Original Research Article

"EVALUATION OF SYSTEM OF WHEAT INTENSIFICATION ON GROWTH AND YIELD ATTRIBUTES OF WHEAT"

ABSTRACT

An experiment was carried out in the field during *Rabi* 2022 to ascertain the "Evaluation of System of Wheat Intensification on growth and yield of wheat" at Crop Research Farm, Department of Agronomy, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (U.P.). The results showed that treatment 3 (SWI + *Azotobacter* + *Azospirillum*) significantly increased plant height (101.93 cm), number of tillers / hill (12.91), plant dry weight (24.53 g), number of effective tillers / hill (9.78), number of grains / spike (58.76)and treatment 9 (Raised bed + *Azotobacter* + *Azospirillum*) significantly increased Leaf area index (3.66) and Crop growth rate (17.42 g/m^2/day).

Keywords: *Wheat, SWI, Azotobacter, Azospirillum*

INTRODUCTION

Wheat is considered one of the most important staple crops. This crop has good persistence of winter hardiness and occasionally 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 in 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 our country. 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 was 220.89 million hectares; the total production was 789.97 million metric tons and the productivity was 3.58 tons per hectare (**USDA, 2022**). Total area of wheat cultivation in India was 30.45 thousand hectares, total production was around 111.32 million tons and productivity was 3.4 tonnes per hectare. In Uttar Pradesh total area of wheat cultivation was 9.2 million ha, total production was 24.5 million tonnes at a productivity of 2.7 tonnes per ha (**GOI, 2022**).

Present-day agriculture still 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, 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^{o} C (**Rao, 1986**).

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 (**El-Lattief, 2016**). Keeping the above points under consideration, the research entitled "**Evaluation of System of Wheat Intensification on growth and yield of Wheat**" was conducted during *Rabi* 2022-23 at Crop Research Farm, Department of Agronomy, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj-211007, (U.P).

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, and low levels of organic C (0.62%), N (225 kg/ha), P (38.2 kg/ha), K (240.7 kg/ha), Zn (2.32 mg/kg) etc. This trial consist 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 are T_1 – SWI + *Azotobacter*, T_2 – SWI + *Azospirillum*, T_3 – SWI + *Azotobacter* + *Azospirillum*, T_4 – Line sowing + *Azotobacter*, T_5 – Line sowing + *Azospirillum*, T_6 – Line sowing + *Azotobacter* + *Azospirillum*, T_7 – Raised bed + *Azotobacter*, T_8 – Raised bed + *Azospirillum* and T_9 – Raised bed + *Azotobacter* + *Azospirillum*.The data recorded on different aspects of crop such as, growth and yield were subjected to statistical analysis by analysis of variance method (**Gomez and Gomez, 1984**).

RESULTS AND DISCUSSION

1. Growth parameters

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*).

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.* (2015)**. Further, significant and higher plant height was with the application of *Azospirillum*, due to its capability to produce Indole-3-acetic acid which helps in growth regulation of wheat. Similar results are in support with **Karimi*et al.* (2018)**. 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 (2018)**.

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 are in support with **Thakur *et al.* (2010)**in **paddy** and **Chatterjee*et al.* (2016)**. 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 are in support with **Taiz** and **Zerger (2010); Safi** and **AL-Faid (2018)**. 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.*(2022)**.

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 obtained by**Alam (2013)**. 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, especially the second leaf in wheat. Similar results are in support with **Chavez-Herrera *et al.* (2018)**. 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 are in support with **Tairo*et al*. (2017)**; **Rani** and **Sharma (2018)**.

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 are in support with **Chatterjee*et al.* (2015)**. 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 are in support with **Zorita andCanigia*et al.* (2009).** Another reason, significant and higher plant dry weight was also with the application of *Azotobacter*, 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 also reported by **Razmjooei*et al.* (2021)** in **lettuce**.

1.5 Crop Growth Rate (g/m^2/day)

The results showed significant and higher Crop growth rate (17.42 g/m^2/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 recorded 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 are in support with **Din *et al.* (2020)**. 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 are in support with **Soleymanifard*et al*. (2013)** in **maize**.

2. Yield Attributes

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 1).

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 also recorded by**Mithilesh and Abraham (2017)**; **Debbarma*et al*.** (**2017**). 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. Similar results corroborate with **Jat *et al.* (2023)**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 are in support with **Togas *et al.* (2017)**in **pearl millet**.

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 1).

Significant and higher number of grains / spike were 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. Similar results are in support with **Reddy*et al*.** (**2019**). 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 are in support with **Patriquin *et al*. (1983)**; **Ozturk *et al*. (2003)**. Another reason, significant and higher number of grains/ spike was also with the application of *Azotobacter* due to enhancement in nutrient uptake of NO_3, NH_4^+, H_2PO_4, K and Fe, improvement of plant water status and increase in nitrate reductase activity, resulted higher number of grains/ spike. Similar results corroborate with **Wani *et al*. (1988)**; **Kader *et al*. (2002)**.

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^2/day)
1.	SWI + *Azotobacter*	99.80	11.72	1.53	22.15	9.64
2.	SWI + *Azospirillum*	100.83	11.90	1.80	22.47	10.43
3.	SWI + *Azotobacter* + *Azospirillum*	**101.93**	**12.91**	1.86	**24.53**	10.80
4.	Line sowing + *Azotobacter*	87.63	9.20	1.51	18.00	16.46
5.	Line sowing + *Azospirillum*	91.11	9.53	2.05	20.47	15.33
6.	Line sowing + *Azotobacter* + *Azospirillum*	96.42	10.47	3.06	21.58	16.96
7.	Raised bed + *Azotobacter*	93.20	9.87	2.61	19.67	16.67
8.	Raised bed + *Azospirillum*	97.13	10.87	3.48	20.93	16.67
9.	Raised bed + *Azotobacter* + *Azospirillum*	99.60	11.67	**3.66**	22.03	**17.42**
	S.Em(±)	0.87	0.57	0.22	1.08	0.01
	C.D. (P = 0.05)	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 + *Azotobacter*	8.91	57.30
2.	SWI + *Azospirillum*	9.29	57.94
3.	SWI + *Azotobacter* + *Azospirillum*	**9.78**	**58.76**
4.	Line sowing + *Azotobacter*	5.88	42.46
5.	Line sowing + *Azospirillum*	5.97	48.40
6.	Line sowing + *Azotobacter* + *Azospirillum*	7.08	54.10
7.	Raised bed + *Azotobacter*	6.80	52.40
8.	Raised bed + *Azospirillum*	7.70	54.60
9.	Raised bed + *Azotobacter* + *Azospirillum*	7.83	57.06
	S.Em(±)	0.39	0.67
	C.D. (P = 0.05)	1.17	2.01

CONCLUSION

The above findings conclude that combination of SWI with *Azotobacter* and *Azospirillum* (treatment 3) resulted in higher plant height, maximum number of tillers / hill, higher plant dry weight and yield attributes. Whereas, combination of raised bed with *Azotobacter* and *Azospirillum*(treatment 9)resulted in higher leaf area index and crop growth rate.

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