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Effect of conservation tillage and precise nitrogen management on growth of wheat

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Abstract
The present investigation entitled "Effect of conservation tillage and precise nitrogen management on growth of wheat" study was carried out at the Crop Research Centre of Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut, (U.P.) during rabi season of 2021-22 and 2022-23. The experiment was conducted under split plot design with three replications, treatments comprising of three conservation tillage treatments {C_1-Conventional tillage, C_2- Reduced tillage and C_3- Furrow irrigated raised bed (FIRB)} as main plots and four precise nitrogen treatments (N_1- Control, N_2- State recommendations, N_3- LCC based nitrogen Application and N_4- SPAD based treatments) as sub plot treatments. The soil of the experimental site was sandy loam having low organic matter (0.43%), low in available nitrogen, low in available phosphorus and high in available potassium. The maximum values of growths attributes (plant height, number of tillers and dry matter accumulation) was recorded in furrow irrigated raised bed (FIRB) system than rest of tillage practices. Among precise nitrogen treatments, the maximum value of growth characters (plant height, number of tillers, dry matter accumulation, CGR and RGR) were noticed with application of nitrogen using SPAD meter while LCC treatments were at par with SPAD meter.

Keywords: SPAD, LCC, wheat, FIRB

Introduction
The world's most significant food crop is wheat. Grown over 217 million hectares of land in 122 countries worldwide, production is 781.7 million tons of wheat in 2021–2022. The yearly global consumption of wheat is estimated to be 777 million tons, and it is anticipated to rise over the next several years (Anonymous, 2022) [3]. India is the world's leading producer of wheat. It is currently producing more wheat than the United States of America and ranks second only to China. In India, 31.6 million hectares of wheat were planted in 2021–2022, yielding 109.52 million tons of grain and 3464 kg ha^{-1} of productivity (Anonymous, 2021) [2]. Even though rice is the most popular staple meal in India, wheat is more popular in the food market due to its superior nutritional qualities when compared to rice, which is consumed by a larger population. During the crop growing period, the soil moisture regime and the current weather patterns have a significant impact on wheat genotype productivity.

Since over 60% of Indians live in rural regions, the wheat crop system's sustainability and profitability are crucial to the country's agricultural future. There are many obstacles to overcome, from investing in new technologies to protecting the environment. A major problem facing India is raising the nation's food output in the next 20 years to keep up with population growth. It is more challenging since the amount of land used for agriculture will either decrease or stagnate, and better land and water resources will be split up and allocated to other sectors of the national economy. Enhancing and maintaining the quality of natural resources such as seed, water, variety, and fuel is necessary to increase the yield of food produced on marginal and high-quality soils. Proper crop establishment techniques, among other agronomic approaches, can significantly boost wheat output to a certain degree. To obtain the most productivity out of wheat and to make better and more efficient use of the resources available for plant growth, ideal planting geometry is crucial. It is also commonly known that one of the key elements in crop production that leads to improved yield is nutrient management. Both crop establishment techniques and fertilization have an impact on wheat's economics and efficiency in using nutrients.

Furrow-irrigated raised-bed planting system (FIRBs) is a form of tillage wherein sowing is done on raised-beds, this optimizes tillage operation, saves water and reduces lodging.

The width of the bed and furrows commonly used are 45-50cm and 25-30 cm, respectively and the bed height is 15-20 cm. Crop production is influenced by its establishment and plant vigour representing the key factors towards crop development Monsefia *et al.* (2016) [13]. In this system, the land is prepared conventionally and raised bed and furrows are prepared manually or using a raised bed planting machine. Crops are planted in rows on top of the raised beds and irrigation water is applied in the furrows between the beds, water moves horizontally from the furrows into the beds. Planting of wheat on beds (FIRBs) is a novel technique to save water and enhancing the productivity of other input applied (Das *et al*., 2013) [7].

The most significant limiting factor affecting wheat output is nitrogen. Because nitrogen is a component of protein, chlorophyll, alkaloids, vitamins, hormones, protoplasm, and chlorophyll, healthy crop production requires an adequate amount of nitrogen. In the end, nitrogen produces more dry matter and higher yields. Application of nitrogen to wheat crops is beneficial, while too much nitrogen cannot be tolerated. On the other hand, excessive nitrogen application to wheat increases the risk of NO3 pollution of ground water and reduces nitrogen recovery efficiency. The crop's production may suffer if nitrogen stress persists during the "critical growth stage" of the crop.

A precise nutrient management method makes use of comprehensive site-specific data to manage the nutrients that crops require. With the use of precise techniques and equipment, producers can enhance the efficiency and effectiveness of nutrients, maintain or boost yields, reduce nutrient losses from fields, and safeguard surface and ground water supplies by implementing a precision nutrient management plan. The 4 R's (Right rate, Right source, Right application method, and Right application time) guarantee that the crop receives the right amount of nutrients where they are needed thanks to precision nutrition management approaches. Farmers have a lot of opportunity to estimate plant Nitrogen (N) needs in real time for efficient use by using leaf color charts (LCCs). The majority of Indian farmers apply nitrogen fertilizer in split applications; nevertheless, there are significant variations in the number of splits, amount of nitrogen applied each split, and application time. LCC improves fertilizer use efficiency by managing nitrogen over a vast region. Using the LCC method resulted in an average nitrogen savings of 25 kg ha^{-1} without compromising production (Balasubramanian, 2002) [4]. The leaf color chart (LCC) is a perfect tool for optimizing wheat's usage of nitrogen at different high yield levels, regardless of the type of nitrogen applied-chemical fertilizers, organic manure, or nitrogen fixed by biological processes (Alam *et al*., 2006) [1]. From plant nutrition point of view, the importance of the concept of balanced fertilizer use lies in adjusting the level of fertilizer use, taking into account available soil nutrients, crops requirement for targeted production levels under specific soil-water-crop management practices (Gupta and Jat, 2010) [9].

A straightforward, portable diagnostic instrument called a SPAD meter, often known as a chlorophyll meter, quantifies the relative chlorophyll content or greenness of plants. Although the link varies depending on the crop's growth stage and/or variety, there is a strong linear correlation between SPAD values and leaf nitrogen content. The SPAD meter was modified to evaluate crop nitrogen status and determine whether extra nitrogen fertilizer is required for the plant due to the linear relationship between nitrogen and SPAD values. According to SPAD measurements, the physiological nitrogen requirements of crops at various growth stages dictate the plant nitrogen status and the quantity of nitrogen to be administered.

Materials and Methods

Split plot design was used for the experiment, with three replications. The treatments included four precise nitrogen treatments (N1-Control, N2-State recommendations, N3- LCC based nitrogen Application, and N4- SPAD based treatments) as sub plot treatments, and three conservation tillage treatments (C1- Conventional tillage, C2- Reduced tillage, and C3- Furrow irrigated raised bed (FIRB)} as main plots. Row spacing was maintained at 20 cm, with a gross plot size of 5 x 4.8 and a net plot size of 4 x 4. A seed rate of 100 kg ha^{-1} was employed, and 150:75:60 kg ha^{-1} of NPK was advised. The variety in question was DBW-222. LCC measurements beginning at 15 DAS. Split plot design was used for the experiment, with three replications. The treatments included four precise nitrogen treatments (N1-Control, N2-State recommendations, N3- LCC based nitrogen Application, and N4- SPAD based treatments) as sub plot treatments, and three conservation tillage treatments (C1- Conventional tillage, C2- Reduced tillage, and C3- Furrow irrigated raised bed (FIRB)} as main plots.

Row spacing was maintained at 20 cm, with a gross plot size of 5 x 4.8 and a net plot size of 4 x 4. A seed rate of 100 kg ha-1 was employed, and 150:75:60 kg ha^{-1} of NPK was advised. The variety in question was DBW-222. LCC measurements beginning at 15 DAS. When LCC readings were obtained again after 7 days, the same 5 plants were discovered. When the color of the leaves was less than the strip's threshold color (4), 20 kg N ha^{-1} was given. At 15 DAS, SPAD readings started. A random selection of five plants per plot were used to get SPAD readings. Every one of the five tagged plants had its top three healthy, fully grown leaves observed. The sample to be examined was placed into the sample slot on the measuring head once the device had been calibrated. It was very carefully made sure the sample completely covered the reception window. It was not attempted to measure very thick portions, like leaf veins. For leaves with lots of tiny veins, several measurements were taken and averaged for best results. Breaking off a leaf was not allowed. Every day between 8 and 10 AM, readings were taken. If the average SPAD value dropped below the crucial value, N was applied to the fields at a rate of 20 kg ha^{-1} if the SPAD readings were less than 45. Nitrogen was obtained by precision nitrogen treatments at a rate of 135 kg ha^{-1} as opposed to 150 kg ha^{-1} for the SR treatment.

Field preparation

Crop will be grown following the recommended package of practices, crop production measures shall be applied on need basis and crop will be established using following tillage systems.

1. **Reduced-tillage (RW):** In this approach, there is still some tillage *per se*, but there are far fewer preliminary tillage operations. Using a zero-till drill and an inclined planting plate, seeds are sown in rows 20 cm apart.
2. **Furrow irrigated raised bed (FIRB):** Using a tractor drawn multi-crop raised bed planter with inclined plate metering for planting wheat, the soil is tilled by two harrowing, followed by one field levelling (using a wooden board). The furrows separating the beds, which have a top width of 140 cm and a height of 12 cm, are each 30 cm broad. Each bed contains seven rows of wheat, spaced 20 cm apart.

3. **Conventional tillage (CTW):** This system uses two harrowing, two ploughing (using a cultivator), and one planking (using a wooden plank) after the harvest of the rice to achieve good tilth. Wheat is then seeded in rows 20 cm apart using a seed drill with a dry fertiliser attachment.

Statistical analysis
The experiment's results were subjected to statistical analysis using the Split Plot Design method, which was recommended by Cochran and Cox (1970). The critical difference (C.D. at 5%) will be calculated when comparing the treatment means whenever the "f" test is found to be significant. The standard error of the mean was calculated.

Results and Discussion
Plant height
Plant height is a crucial metric that may be utilized to examine how various treatments affect crop growth. Table 1 presents the data on periodic plant height that were measured at 30, 60, 90, and days after planting, as well as at harvest. Fig. 1 illustrates the data.

The early crop growth stage is when wheat plants reach their greatest height. After that, during both study years, there is a gradual rate of rise in plant height. With the exception of 30 DAS, where FIRB (C3) and decreased tillage (C2) treatment generated plants with identical heights over both trial years, FIRB (C3) recorded much taller plants than the other treatments. Similar results were also reported by Humphreys *et al.* (2009) [10].

The treatment plant height was not significantly affected by precise nitrogen management at the 30-day absorption stage; nevertheless, the control and SPAD-based nitrogen application treatment showed the lowest and greatest values in both years. When compared to treatments grown with alternative nutrient management systems during both years, treatments receiving LCC (N3) and SPAD (N4) based nutrients had produced noticeably taller plants at the 60, 90, and harvest stages. Treatments based on SPAD (N4) yielded the tallest plants, but they did not outperform LCC treatments. In both years, treatments that received nitrogen according to exact agriculture principles had plants that were around 5% taller than SR (150:75:60).

No. of tillers m^{-2}
The number of tillers per unit area is a crucial factor in assessing how a treatment will affect the development and production of a crop, such as wheat. Throughout both experimentation years, the number of tillers increased steadily as crop age increased and peaked at 90 DAS (Table 2 and Fig. 2). Exact nitrogen management treatments and conservation tillage had a major impact on the number of tillers.

Table 1: Effect of conservation tillage methods and precise nitrogen management on plant height (cm) of wheat at various crop growth stages

Treatments	Plant height (cm)							
	30 DAS		60 DAS		90 DAS		At harvest	
	21-22	22-23	21-22	22-23	21-22	22-23	21-22	22-23
Conservation tillage (Main plot)								
CT	15.9	15.4	54.4	53.7	79.7	81.1	86.7	86.3
RT	16.2	15.9	51.1	51.3	79.9	79.6	85.2	84.8
FIRB	16.6	16.2	56.9	57.2	86.8	83.6	88.5	88.9
S.Em±	0.07	0.1	0.6	0.4	1.1	0.5	0.6	0.5
C D (P=0.05)	0.28	0.4	2.7	1.9	4.7	2.1	2.3	2.1
Precise nitrogen management (Sub plot)								
Control	15.1	15.9	51.2	52.1	79.2	77.9	83.5	83.2
SR	15.5	15.3	53.3	53.9	81.4	80.6	86.3	85.9
LCC	15.2	16.0	55.6	55.2	83.7	83.1	87.7	88.4
SPAD	15.8	16.1	56.6	55.1	84.2	83.9	89.7	89.2
S.Em±	0.1	0.09	0.6	0.5	0.7	0.56	0.8	0.56
C D (P=0.05)	NS	NS	1.9	1.6	2.1	1.67	2.5	1.67

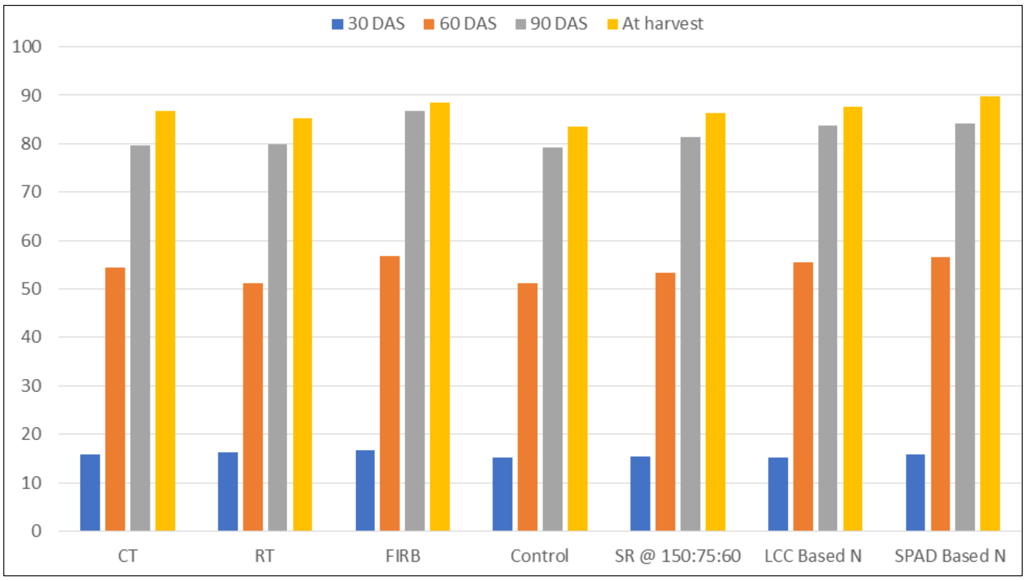

Fig 1: Effect of conservation tillage methods and precise nitrogen management on plant height (cm) of wheat at various crop growth stages during 2021-22

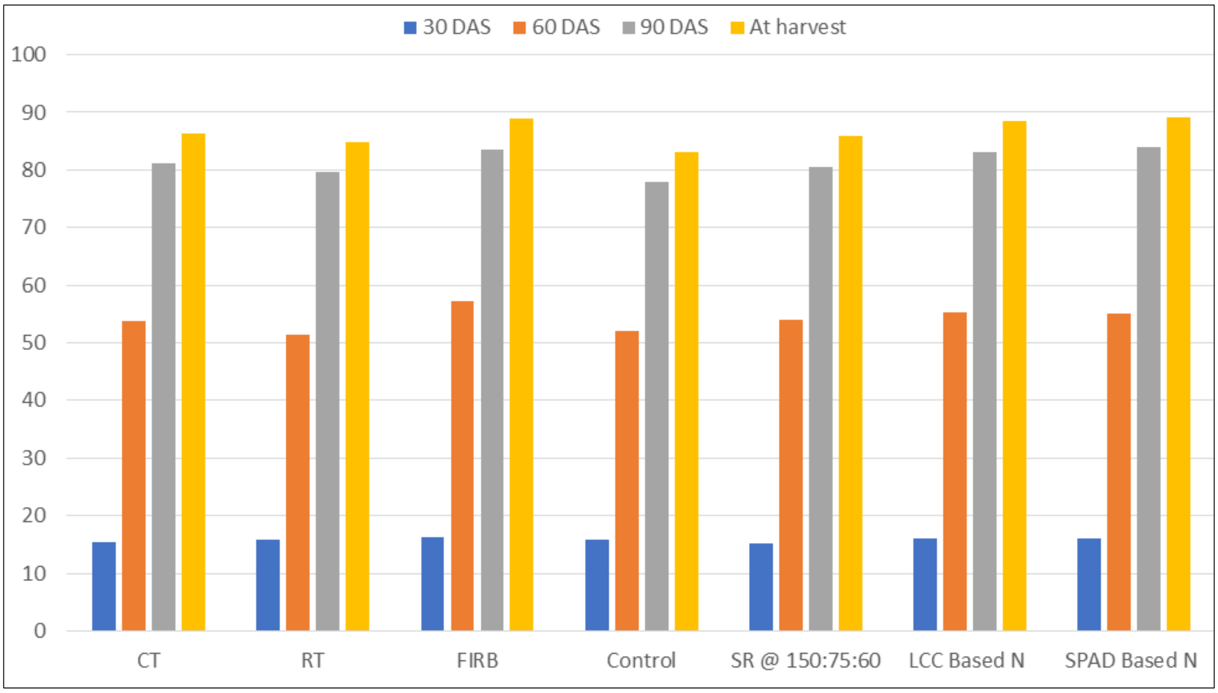

Fig 2: Effect of conservation tillage methods and precise nitrogen management on plant height (cm) of wheat at various crop growth stages during 2022-23

The analysis of the data showed that the number of tillers m-2 generated by wheat plants peaked at 90 days after seeding and then declined as crop age increased. During both of the experimental years, wheat planted on FIRB (C3) yielded the highest number of tillers at every stage, outperforming all other tillage crop establishment techniques. During both research years, the reduced tillage (C2) condition had the fewest number of tillers. During both of the testing years, the FIRB (C3) treatment outperformed the other treatments at every stage of crop growth. Throughout both trial years, a considerably higher number of tillers was documented in the conventionally tilled (C1) plots than in the decreased tillage (C2) plots.

Precise nitrogen control did not significantly affect the quantity of tillers at 30 DAS in either of the two years. However, throughout both of the testing years, the maximum and smallest number of tillers were seen with the administration of nitrogen using LCC (N3) and in the control plot, respectively. Due to precise nitrogen management treatments, a notable increase in the number of tillers was seen in both years' SPAD (N4) and LCC (N3) based nitrogen delivery at the 60, 90, and harvest stages. During both years, the control treatment showed a noticeably lower number of tillers.

Table 2: Effect of conservation tillage methods and precise nitrogen management on No. of tillers of wheat at various crop growth stages

Treatments	No. of tillers m^{-2}							
	30 DAS		60 DAS		90 DAS		At harvest	
	21-22	22-23	21-22	22-23	21-22	22-23	21-22	22-23
Conservation tillage (Main plot)								
CT	103	96	258	250	416	400	395	383
RT	94	91	251	243	392	376	371	361
FIRB	118	116	280	274	452	436	423	418
S.Em±	1.3	0.99	3.1	2.8	4.20	2.61	2.51	3.53
C D (P=0.05)	4.88	4.02	12.2	11.3	15.1	10.5	9.87	14.2
Precise nitrogen management (Sub plot)								
Control	101	97	232	225	372	349	321	332
SR	105	102	261	253	413	402	398	387
LCC	108	104	274	266	433	422	412	407
SPAD	104	101	284	278	461	442	432	423
S.Em±	1.6	2.36	2.11	3.58	6.72	6.13	5.37	5.35
C D (P=0.05)	NS	NS	9.65	10.7	19.9	18.3	15.9	16.0

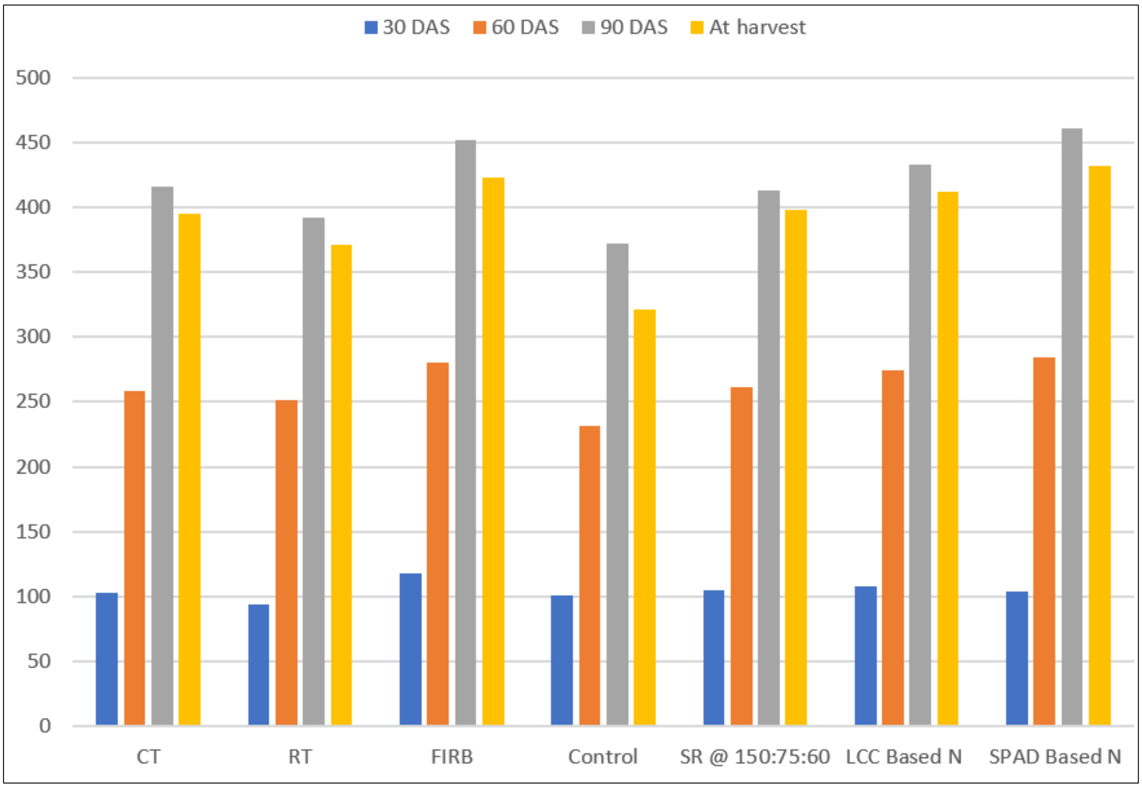

Fig 3: Effect of conservation tillage methods and precise nitrogen management on number of tillers of wheat at various crop growth stages during 2021-22

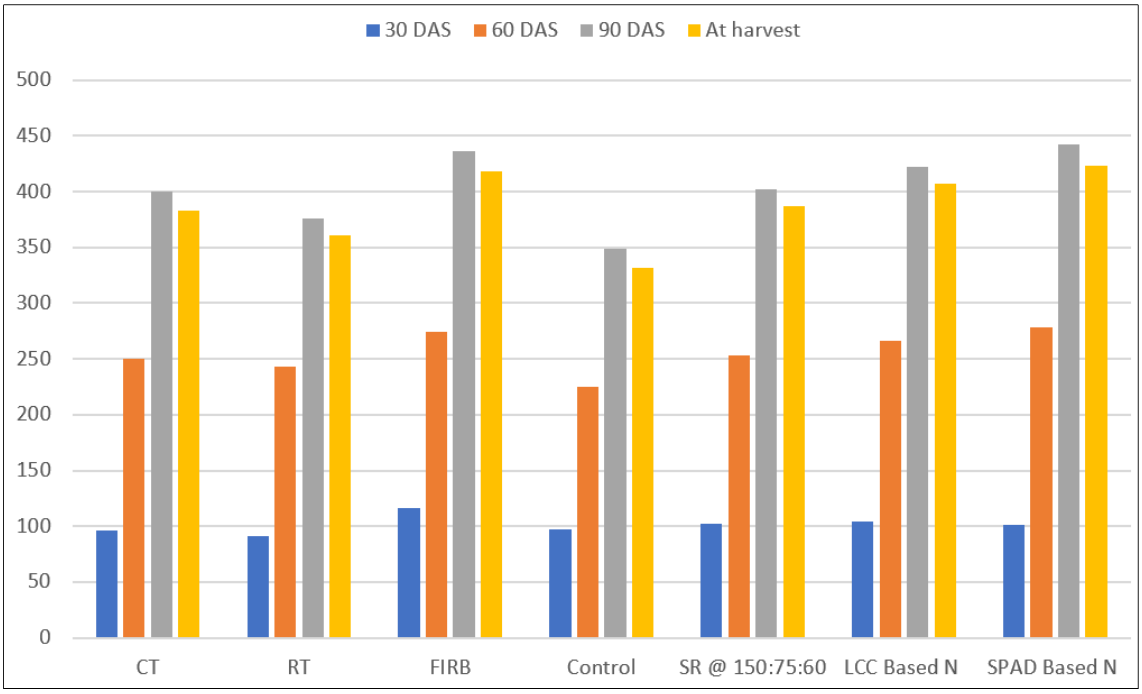

Fig 4: Effect of conservation tillage methods and precise nitrogen management on number of tillers of wheat at various crop growth stages during 2022-23

Dry matter accumulation (g m^{-2})

The increase of dry matter points to the photosynthates that are still present after respiration. It is therefore the most accurate measure of crop growth. The information about dry matter accumulation is shown in Fig. 4.3 and Table 4.3. During both of the test years, the wheat crop's dry matter accumulation was greatly impacted by various tillage techniques and exact nitrogen applications. Generally speaking, dry matter rose as crops became older and peaked during harvest. Due to moisture retention and the furrow irrigated raised bed technique (C3), which was substantially greater than the other tillage procedures at all stages of crop growth during both years, the maximum dry matter accumulation was obtained among the other tillage treatments. Increased input efficiency improved N, P, K supplying capacity of soil resulting in higher plant height because nitrogen is needed for the formation of chlorophyll, phosphorus for the synthesis of nucleic acids and similarly potassium is important for the growth and elongation probably due to its function as an osmoticum and may react synergistically with indole acetic acid (Cocucci and Dallarosa, 1980) [6] which is responsible for growth and development. Under FIRB system after every few rows furrow was made which made way for proper drainage of water and provided moisture to the crop on the bed in a more uniform way and not only this but space left open because of the furrow permits more light penetration and promotes aeration which in turn results in increased plant growth in wheat. The higher amount of available water kept the higher turgor potential, which leads to higher rate of photosynthesis due to larger opening of stomata for longer period of time. This has also increased for faster cell division and enlargement, which leads to higher growth rate. Similar results were also reported by Singh *et al.* (2010) [15] and Mahajan (2018) [11].

During the early phases of crop growth, applying nitrogen regardless of dose increased dry matter accumulation much more than doing nothing. At the harvest stage, the effect was more noticeable. Up until 90 DAS, there was a relatively greater increase in dry matter accumulation; beyond that, all treatments saw a slowdown. Throughout both of the testing years, the control plot, which received no nitrogen administration, showed noticeably less dry matter formation at every stage of crop growth. Precise nitrogen management treatments started to exhibit noticeable effects at 60, 90 DAS and harvest stage, while SPAD (N4) and LCC (N3) treatments were comparable to one another at all growth stages in both experimentation years. Using SPAD (N4) to apply nitrogen, maximum and minimum dry matter accumulation was seen in the control plot. As the crop growth spectrum advanced, the differences between the treated and control plots became more noticeable in both experiment years. Effect of precision nitrogen management on growth characters were also reported by Mathukia *et al.* (2014) [12] and Reena *et al.* (2017) [14], Gawdiya (2020) [8], Barad *et al.* (2018) [5] and Mahajan (2018) [11].

Table 3: Effect of conservation tillage methods and precise nitrogen management on dry matter accumulation of wheat at various crop growth stages

Treatments	Dry matter accumulation (g m^{-2})							
	30 DAS		60 DAS		90 DAS		At harvest	
	21-22	22-23	21-22	22-23	21-22	22-23	21-22	22-23
Conservation tillage (Main plot)								
CT	25.9	25.6	159.9	150.9	689.1	641.8	1089.4	1049.7
RT	24.9	24.4	149.7	143.1	630.6	596.7	1028.3	995.9
FIRB	31.1	30.5	182.5	174.3	734.4	695.4	1125.6	1193.4
S.Em±	0.3	0.2	2.1	1.1	11.2	6.3	13.4	9.5
C D (P=0.05)	0.9	0.9	6.8	3.5	35.1	19.2	41.3	29.7
Precise nitrogen management (Sub plot)								
Control	25.1	24.3	133.8	125.7	546.6	501.0	945.5	896.7
SR	26.1	25.6	169.4	153.9	706.7	665.0	1077.5	1042.0
LCC	26.2	25.7	178.8	166.2	732.4	694.4	1134.4	1107.2
SPAD	26.4	25.8	186.5	178.7	753.0	718.2	1167.0	1139.5
S.Em±	0.2	0.2	4.2	1.4	10.5	5.7	12.7	9.2
C D (P=0.05)	0.7	0.8	12.5	4.4	31.4	17.0	37.9	28.5

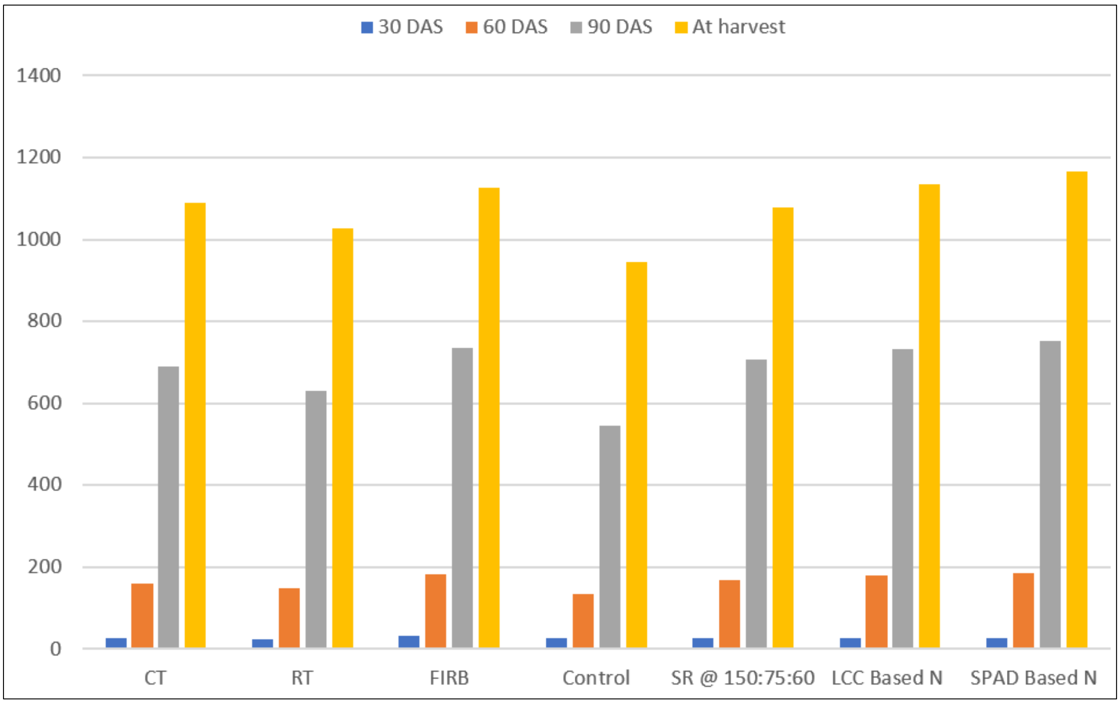

Fig 5: Effect of conservation tillage methods and precise nitrogen management on dry matter accumulation of wheat at various crop growth stages during 2021-22

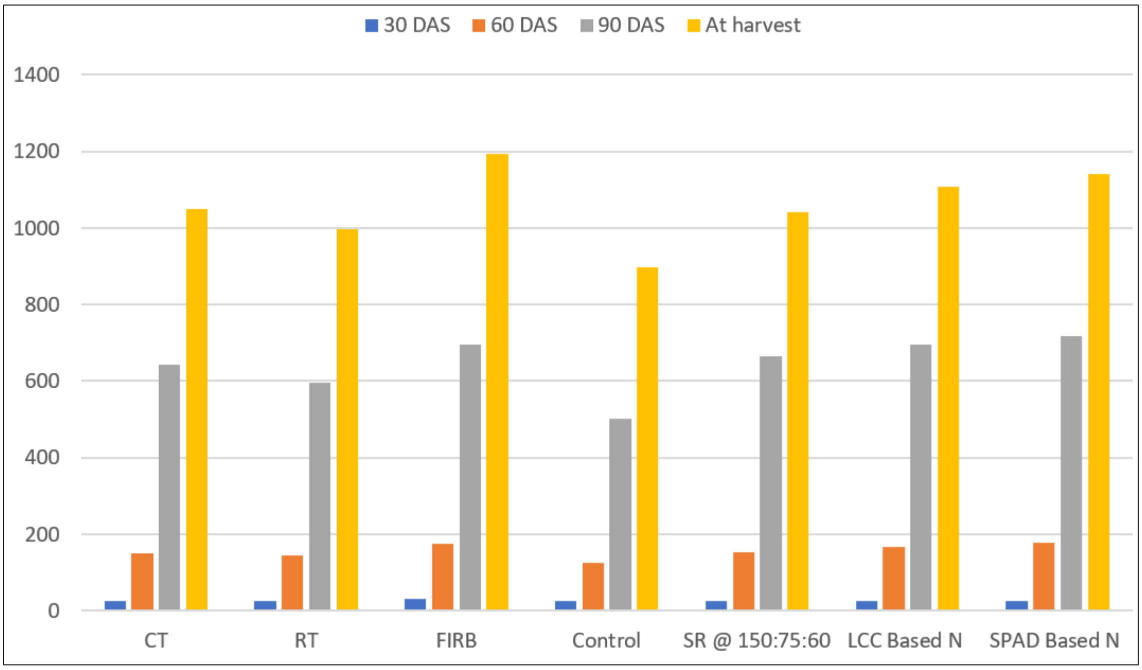

Fig 6: Effect of conservation tillage methods and precise nitrogen management on dry matter accumulation of wheat at various crop growth stages during 2022-23

Conclusion

Crop growth parameters plant height, number of tillers and dry matter accumulation were influenced by tillage practices treatments during both the years. Plant height increased with advancement of age and increase in moisture supply and reached maximum at harvest. The plant height increased significantly with successive increase in moisture and nutrient availability during both the year of experimentation. Number of tillers and dry matter accumulation also increased with increase in moisture supply due to planting techniques and reached maximum at 90 DAS for number of tillers and at harvest for dry matter accumulation in all tillage practices during both the years. FIRB produced significantly higher growth parameters than rest of the tillage practices. There was significant difference in growth parameters due to precise nitrogen management-based practices which gave significant higher plant height, dry matter accumulation, total number of tillers, CGR and RGR at 30, 60 and 90 DAS during both the years.

With regards to effect of different precise nitrogen management practices on growth parameters like plant height, dry matter accumulation, total number of tillers, CGR and RGR at 30, 60 and 90 DAS were recorded significantly highest with SPAD based N management and LCC performed at par with SPAD based N management during both the years. Among the different precise nitrogen management practices, SPAD based treatments recorded significantly higher number of effective tillers m^{-2}, grains $spike^{-1}$, test weight, grain yield, straw yield, biological yield and harvest index and LCC treatments performed at par with SPAD based N management during both the years.

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