



# **Evaluation of System of Wheat Intensification on Growth Parameters and Yield Attributes of Wheat**

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## **Authors' contributions**

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

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## **ABSTRACT**

An experiment was carried out in the field during *rabi* season 2022-23 at Crop Research Farm, Department of Agronomy, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (U.P.). The experiment was conducted to determine the response of wheat crop to different planting methods and biofertilizer application. There were nine treatments in the experiment, each replicated thrice and it was laid out in Randomized Block Design. The results showed that System of Wheat Intensification in combination with *Azotobacter* and *Azospirillum* recorded significant and higher plant height (101.93 cm), number of tillers / hill (12.91), plant dry weight (24.53 g), number of effective tillers / hill (9.78) and number of grains / spike (58.76). Whereas, Raised bed in combination with *Azotobacter* and *Azospirillum* significantly increased Leaf area index (3.66) and Crop growth rate (17.42 g/m<sup>2</sup>/day) compared to other treatments.

**Keywords:** *Wheat; SWI; biofertilizer; growth; yield.*

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## 1. INTRODUCTION

Wheat, the second most important cereal crop of India has a vital role in the nutritional security of the country. It is one of the chief sources of diet as it provides the rising population of country with half of the dietary protein and calories. This crop has good persistence of winter hardiness and less susceptible to climate and soil changes that alter its nutritional composition. The average wheat kernel has about 12% water, 70% carbohydrates, 12% protein, 2% fat, 1.8% minerals, 2.2% crude fibers, and thiamin, riboflavin, niacin, and vitamin A in minute quantity. Wheat grain flour is used for consumption in the form of chapati, puri, bread, cake, sweetmeats, halwa, etc. It provides 20% of total calories for human race. Wheat provides characteristic substance "Gluten" which is very essential for bakers. Wheat straw is also a good source of feed for a large population of cattle in India. Straw is used in paper industries and for making temporary huts and roof. The bran, husk, and other portion of grain and straw are valuable feed for livestock.

The world's total area under cultivation of wheat is 220.89 million hectares; with total production of 789.97 million metric tons; with productivity of 3.58 tons per hectare; and the change in production from the year before to the present was around a 0.43% increase [1]. Total area under wheat cultivation in India is 30.45 thousand hectares, with total production of around 111.32 million tons and productivity 3.4 tonnes per hectare. In Uttar Pradesh total area of wheat cultivation is 9.2 million hectares with total production of 24.5 million tonnes and a productivity of 2.7 tonnes per hectare. The wheat sown area in Uttar Pradesh in the year 2022 has decreased by 0.96 % due to aberrant weather, which resulted in decreased production [2].

Present-day agriculture sustain problems related to cereal production like poor seed quality, excess chemical fertilization, poor soil quality, low crop stand, less efficient weeding practices, poor establishment of crops, pollution through chemical fertilizers, high input cost, etc. To overcome these problems, production should be enhanced using the right principles and procedures, as in crop intensification, to fulfill current and future demands. SWI is a type of crop intensification, an innovative approach involving wheat cultivation components such as sowing, weeding, irrigation and nutrient management that provide better condition of

growth for wheat crop in the root zone compared to conventional cultivation practices. SWI is based on the principle of root development and the principle of intensive care. Proper development of crop requires well establishment of roots for which, roots require adequate nourishment and sufficient space around the plant. Intensive care in every stage of plant growth will enhance productivity.

In addition to good crop upkeep and input supply, organic fertilizers should be used to increase crop production. *Azotobacter* is an aerobic, free-living, gram positive, spherical or oval-shaped bacterium that prefers to live in soil. The atmospheric Nitrogen is utilized by these bacteria for their cell protein synthesis. The cell protein gets mineralized in the soil after the death of *Azotobacter* cells thereby releasing the available form of Nitrogen into the soil for the plants to absorb. These bacteria are sensitive to acidic pH, high salts and temperature above 35° C. Apart from N fixation, they also synthesize and secrete considerable amounts of biologically active substances like B vitamins, nicotinic acid, pantothenic acid, biotin, heteroxins and gibberellins which help in plant root growth [3]. One of the important characteristic of *Azotobacter* association with crop improvement is secretion of ammonia in the rhizosphere in presence of root exudates, which help in modification of nutrient uptake by the plants [4]. Agricultural crop yield increase due to *Azotobacter* is about 10-12 percent [5].

*Azospirillum* is an aerobic, gram negative, motile, surface colonizing, rod shaped bacteria which can survive even in low oxygen conditions (microaerophilic). Belonging to the order Rhodospirillales, these are associated with roots of monocots. Worldwide *Azospirillum* is considered as primary commercial phytostimulator inoculant for cereal crops. It establishes an associative symbiosis with cereals, where the association is not accompanied with formation of new organs. These benefit the plant directly by associative nitrogen fixation, synthesis of phytohormones (IAA, Indole-3 Acetic acid), and modulation of plant hormonal balance by deamination of the ethylene precursor [6]. Keeping the above benefits under consideration, the research titled "Evaluation of System of Wheat Intensification on growth and yield of Wheat" was carried out to study the effect of biofertilizers and different sowing methods on growth and yield of wheat.

## 2. MATERIALS AND METHODS

The research trial was carried out at the Crop Research Farm, Department of Agronomy, SHUATS, during *rabi* season 2022-23. The soil of the experimental area has its parenthood from the central Gangetic alluvium, with characteristics of sandy loam texture, neutral pH (8.0), and low levels of organic elements such as C (0.62%), N (225 kg/ha), P (38.2 kg/ha), K (240.7 kg/ha), Zn (2.32 mg/kg) etc. This experiment consisted of nine treatments; each replicated thrice and was laid out in Randomized Block Design. Biofertilizers (*Azotobacter* and *Azospirillum*) were combined with different planting methods in each treatment. The treatment combinations used were T1 (System of Wheat Intensification + *Azotobacter*), T2 (System of Wheat Intensification + *Azospirillum*), T3 (System of Wheat Intensification + *Azotobacter* + *Azospirillum*), T4 (Line sowing + *Azotobacter*), T5 (Line sowing + *Azospirillum*), T6 (Line sowing + *Azotobacter* + *Azospirillum*), T7 (Raised bed + *Azotobacter*), T8 (Raised bed + *Azospirillum*) and T9 (Raised bed + *Azotobacter* + *Azospirillum*). The data was recorded on different growth and yield contributing parameters of the crop which were subjected to statistical analysis by analysis of variance method as per Gomez and Gomez [7].

## 3. RESULTS AND DISCUSSION

### 3.1 Growth Parameters

#### 3.1.1 Plant height (cm)

The results showed significant and higher plant height (101.93 cm) in the treatment 3 (SWI + *Azotobacter* + *Azospirillum*). However, the treatment 2 (SWI + *Azospirillum*) was statistically at par with treatment 3 (SWI + *Azotobacter* + *Azospirillum*) (Table 1).

Significant and higher plant height was recorded with SWI, might be due to adequate space available for roots to establish well, increasing their length and diameter, by providing strong root systems foundation for effective growth and development of the plants. Similar results were reported by Dhar et al. [8]. Further, significant and higher plant height was with the application of *Azospirillum*, might be due to its capability to produce Indole-3-acetic acid which helps in growth regulation of wheat. Similar results were reported by Karimi et al. [9]. Another reason, significant and higher plant height was also

increased with application of *Azotobacter*, might be due to the stimulation effect between *Azotobacter* and NPK on improving nutrient uptake, which in turn improves plant growth. Similar findings were also reported by Mahato and Kafle [10].

#### 3.1.2 Number of tillers/hill

The results showed significant and maximum number of tillers / hill (12.91) in the treatment 3 (SWI + *Azotobacter* + *Azospirillum*). However, the treatment 2 (SWI + *Azospirillum*) was statistically at par with treatment 3 (SWI + *Azotobacter* + *Azospirillum*) (Table 1).

Significant and higher number of tillers/hill was recorded with SWI, might be due to efficient usage of available resources such as space, foraging area for root system, better root spread, more light interception, etc. Similar findings were reported by Thakur et al. [11] in paddy and Chatterjee et al. [12]. Further, significant and higher number of tillers/hill was with the application of *Azospirillum*, might be due to the role of kinetin in encouraging nutrient movement and transfer towards treated parts as being parts of high metabolism in wheat. Similar results were reported by Taiz and Zenger [13]; Safi and AL-Faid [14]. Another reason, significant and higher number of tillers was also with the application of *Azotobacter*, might be due to its capacity for nitrogen fixation, expansion of root area, optimal absorption of water with nutrients and production of growth hormones. Similar findings were reported by Sorady et al. [15].

#### 3.1.3 Leaf area index

The results showed significant and higher Leaf area index (3.66) in the treatment 9 (Raised bed + *Azotobacter* + *Azospirillum*). However, the treatment 8 (Raised bed + *Azospirillum*) was statistically at par with treatment 9 (Raised bed + *Azotobacter* + *Azospirillum*) (Table 1).

Significant and higher leaf area index was reported with raised bed, might be due to favourable synthesis of growth favouring constituents in plant system with better supply of nitrogen, which led to increased number of leaves per unit area resulting in enlargement in leaf area. Similar results were reported by Alam [16]. Further, significant and higher leaf area index was with the application of *Azospirillum*, might be due to lipopolysaccharides present on outer membrane of bacterium which affect the leaf area index by increasing leaf length,

Table 1. Effect of planting methods and biofertilizers on growth parameters of wheat

S. No	Treatment combination	Plant height (cm)	Number of tillers/hill	Leaf Area Index	Plant dry weight (g)	Crop Growth Rate (g/m <sup>2</sup> /day)
1.	SWI + <i>Azotobacter</i>	99.80	11.72	1.53	22.15	9.64
2.	SWI + <i>Azospirillum</i>	100.83	11.90	1.80	22.47	10.43
3.	SWI + <i>Azotobacter</i> + <i>Azospirillum</i>	101.93	12.91	1.86	24.53	10.80
4.	Line sowing + <i>Azotobacter</i>	87.63	9.20	1.51	18.00	16.46
5.	Line sowing + <i>Azospirillum</i>	91.11	9.53	2.05	20.47	15.33
6.	Line sowing + <i>Azotobacter</i> + <i>Azospirillum</i>	96.42	10.47	3.06	21.58	16.96
7.	Raised bed + <i>Azotobacter</i>	93.20	9.87	2.61	19.67	16.67
8.	Raised bed + <i>Azospirillum</i>	97.13	10.87	3.48	20.93	16.67
9.	Raised bed + <i>Azotobacter</i> + <i>Azospirillum</i>	99.60	11.67	3.66	22.03	17.42
	<b>S.Em(±)</b>	0.87	0.57	0.22	1.08	0.01
	<b>C.D. (P = 0.05)</b>	2.60	1.72	0.65	3.22	0.04

Table 2. Effect of planting methods and biofertilizers on yield attributes of wheat

S. No	Treatment combination	Number of effective tillers/hill	Number of grains/spike
1.	SWI + <i>Azotobacter</i>	8.91	57.30
2.	SWI + <i>Azospirillum</i>	9.29	57.94
3.	SWI + <i>Azotobacter</i> + <i>Azospirillum</i>	9.78	58.76
4.	Line sowing + <i>Azotobacter</i>	5.88	42.46
5.	Line sowing + <i>Azospirillum</i>	5.97	48.40
6.	Line sowing + <i>Azotobacter</i> + <i>Azospirillum</i>	7.08	54.10
7.	Raised bed + <i>Azotobacter</i>	6.80	52.40
8.	Raised bed + <i>Azospirillum</i>	7.70	54.60
9.	Raised bed + <i>Azotobacter</i> + <i>Azospirillum</i>	7.83	57.06
	<b>S.Em(±)</b>	0.39	0.67
	<b>C.D. (P = 0.05)</b>	1.17	2.01

especially the second leaf in wheat. Similar results were reported by Chavez-Herrera et al. [17]. Another reason, significant and higher leaf area index was with the application of *Azotobacter*, might be due to greater mobilization of nutrients, through the production of growth-promoting substances and enhancing the production of leaf area per unit ground area. Similar findings were reported by Tairo et al. [18]; Rani and Sharma [19].

### 3.1.4 Plant dry weight (g)

The results showed significant and higher plant dry weight (24.53 g) in the treatment 3 (SWI + *Azotobacter* + *Azospirillum*). However, the treatment 2 (SWI + *Azospirillum*) was statistically at par with treatment 3 (SWI + *Azotobacter* + *Azospirillum*) (Table 1).

Significant and higher plant dry weight was recorded with SWI might be due to the fact that, dry matter accumulation is the sum total effect of overall growth. Higher number of plant stand, tillers and LAI indicating higher photosynthetic efficiency resulted in higher plant dry weight. The similar findings were reported by Chatterjee et al. [12]. Further, significant and higher plant dry weight was with the application of *Azospirillum*, might have improved nutrient uptake and increased number of tillers, resulted higher plant dry weight. The similar results were reported by Zorita and Canigia et al. [20]. Another reason, significant and higher plant dry weight was also with the application of *Azotobacter*, might be due to improvement in availability of leaf nutrient content and growth promoting substances contributing to an increase of leaf number, leaf area, fresh weight and dry weight of head and canopy area which finally resulted in increased plant dry weight. Similar findings were reported by Razmjooei et al. [21] in lettuce.

### 3.1.5 Crop growth rate (g/m<sup>2</sup>/day)

The results showed significant and higher Crop growth rate (17.42 g/m<sup>2</sup>/day) in the treatment 9 (Raised bed + *Azotobacter* + *Azospirillum*). However, the treatment 8 (Raised bed + *Azospirillum*) was statistically at par with treatment 9 (Raised bed + *Azotobacter* + *Azospirillum*) (Table 1).

Significant and higher crop growth rate was with raised bed, might be due to suitable environmental condition resulting in efficient

vegetative growth, photosynthesis, increase in leaf area index and plant dry weight. Similar results were reported by Khan et al. (2022). Further, significant and higher crop growth rate was with application of *Azospirillum*, might be due to optimum availability of essential nutrients and nitrogen in the rhizosphere of the plant due to the positive activity of soil microbes. Similar findings were reported by Din et al. [22]. Another reason, the significant and higher crop growth rate was also with the application of *Azotobacter*, due to increase in auxin production which provoke root-generator system, increase assimilation and maintain new photosynthetic organs durability. Similar findings were reported by Soleymanifard et al. [23] in maize.

## 3.2 Yield Attributes

### 3.2.1 Number of effective tillers/hill

The results showed significant and maximum number of effective tillers / hill (9.78) in the treatment 3 (SWI + *Azotobacter* + *Azospirillum*). However, the treatment 2 (SWI + *Azospirillum*) was statistically at par with treatment 3 (SWI + *Azotobacter* + *Azospirillum*) (Table 2).

Significant and higher number of effective tillers / hill was found with SWI, may be due to adequate space provided to the root to function at its maximum and uptake nutrients efficiently leading to increase in photosynthesis and effective tiller count. Similar results were reported by Mithilesh and Abraham [24]; Debbarma et al. [25]. Further, significant and higher number of effective tillers / hill was with the application of *Azospirillum* due to phytohormones, antibacterial and antifungal compounds which stimulate root system and change in root morphology which in turn affect assimilates of nutrients thus influence the development of reproductive structures. Among phytohormones, auxin, gibberellins and cytokinins are considered to play a vital role at early stage (vegetative) by affecting bud formation therefore development of effective tillers. The present results corroborate with Jat et al. [26] in barley. Significant and higher number of effective tillers / hill was also with the application of *Azotobacter* due to increased availability of nitrogen to plants through biological fixation in rhizosphere by the bacterium, where greater availability of nitrogen helped in better root proliferation, resulting in more dry matter production ultimately higher number of effective tillers. Similar findings were reported by Togas et al. [27] in pearl millet.

### 3.2.2 Number of grains/spike

The results showed significant and maximum number of grains / spike (58.76) in the treatment 3 (SWI + *Azotobacter* + *Azospirillum*). However, the treatment 2 (SWI + *Azospirillum*) was statistically at par with treatment 3 (SWI + *Azotobacter* + *Azospirillum*) (Table 2).

Significant and higher number of grains/spike was found with SWI, may be due to wider spacings which reduced competition between plants for water, nutrient, light and space lead better growth of plants and yield attributes particularly number of grains/ spike. The findings corroborate the results of Reddy et al. [28]. Further, significant and higher number of grains/spike was recorded with the application of *Azospirillum*, may be due to three possible mechanisms of activity of the living bacterium i.e. nitrogen fixation, production of plant growth promoting substances and interactions with plant nitrate assimilation. Similar findings were reported by Patriquin et al. [29]; Ozturk et al. [30]. Another reason, significant and higher number of grains/spike was also with the application of *Azotobacter* due to enhancement in nutrient uptake of  $\text{NO}_3$ ,  $\text{NH}_4^+$ ,  $\text{H}_2\text{PO}_4$ , K and Fe, improvement of plant water status and increase in nitrate reductase activity that further resulted in higher number of grains/ spike. The above results corroborate with Wani et al. [31]; Kader et al. [32].

## 4. CONCLUSION

It is concluded that in wheat, combination of SWI with *Azotobacter* and *Azospirillum* (treatment 3) resulted in higher plant growth and yield.

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## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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