# Evaluating Productivity of Wheat under Various Sowing methods

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# Abstract

The productivity of wheat crop may be affected by multitude of factors including soil moisture, seed quality, soil fertility, rainfall pattern and field management practices. However, this study is focused on evaluating the impact of different sowing methods on the yield of wheat in silty loam soil. Over two consecutive wheat growing seasons (2021-22 and 2022-23), the research focused on comparing four sowing methods: Flat Basin with Broadcasting (FB-B), Flat Basin with Line sowing (FB-L), Narrow Bed with Line sowing (NB-L) and Wide Bed with Line sowing (WB-L). The study utilized a Randomized Complete Block Design (RCBD) to ensure robust experimental design and data collection. Statistical analysis revealed that the NB-L method consistently outperformed other methods, demonstrating superior crop growth and maximizing grain yield. On average, NB-L exhibited an increase of 4.20% in crop height, 25.18% in dry biomass production, and 26.10% increase in grain yield compared to conventional broadcasting method for sowing. Conversely, flat basin line sowing (FB-L) exhibited mixed performance, with advantages in grain quality metrics having 5.43% higher grain weight and 6.59% harvesting index compared to broadcasting method, but shorter spikes and lower dry biomass production compared to other sowing methods. The study's findings provide crucial insights for agricultural practices, suggesting the robustness and adaptability of the NB-L method. This research offers valuable insights for farmers and policymakers, guiding the adoption of more efficient and sustainable wheat cultivation practices like narrow beds. Future research should investigate the long-term effects of these practices on soil health and assess their adaptability across various soil types and climatic conditions.

# INTRODUCTION

Global crop yields for major staples like maize, rice, wheat, and soybean are rising; however, the pace of this increase is insufficient to meet the projected demands by 2050 (Ray et al., 2013). Current yield growth rates fall below the required 2.4% annually needed to double global production by 2050, posing a significant challenge to future agricultural needs (Negro et al., 2019). Thus, increasing crop yields and combating yield stagnation is essential to meet growing global agricultural demands.

In Pakistan, agriculture is of immense significance, particularly the cultivation of wheat—a crucial staple crop for food security and economic stability. Wheat production plays a vital role in the country’s economy, contributing substantially to GDP, employment, and exports (Shar et al., 2021). However, this sector faces numerous challenges and has significant potential for growth. Aslam (2016) highlighted a significant yield gap between actual and potential yields for major crops in Pakistan. For instance, the actual wheat yield is 2.26 tons per hectare compared to a potential yield of 6.80 tons per hectare, resulting in a 66.76% gap. Wheat, as a winter crop, benefits from cool temperatures and relatively dry conditions during its growth phase (Fang et al., 2017). Despite significant advancements in wheat cultivation, particularly in Sindh, Pakistan’s yield levels still lag behind those of major producers like China, India, and Bangladesh (Abid et al., 2018; Ahmad et al., 2021).

Suboptimal farming practices, such as broadcasting, intensive tillage and conventional flooding methods, present significant challenges to wheat cultivation in Pakistan. Broadcasting, where seeds are scattered manually, leads to uneven crop emergence and lower yields (Shahid et al., 2023). Addressing these challenges requires a shift towards more sustainable agricultural practices, such as precision seeding techniques. Precision seeding methods, like GPS-guided seed placement, can optimize seed distribution, improve crop uniformity, and enhance yields (Ikram et al., 2023).

Wheat sowing methods have been extensively studied, with evidence suggesting that drilling methods yield better results than broadcasting (Shahid et al., 2023). Techniques like narrow and wide bed sowing have shown potential for increasing yields by 4.5% and 5.8%, respectively, compared to broadcasting (Ghani Akbar et al., 2007).

This study aims to explore the specific gaps in wheat cultivation practices in silty loam soil. It evaluates the effectiveness of different sowing methods (narrow bed, wide bed, line sowing, and broadcasting) to identify practical solutions for enhancing wheat productivity. By focusing on these critical factors, the research seeks to provide actionable insights to address the challenges faced by wheat farmers in Pakistan, contributing to sustainable agricultural practices and ensuring food security.

This research is crucial for improving wheat productivity in silty loam soils by identifying the most effective sowing techniques. The findings will guide farmers and policymakers in adopting practices that enhance yield, ensure food security, and promote sustainable agriculture in Pakistan.

# METHODOLOGY

# Experimental Site/Study Area

The Climate, Energy and Water Research Institute (CEWRI) of National Agricultural Research Center (NARC) having coordinates 33.67531° N, 73.13770° E was selected as our experimental site for this research study as shown in Figure 1. The altitude of NARC-CEWRI field station is 498 m, where temperature ranges from 0 to 45 degree Celsius and annual rainfall of 1200 mm out of which 70% occurs in monsoon.

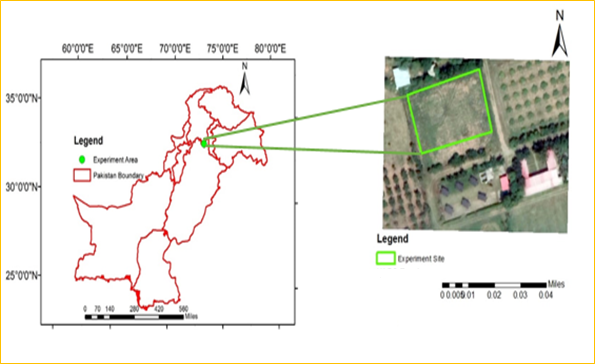


Figure 1 Experimental site ‘CEWRI Field Station NARC’ location on Pakistan map

## Treatments Applied

Experimental plot was established at NARC under irrigated conditions. The experiment was comprised of four plots of sowing methods with three replications at NARC Islamabad. The four sowing methods were:

1. Flat basin with Broadcasting (FB-B)
2. Flat basin with Line sowing (FB-L)
3. Narrow Beds (NB) with Line sowing
4. Wide Beds (WB) with Line sowing

Each treatment with their basic details, like plot size, no. of beds, no. of lines and seed rate are listed in Table 1

Table 1 Treatments with their basic details

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Treatments** | **Plot Size** | **No. of Beds** | **No. of Lines** | **Seed Rate** | **123.55 kg/ha**  **(50 kg/Acre)** |
| FB-Broadcasting | 29.26 m2 | 0 | 0 | 365 g/plot |
| FB-Line Sowing | 29.26 m2 | 0 | 15 | 365 g/plot |
| NB-Line Sowing | 29.26 m2 | 4 | 8 | 365 g/plot |
| WB-Line Sowing | 29.26 m2 | 2 | 10 | 365 g/plot |

## Experimental Layout

The experimental layout follows a Randomized Complete Block Design (RCBD) comprising four sowing methods, shown in Figure 2 below. Each treatment is replicated three times, distributed randomly within the experimental plot to minimize error and enhance result accuracy.

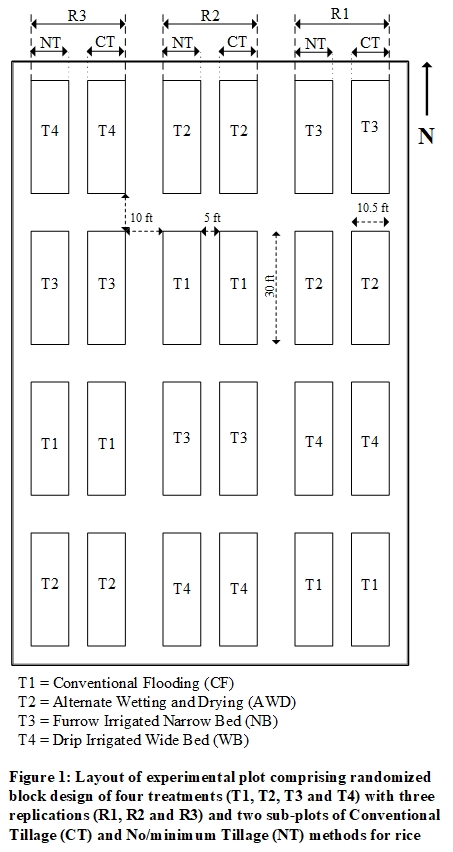
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Figure 2 Randomized Complete Block Design for our experimental plot

The experimental plot is fully equipped with the necessary resources. An irrigation pump, powered by a 20 KW solar system, is installed on site. Two types of pipes, for flood and drip irrigation, are laid underground with water meters to measure the water supply to each plot.

## Data Collection

The required weather data on the site was recorded and noted from a weather station situated at the “Climate Energy and Water Research Institute” (CEWRI) field station, NARC. The weather station at NARC records the daily minimum and maximum temperature in degree Celsius, wind speed in km/day, evaporation by pan evaporation method in mm/day, rainfall in mm/day and relative humidity in percentage. The data available was enough for this research study.

### **Weather Data**

The weather data encompassing rainfall and temperature, during the wheat growing seasons of 2021-22 and 2022-23 was gathered from the weather station situated at CEWRI field station of NARC. The data has been organized and presented in Table 2.

Table 2 Monthly weather (rainfall and temperature) data obtained from CEWRI field station of NARC Islamabad for two consecutive wheat growing seasons of 2021-22 and 2022-23

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Month-Year**  **(2021-22)** | **Rainfall (mm)** | **Temperature (**°**C)** | | **Month-Year**  **(2022-23)** | **Rainfall**  **(mm)** | **Temperature (**°**C)** | |
| **Max** | **Min** | **Max** | **Min** |
| Nov-21 | 0.00 | 24.63 | 7.3 | Nov-22 | 64.26 | 23.77 | 8.63 |
| Dec-21 | 9.59 | 19.39 | 3.42 | Dec-22 | 8.47 | 20.68 | 4.13 |
| Jan-22 | 164.92 | 15.84 | 5.35 | Jan-23 | 45.48 | 16.61 | 3.26 |
| Feb-22 | 22.18 | 19.43 | 6.36 | Feb-23 | 14.94 | 23.11 | 6.93 |
| Mar-22 | 53.94 | 28.74 | 13 | Mar-23 | 94.80 | 24.32 | 10.77 |
| Apr-22 | 5.11 | 35.3 | 16.33 | Apr-23 | 70.05 | 28.63 | 14.43 |

### **Soil Physical Properties**

Soil samples were collected from the top 15 cm depth at randomly selected locations within each block using soil auger method prior to field preparation for determining its physical, chemical and hydraulic properties. The samples are weighted and then dried. The dried samples were weighted again. The soil tests have been done and the obtained results are shown in the Table 3 below.

Table 3 Physical properties of soil at experimental site

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Texture** | **Permanent Wilting Point (%)** | **Field Capacity (%)** | **Saturation (%)** | **Hydraulic Conductivity (mm/day)** |
| Silt Loam | 13.0 | 33.0 | 46.0 | 575.0 |

## Field Activities

In the Wheat growing seasons, a detailed log of field activities was maintained, capturing critical factors such as plot size, sowing date, seed variety, urea, and applications of weed control measures. These recorded activities provide invaluable insights into the management practices employed and their influence on crop development and yield outcomes. The activities detail for both wheat growing seasons, 2021-22 and 2022-23 are given in Table 4 below.

Table 4 Record of field activities performed at wheat growing seasons 2021-22 and 2022-23

|  |  |  |  |
| --- | --- | --- | --- |
| **S. No** | **Input/Activity** | **Date/year**  **(Season 2021-22)** | **Date/year**  **(Season 2022-23)** |
| 1 | Plot size | 29.26 m2 | 29.26 m2 |
| 2 | Sowing date | 12th Nov 2021 | 4th Nov 2022 |
| 3 | Urea 178 kg/ha | 24/1/2022 | 02/11/2022 |
| 4 | DAP 170.5 kg/ha | 09/12/2021 | 02/11/2022 |
| 5 | Zinc 18.8 kg/ha | 29/03/2022 | 02/11/2022 |
| 6 | Weedicides (Ally Mix, Axial) | 30/12/2021 | 03/01/2023 |
| 7 | Harvesting | 26/4/2022 | 27/04/2023 |

### **Field preparation**

The entire area spans 37.79 m (124 feet) by 48.15 m (158 feet), totaling 1820.15 square meters. Within this space, twenty-four plots are demarcated, each measuring 3.20 m (10.5 feet) in width and 9.14 m (30 feet) in length, equivalent to 29.26 square meters. To maintain separation between the plots and prevent water seepage, a 1.52 m (5 feet) buffer zone is delineated. Additionally, a designated pathway, 3.04 m (10 feet) wide, is established to facilitate easy movement and field operations.

The land preparation process commences with an initial ploughing phase to break and loosen the soil, followed by careful use of a rotavator to further refine and prepare the seedbed. These sequential steps are executed with precision to create an optimal environment conducive to wheat crop growth and development, ensuring a well-prepared area for the experiment.

### **Fertilizer Application**

After the field preparation, fertilizers (Urea, DAP and Potash) at the rate of 123.55 kg/ha were applied to each subplot. To apply fertilizer equally to each plot, the quantity was assured using an electronic weighing balance. Detail of fertilizer applied to each plot are shown in Table 5.

Table 5 Details of the fertilizer applied to the field

|  |  |  |
| --- | --- | --- |
| **Fertilizer** | **Quantity/Plot** | **Quantity/Per Area** |
| NPK | 500 g per plot | 123.55 kg/ha (50 kg/acre) |
| DAP | 500 g per plot | 123.55 kg/ha (50 kg/acre) |
| Potash K2O | 500 g per plot | 123.55 kg/ha (50 kg/acre) |

### **Sowing**

The sowing process involved the careful application of various techniques, using both hand drills and manual broadcasting methods. To ensure precision, flat basin line sowing, narrow bed line sowing, and wide bed line sowing were conducted using hand drills. Broadcasting technique was utilized for sowing on flat basins.

Each plot received a consistent seed rate of 365 grams (equivalent to 123.55 kg/ha), which remained uniform across all plots. This standardized approach ensured consistency and comparability in the sowing process across the experimental setup.

### **Weedicides Application**

The weedicides were applied to the wheat crop using manual hand pump spraying to target both narrow-leaved and broad-leaved weeds. This precise application, timed strategically to coincide with weed growth stages, effectively controlled weed infestation while safeguarding wheat plants. The following Weedicides were applied and their details are listed in Table 6.

Table 6 Weedicide applied to the experimental field and their details

|  |  |
| --- | --- |
| **Weedicides** | **Quantity** |
| Ally Mix (Broad leaves weedicides) | 4 g with 20 liters water |
| Axial (Narrow leaves weedicides) | 66 ml with 20 liters water |

### **Irrigation Application**

Irrigation was applied based on the crop water requirements of the experimental plots. The installed 20 kw solar power plant at the CEWRI field station of NARC, were used for pumping irrigation water. This system incorporated irrigation pipes equipped with two distinct flow meters dedicated to flood and drip irrigation management within the experimental plots. These flow meters facilitated detailed and accurate measurements, offering essential insights into the precise quantity of water dispensed to the wheat crop. By aligning the irrigation process with crop water requirements and utilizing advanced technology for monitoring, the study ensured optimal water management strategies, contributing crucial data for evaluating the impact of irrigation techniques on wheat crop growth and productivity.

## Agronomic Parameters

The collection of agronomic parameters involved a systematic and comprehensive approach throughout the wheat crop's growth stages in the experimental plots. Regular field visits were conducted, during which various parameters including plant height, tiller count, flowering stages, and maturity were meticulously observed and recorded at predetermined intervals. Additionally, measurements of yield-related traits such as spike length, number of grains per spike, and grain weight were meticulously gathered during harvest. This diligent and consistent data collection process aimed to capture crucial information regarding the growth, development, and yield components of the wheat crop under different sowing and tillage methods. These parameters are pivotal in assessing the effects of agronomic practices on wheat productivity, facilitating an in-depth analysis of the experimental outcomes.

### **Plant Height**

Plant height measurements were taken during the harvesting stage using a measuring tape in the experimental plots. The height of wheat plants was systematically recorded from the base to the tip of the main stem, employing standardized measurement techniques. The data collected at harvest regarding plant height served as a fundamental parameter for evaluating the overall growth performance and stature of the wheat crop, facilitating an in-depth analysis of the agronomic practices' impact on the crop's vertical development.

### **Spike Length**

Spike length measurements were carried out at the harvesting stage across the experimental plots, employing a measuring tape to determine the length of wheat spikes. This systematic approach ensured consistent and accurate recording of spike length, measuring from the base to the tip of the spikes.

### **Number of Tillers**

Tiller quantification was conducted meticulously across the experimental wheat plots, encompassing both the counting of tillers per individual plant and the assessment of tiller density within a one-meter square area.

### **Wet Weight (plants/m2)**

Using a one-meter square frame, the wheat crop within the frame was carefully harvested, and its biomass was measured using an electronic measuring balance. By employing this method, precise measurements of the crop's biomass per square meter were obtained, providing essential data regarding the yield potential and biomass production of the wheat crop under various sowing and tillage methods.

### **Thousand Grain Weight**

The grain weight analysis was conducted by meticulously counting and weighing 1000 grains from each sample of the wheat crop, employing a precise measuring balance for accurate measurements.

### **Number of Grains per Spike**

In the evaluation of the wheat crop, an examination was conducted by randomly selecting three spikes from each plot sample. The primary objective was to precisely count the number of grains present on each spike, while concurrently noting the count of unfilled grain spaces, a measure indicating sterility. This detailed assessment aimed to provide comprehensive insights into the reproductive success and potential yield of the wheat crop under varying sowing methods. Assessing both the abundance of grains per spike and the presence of unfilled grain spaces allowed for a comprehensive understanding of the crop's reproductive health and grain development dynamics. The data acquired from these observations significantly contributed to the assessment of the wheat crop's overall productivity and reproductive efficiency, essential components crucial to the comprehensive analysis within the framework of my thesis.

# RESULTS AND DISCUSSION

## Yield and yield components

Yield refers to the total production or output of a crop, usually measured in tonnes per hectare. Yield component on the other hand are the individual factors that contribute to the overall yield of a crop.

Figure 13 Two years’ average wheat yield under different treatments

The provided graph illustrates the overall yield data (ton/ha) for wheat under different treatments labelled as FB-B, FB-L, NB-L, and WB-L, each with respective yield values and error bars. FB-B (Flat Bed - Broadcasting) yielded 6.16 tons per hectare, the lowest among the treatments, while FB-L (Flat Bed - Line sowing) yielded 6.90 tons per hectare, showing a higher yield. NB-L (Narrow Bed - Line sowing) yielded the highest at 7.77 tons per hectare, indicating significant improvement with this method. WB-L (Wide Bed - Line sowing) also yielded 6.90 tons per hectare, suggesting that bed width does not significantly affect yield when line sowing is used. The error bars indicate variability, with shorter bars suggesting more consistent data. Line sowing methods clearly outperform broadcasting, with narrow bed line sowing (NB-L) being the most effective. These findings suggest that adopting narrow bed line sowing could significantly benefit wheat farmers aiming to enhance productivity.

### **Conclusion and Discussion**

This study offers valuable insights into optimizing wheat cultivation through the comparative analysis of various sowing methods in silty loam soil. The research underscores the superior performance of the narrow bed line (NB-L) sowing method, which demonstrated significant increases in crop height, spike length, dry biomass production, and grain yield compared to traditional broadcasting methods. NB-L consistently showed a 4.20% increase in crop height, a 2.28% increase in spike length, a 25.18% increase in dry biomass production, and a 26.10% increase in grain yield, highlighting its potential as a preferred method for maximizing wheat productivity.

Conversely, flat basin line (FB-L) sowing exhibited mixed results, with advantages in grain quality metrics such as 1000-grain weight and harvest index but consistently shorter spikes and lower dry biomass production compared to NB-L.

The dynamic nature of agricultural systems necessitates the adoption of innovative and sustainable practices to enhance crop productivity and resource efficiency. This study has highlighted the critical role of sowing methods in optimizing wheat yields in silty loam soil. The NB-L sowing method consistently outperformed other methods across multiple agronomic metrics, demonstrating its effectiveness in promoting robust crop growth and maximizing grain production. This method's superior performance in crop height, spike length, dry biomass production, and grain yield underscores its potential as a preferred sowing method for sustainable wheat cultivation.

Conversely, the FB-L sowing method showed mixed results, with advantages in grain quality but consistently shorter spikes and lower dry biomass compared to NB-L. These observations suggest that while FB-L may be beneficial for improving grain quality, it may not be the best method for maximizing overall crop productivity. Further investigation into the underlying mechanisms influencing FB-L performance is warranted to assess its comprehensive suitability for wheat cultivation.

The findings of this research provide evidence-based recommendations for optimizing wheat cultivation, to enhance productivity and resource efficiency. Continued research, collaboration, and innovation are essential to advance the adoption of sustainable agricultural practices, ensuring food security and environmental sustainability in the face of changing climatic conditions.

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