.25)	11.189 (133)	9.961 (104)
SEm±	0.185	1.548	0.763
CD (at 5%)	NS	NS	2.376

Table 4.7: Effect of treatments on *Parthenium hysterophorus* weed density (No./m²) in the crop field of experimental site during Rabi 2020-2021.

Treatments	30 DAS	60 DAS	90 DAS
T ₁	1.000(0)	1.309(1)	3.492(14)
T ₂	1.000(0)	1.927(3)	4.263(21)
T ₃	1.309(1)	5.322(31.75)	5.140(29)
T ₄	1.000(0)	7.053(49)	8.970(80.1)
T ₅	1.000(0)	7.364(56)	10.08(111.9)
SEm±	0.138	0.598	0.700
CD (at 5%)	NS	1.864	2.182

Table 4.8: Effect of treatments on *Parthenium hysterophorus* weed density (No./m²) in the crop field of experimental site during Rabi 2021-2022.

Treatments	30 DAS	60 DAS	90 DAS
T ₁	1.000 (0)	1.309 (1)	1.585 (13.5)
T ₂	1.000 (0)	1.500 (3)	5.268 (20.5)
T ₃	1.309 (1)	1.955 (30.75)	6.709 (27.55)
T ₄	1.000 (0)	2.053 (48)	8.870 (79.45)
T ₅	1.309 (1)	2.387 (55)	9.811 (110.8)
SEm±	0.203	0.157	0.676
CD (at 5%)	NS	0.490	2.106

Table 4.9: Effect of treatments on *Phalaris minor* density (No./m²) at different stages of the crop growth during Rabi 2020-2021.

Treatments	30DAS	60 DAS	90 DAS
T ₁	3.054 (8.4)	3.339 (10.18)	3.458 (11.07)
T ₂	5.020 (24.233)	5.627 (30.77)	4.647 (20.6)
T ₃	6.356 (39.43)	6.941 (47.45)	5.914 (34.06)
T ₄	6.996 (38.16)	7.422 (54.56)	6.111 (36.5)
T ₅	7.625 (57.3)	8.046 (63.92)	6.712 (44.34)
SEm±	0.141	0.192	0.601
CD (at 5%)	NS	NS	NS

Table 4.10: Effect of treatments on *Phalaris minor* density (No./m²) at different stages of crop growth during Rabi 2021-2022.

Treatments	30 DAS	60 DAS	90 DAS
T ₁	2.295 (4.40)	2.447 (5.18)	2.606 (6.07)
T ₂	4.490 (19.23)	5.258 (26.67)	4.066 (15.06)
T ₃	5.947 (34.43)	6.644 (43.47)	5.472 (29.06)
T ₄	6.626 (43.17)	7.145 (50.56)	5.684 (31.5)
T ₅	7.288 (52.30)	7.792 (59.92)	6.325 (39.34)
SEm±	0.168	0.264	0.221
CD (at 5%)	NS	NS	NS

Table 4.11: Effect of treatments on *Cyanodon dactylon* density (No./m²) at different stages of crop growth stages during Rabi 2020-2021.

Treatments	30 DAS	60 DAS	90 DAS
T ₁	2.11 (4)	4.87 (29.25)	1.309 (1)
T ₂	2.46 (6)	5.72 (36.50)	1.809 (3)
T ₃	3.78 (14)	7.05 (77.0)	2.432 (7)
T ₄	4.14 (17)	8.79 (79.25)	5.043 (25)
T ₅	5.26 (27)	10.18 (121)	11.033 (107.50)
SEm±	0.471	1.216	0.943
CD (at 5%)	1.468	NS	NS

Fig. 4.12: Effect of treatments on *Cyanodon dactylon* density (No./m²) at different stages of the crop growth stages during Rabi 2021-2022.

Treatments	30DAS	60 DAS	90 DAS
T ₁	1.927 (3)	4.784 (28.25)	1.183 (0.5)
T ₂	2.309 (5)	5.690 (36.0)	1.720 (2.5)
T ₃	3.651 (13)	7.007 (76.0)	2.401 (6.75)
T ₄	4.087 (16.5)	8.748 (78.0)	4.972 (24.25)
T ₅	5.217 (26.5)	10.140 (119.5)	11.033(107.5)
SEm±	0.457	1.217	0.312
CD (at 5%)	1.423	NS	NS

Table 4.13 Effect of various treatments on germination % during Rabi 2020-2021 trial.

Treatments	Germination %
T₁	82.475
T₂	80.200
T₃	57.500
T₄	69.500
T₅	69.075
SE m±	3.459
CD (at 5%)	10.776

Table 4.14: Effect of various treatments on germination % during Rabi 2021-2022 trial.

Treatments	Germination %
T₁	84.475
T₂	82.200
T₃	59.500
T₄	71.500
T₅	71.075
SE m±	3.459
CD (at 5%)	10.776

Table 4.15: Effect of treatments on plant height (cm) at different stages of crop growth during Rabi 2020-2021.

Treatment	30 DAS	60 DAS	90DAS	At harvest
T₁	23.43	73.85	95.650	103.325
T₂	19.82	63.50	93.325	95.650
T₃	19.65	45.65	88.325	93.00
T₄	18.85	42.65	86.325	90.325
T₅	18.22	40.02	84.650	89.650
SE m$\pm$	0.62	1.63	1.452	1.519
CD (at 5%)	1.94	NS	4.524	4.731

Table 4.16: Effect of treatments on plant height (cm) at different stages of crop growth during year 2021-2022

Treatment	30 DAS	60 DAS	90DAS	At harvest
T₁	27.163	76.850	98.650	105.575
T₂	23.583	67.250	96.325	97.900
T₃	23.417	48.650	91.325	96.000
T₄	22.617	45.650	89.325	92.575
T₅	21.983	43.025	87.650	91.900
SE m$\pm$	0.624	1.670	1.452	1.556
CD (at 5%)	1.943	NS	4.524	4.849

Table 4.17: Effect of treatments on tiller count at various crop growth stages during *Rabi* 2020-2021.

Treatment	30 DAS	60 DAS	90 DAS	At harvest
T ₁	1	3.000	4.250	4.250
T ₂	1.25	2.333	3.750	3.250
T ₃	1	1.668	2.750	2.563
T ₄	1	2.333	3.250	3.050
T ₅	1	2.000	3.250	2.825
SEm±	0.112	0.197	0.274	0.346
CD	NS	0.614	0.853	1.077

Table 4.18: Effect of treatments on tiller count at various crop growth stages during the *Rabi* 2021-2022.

Treatment	30 DAS	60 DAS	90 DAS	At harvest
T ₁	1.333	4.250	5.250	4.500
T ₂	1.250	3.583	4.750	3.750
T ₃	1.000	2.917	3.750	2.813
T ₄	1.000	3.583	4.250	3.050
T ₅	1.000	3.250	4.000	3.025
SEm±	0.154	0.197	0.310	0.376
CD	NS	0.614	0.964	1.173

Table 4.19: Effect of treatments on leaf count/plant at different stages of crop growth during *Rabi* 2020-2021.

Treatments	30 DAS	60 DAS	90 DAS
T ₁	4.000	10.000	15.750
T ₂	4.000	9.000	14.250
T ₃	2.250	5.250	9.750
T ₄	4.000	7.250	12.000
T ₅	3.750	6.250	10.000
SEm±	0.151	0.421	0.614
CD (at 5%)	0.472	1.311	1.913

Table 4.20: Effect of treatments on leaf count/plant at different stages of crop growth during *Rabi* 2021-2022.

Treatments	30 DAS	60 DAS	90 DAS
T ₁	4.333	11.250	16.750
T ₂	4.000	10.250	15.250
T ₃	2.500	6.583	10.750
T ₄	4.000	8.583	13.250
T ₅	3.500	7.583	11.250
SEm±	0.230	0.418	0.626
CD (at 5%)	0.716	1.303	1.950

Fig.4.21: Effect of treatments on LAI at various growth stages of the crop during Rabi 2020-2021.

Treatments	30 DAS	60DAS	90DAS
T₁	1.333	2.805	4.998
T₂	1.263	2.585	4.693
T₃	1.168	2.400	3.548
T₄	1.243	2.560	4.473
T₅	1.228	2.525	3.908
SEm±	0.020	0.070	0.319
CD (at 5%)	0.062	0.099	0.995

Fig.4.22: Effect of the treatments on LAI at various growth stages of the crop during Rabi 2021-2022.

Treatments	30 DAS	60DAS	90DAS
T₁	1.453	2.978	5.148
T₂	1.383	2.788	4.843
T₃	1.288	2.554	3.698
T₄	1.363	2.761	4.623
T₅	1.348	2.688	4.058
SEm±	0.020	0.076	0.319
CD (at 5%)	0.062	0.237	0.995

Table: 4.23 Effect of treatments on days to flowering during Rabi 2020-2021 trial.

Treatments	50 %	75 %	100 %
T₁	72.500	72.667	78.650
T₂	69.000	69.000	73.625
T₃	64.000	68.000	72.600
T₄	77.000	77.333	79.575
T₅	75.250	75.667	78.625
SEm±	1.966	2.559	3.443
CD (at 5%)	6.126	NS	NS

Table: 4.24: Effect of treatments on days to flowering during Rabi 2021-2022 trial.

Treatments	50 %	75 %	100 %
T₁	73.500	73.917	79.650
T₂	70.000	70.250	74.625
T₃	65.000	69.250	73.600
T₄	78.000	78.583	80.575
T₅	76.250	76.917	79.625
SEm±	1.966	2.559	3.443
CD (at 5%)	6.126	NS	NS

Table 4.25: Effect of treatments on awn length during *Rabi* season 2020-2021 trial.

Treatments	Awn length (cm)
T₁	7.150
T₂	7.050
T₃	7.025
T₄	6.900
T₅	5.825
SEm±	0.103
CD (at 5%)	0.321

Table 4.26: Effect of treatments on awn length during *Rabi* 2021-2022 trial.

Treatments	Awn length (cm)
T₁	7.950
T₂	7.850
T₃	7.825
T₄	7.700
T₅	6.625
SEm±	0.103
CD (at 5%)	0.321

Table 4.27: Effect of treatments on days to maturity during Rabi 2020-2021 trial.

Treatments	Days to maturity (DAS)
T₁	122.500
T₂	116.750
T₃	107.500
T₄	126.750
T₅	125.000
SEm$\pm$	4.073
CD (at 5%)	12.688

Table 4.28: Effect of treatments on days to maturity during Rabi 2021-2022 trial.

Treatments	Days to maturity (DAS)
T₁	123.500
T₂	117.750
T₃	108.500
T₄	127.750
T₅	126.000
SEm$\pm$	4.073
CD (at 5%)	12.688

Table 4.29: Effect of treatments on leaf orientation during *Rabi* 2020-2021 trial.

Treatments	Leaf orientation
T₁	Erectophile
T₂	Erectophile
T₃	Erectophile
T₄	Planophile
T₅	Planophile

Table 4.30: Effect of treatments on leaf orientation during *Rabi* 2021-2022.

Treatments	Leaf orientation
T₁	Erectophile
T₂	Erectophile
T₃	Erectophile
T₄	Planophile
T₅	Planophile

Table 4.31: Effect of treatments on SPAD reading at various growth stages of the crop during *Rabi* 2020-2021.

Treatments	30 DAS	60 DAS	90 DAS
T₁	43.300	55.475	36.900
T₂	38.200	47.300	35.700
T₃	36.550	44.650	34.650
T₄	35.525	40.050	33.600
T₅	33.900	38.100	29.625
SEm±	1.000	2.852	1.238
CD (at 5%)	3.116	8.886	3.856

Table 4.32: Effect of treatments on SPAD reading at various growth stages of the crop during *Rabi* 2021-2022.

Treatments	30 DAS	60 DAS	90 DAS
T₁	44.883	58.183	37.9
T₂	39.783	49.583	37.283
T₃	38.133	44.017	36.233
T₄	36.775	40.683	35.183
T₅	34.9	36.783	30.875
SEm±	0.974	2.245	1.294
CD (at 5%)	3.035	6.993	4.033

Table 4.33: Effect of different treatments on yield attributes of the wheat crop during Rabi 2020-2021.

Treatments	Spike length (cm)	Grains no./spike	Test weight (g)
T ₁	19.725	40.400	45.625
T ₂	18.775	37.350	45.200
T ₃	22.338	33.000	50.825
T ₄	18.094	35.500	39.575
T ₅	16.438	30.000	34.625
SEm±	0.037	2.715	1.438
CD (at 5%)	NS	NS	4.480

Table 4.34: Effect of different treatments on yield attributes of the crop during Rabi 2021-2022.

Treatments	Spike length (cm)	Grains no. /spike	Test weight (g)
T ₁	19.363	43.400	49.933
T ₂	20.313	40.350	47.467
T ₃	22.925	36.000	53.600
T ₄	18.681	38.500	37.800
T ₅	17.025	33.000	42.267
SEm±	0.036	2.715	1.210
CD (at 5%)	NS	NS	3.770

Table: 4.35 Effect of treatments on spikelet no./spike during Rabi 2020-2021 trial.

Treatment	Spikelet per spike
T ₁	20.000
T ₂	19.750
T ₃	15.000
T ₄	17.250
T ₅	16.750
SEm±	0.607
CD (at 5%)	1.892

Table: 4.36 Effect of treatments on spikelet no./spike during Rabi 2021-2022 trial.

Treatment	Spikelet per spike
T ₁	20.500
T ₂	20.250
T ₃	15.000
T ₄	17.250
T ₅	16.625
SEm±	0.643
CD (at 5%)	2.003

Table 4.37: Effect of various treatments on grain yield (q/ha), straw yield (q/ha), biological yield (q /ha), and harvest index (%) of the wheat crop during *Rabi* season 2020-2021

Treatments	Grain Yield (q/ha)	Straw Yield (q/ha)	Biological Yield (q/ha)	Harvest Index (%)
T₁	43.438	57.425	99.756	44.346
T₂	41.458	53.427	95.458	43.281
T₃	37.150	54.920	90.030	41.921
T₄	37.475	46.605	89.271	42.150
T₅	31.813	46.810	75.029	40.234
SEm±	2.079	2.963	4.745	0.933
CD (at 5%)	6.478	NS	14.781	NS

Table 4.38: Effect of various treatments on grain yield (q/ha), straw yield (q/ha), biological yield (q/ha) and harvest index (%) of the wheat crop during *Rabi* season 2021-2022.

Treatments	Grain Yield (q/ha)	Straw Yield (q/ha)	Biological Yield (q/ha)	Harvest Index (%)
T₁	45.938	60.550	103.506	44.3
T₂	43.458	56.552	99.208	44.3
T₃	39.150	58.045	93.780	41.8
T₄	39.975	49.730	93.021	43.5
T₅	34.313	49.935	78.779	44.0
SEm±	2.110	2.963	4.745	0.028
CD (at 5%)	6.573	NS	14.781	NS

Table 4.39: Effect of treatments on nutrient uptake (Kg/ha) of the wheat crop during Rabi 2020-2021.

<i>Potassium</i> Treatments	<i>Nitrogen</i>			<i>Phosphorus</i>					
	Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total
T₁	89.400	47.200	136.600	17.275	9.700	26.975	38.225	128.475	166.700
T₂	85.405	45.175	130.580	16.325	9.275	25.600	36.325	125.000	161.325
T₃	81.075	33.350	114.425	14.750	7.825	22.575	34.025	122.050	156.075
T₄	82.775	34.550	117.325	15.275	8.200	23.475	35.425	122.825	158.250
T₅	76.675	31.250	107.925	11.173	6.823	17.995	29.773	116.725	146.498
SEm±	1.580	1.416	1.909	0.575	0.651	0.766	1.912	3.051	2.904
CD (at 5%)	4.924	4.411	5.948	1.790	NS	2.386	NS	NS	9.047

Table 4.40: Effect of treatments on nutrient uptake (Kg/ha) of the wheat crop during Rabi 2021-2022

Treatments	Potassium			Nitrogen			Phosphorus		
	Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total
T₁	94.400	50.200	144.600	18.475	10.200	28.675	40.525	135.175	175.700
T₂	90.405	48.175	138.580	17.525	9.775	27.300	38.625	131.700	170.325
T₃	86.075	36.350	122.425	15.950	8.325	24.275	36.325	128.750	165.075
T₄	87.775	37.550	125.325	16.475	8.700	25.175	37.725	129.525	167.250
T₅	81.675	34.250	115.925	12.373	7.323	19.695	32.073	123.425	155.498
SEm±	1.581	1.416	1.909	0.575	0.651	0.766	1.912	3.051	2.904
CD (at 5%)	4.924	4.411	5.86	1.790	NS	2.386	NS	NS	9.047

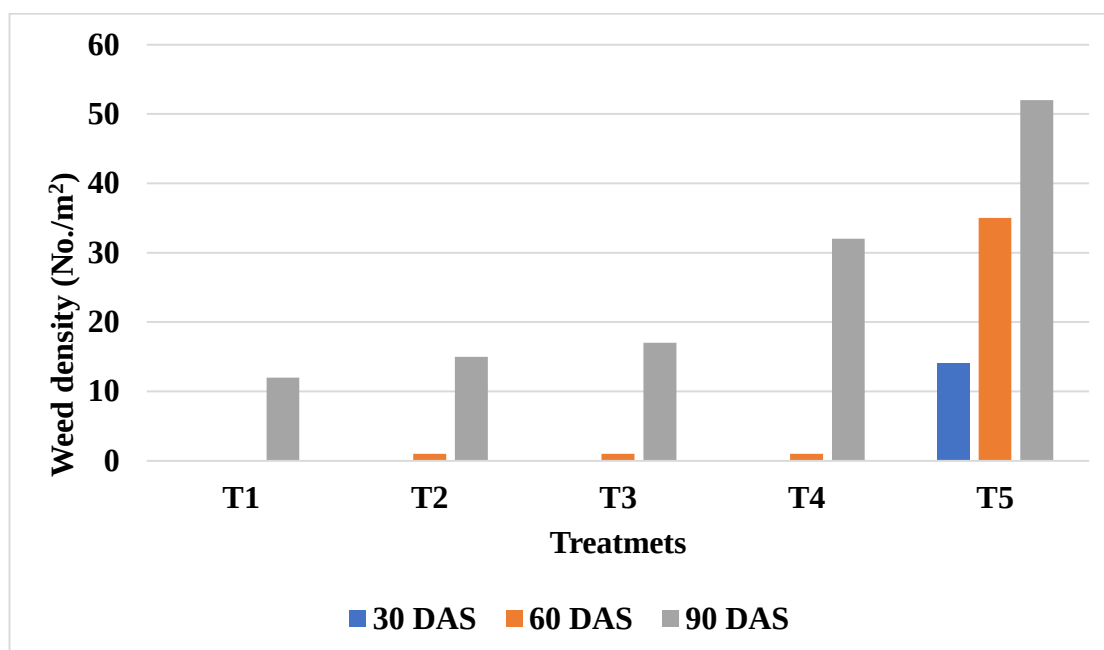


Fig. 4.1: Effect of treatments on *Chenopodium album* density (No./m²) at different stages of crop growth

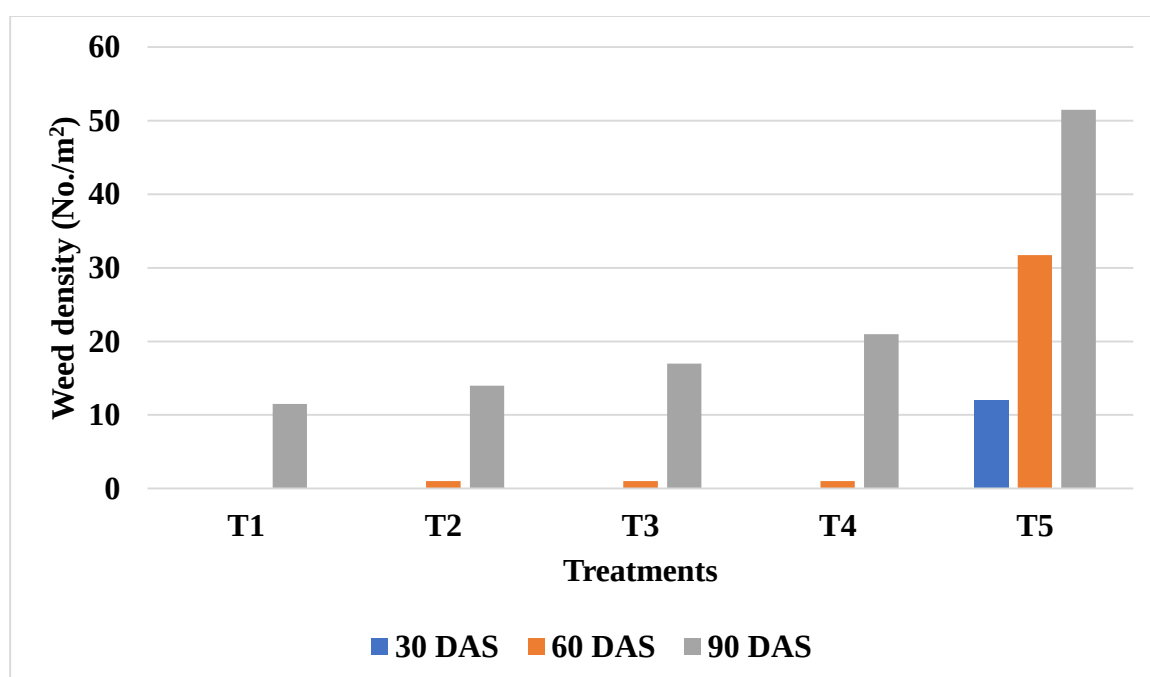


Fig.4.2 Effect of treatments on *Chenopodium album* weed density (No./m²) in the crop field at different growth stages during Rabi 2021-2022.

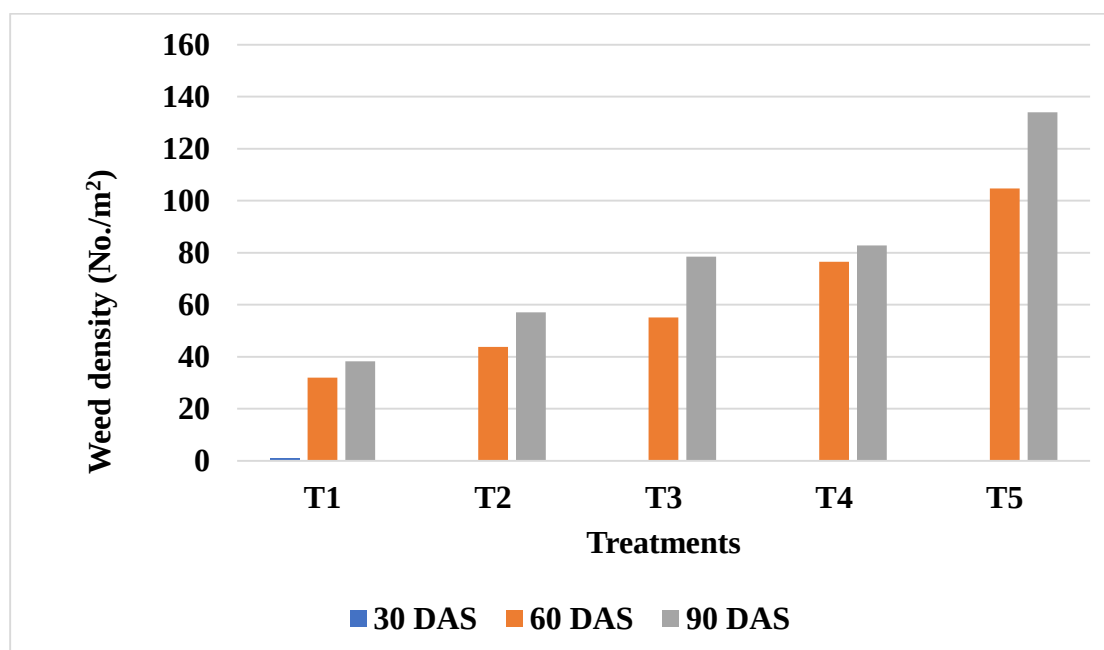


Fig. 4.2: Effect of treatments on *Anagallis arvensis* density (No./m²) at different stages of crop growth during Rabi 2020-2021.

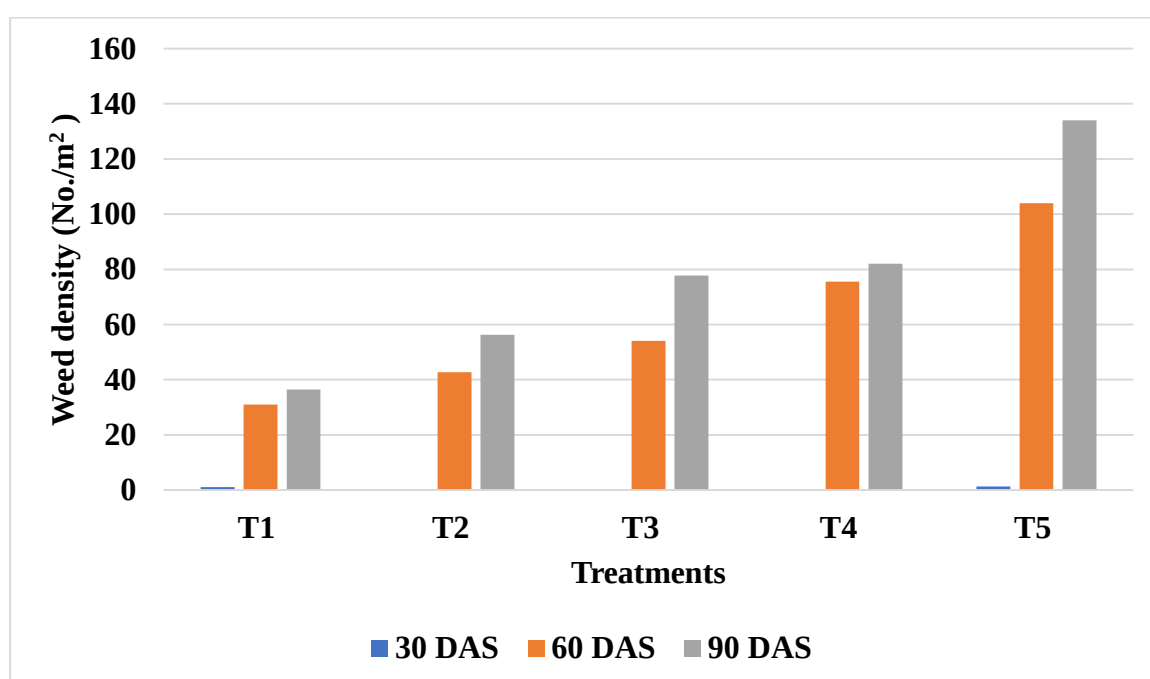


Fig 4.3: Effect of treatments on *Anagallis arvensis* weed density (No./m²) in the crop field of experimental site during Rabi 2021-2022.

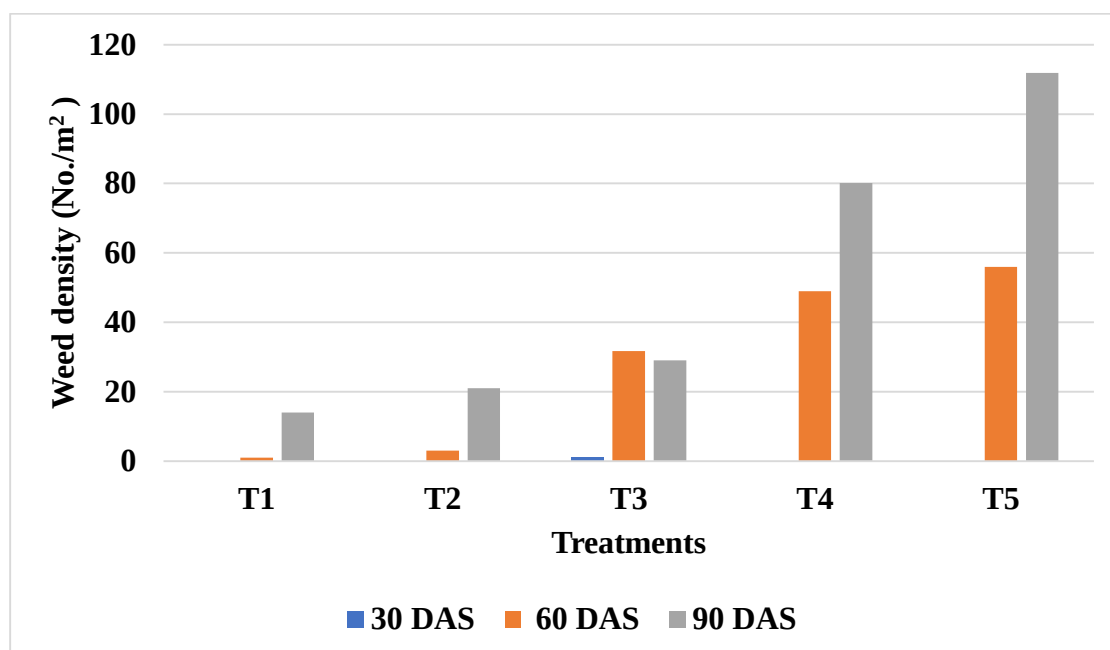


Fig. 4.5: Effect of treatments on *Parthenium hysterophorus* density (No./m²) at different stages of crop growth during 2020-2021.

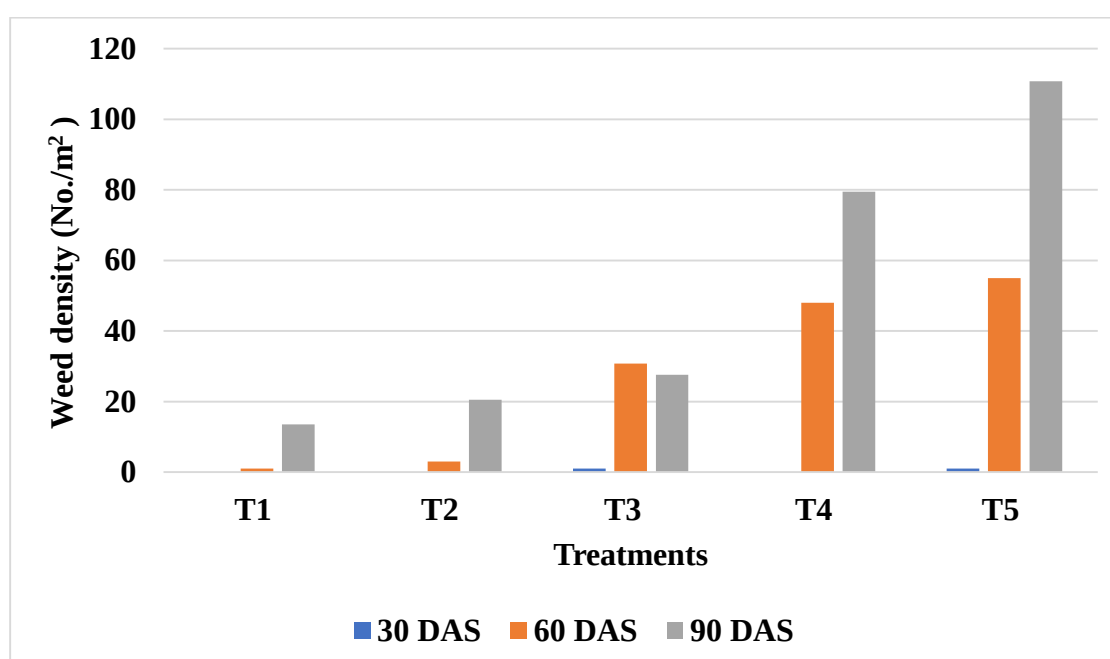


Fig 4.6: Effect of treatments on *Parthenium hysterophorus* weed density (No./m²) in the crop field of experimental site during Rabi 2021-2022.

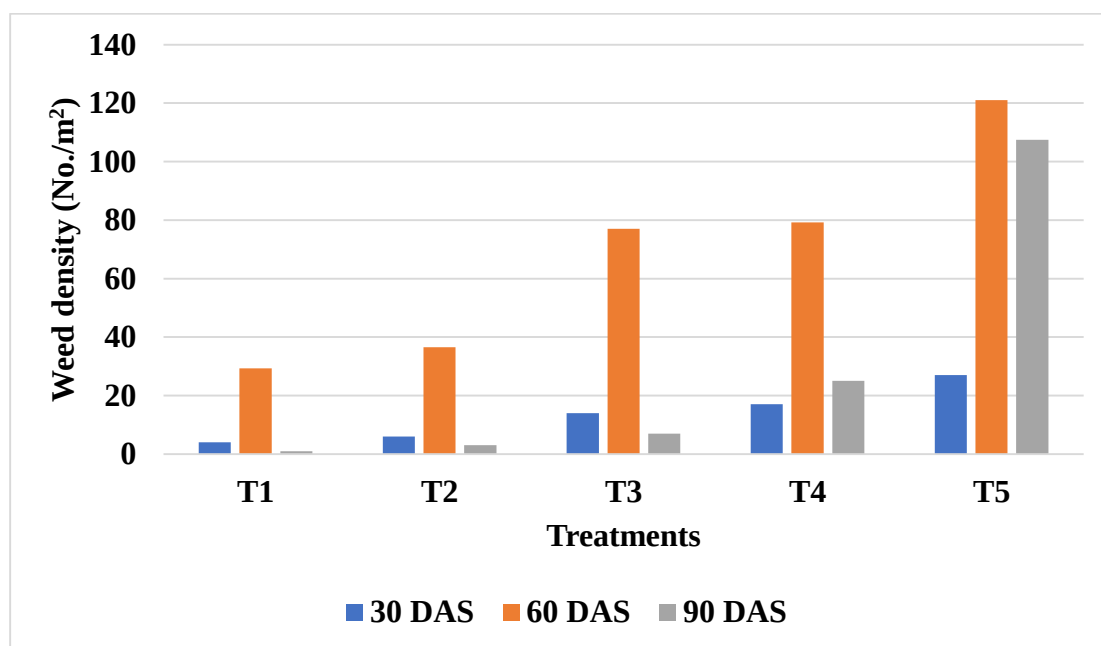


Fig. 4.7: Effect of treatments on *Cyanodon dactylon* density (No./m²) at different stages of crop growth during Rabi 2020-2021.

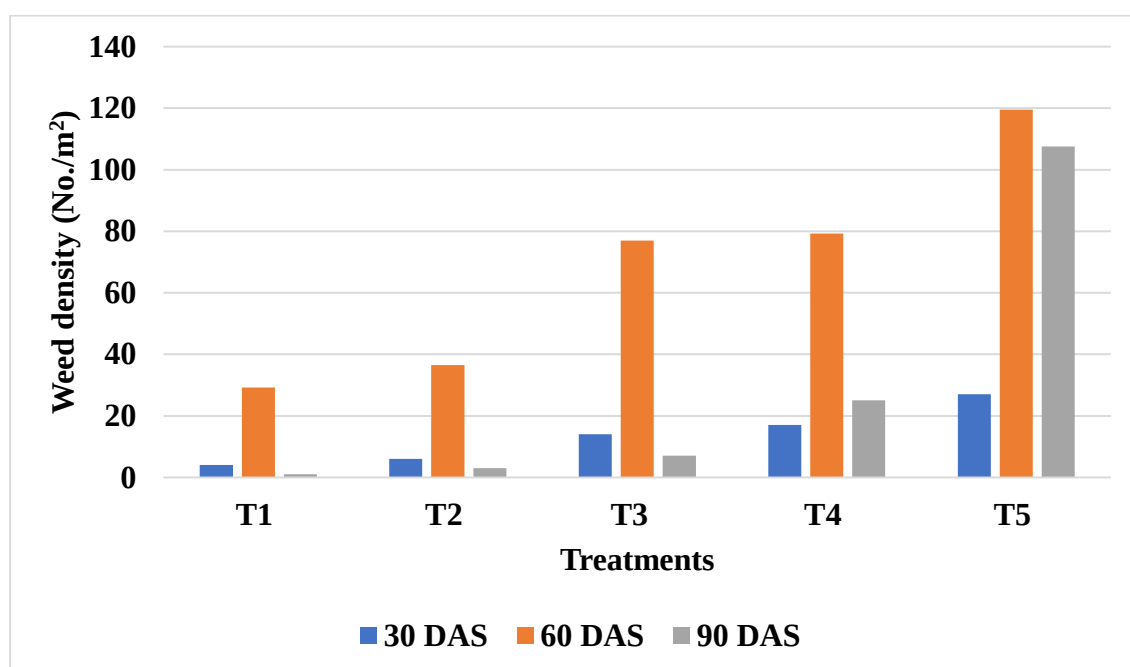


Fig. 4.8: Effect of treatments on *Cyanodon dactylon* density (No./m²) at different stages of crop growth during Rabi 2021-2022.

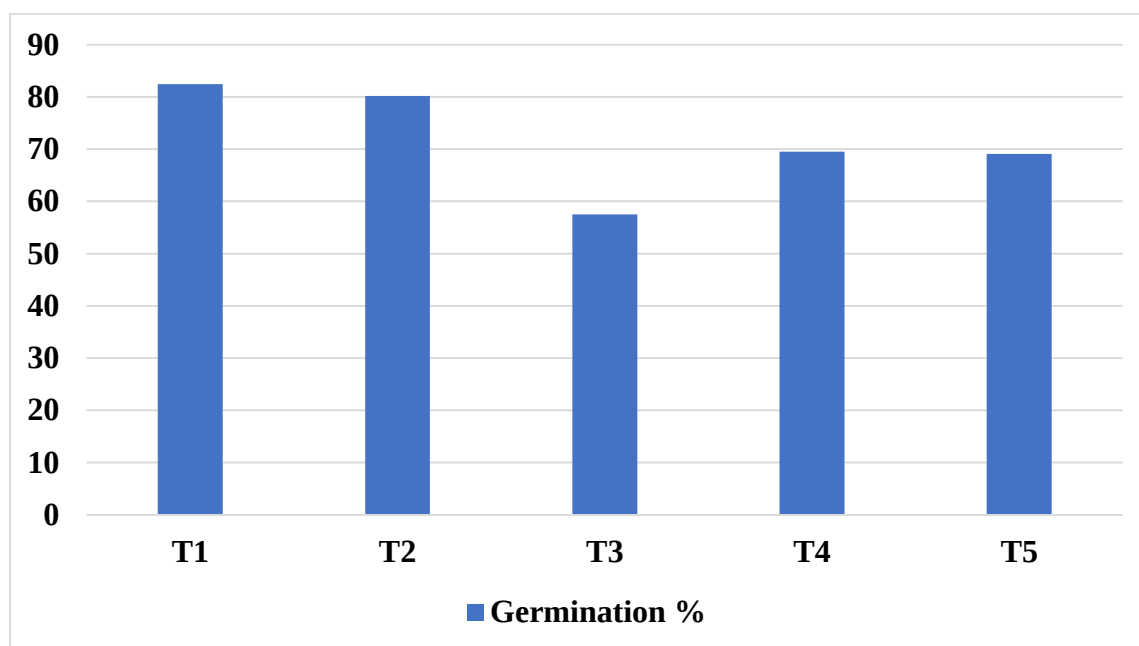


Fig.4.9: Effect of various treatments on germination % during *Rabi* 2020-2021.

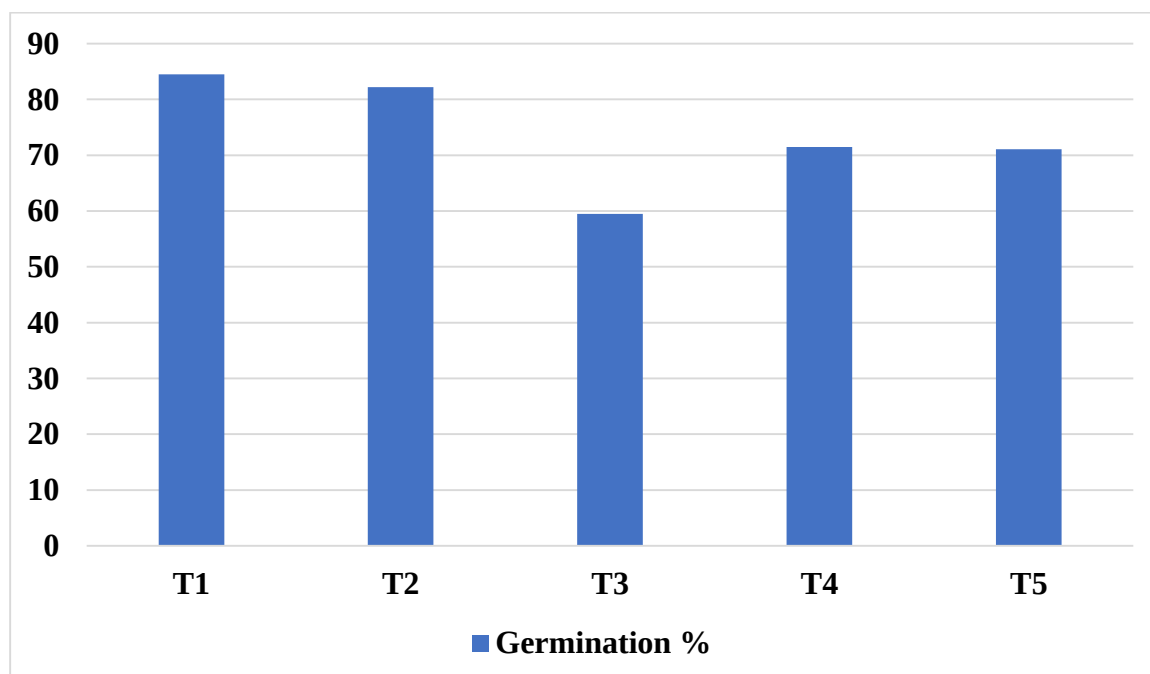


Fig.4.10: Effect of various treatments on germination % during *Rabi* 2021-2022.

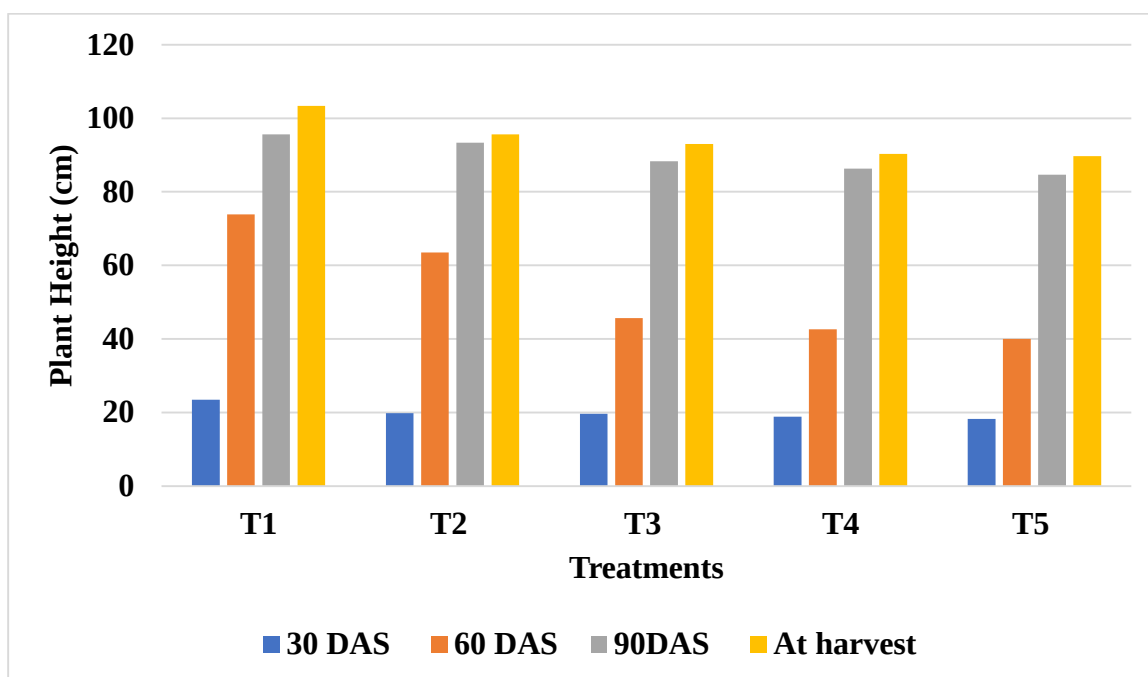


Fig. 4.11: Effect of treatments on plant height (cm) at various stages of crop growth during *Rabi* 2020-2021.

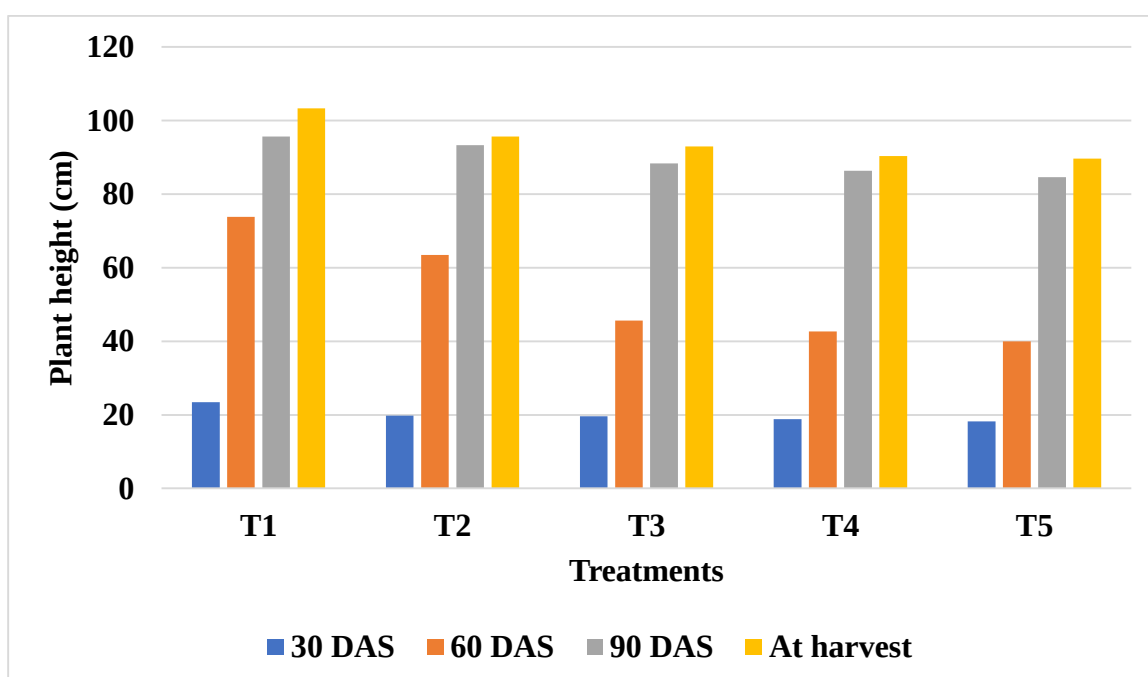


Fig. 4.12: Effect of treatments on plant height (cm) at various stages of crop growth during *Rabi* 2021-2022.

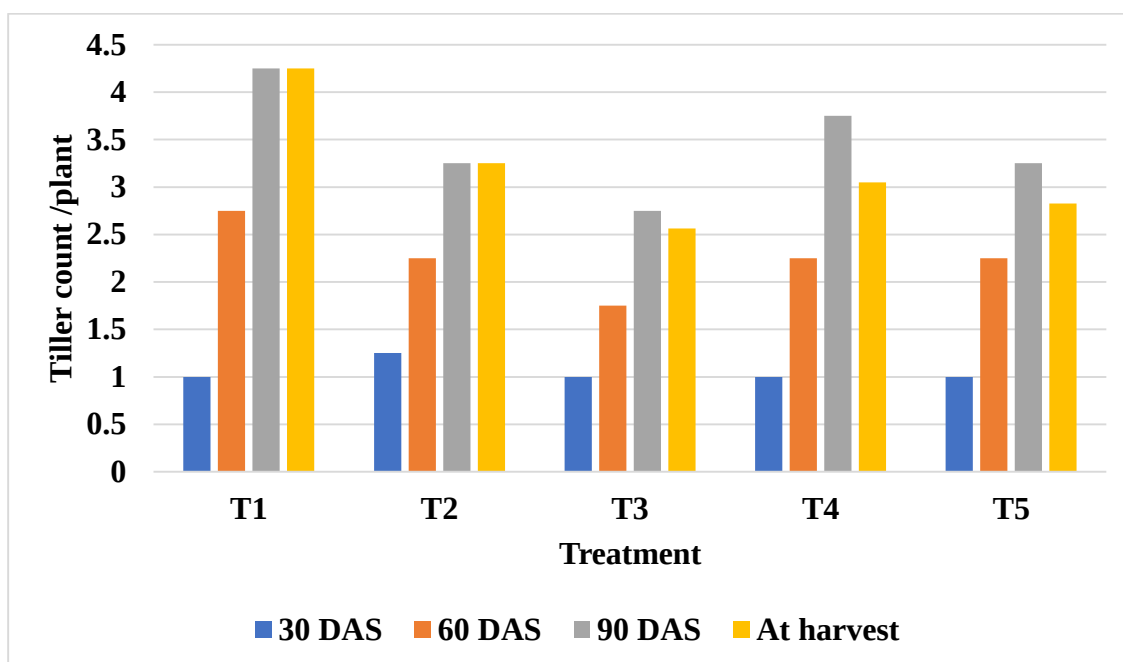


Fig.4.13: Effect of treatments on tiller count/plant at various stages of crop growth during year 2020-2021.

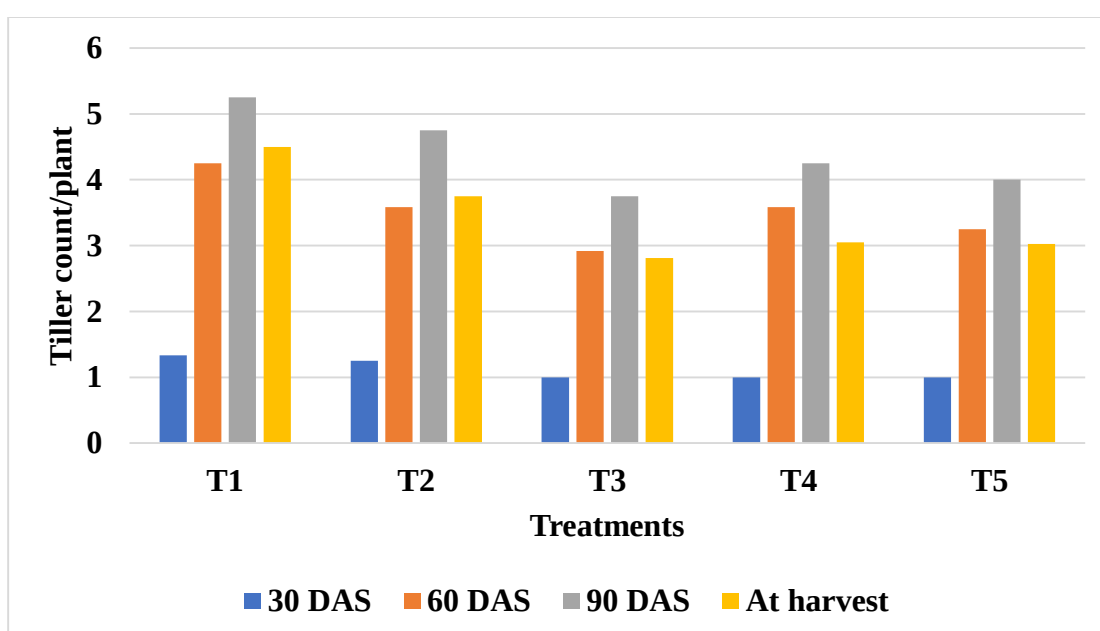


Fig. 4.14: Effect of treatments on tiller count/plant at various growth stages during Rabi 2021-2022.

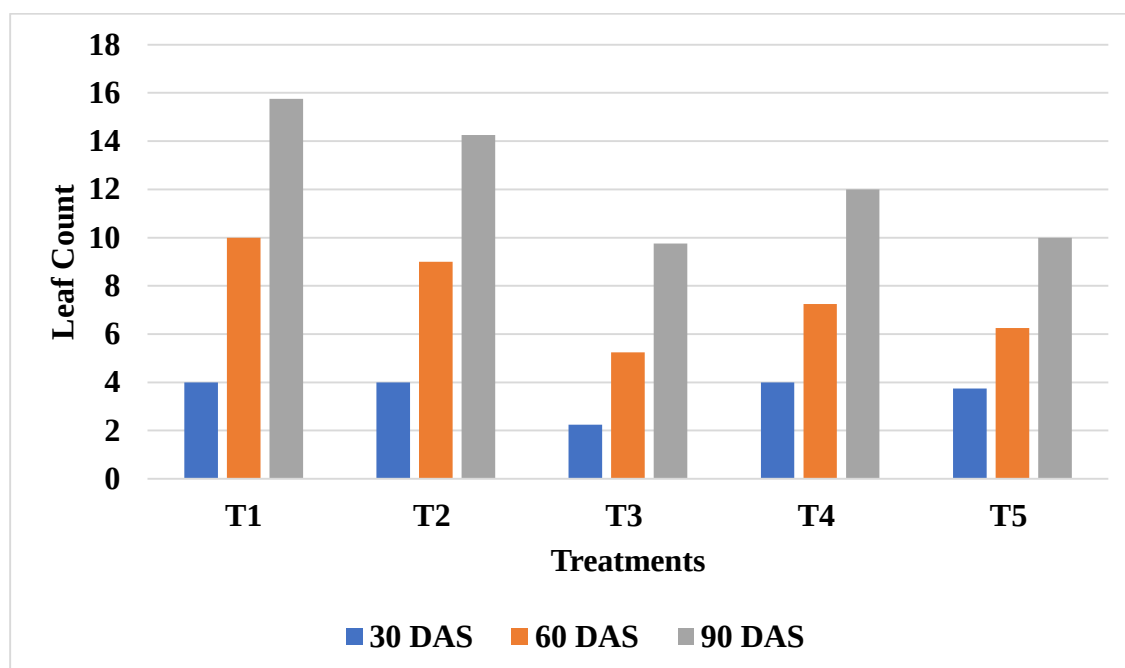


Fig.4.15: Effect of treatments on leaf count/plant at various stages of crop growth during Rabi 2020-2021

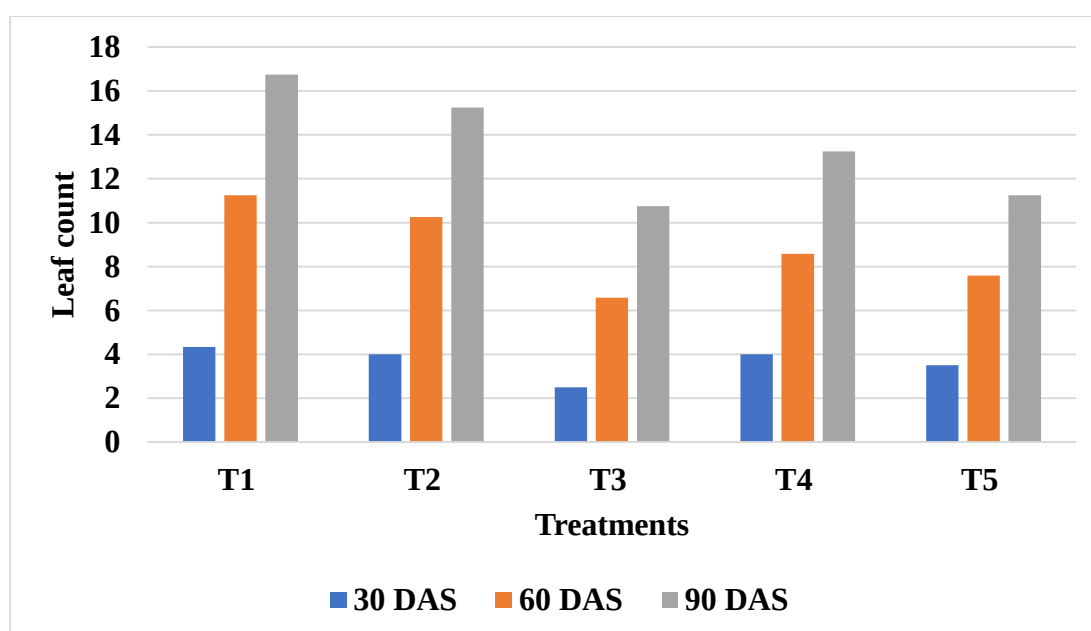


Fig.4.16: Effect of treatments on leaf count/plant at different stages of crop growth during the year 2021-2022.

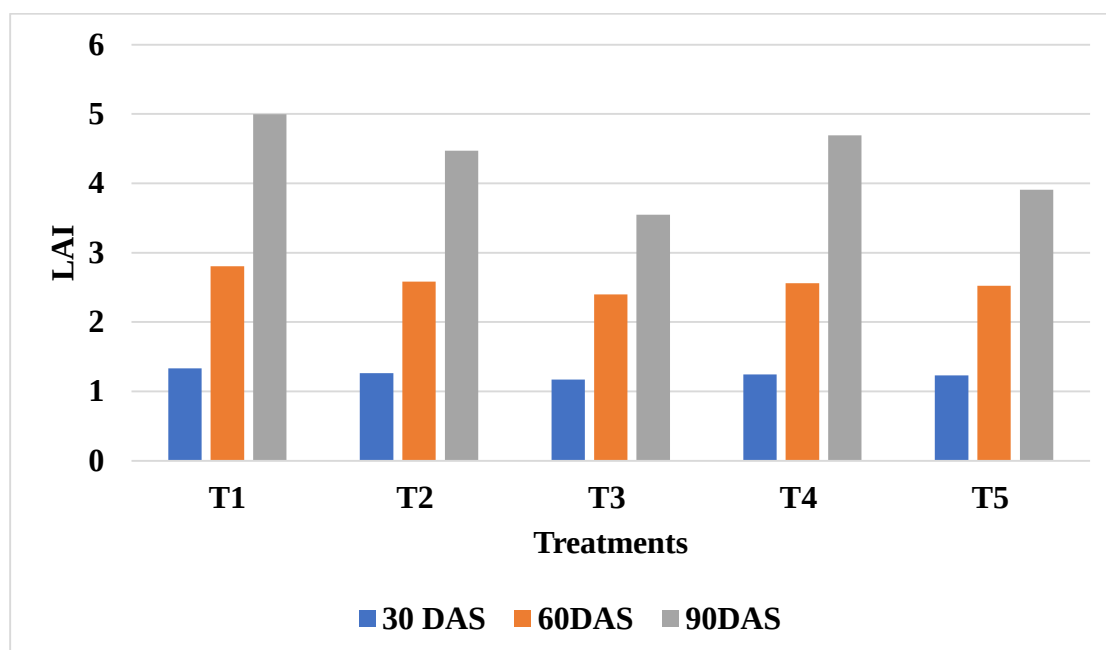


Fig.4.17: Effect of treatments on LAI at various stages of crop growth during Rabi 2020-2021

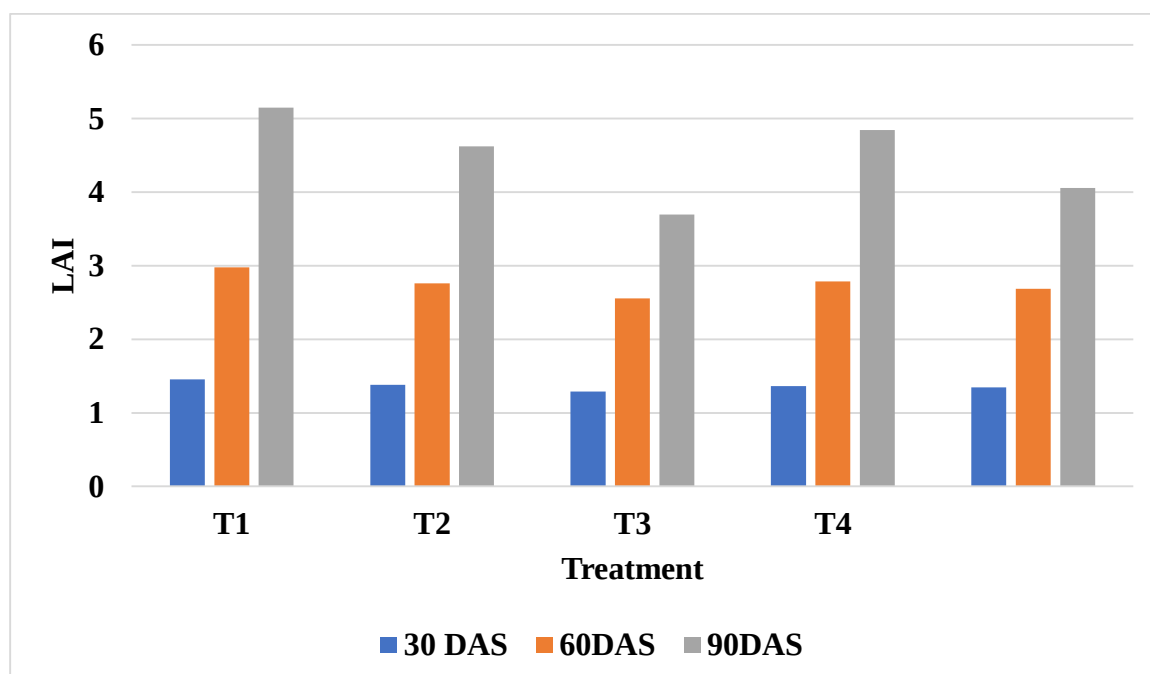


Fig. 4.18: Effect of treatments on LAI of treatments at various growth stages of wheat crop during Rabi season of year 2021-2022.

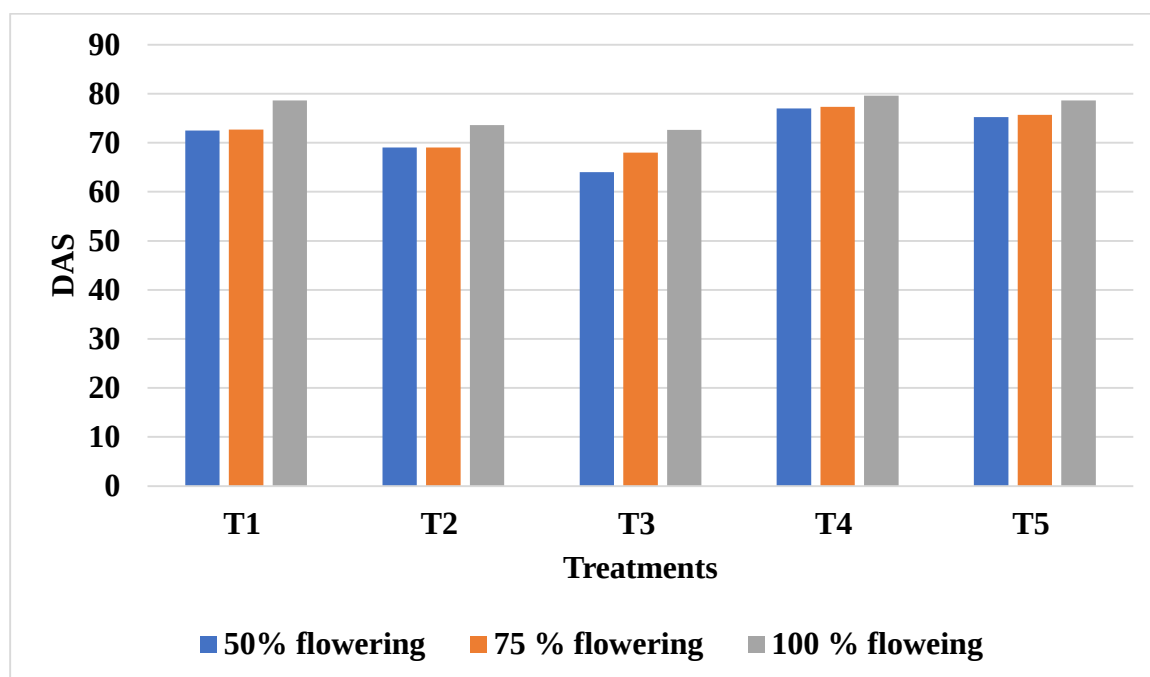


Fig. 4.19: Effect of treatments on days to flowering during *Rabi* 2020-2021 trial.

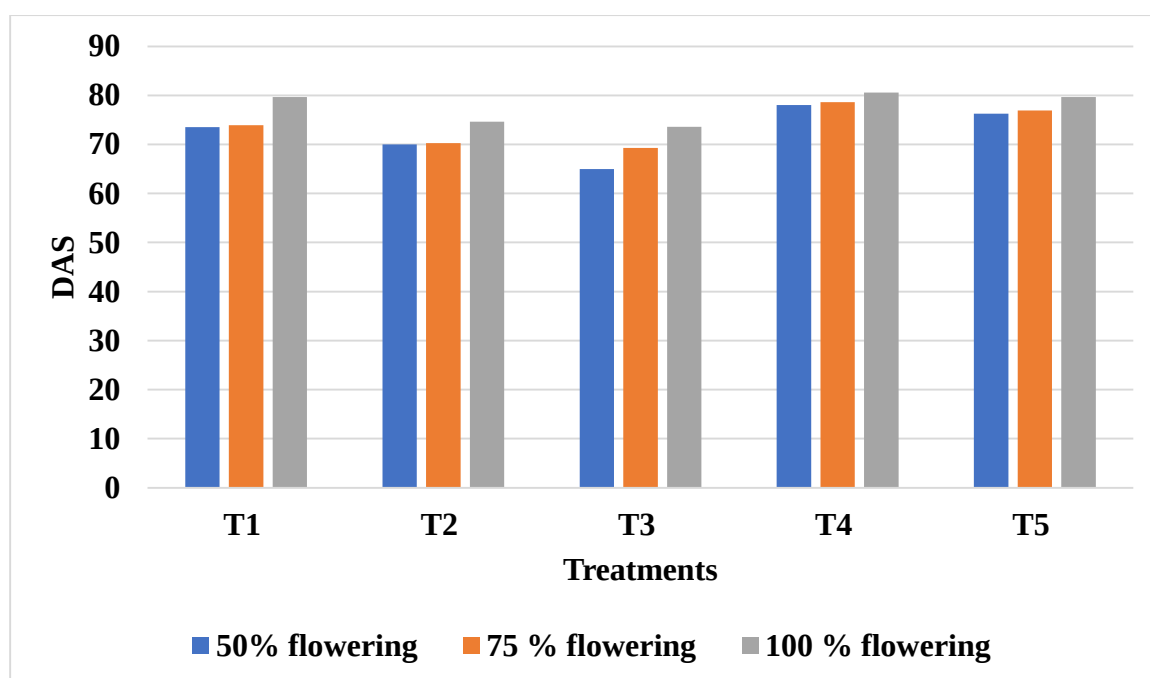


Fig.4.20: Effect of treatments on days to flowering during *Rabi* 2021-2022 trial.

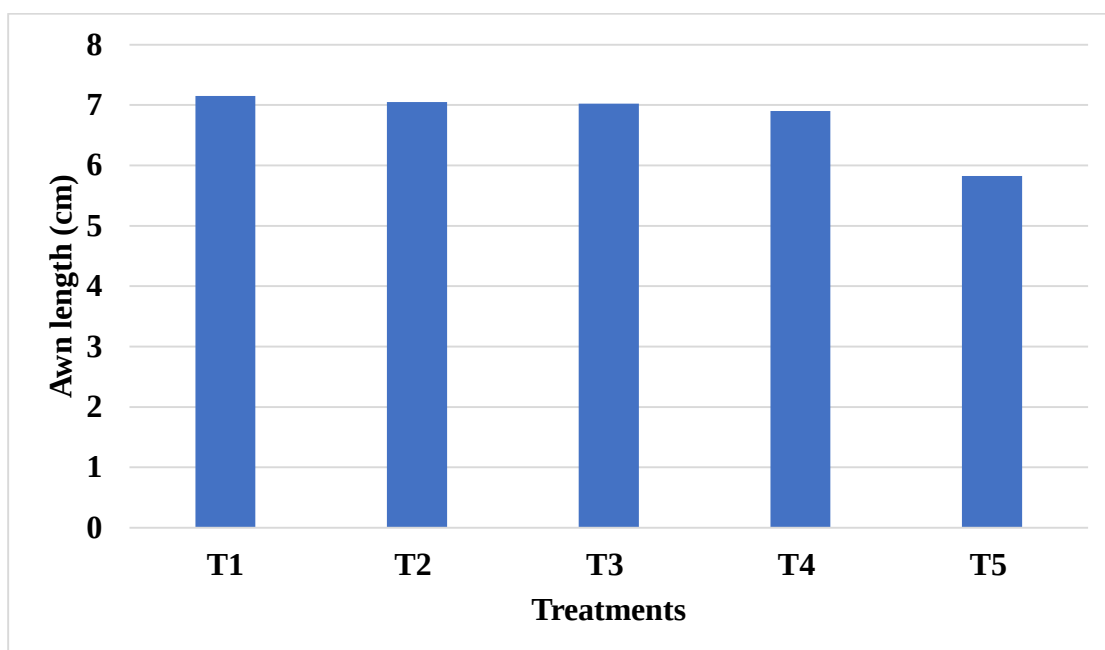


Fig.4.21: Effect of treatments on awn length during *Rabi* 2020-2021 trial.

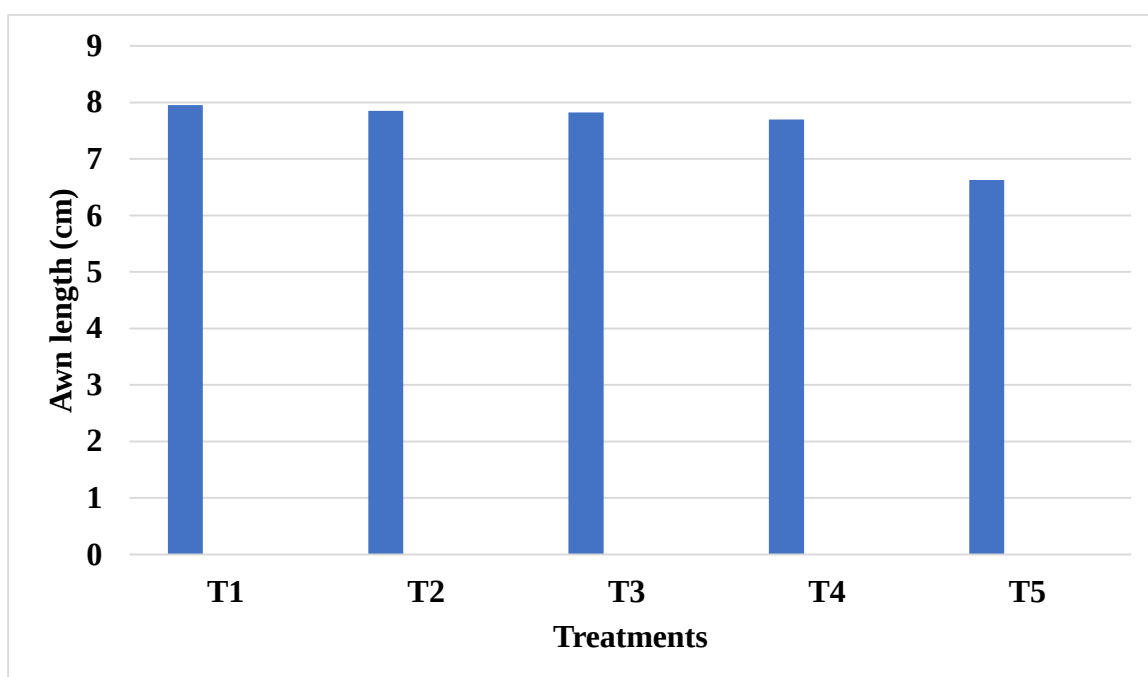


Fig.4.22: Effect of treatments on awn length (cm) during *Rabi* season 2021-2022 trial.

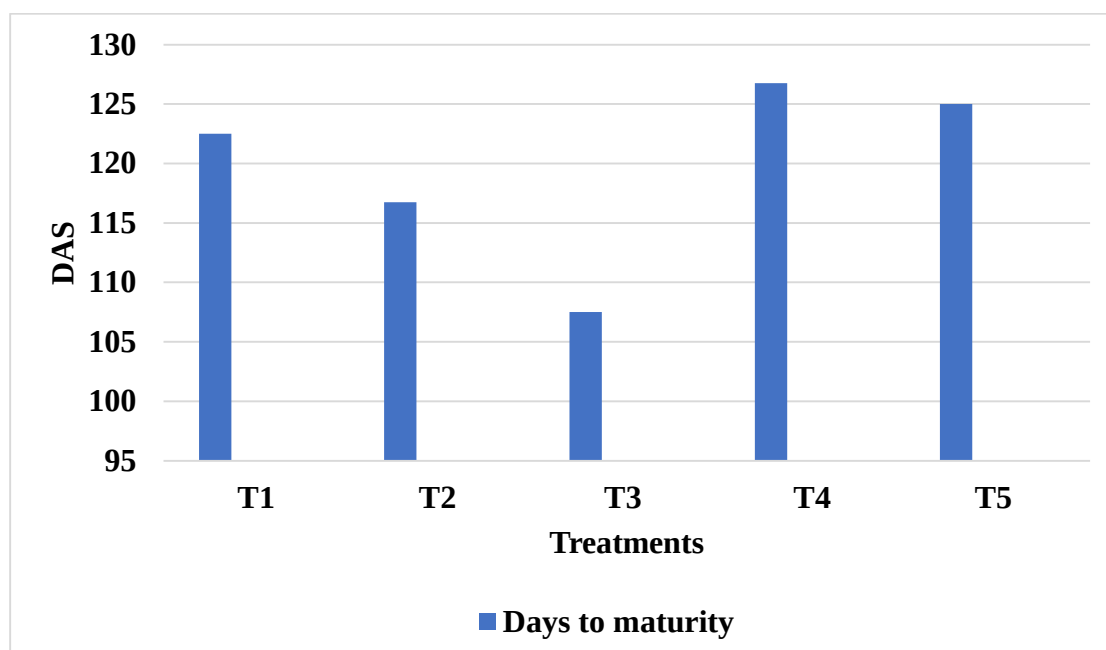


Fig. 4.23: Effect of treatments on days to maturity during *Rabi* 2020-2021 trial.

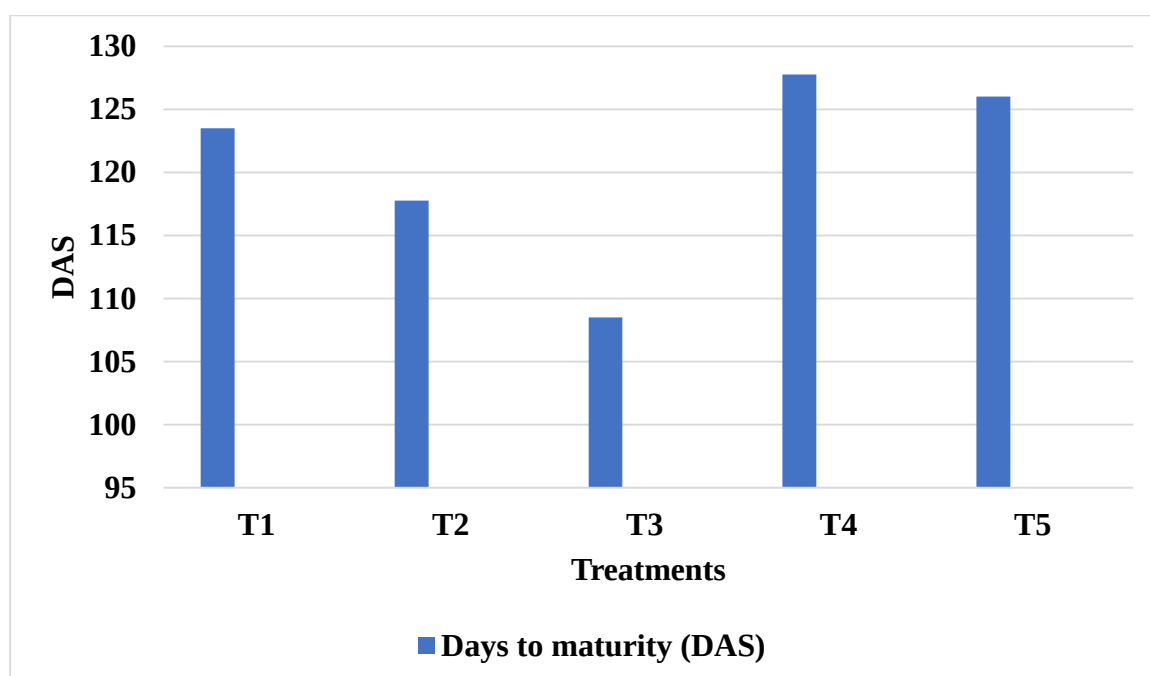


Fig.4.24: Effect of treatments on days to maturity during *Rabi* 2021-2022 trial.

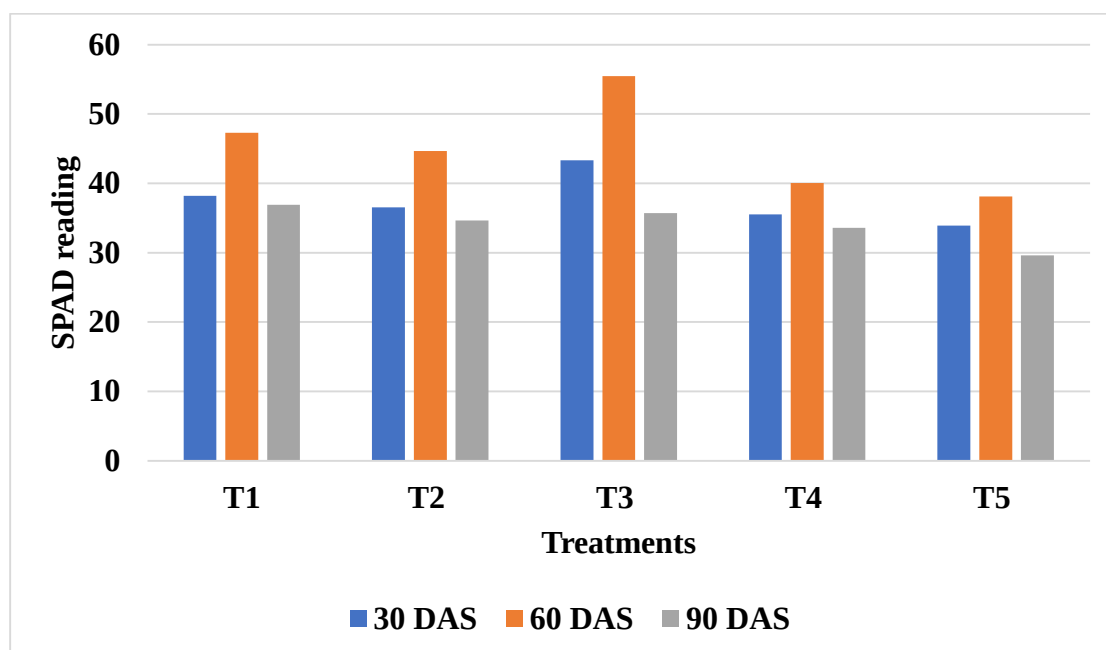


Fig 4.25: Effect of treatments on SPAD reading at various stages of the crop growth during *Rabi* 2020-2021 trial.

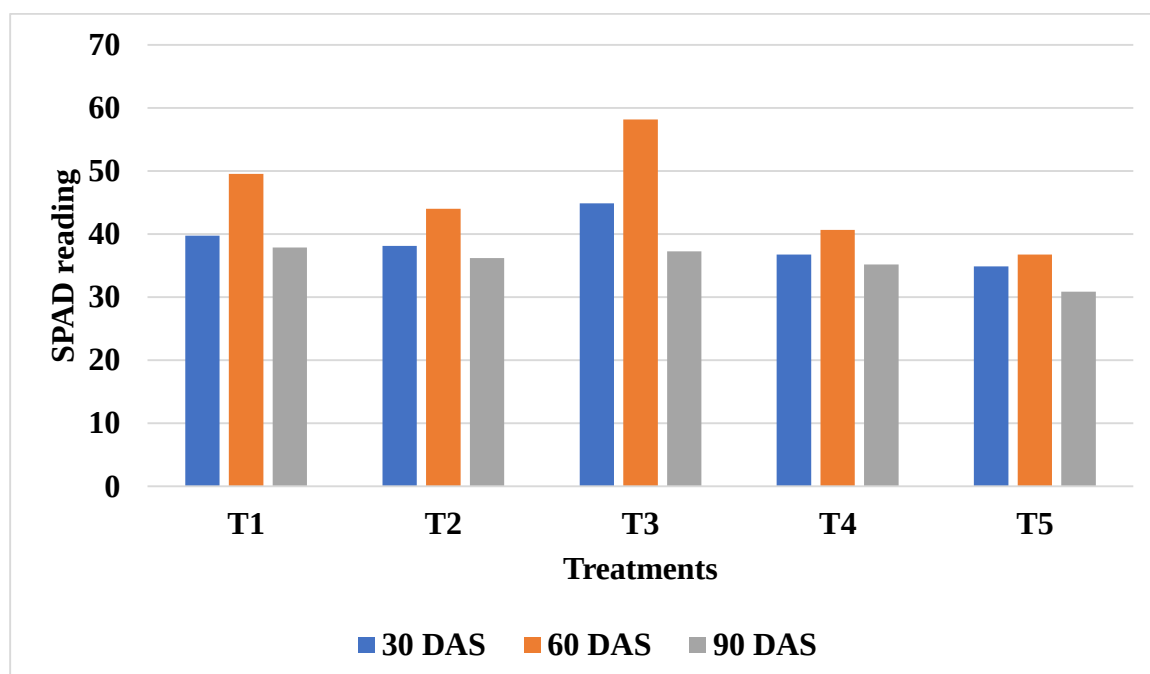


Fig.4.26: Effect of treatments on SPAD reading at various growth stages of the crop during 2021-2022 trial.

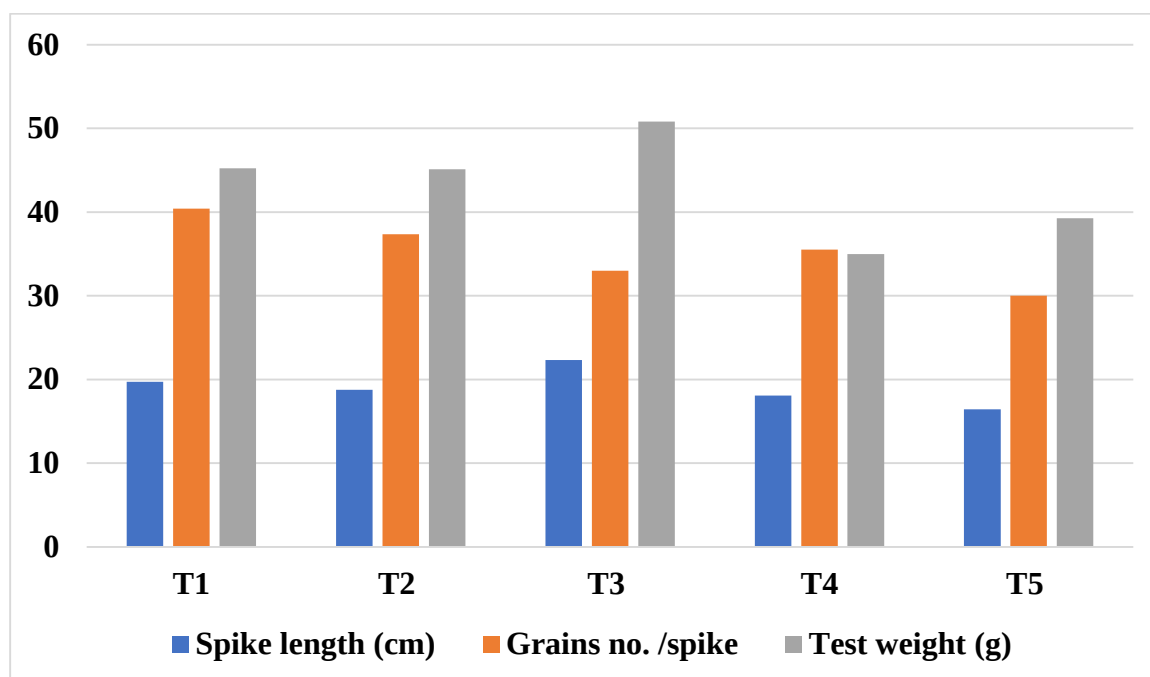


Fig: 4.27: Effect of treatments on yield attributes during Rabi 2020-2021.

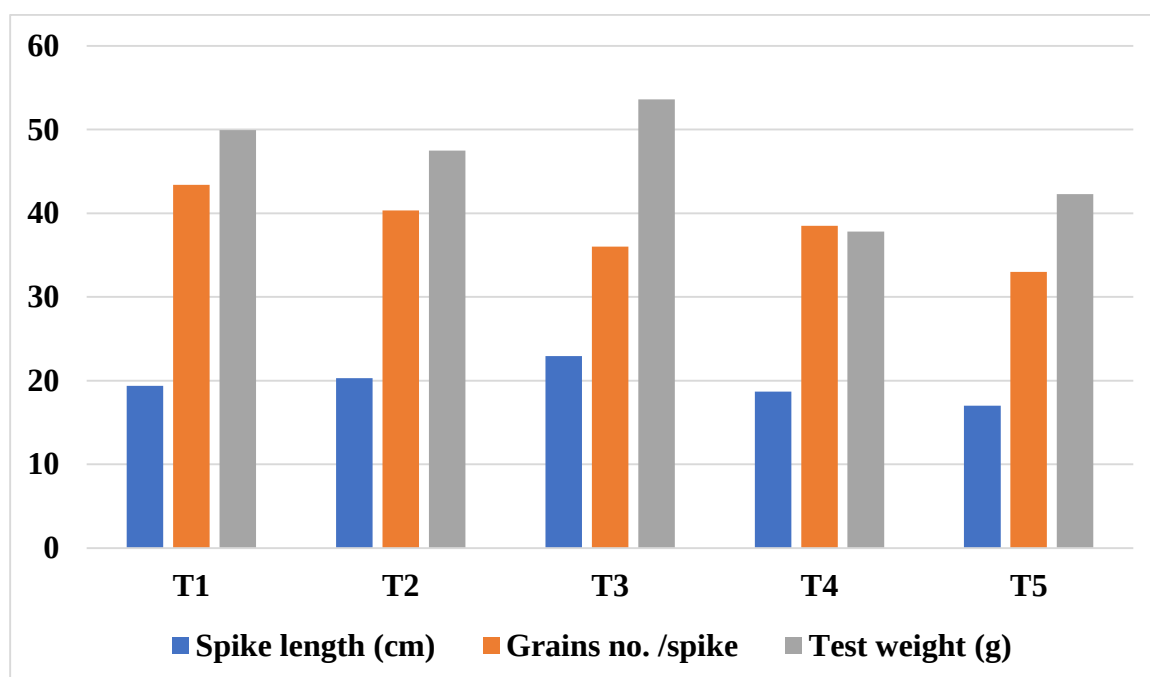


Fig: 4.28: Effect of treatments on yield attributes during Rabi 2021-2022.

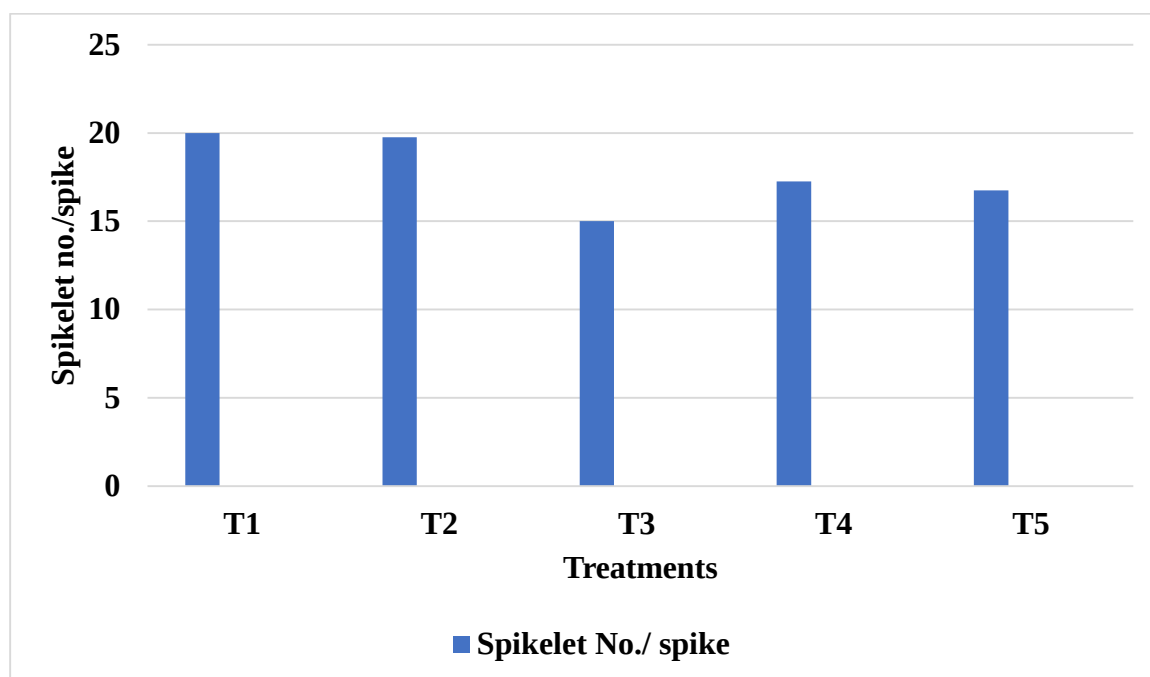


Fig.4.29: Effect of treatments on spikelet No./spike during *Rabi 2020-2021* trial.

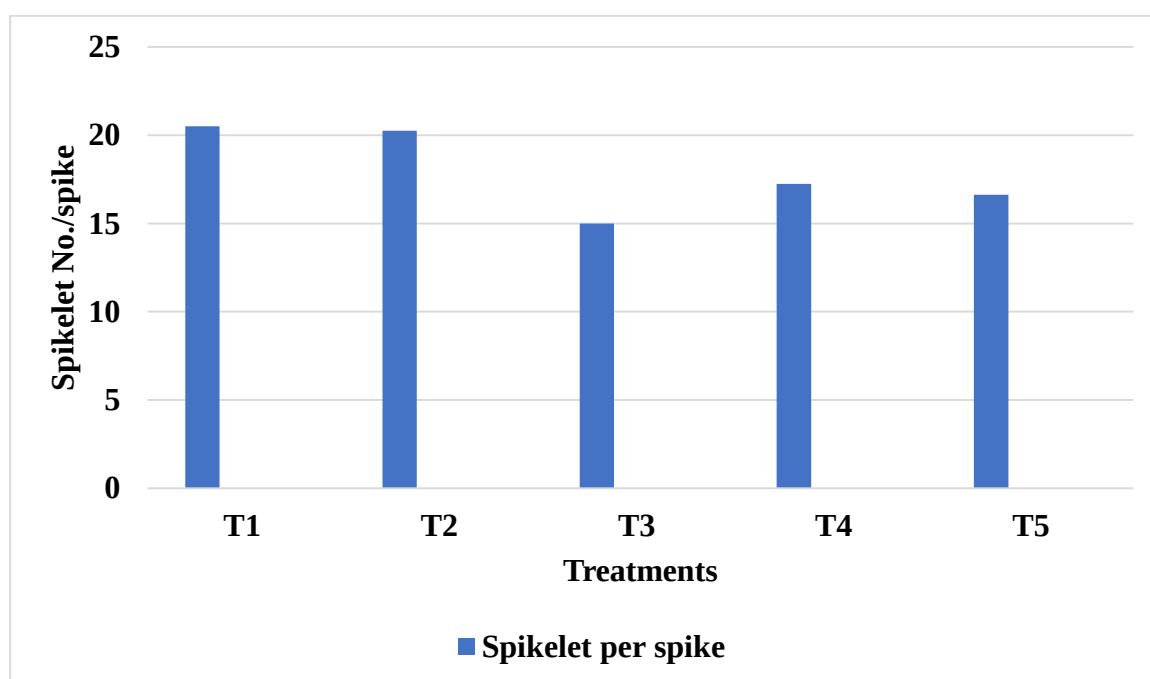


Fig.4.30: Effect of treatments on spikelet No./spike during *Rabi 2021-2022* trial.

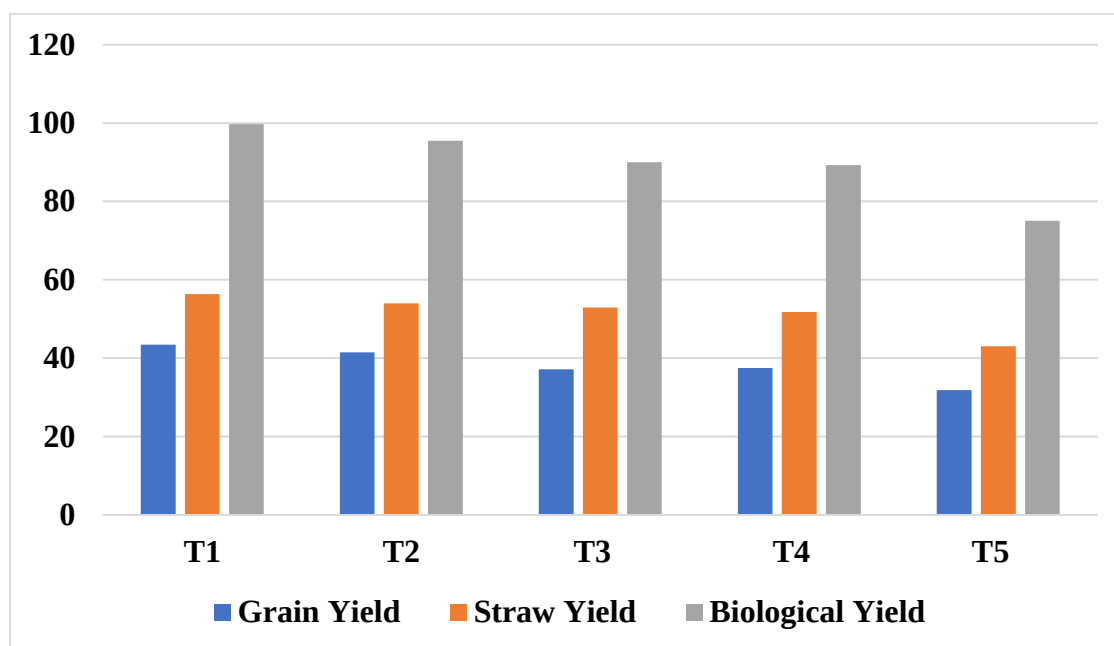


Fig. 4.31: Effect of various treatments on grain yield (q/ha), straw yield (q/ha), and biological yield (q /ha), of the Wheat crop during *Rabi* season 2020-2021.

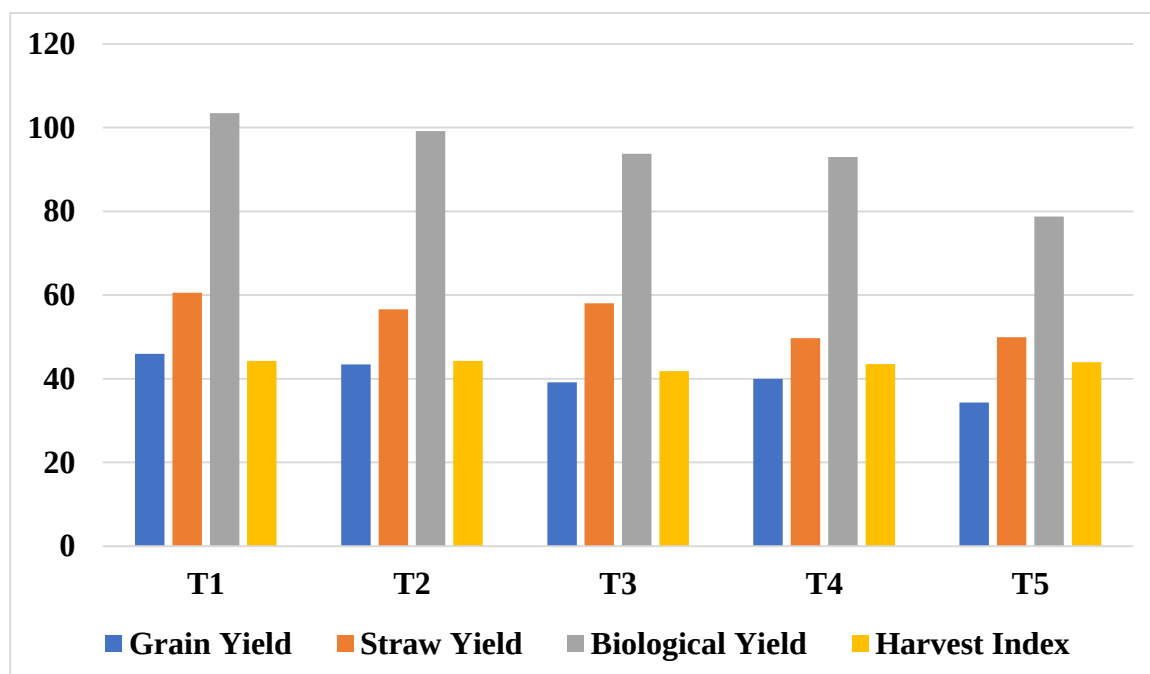


Fig 4.32: Effect of various treatments on grain yield (q/ha), straw yield (q/ha), and biological yield (q/ha) of the Wheat crop during *Rabi* season 2021-2022

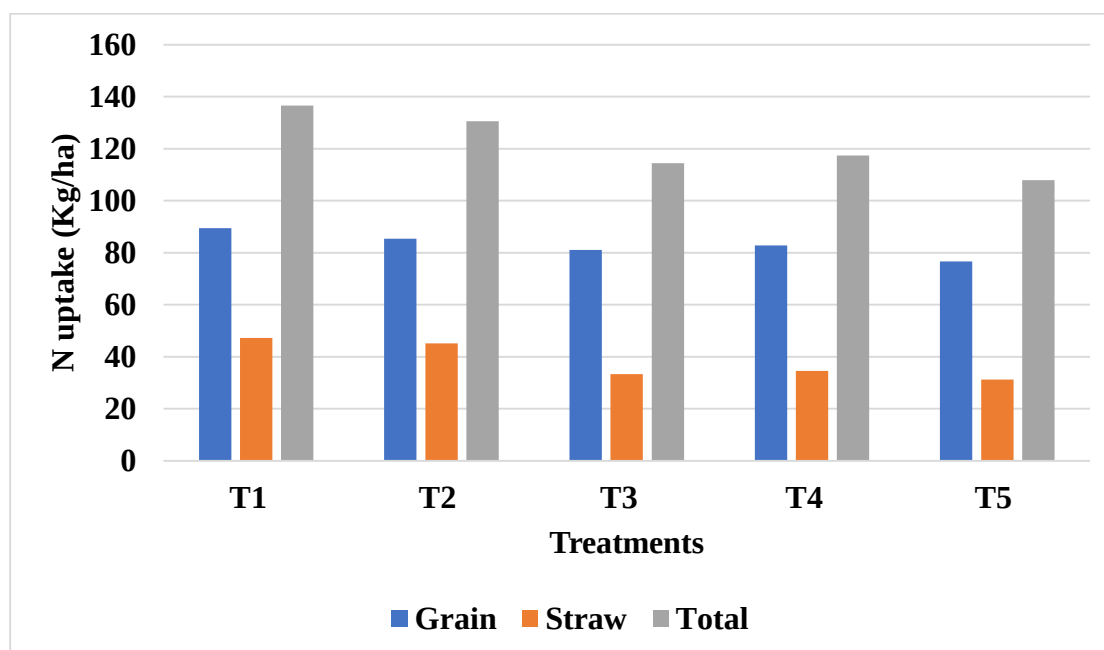


Fig. 4.33: Effect of treatments on N uptake by grain, straw, and total uptake (Kg/ha) during *Rabi* 2020-2021.

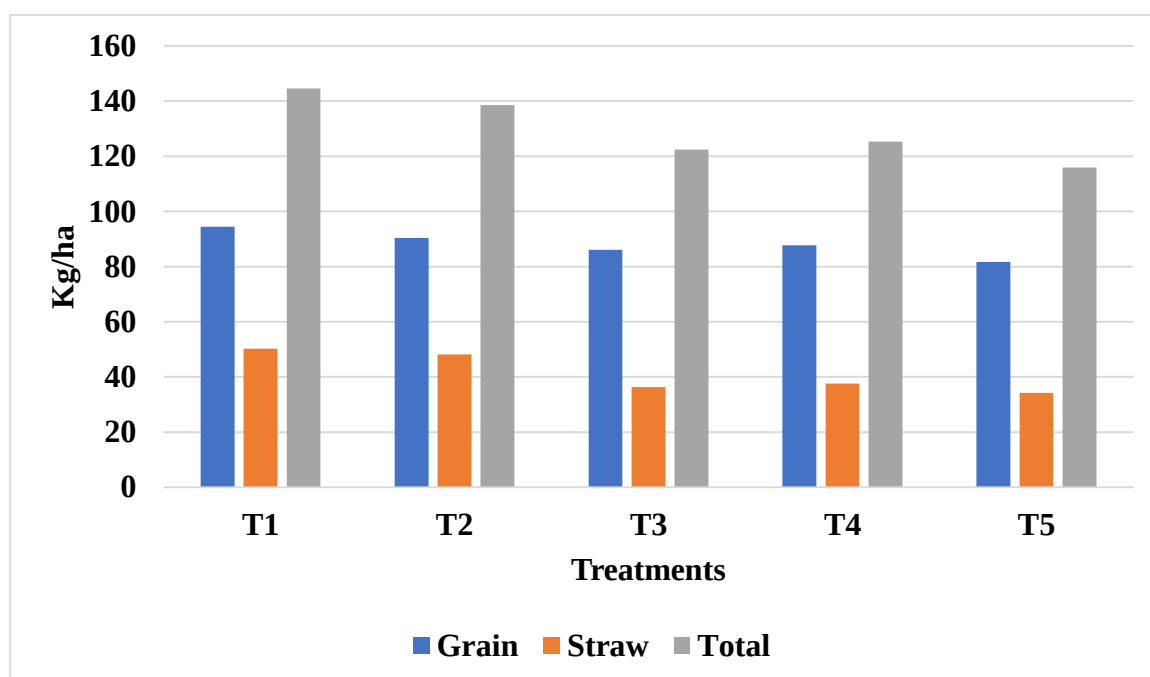


Fig. 4.34: Effect of treatments on N uptake by grain, straw, and total uptake (Kg/ha) during *Rabi* 2021-2022.

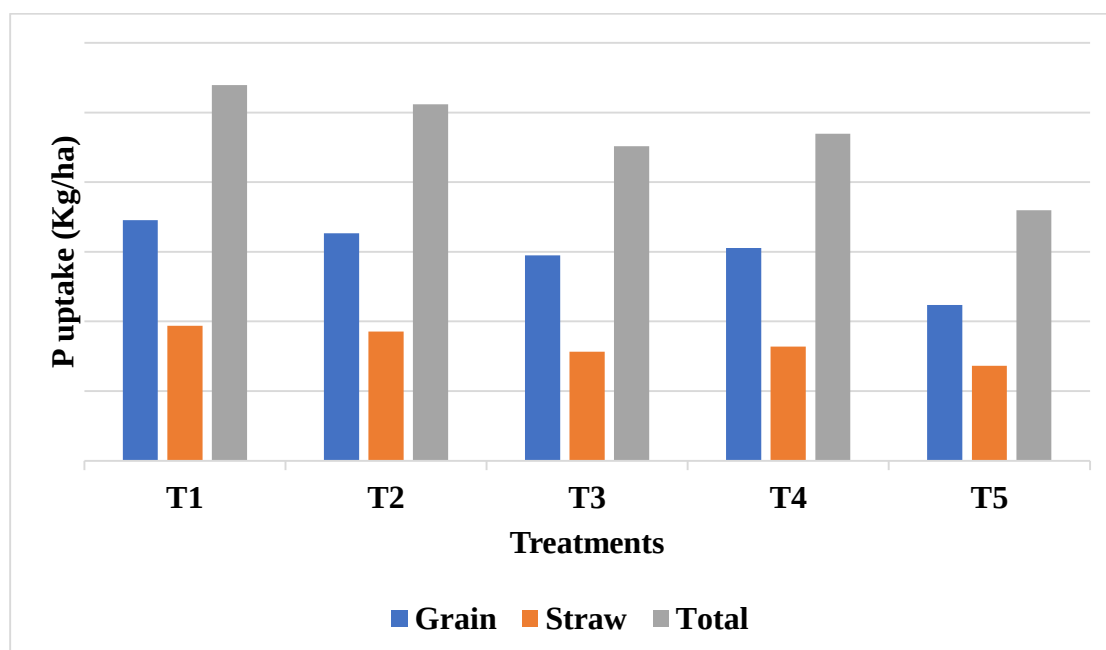


Fig. 4.35: Effect of treatments on P uptake by grain, straw, and total uptake (Kg/ha) during *Rabi* 2020-2021.

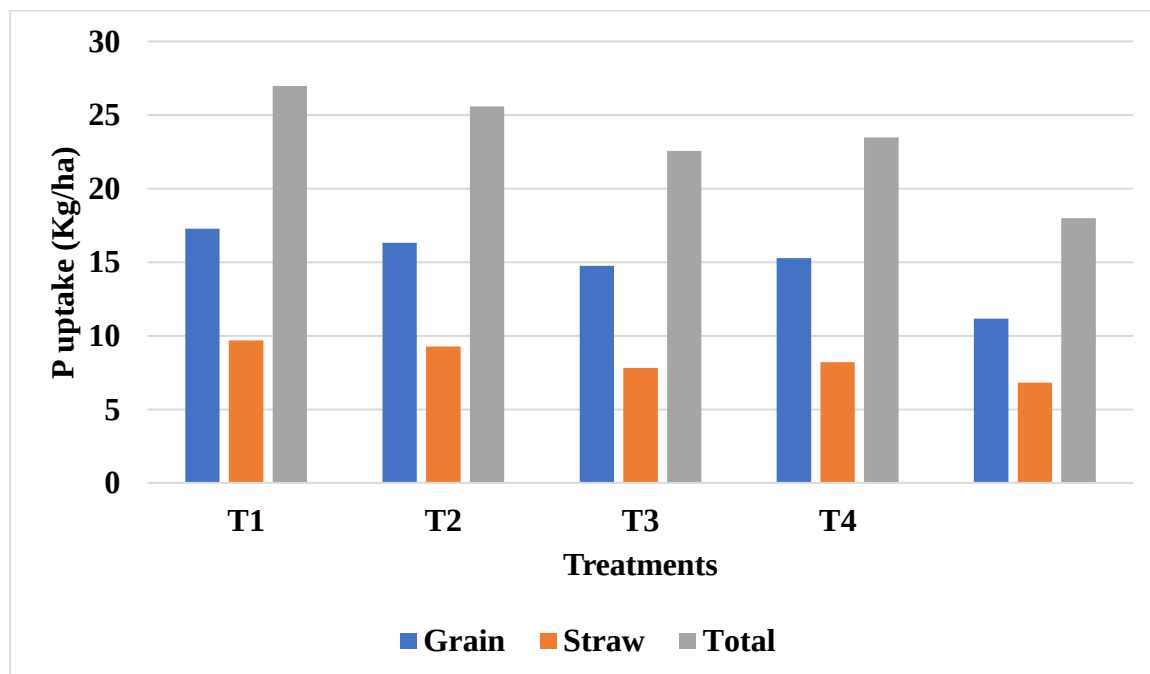


Fig. 4.36: Effect of treatments on P uptake by grain, straw, and total uptake (Kg/ha) during *Rabi* 2021-2022.

DISCUSSION

In this chapter, the findings of the current study "**Effect of plant morphology and chlorophyll content on weed dynamics, germination, growth, yield, and quality parameters of wheat (*Triticum aestivum* L.)**" have been reviewed and discussed in light of the analysis of literature that includes research findings. The conversation is limited to pertinent areas such as weed research, agricultural research, and economics.

5.1 WEATHER AND CLIMATE EFFECTS ON CROP GROWTH

In comparison to the usual rainfall, the total amount of rainfall received throughout the crop growing season was 4.2 mm during *Rabi* 2020-2021 and 69.2 mm during *Rabi* 2021-2022 with uneven distribution, requiring more water for irrigation. During the crop growing period, the maximum temperature ranged from 19.4 to 40.7°C, 18.5–42.0°C during *Rabi* 2020-2021 and *Rabi* 2021-2022 respectively while the minimum temperature ranged from 7.3 to 22.1°C, and 6.7–21.9°C during *Rabi* 2020-2021 and *Rabi* 2021-2022 respectively, all of which were within the ideal temperature range for wheat. Table 3.1, 3.2 and Fig 3.1, 3.2 show the mean weekly weather data for the cropping season.

External and internal factors influence crop growth and yield, with moisture and nutrient availability being the most important external factors. Agricultural performance is also influenced by the presence of weed flora infesting the crop field, which competes with crop plants for external resources and can change the microclimate.

During both the trials, *Rabi* 2020-2021 and *Rabi* 2021-2022 same trend was observed.

5.2 EFFECT OF VARIOUS TREATMENTS ON WEED DYNAMICS

5.2.1 Weed flora

Depending on the soil, place, temperature, and existing weed seeds, weed infestation in the agricultural field was noticed. These were broad-leaved weeds such as *Chenopodium album* L., *Anagallis arvensis* L., and *Parthenium hysterophorus* L., as well as narrow-leaved weeds like *Cynodon dactylon* Pers., and *Cyperus rotundus* L.

Labar *et al.* (2017) and Punia *et al.* (2018) also observed these weeds in their experimental fields.

5.2.2 Weed density

Various treatments used had a substantial effect on weed density at 30 DAS, 60 DAS and 90 DAS. Treatments having higher leaf area index, initial faster rate of growth, more tillers/m², and more height showed less weed infestation than others. Similar results were obtained by Alex G. Ogg Jr. and Steven S. Seefeldt (2017)

Gail A. Wicks *et al.* (2017) and K.M Murphy *et al.* (2008) also found similar results.

5.3 EFFECT OF TREATMENTS ON CROP GROWTH

Wheat has a predictable growth pattern. Wheat plant development is influenced by its photosynthetic process and nutrient absorption capacity from the initial stage to the harvest stage.

5.3.1 PLANT GROWTH PARAMETERS

5.3.1.1 Germination *per cent*

As per statistical analysis, the highest germination % was recorded in T₁ followed by T₂, while T₅ showed the least owing to the genetic superiority of these treatments. Buriro *et al.* (2011) also found similar results.

5.3.1.2 Plant height

Owing to genetics, T₁ achieved the longest height at all the growth stages followed by T₂, resulting in better weed suppression and better competitive ability and thus better resource use efficiency producing more yield. Similar results were obtained by R. K. Vandeleur and G. S. Gill (2004).

5.3.1.3 Fertile tiller count/plant

It was found highest in T₁, followed by T₂. These treatments showed greater yield, as fertile tiller count is proportional to yield.

Similar results were obtained by Quan Xie *et al.* (2016) and S. Elhani *et al.* (2007).

5.3.1.4 Leaf count

It was found highest in T₁, followed by T₂ owing to genetics. It was also observed that T₁ had the highest yield, followed by T₂, due to more leaf count, ultimately leading to more leaf area, photosynthetic accumulation, and better competitive ability against weed. Similar results were obtained by Rai *et al.* (2018).

5.3.1.5 Awn length

T₁, T₂, T₃ and T₄ were found at par with each other in terms of awn length. As awns contribute to a large extent in grain filling T₁, T₂ and T₃ showed greater thousand kernel weight in comparison to others, thus leading to more grain yield/ha. Similar results were obtained by Maydup *et al.* (2014).

5.3.1.6 Leaf Area Index

It was found highest in T₁ followed by T₂ owing to greater leaf count and more leaf area. These treatments showed greater yield due to better use of PAR (Photosynthetically active radiation). Weeds and crops have less competition for scarce

resources such as nutrients, water, sunshine, and space as weeds are suppressed better in T₁. Similar results were obtained by Murphy *et al.* (2008)

5.3.2 YIELD ATTRIBUTES AND YIELD

5.3.2.1 Spike length

All the treatments were statistically found non-significant for spike length.

5.3.2.2 Grain number/spike

All the treatments were statistically found non-significant for grain no./spike.

5.3.2.3 Grain yield

T₁ treatment produced the highest yield in terms of grain (41.46 q/ha and 43.46 q/ha respectively in 2020–2021 and in 2021–2022) followed by T₂ (45.93 and 43.45 q/ha in 2020–2021 and in 2021–2022 respectively) due to superior morphology and high chlorophyll content, resulting in good weed suppression ability and better use of resources. These results were achieved because these plots had proper vegetative development, which improved tillering, blooming, and fruiting, resulting in an increase in yield attributable features. Similar results were obtained by Murphy *et al.* (2008) and Richards *et al.* (2018).

5.3.2.4 Straw yield

All the treatments were statistically found non – significant for both the years.

5.3.3 NUTRIENT UPTAKE BY CROP

NPK depletion by crop were maximum in T₁ while NPK uptake by crop was minimum in T₅ signifying the fact that the plants with superior morphological traits utilize resources better and suppress weeds that deplete a large amount of nutrients due to their competitive ability resulting in a shortage of nutrients for uptake by crop plant (Singh *et al.* 2013).

5.4 ECONOMICS

The cost of cultivation incurred in all treatments was the same as all the agronomic practices done were the same in order to find the most profitable treatment.

The highest gross return was found in the T₁ treatment followed by T₂ due to higher grain and straw yields, and the lowest gross return was incurred under T₅ owing to the decline in yield due to weeds, poor morphological characteristics, and less chlorophyll content in the treatment.

Interestingly, the highest net returns were observed under T₁, followed by T₂. Also, it should be noted that the quality of T₁ and T₂ treatments is better than the rest of the treatments which may fetch a higher price, although at some markets, T₃ may also fetch a remunerative price owing to bolder grains and good nutritional properties. The B-C ratio was found to be highest under T₁ treatment due to greater net returns, followed by T₂ treatment. The lowest B-C ratio was obtained under T₅. The main profit difference was caused by the ultimate yield, *i.e.*, the grains and straw that can be sold to earn a profit.

Since T₁ showed greater yield both in terms of grain yield and straw yield, followed by T₂, they seemed to be the most economical options, but it is important to note that T₃ matured earlier than all the treatments, providing scope for better land utilization, which may be economical. D'ixon *et al.* (2005) and Islam *et al.* (2014) also reported similar results.



SUMMARY AND CONCLUSION

During the *Rabi* season of 2020-21 and 2021-2022 an experiment on “**Effect of plant morphology and chlorophyll content on weed dynamics, germination, growth, yield and quality parameters of wheat (*Triticum aestivum* L.)**” was conducted at the Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi in a Randomized Block Design, five treatments were laid out having different morphology and chlorophyll content.

The salient features of the findings are briefed below:

6.1 EFFECT ON WEEDS

1. Both narrow and broad-leaved weeds were present in the experimental field, with narrow-leaved weeds having a higher prevalence than broad-leaved weeds.

2. At 60 DAS and 90 DAS, different treatments had a substantial effect on the weed density of broad-leaved and narrow-leaved weeds, ultimately influencing overall weed density. The T₁ treatment showed the lowest weed density, while T₅ showed the highest weed density.

6.2 EFFECT ON CROP

6.2.1 Effect on growth parameters

1. Owing to good genetics, T₁ treatment reported the highest germination rate, followed by T₂ and T₅ reported the least.
2. A significant effect was noticed on plant height with different treatments at 30 DAS, 90 DAS and at harvest stage. The maximum plant height was

recorded under T₁ treatment, which was on par with T₂ at 90 DAS and at harvest. However, no treatment had any significant difference on height at 60 DAS.

3. Various treatments exhibited a significant impact on tiller count at 90 DAS and at harvest. The maximum tiller count was observed under T₁ treatment among all the treatments at 60 DAS, 90 DAS and at harvest. However, the tiller count in T₁ was at par with T₂ at the harvest stage.
4. Various treatments exhibited a significant impact on leaf count at 90 DAS and at harvest. The maximum leaf count was observed under T₁ treatment among all the treatments at 30 DAS, 60 DAS, 90 DAS and harvest and the least in T₅.
5. Various treatments exhibited a significant impact on LAI at 30 DAS, 60 DAS, 90 DAS, and at harvest. The maximum LAI was observed under T₁ treatment among all the treatments at 30 DAS, 60 DAS, 90 DAS and at harvest.
6. Various treatments exhibited a significant impact on awn length. The maximum was observed under the T₁ treatment among all the treatments. However, the awn length in T₁ was on par with T₂ at harvest stage.
7. Various treatments exhibited a significant impact on days to maturity. T₄ took the longest time to mature and T₃ took the shortest number of days to mature. However, T₁, T₂, T₄, and T₅ were found to be at par.

6.2.2 Effect on yield attributes and yield

1. The different treatments employed in the present study had no significant impact on spike length, grain no./spike.

2. Treatments exhibited significant impacts on test weight. The highest test weight was found in T₃. T₁ and T₂ were at par with each other.
3. The different treatments employed in the present study had significant impacts on grain yield and biological yield with the highest recorded in T₁, which was at par with T₂ and significantly superior to all other treatments.
4. Treatments exhibited significant impacts on spikelet/spike. The highest was found in T₁ which was superior to the rest. T₁ and T₂ were at par with each other.
5. The maximum biological yield was recorded under T₁, which was at par with T₂ and T₃.
6. The harvest index was reported as non-significant.
7. The maximum nutrient uptake by crop was recorded in T₁, followed by T₂ due to better utilization of resources owing to good morphology and less crop weed competition in these plots.

6.3 EFFECT OF TREATMENTS ON SPAD READING.

The maximum SPAD reading was observed in T₁ followed by T₂ owing to genetic constitution.

6.4 ECONOMICS

1. The cost of cultivation was the same for all the treatments and maximum gross returns were obtained under the T₁ treatment, followed by T₂.
2. The T₁ plot had the highest benefit-to-cost ratio, followed by T₂.
3. T₁ yielded the highest net returns, which was closely followed by T₂.

6.5 CONCLUSION

On the basis of the results of the two years trial, following three groups can be made.

1. Group A comprising of treatment 1 and 2 were found superior over group B (T₄ and T₅) and group C (T₃) in terms of physico-morphological characteristics, yield attributing characters, and grain quality except days to maturity, 50% flowering and seed boldness.
2. Group B comprising treatments 4 and 5 was found superior over group C in terms of physico-morphological characteristics, yield attributing characters, and grain quality except days to maturity, 50% flowering, seed boldness, plant height, awn length, SPAD reading, TKW.
3. Group C comprising treatment 3 was found low performing than group B (T₃ and T₄) in terms of physico-morphological characteristics and yield attributing characters, except days to maturity, 50% flowering and seed boldness, plant height, awn length, SPAD reading, and TKW.

Group	Treatments falling	Characteristics
A	T ₁ , T ₂	• Germination % 80.20-84.40 • Plant height (At harvest) 95.60-105.70 cm • Tillers (At harvest) 3.75-4.50 • Leaf count (90 DAS) 14.25-16.75 • 50% flowering (DAS) 73.50-69.00 • LAI 2.70-3.10 • Awn length 7.90-7.05 cm • Days to maturity 116.50-123.50 DAS • Av. SPAD reading 42-45.30

		• Spikelet/spike 19.70-20.50 • Test weight 49.90-45.20 g • Grain yield 41.50-45.90 q/ha • Straw yield 53.42-60.55 q/ha • Leaf Erectophile
B	T ₄ , T ₅	• Germination % 69.00-71.50 • Plant height 89.60-91.90 cm (At harvest) • Fertile tillers 2.80-3.02 • Leaf count (90DAS) 10.00-15.20 • 50% flowering 76-75 DAS • LAI 2.69-2.84 • Awn length 5.80-7.80 cm • Days to maturity 125.00-127.00 DAS • SPAD reading 35.30-35.80 • Spikelet/spike 17.25-16.60 • Test weight 34.60-42.00 g • Grain yield 31.81-39.90 q/ha • Straw yield 46.80-49.90 q/ha • Leaf Planophile
C	T ₃	• Germination % 64.00-65.00 • Plant height 93.00-96.00 cm (At harvest) • Fertile tillers 2.50-2.80 • Leaf count (90DAS) 9.75-10.75 • 50% flowering 64-65 (DAS) • LAI 2.30-2.50 • Awn length 7.02-7.70 cm • Days to maturity 107.50-108.50 DAS • SPAD reading 38.20-39.40 • Spikelet/spike 15 • Test weight 50.80-53.60 g • Grain yield 37.15-39.15 q/ha • Leaf Erectophile



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APPENDICES

Appendix I (a). Common cost of cultivation/ha.

S. No.	Operation	Rate/unit (₹)	Quantity	Cost/ha (₹)
1.	Field Preparation	610/hr	8hrs	4,808
2.	Land Layout	300/labour	5 labourers	1,500
3.	Seed	42/Kg	100 Kg	4,200
4.	Sowing	300/labour	12 labourers	3,600
5.	Fertilizer ▪ Urea ▪ DAP ▪ MOP ▪ 2 labourers for 1 day	5.36/Kg 24/Kg 16/Kg 294/labour	275 Kg 130.50 Kg 66.66 Kg 2 labourer	1,474 3,132 1,066.56 588
6.	Irrigation (3) ▪ Tubewell ▪ 2 labourers for 1 day	50/hr 300/labour	8×3=24 hours 2×3= 6 labourers	1,200 1,800
7.	Harvesting	300/labour	15 labourers	4,500
8.	Threshing ▪ Machine Charge ▪ Labour Charge	 300/labour	1 6 labour	2,400 1,800
Total				₹ 32,090.56

(Note – Cost of cultivation may vary due to price difference in varieties' seed.)

Appendix I (b). Common cost of cultivation/ha

S. No.	Operation	Rate/unit (₹)	Quantity	Cost /ha (₹)
1.	Field Preparation	610/hr	8hrs	4,808
2.	Land Layout	350/labour	5 labourers	1,750
3.	Seed	42/ Kg	100 Kg	4,200
4.	Sowing	350/labour	12 labourers	4,200
5.	Fertilizer ▪ Urea ▪ DAP ▪ MOP ▪ 2 labourers for 1 day	5.36/Kg 24/Kg 16/Kg 350/labour	275 Kg 130.50 Kg 66.66 Kg 2 labourer	1,474 3,132 1,066.56 700
6.	Irrigation (3) ▪ Tubewell ▪ 2 labourers for 1 day	50/hr 350/labour	8×3=24 hours 2×3= 6 labourers	1,200 2,100
7.	Harvesting	300/labour	15 labourers	4,500
8.	Threshing ▪ Machine Charge ▪ Labour Charge	 300/labour	1 6 labour	2,400 1,800
Total				₹ 33,330

Appendix II (a): Cost occurred for weed control

Weed Control	Number of labour required for hand weeding	Labour Charge/day (₹)	Total Cost/ha (₹)
Weeding	21	300	6,300

Appendix II (b): Cost occurred for weed control

Weed Control	Number of labour required for hand weeding	Labour Charge/day (₹)	Total Cost/ha (₹)
Weeding	21	350	7,350

Appendix III (a): Economics of different treatments

Treatments	Cost of Cultivation (₹)	Gross Returns (₹)	Net Returns (₹)	B: C Ratio
T ₁	36,714	99,868.75	63,154.75	1.72
T ₂	36,714	95,378.56	58,664.56	1.59
T ₃	36,714	86,591.25	49,877.25	1.35
T ₄	36,714	86,962.19	50,248.19	1.36
T ₅	36,714	73,594.09	36,880.09	1.00

Minimum Support Price (2020-21) of wheat- ₹ 1,975 q ha⁻¹; Price of straw of wheat- ₹ 250/q

Appendix III (b): Economics of different treatments

Treatments	Cost of Cultivation (₹)	Gross Returns (₹)	Net Returns (₹)	B: C
T₁	40,680	107,702.60	67,022.57	1.64
T₂	40,680	101,705.90	61,025.87	1.50
T₃	40,680	93,398.50	52,718.50	1.29
T₄	40,680	92,982.13	52,302.13	1.28
T₅	40,680	81,624.45	40,944.45	1.00

Minimum Support Price (2021-22) of wheat- ₹ 2,015 q ha⁻¹; Price of straw of wheat- ₹ 250/q

Glossary



General view of the experimental field



Tillering



Late Jointing



Booting





Heading

Maturity



Photographs of the experimental analysis