



International Journal of Research in Agronomy

E-ISSN: 2618-0618
P-ISSN: 2618-060X
© Agronomy
www.agronomyjournals.com
2024; 7(8): 471-478
Received: 01-05-2024
Accepted: 05-06-2024

Amritpal Singh
Research Scholar, Guru Kashi
University, Punjab, India

Bablu Singh
Assistant Professor, Guru Kashi
University, Punjab, India

Veerpal Kaur
Assistant Professor, Guru Kashi
University, Punjab, India

Effect of nitrogen levels and spacing on growth and yield of wheat cv PBW 869

Amritpal Singh, Bablu Singh and Veerpal Kaur

DOI: <https://doi.org/10.33545/2618060X.2024.v7.i8g.1297>

Abstract

The present research is on “Effect of N levels and spacing on growth and yield of wheat PBW 869” was conducted at Agronomy Research Farm, Guru Kashi University, Talwandi sabo, Bathinda, Punjab during Rabi season of 2023-24. Three replications of the experiment were carried out using a split plot design. Three nitrogen levels (75%, 100%, and 125% RDF) are used in the main plot's treatment, while five row spacings are used in the subplots (15, 17.5, 20, 22.5, and 25 cm). The results of research findings revealed that the nitrogen levels and row spacing significantly influenced the growth and yield of wheat crop. All growth and yield parameters like plant height (102.10 cm), number of effective tillers per plant (10.57), leaf area index (1.90), dry matter accumulation (79.40 q ha⁻¹). Number of leaves per plant (11.49), ear length (9.77 cm) number of grains per spike (44.93), test weight (46.52 g), grain yield (54.52 q ha⁻¹), straw yield (65.42 q ha⁻¹), biological yield (109.94 q ha⁻¹) were significantly higher on 125% RDF followed by other nitrogen levels (100% RDF and 75% RDF). However, growth and yield parameters like plant height (92.40 cm), number of effective tillers per plant (10.91), leaf area index (1.42), dry matter accumulation (55.23 q ha⁻¹) number of leaves per plant (9.38), Ear length (7.86), number of grains per spike (40.12), test weight (38.24 g), grain yield (54.30 q ha⁻¹), straw yield (65.16 q ha⁻¹) and biological yield (109.46 q ha⁻¹) were significantly higher than other row spacing. The highest gross return (Rs. 115855ha⁻¹), net return (Rs. 32385.15 ha⁻¹) and benefit cost ratio (1.05) were also significantly higher on 125% RDF than other nitrogen levels. In comparison to different row spacing treatments, the greatest gross return (Rs. 115387.5 ha⁻¹), net return (Rs.30480.75 ha⁻¹), and benefit cost ratio (1.15) were all significantly higher. Significantly lower benefit-cost ratio (1.62), net return (Rs. 45152.64ha⁻¹) and gross return (Rs.95922.5 ha⁻¹) were found at 75% RDF nitrogen level.

Keywords: Wheat, nitrogen levels, row spacing, growth, yield, economics and B:C ratio

Introduction

Wheat (*Triticum aestivum* L.) is the world's most outstanding crop that excels all other cereals both in area and production, known as the king of cereals (Costa *et al.*, 2013) [6]. It is mostly grown in temperate climates, while it is also grown in tropical climates during the winter at higher altitudes. It is the most significant cereal crop and is regarded as a crucial part of food security systems of many countries. Wheat production stood at a record 110.55 million tonnes in the 2022-23 crop year (July-June), compared to 107.7 million tonnes achieved in the previous year (Anonymous 2024) [4]. In Punjab, wheat crop grown on an area of 35.26 lakh ha during 2021-22 with production of 148.65 lakh tones Anonymous (2022) [3].

Introduction of semi dwarf varieties increased the consumption of fertilizer per unit area tremendously and promoted mechanization in agriculture. It increased the overall production and seen dangerous cloud of the great famine due to population explosion (Anonymous, 2017) [2]. However in long term advantages of green revolution were taken only by developed country and farmers who were fortified by irrigation, mechanization and high agricultural inputs. The main wheat-producing states in India are Uttar Pradesh, Punjab, Haryana, Madhya Pradesh, Rajasthan, Bihar, Maharashtra, Gujarat, Karnataka, West Bengal, Uttarkhand, and Himachal Pradesh (Sendhil *et al* 2008) [18]. Consequently, another very serious initiative was needed to increase the productivity of the major crop in the very marginal land with low input and sustainable way. In this context, system of wheat intensification created government attention in many parts of the world.

Corresponding Author:
Amritpal Singh
Research Scholar, Guru Kashi
University, Punjab, India

The wheat yield of Punjab was 49.98 q/ha for 2023-24, highest among all the states. Wheat has been the staple food of the majority of population of Punjab (Kumar *et al* 2023) ^[12]. It forms the very basis of food security system of our state. Wheat production of our state has maintained an uprising trend despite of various unpredictable situations of weather uncertainties. It has been noticed that farmers are adopting the higher doses of seed, chemical fertilizers, chemical insecticides and weedicides for cultivation of wheat. As a result, the fertility as well as structure of the soil has been disturbed, resulting in the continuous decreasing in the production and productivity.

The productivity of wheat is significantly affected by the use of different spacing and sowing techniques (Dagash *et al.*, 2014) ^[7]. In fact, dispersing seeds has grown to be a very common method of seeding among farmers these days. Root development is the initial step toward a plant's healthy growth and development. This needs good food and adequate space around the plants. As a result, the space between plants is critical for the appropriate growth and development of plants that follow the concept of root development. Intensification does not imply a high plant density per unit space; rather, it entails good space maintenance and meticulous plant care. To increase output, intense care is required at all stages of plant growth, including weed, pest, and disease management, organic manure, and irrigation. The common wheat-growing method calls for more chemical fertilizers and between 120 and 180 kg of N per hectare. Higher wheat yield can be ensured by planting seeds using Nitrogen fertilizer and organic manure and optimum spacing of 15 to 20 cm between rows and plants (Akhtar *et al* 2009) ^[1]. The proper amount of moisture, aeration, nutrition, and light to the crop roots is facilitated by maintaining a sufficient distance between plants and sowing two seed grains at the same time.

Apart from genetic makeup, agronomic practices as well as environmental factors play an important role in crop performance. High tillering or tall varieties perform better in wider rows and low tillering or dwarf varieties utilize the resources with higher efficiency when cultivated narrowly spaced (Hussain *et al* 2012) ^[10]. The same agronomic practices in various agro-ecological regions may perform in different ways. On row spacings, extensive research work has been conducted in various parts of the world but the results are variable. A deep and critical study of literature is required to study the effect of row spacing as some studies favor narrow row spacing (Ghafari *et al* 2017 & Chhokar *et al* 2017) ^[9, 5].

Nitrogen, most essential plant nutrient among the primary nutrients and is necessary for the growth and development of plants. Protein production in plants, which provides a direct or indirect source of protein for animal and human nutrition, depends on nitrogen. Not only can proteins comprise human and animal body tissue, but they also function as the building blocks of all physiological processes through the production of enzymes. In the past, protein deficiency has drawn a lot of attention (Prasad, 2003) ^[17]. Nitrogen deficiency is perhaps the most common nutritional problem that plants encounter worldwide, despite nitrogen being one of the elements that is most abundant in the world. A significant amount of nitrogen controls how potassium and phosphorus are used. Therefore, it has a direct bearing on the physiological processes that plants go through. Fertilizer needs to be applied at the proper time and in the ideal quantity in order to yield the greatest possible benefit. Agronomic techniques have significantly improved the efficiency of nitrogen utilization as timely applications of nitrogen. It is widely known that when growth of crop is higher nitrogen must be administered in two or three splits corresponding to the crop during different stages of growth. Nitrogen applied in two equal splits (basal & first node stage) yielded the best quality and production results, with a notable differential in grain N uptake (Patel *et al.*, 2004) ^[16].

Materials and Methods

Climate and Weather

The research area has a semi-humid climate with severe winters and summers. In the summer, a high temperature of between 34 °C and 36 °C is not unusual. While frost events and freezing temperatures are possible in December and January. Typically, the monsoon begins in the first week of July. One of the most important factors affecting agricultural results in Punjab throughout the wheat crop season is the monthly difference in temperature. Punjab suffers dramatic temperature swings from November to April.

Table 1: Weather data of study area

Particulars	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.
Minimum temperature (°C)	25.7	20.8	15	8.5	6.9	9.6	14.6	20.4
Maximum temperature (°C)	34.6	33.2	27.7	22.1	19.4	22.9	29.2	36.3
Rainfall (mm)	68	12	5	9	19	33	25	20
Humidity (%)	61	47	51	60	67	60	48	30

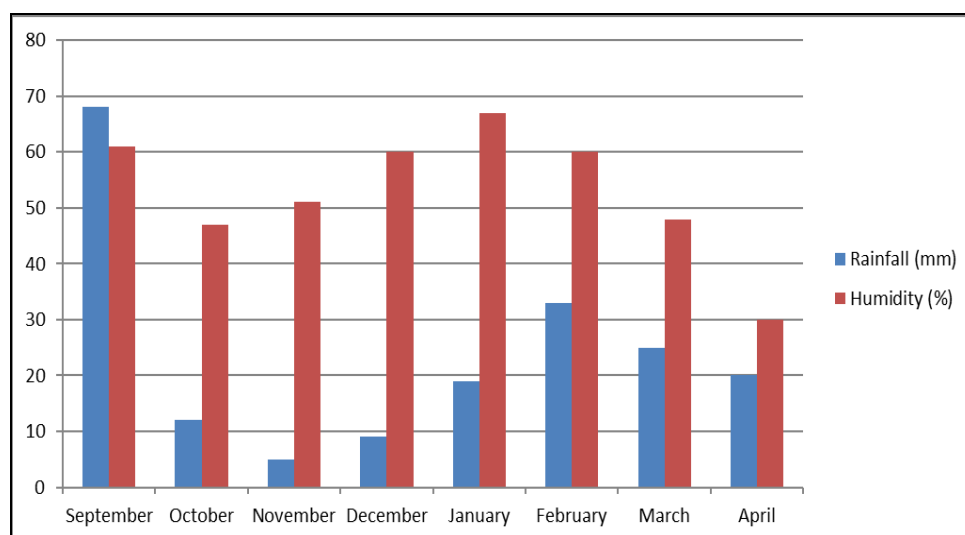


Fig 1: Rainfall and humidity obtained during *Rabi* season 2023-24

Temperatures begin to drop in November, signalling the arrival of the wheat crop season. These months are marked by cold mornings and nights, with frequent drops in temperature to around freezing. But as the season goes on into February and

March, the temperature progressively begins to rise indicating the arrival of spring. Temperatures moderately rise throughout this time, providing ideal growing and development conditions for wheat.

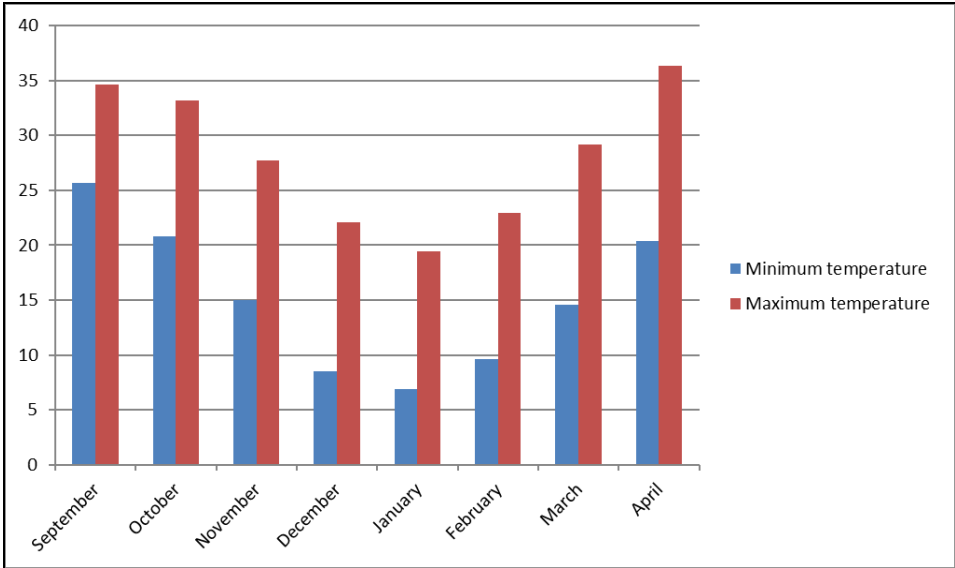


Fig 2: Weather report during research period

Soil Characteristics

Before the experiment started, random samples were taken from the experimental location up to a depth of 15 cm in order to assess the different parameters of the soil. A composite sample

was then measured. The physical and chemical characteristics of the experimental soils were determined by mechanical, physical, and chemical investigation.

Table 2: Physical and chemical properties of experimental soils 0 to 15 centimeters

Properties	Value	Method used for Analysis
pH	7.15	Bechman’s Glass Electrode pH meter method (Jackson 1967)
EC (d Sm ⁻¹)	0.25	Solu-bridge Conductivity meter (1.2 soil:water suspension) (Jackson 1967)
Organic Carbon (%)	0.36	Walkley and black’s Titration method (Jackson 1967)
Available N (kg/ha)	129.1	Alkaline potassium permanganatic method (Subbiah and Asija, 1956)
Available P ₂ O ₅ (kg/ha)	21.8	0.5 N Sodium Bicarbonate Extractable method (Olsen <i>et al</i> 1954)
Available K ₂ O (kg/ha)	248.7	1N Ammonium Bicarbonated extractable method (Jackson, 1967)

The soils of Guru Kashi University pH 7.15- Neutral, EC- 0.25 (Low), O.C.- 0.36% (Low) and Available Nitrogen - low, high in Available Phosphorus and Potassium.

Results and Discussion

In Punjab, wheat is becoming more and more important, and its area is growing. High yielding cultivars that are currently accessible are responding to control. The Effect of Nitrogen Treatment on Wheat is well understood; nonetheless, Nitrogen needs for recently created cultivars needs to be optimized. The growth, yield, and yield qualities of various rows spacing cultivation were evaluated in connection to the administration of nitrogen. This chapter discusses the statistical analysis that was done on the data related to these parameters.

Growth or Vegetative characters
Plant height (cm)

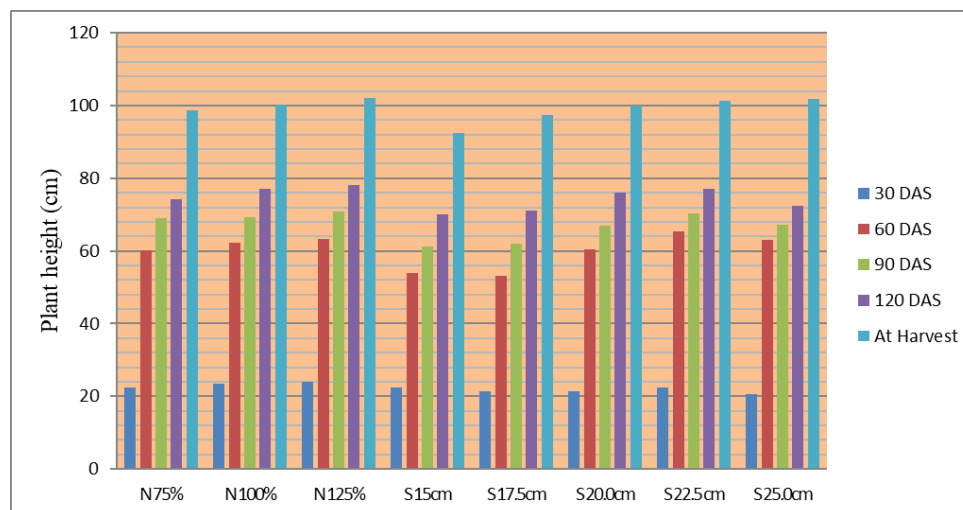
Different nitrogen levels and row spacing at different phases of wheat growth considerably affected plant height, and their interaction was found to be significant at different days after sowing (Table 3 and figure 2). At every stage of growth was a considerable increase in plant height corresponding with increasing nitrogen levels. When 125% RDF was applied, significantly taller plants were observed at every growth stage.

(Table 3). The plant height at 30, 60, 90, 120 DAS and at harvest with N1-75% RDF recorded 22.30, 60.19, 68.91, 74.32 and 98.62 cm significantly lowest than N2- 100% RDF 23.56, 62.35, 69.30, 77.12 at 100.35 cm significantly highest plant height recorded with N3- 125% RDF 24.09, 63.36, 70.90, 78.02 and 102.19 cm than all other treatments. Nitrogen directly affects plant growth and development through improved photosynthetic usage since it is a component of proteins, amino acids, and protoplasts. The results obtained agreed with those of Kachroo and Razdan (2006).

At 30 DAS 15 cm recorded height 22.30 cm and found to be at par with S₄ – 22.5 cm S₂- 17.5 cm and S₃ 20 cm spacing 22.5 cm here at par with each other. Later stage, 60 DAS, 90 DAS, 120 DAS and lowest significantly lowest plant recorded in S₁-15 cm of54.01, 61.19, 70.08 and 92.40 com respectively, The plant height increased with increased spacing 17.5 cm to 25 cm at all stages of growth except 30 DAS. The plant height at S₄- 22.5 cm at 60 DAS, 90DAS, 120 DAS and at harvest was found to be 65.25, 70.41, 77.20 and 101.31 cm respectively.

Table 3: Plant height (in cm) at different growth stages of wheat crop

Treatments	30 DAS	60 DAS	90 DAS	120 DAS	At Harvest
Nitrogen Levels					
N1= 75% RDF	22.30	60.19	68.91	74.32	98.62
N2= 100% RDF	23.56	62.35	69.30	77.12	100.35
N3= 125% RDF	24.09	63.36	70.90	78.02	102.10
CD (P=0.05)	0.56	0.99	1.20	1.18	1.06
Spacing					
S ₁ - 15 cm	22.30	54.01	61.19	70.08	92.40
S ₂ - 17.5 cm	21.25	53.02	62.03	71.01	97.33
S ₃ - 20.0 cm	21.30	60.32	67.02	76.16	100.03
S ₄ - 22.5 cm	22.41	65.25	70.41	77.20	101.31
S ₅ - 25.0 cm	20.56	63.02	67.25	72.50	101.80
CV	5.13	10.3	7.3	7.4	6.9
CD (P=0.05)	0.97	3.25	2.70	2.90	3.0

**Fig 2:** Plant height (in cm) at different growth stages of wheat crop**Leaf area index**

The leaf area index of the wheat crop grew until 60 DAS and subsequently dropped. LAI was strongly impacted by nitrogen levels and spacing. The relationship between nitrogen levels and spacing was found to be non-significant (Table 4 and Figure 3). LAI increased as nitrogen levels increased, from 75% RDF to 125% (Table 4). Increased leaf area index with increased nitrogen level might be the result of enhanced tiller production. These findings were consistent with Ejaz *et al.* (2002).

At all growth stages, spacing 22.5 cm showed the highest leaf area index when compared to other treatments (Table 4 and figure 4). The change in row spacing can be due to the increased number of tillers. LAI increased up to 60 DAS, then declined owing to leaf withering as maturity approached. Pandey *et al.* (1999) similarly observed differences in LAI between row spacing treatments.

Dry matter accumulation (q ha^{-1})

Dry matter accumulation was observed to be affected by variable nitrogen levels and varying spacing, with interaction being significant at harvest (Table 5 and Figure 4). The crop responded effectively to increases in applied nitrogen, regardless of row spacing, resulting in greater dry matter accumulation

(Table 5 and Figure 4) due to increased photosynthesis, which was enhanced by increased leaf area, resulting in considerably higher dry matter accumulation. These findings were consistent with those of Kumar *et al.* (1998)^[13] and Mosalem *et al.* (2000). The interaction between spacing and nitrogen levels was shown to be substantial during harvest. At harvest, 125% RDF yielded the most dry matter (61.90 q ha^{-1}).

Table 4: Leaf area index at different growth stages of wheat crop

Treatments	30 DAS	60 DAS	90 DAS	Harvest
Nitrogen Levels				
N1= 75% RDF	1.159	2.53	1.35	1.54
N2= 100% RDF	1.472	3.18	1.80	1.89
N3= 125% RDF	1.817	3.46	1.87	1.90
CD (P=0.05)	0.07	0.10	0.06	0.04
Spacing				
S ₁ - 15 cm	1.260	2.65	1.44	1.42
S ₂ - 17.5 cm	1.238	2.63	1.42	1.41
S ₃ - 20.0 cm	1.235	2.60	1.40	1.40
S ₄ - 22.5 cm	1.273	2.70	1.48	1.47
S ₅ - 25.0 cm	1.23	2.50	1.38	1.35
CV	4.76	4.9	4.85	4.73
CD (P=0.05)	0.19	0.40	0.21	0.21
Interaction (N S)	NS	NS	NS	NS

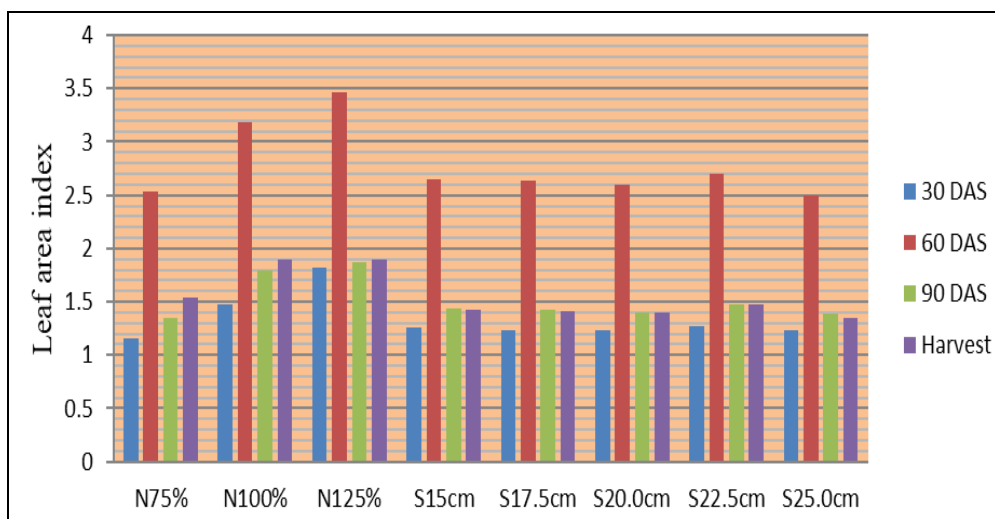


Fig 3: Leaf area index at different growth stages of wheat crop

Table 5: Dry matter accumulation (q ha^{-1}) affected by varying nitrogen levels and spacing at different wheat crop stages.

Treatments	30 DAS	60 DAS	90 DAS	120 DAS	At Harvest
Nitrogen Levels					
N1= 75% RDF	10.27	24.80	44.35	72.60	79.92
N2= 100% RDF	10.30	24.40	43.09	72.08	103.20
N3= 125% RDF	10.50	23.14	44.63	71.90	109.40
CD (P=0.05)	0.9	3.73	5.44	10.64	14.39
Spacing					
S ₁ - 15 cm	10.18	23.02	43.56	72.32	109.36
S ₂ - 17.5 cm	10.21	22.98	44.56	73.23	104.54
S ₃ - 20.0 cm	10.26	23.25	45.05	74.03	100.65
S ₄ - 22.5 cm	10.31	24.59	47.05	75.36	96.31
S ₅ - 25.0 cm	10.27	23.35	45.75	74.57	91.26
CD (P=0.05)	NS	1.40	1.50	2.10	2.30
CV (%)	5.3	5.7	4.7	5.1	8.0

At 30 DAS, 22.5 cm spacing had increased dry matter (1.31q ha^{-1}), which was comparable to 25.0 cm (1.27q ha^{-1}). At 30, 60, 90, and harvest, row spacing of 22.5 cm produced considerably more dry matter than the other treatments (Table 5). This may be

linked to variations in the number of tillers and leaf area, which have resulted in a greater accumulation of photosynthates at row spacing of 22.5 cm. Kumar *et al.* (1998) and Mosalem *et al.* (2000) have also reported on treatment variance.

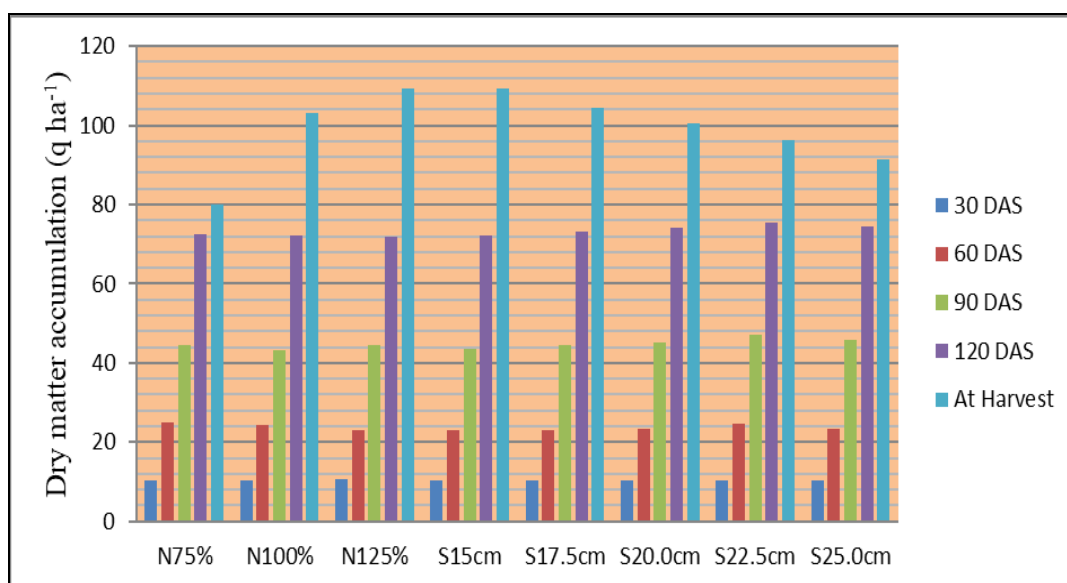


Fig 4: Dry matter accumulation (q ha^{-1}) affected by varying nitrogen levels and spacing at different wheat crop stages.

Number of effective tillers plant⁻¹

The number of tillers increased as dose N increased N₁- RDF 75% to N₂ and N₃ RDF% at 75,100 DAS and at harvest 8.12, 9.12 and 9.12 to 9.57, 10.57 and 10.57 to 9.61, 10.57 and 10.57 N₂ RDF 100% and N₃ 125% RDF were found to be at par with each other.

As the dose of N₁ (75% RDF) on 30 DAS, 60 DAS, 90 DAS and at harvest was found to be 5.59, 16.11, 16.09 and 14.01 was significantly lower than the N₃- 125% RDF (6.11, 21.04, 20.78 and 18.96). Number of effective tiller plant⁻¹ was recorded periodically at 75,100 DAS and at harvest. The data are present in Table 6 and graphically depicted in Fig. 5. From the data it is evident that number of effective tiller increased with the increased in the age of crop. At harvest mean number of tillers was 9.84. The leaf area index at 22.5 cm of 60 DAS and 90 DAS and Harvest was found to be 19.59, 19.50 and 17.97 was significantly highest than S₁ (18.80, 18.60 and 16.38). The leaf

area index of 30 DAS was found to be non-significant.

Table 6: Number of effective tillers plant⁻¹ as influenced by different treatments of wheat crop

Treatments	75 DAS	100 DAS	At Harvest
Nitrogen levels			
N1= 75% RDF	8.12	9.12	9.12
N2= 100% RDF	9.57	10.57	10.57
N3= 125% RDF	9.61	10.57	10.57
CD (P=0.05)	0.98	0.97	0.97
Spacing			
S ₁ - 15 cm	9.91	10.91	10.91
S ₂ - 17.5 cm	8.16	9.16	9.16
S ₃ - 20.0 cm	8.15	9.15	9.15
S ₄ - 22.5 cm	8.15	9.15	9.15
S ₅ - 25.0 cm	8.15	9.15	9.15
CD (P=0.05)	0.72	0.72	0.71

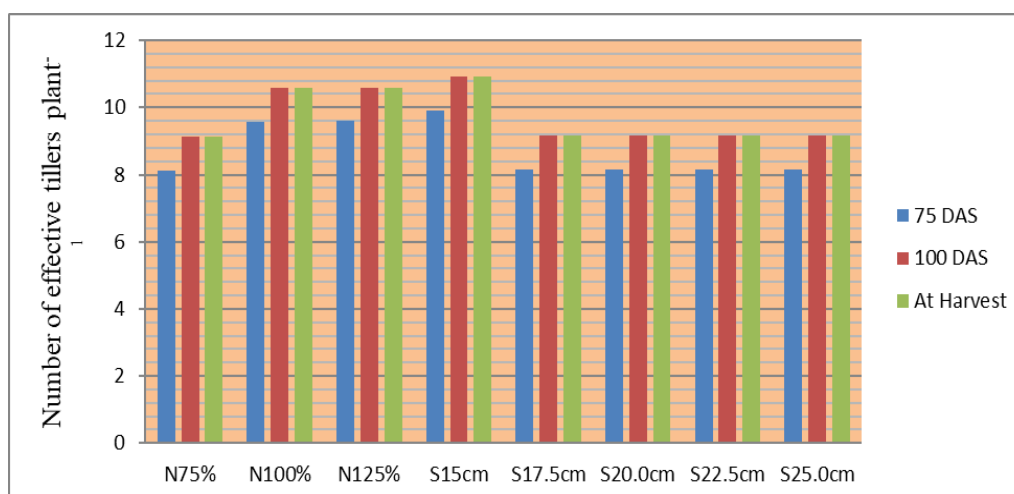


Fig 5: Number of effective tillers plant⁻¹ as influenced by different treatments of wheat crop

Number of Grains per Spike

The number of grains per spike significantly increased from 38.15 to 41.72 and 44.93 as the level of nitrogen increased from N₁- 75% RDF to N₂- 100% RDF and N₃- 125% RDF. The number of grains per spike significantly increased from 40.12 to 43.63, 40.96 S₁-15 cm to S₂-17.5 cm and S₃- 20 cm (Table 7 and Figure 6). The spacing treatment S₂-17.5 cm and S₃- 20 cm were at par with each other. Increased number of ears per spike with higher levels of nitrogen might be attributed to N's stimulatory impact on tillering through cytokinin production, which results

in a greater number of tillers. The concentration of photosynthates in the ears may have enhanced the length of the spike. Higher nitrogen dosages resulted in more photosynthetic accumulation as well as more grains per spike.

Spacing differed significantly in terms of yield parameters. Number of grains per spike, length of ear and test weight was significantly superior in the spacing 22.5 cm followed by 25.0 cm and the all the yield attributes were lower in 15.0 cm treatment.

Table 7: Effect of nitrogen and row spacing on the Number of grains per spikes of wheat Crop

Treatments	Number of grains per spikes
Nitrogen Levels	
N1= 75% RDF	38.15
N2= 100% RDF	41.72
N3= 125% RDF	44.93
CD (P=0.05)	3.92
Spacing	
S ₁ - 15 cm	40.12
S ₂ - 17.5 cm	43.63
S ₃ - 20.0 cm	43.96
S ₄ - 22.5 cm	45.35
S ₅ - 25.0 cm	43.72
CD (P=0.05)	1.73
CV	7

Grain Yield

The grain yield of wheat was greatly affected by nitrogen levels and spacing. Increasing the nitrogen level from 75% RDF to 125% RDF resulted in a considerable increase in grain production, from 45.14 qha⁻¹ to 54.52 qha⁻¹. The increase in grain yield with increased N levels can be attributed to improved plant growth and dry matter production as a result of increased photosynthetic translocations from source to sink. Kachroo and Razdan (2006) [11] found similar results.

Wheat crop rows spaced 15.0 cm apart had the maximum grain

production (54.30qha⁻¹), which was considerably more efficient than the other treatments (Table 8 and Figure 7). The lowest grain yield (45.90 q ha⁻¹) was reported at 25 cm spacing. The increase in yield is due to the effective use of solar energy. Differences in yields between treatments can also be attributed to their genetic ability to transport photosynthates from source to sink. The spacing of 25.0 cm in terms of tiller number and leaf area resulted in better dry matter accumulation, which contributed to more yield attributes and was reflected in higher yields.

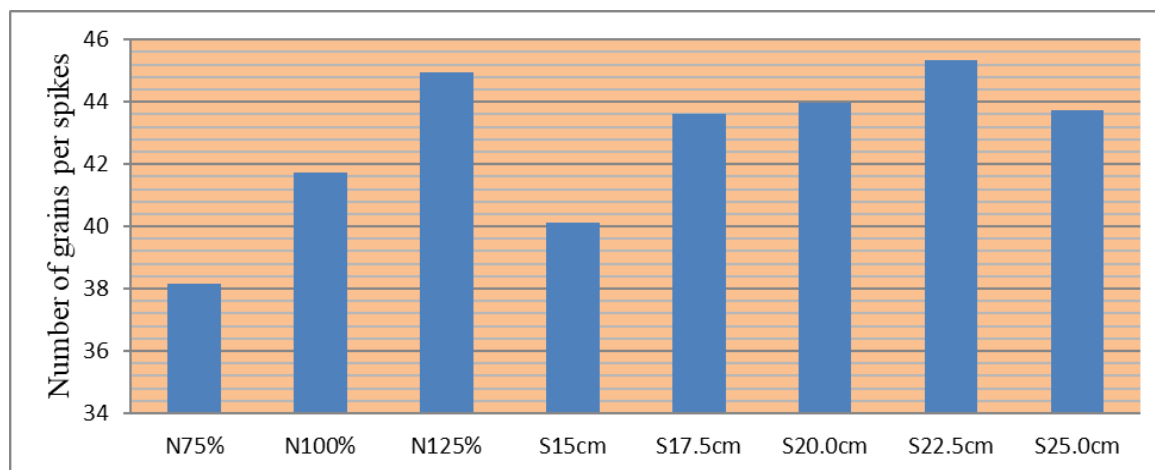


Fig 6: Effect of nitrogen and row spacing on the Number of grains per spikes of wheat Crop

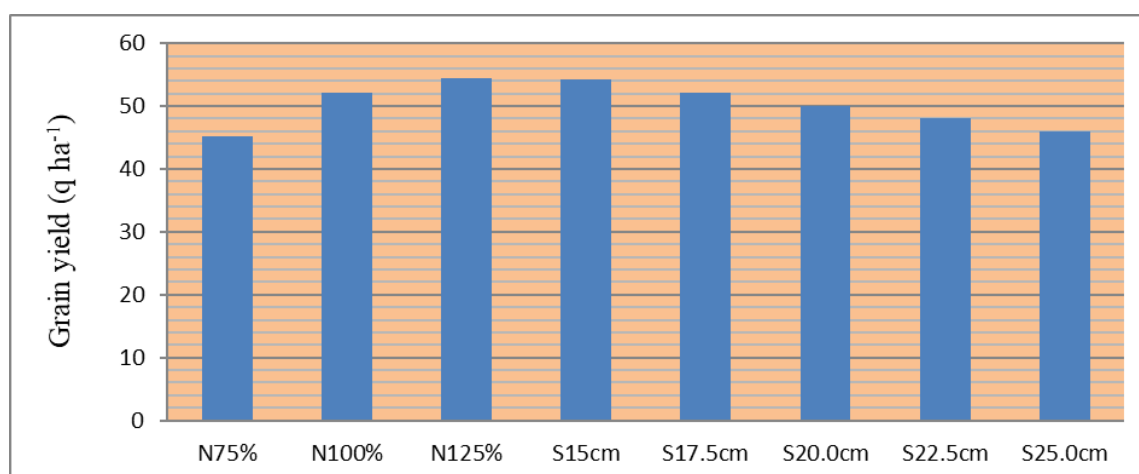


Fig 7: Effect of nitrogen and row spacing on the Grain yield of Wheat

Table 8: Effect of nitrogen and row spacing on the Grain yield of wheat crop

Treatments	Grain yield (q ha ⁻¹)
Nitrogen Levels	
N1= 75% RDF	45.14
N2= 100% RDF	52.18
N3= 125% RDF	54.52
CD (P=0.05)	2.34
Spacing	
S ₁ - 15 cm	54.3
S ₂ - 17.5 cm	52.2
S ₃ - 20.0 cm	50.05
S ₄ - 22.5 cm	48
S ₅ - 25.0 cm	45.9
CD (P=0.05)	1.99
Interaction (N×S)	NS
CV (%)	8.2

Reference

1. Akhtar MJ, Asghar HN, Shahzad K, Arshad M. Role of plant growth promoting rhizobacteria applied in combination with compost and mineral fertilizers to improve growth and yield of wheat (*Triticum aestivum* L.). Pak J Bot. 2009;41(1):381-390.
2. Anonymous. As per the advanced estimate of the United States Department of Agriculture and Directorate of Economics and Statistics. USDA, USA; c2017.
3. Anonymous. Package of Practices for Rabi Crops. Ludhiana: Punjab Agricultural University; c2022. p. 20-25.
4. Anonymous. Available from: <https://agriexchange.apeda.gov.in/news/NewsSearch.aspx?newsid=53960>; 2024.
5. Chhokar RS, Sharma RK, Kumar N, Singh RK, Singh GP. Advancing sowing time and conservation tillage—the climate-resilient approach to enhance the productivity and profitability of wheat. Int J Plant Prod. 2017;11(1):121-31.

6. Costa R, Pinheiro N, Almeida AS, Gomes C, Coutinho J, Coco J, *et al.* Effect of sowing date and seeding rate on bread wheat yield and test weight under Mediterranean conditions. *Emirates J Food Agric.* 2013;25:51-61.
7. Dagash MI, Ahmed S, Khalil NA. Effect of nitrogen fertilization, sowing methods, and sowing dates on yield and yield attributes of wheat (*Triticum aestivum* L.). *Univ J Agric Sci.* 2014;2(6):108-113.
8. Ejaz A, Warraich NA, Shahzad B, Irfan A. Effect of nitrogen on source-sink relationship in wheat. *Int J Agric Biol.* 2002;4(2):300-302.
9. Ghafari SR, Dass A, Hamayoun H, Mangal MQ, Omran AH. Effect of row spacing on different wheat (*Triticum aestivum* L.) varieties in semi-arid region of Kandahar. *Int J Appl Res.* 2017;3(7):93-97.
10. Hussain M, Zahid M, Khan MB, Farooq S, Lee DJ, Farooq M. Narrow spacing insures higher productivity of low tillering wheat cultivars. *Int J Agric Biol.* 2012;14(3):413-418.
11. Kachroo D, Razdan R. Growth, nutrient uptake and yield of wheat (*Triticum aestivum*) as influenced by biofertilizers and nitrogen. *Indian J Agron.* 2006;51(1):37-39.
12. Kumar B, Shaloo BH, Meena MC, Dey A, Dass A, Paramesh V, *et al.* Nitrogen management sensor optimization, yield, economics, and nitrogen use efficiency of different wheat cultivars under varying nitrogen levels. *Front Sustain Food Syst.* 2023;7:122-221.
13. Kumar S, Bangwara AS, Singh DP, Phogat SB. Dry matter accumulation in dwarf wheat varieties under different nitrogen levels and sowing dates. *HAU J Res.* 1998;28:151-57.
14. Mosalem ME, Zahran M, El Menoufi MM, Moussa AM. Effect of nitrogen fertilization levels on some wheat cultivars. *Soil Fert Plant Nutr.* 2000;50:267-274.
15. Pandey KA, Prasad K, Prakash V, Singh RD. Planting pattern in wheat (*Triticum aestivum*) and Indian mustard (*Brassica juncea*) crop mixture under irrigated conditions in mid-hill of North Western Himalayas. *Indian J Agron.* 1999;44(1):21-25.
16. Patel AP, Augustine N, Patel DR. Nitrogen management for productivity and quality of macaroni wheat (*Triticum durum*). *Indian J Agron.* 2004;49(3):168-170.
17. Prasad R. Protein-energy malnutrition and fertilizer use in India. *Fertiliser News.* 2003;49(5):65-67.
18. Sendhil R, Jha A, Kumar A, Singh S. Extent of vulnerability in wheat producing agro-ecologies of India: Tracking from indicators of cross-section and multi-dimension data. *Ecol Indic.* 2018;89:771-780.