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Impact of Variable Seed Rates and Nutrient Regimes on Leaf area index and Yield Characteristics of Late-Sown Wheat Crop (*Triticum aestivum* L.)

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ABSTRACT

The field experiment was carried out at Agronomy farm, Acharya Narendra Deva University of Agriculture and technology, Ayodhya during *Rabi* season 2023-24 and 2024 – 2025. The study aimed to evaluate the effect of different seed rates with nutrient management practices on LAI and yield attributes of late sown wheat crop. The experiment followed a split plot design with four treatments in main plot and five treatments in sub plot. The purpose of the experiment was to examine the different seed rates S1-100 kg ha^{-1}, S2-125 kg ha^{-1}, S3-150 kg ha^{-1} and S4-175 kg ha^{-1} with effects of five nutrient management practices N1-100%RDF, N2- FYM 10 t ha^{-1}, N3-100% RDF + FYM 10 t ha^{-1}, N4- 75% RDF + FYM 10 t ha^{-1} + Biofertilizer consortium 5 kg ha^{-1} and N5-50% RDF + FYM 10 t ha^{-1} + Biofertilizer consortium 5 kg ha^{-1} on LAI and yield attributes of late sown wheat crop. Data pertains effect of seed rate on leaf area index recorded maximum with S4 175 kg ha^{-1} (0.37 and 0.39), (2.59 and 2.62) and (3.06 and 3.09) at 30,60 and 90 DAS during 2023-24 and 2024-25 respectively. Among nutrient management practices recorded maximum LAI with N4 -75% RDF + FYM (10 t ha^{-1}) + Biofertilizer consortium 5 kg ha^{-1} (0.39 and 0.40), (2.80 and 2.83) and (3.26 and 3.35) at 30,60 and 90 DAS during 2023-24 and 2024-25 respectively. Data also pertains effect of seed rate S4 150 kg ha^{-1} recorded maximum number of grain $spike^{-1}$ (41.26 and 45.35), test weight (40.30 and 41.13), spike length (9.00 and 9.04), number of spike m^{-2} (298.57 and 300.22) weight of grain $spike^{-1}$ (1.81 and 1.83) during 2023-24 and 2024-25 respectively. Among nutrient management practices N4 75% RDF + FYM (10 t ha^{-1}) + Biofertilizer consortium 5 kg ha^{-1} recorded maximum number of grain $spike^{-1}$ (45.65 and 50.66), test weight (40.81 and 42.53), spike length (9.02 and 9.06), number of spike m^{-2}(303.32 and 305.15) weight of grain $spike^{-1}$ (1.86 and 1.89) during 2023-24 and 2024-25 respectively.

INTRODUCTION

Wheat (*Triticum aestivum* L.) belongs to family *Poaceae*, the second most important cereal crop in the world after rice. Wheat is a temperate and sub-tropical region crop. It is grown in wide range of temperature, requires 600-900 mm annual rainfall, from sandy loam or loam texture, good structure and moderate water holding capacity. Wheat grains contain starch 60-68%, protein 8-15%, fat 1.5-2.0%, cellulose 2.0-2.5%, and minerals 1.5-2.0% (**Rathore, 2001**).

The seed rate is an important factor for successful wheat production, as it strongly influences the use of environmental resources by altering intra-plant and inter-plant competition for light, water and nutrients during crop development, resulting in different population structures and ultimately affecting grain yield and furthermore, it is within the control of the farmer **(Kiss *et. al.*, 2018)**. Furthermore, several studies have shown that crop yield usually revealed a curvilinear response to plant density, and it reached a maximum level at the optimum plant density indicating that the seed rate also affects grain yield. Growth of wheat was affected by different seeding rates. At higher seed rate, there was death of plants in early stage of growth due to more competition for the resources. FYM (farm yard manure) is one of the organic components to make the production system more sustainable without adverse effects on the natural resources and the environment **(Stockdale *et. al*. 2001; Ram *et. al*. 2011a).** The role of biofertilizers for enhancing the productivity of soil by fixing atmospheric nitrogen, or by solubilizing soil phosphorus, or by stimulating plant growth through synthesis of growth promoting substances has special importance in organic farming. The present paper implements different treatments and is aimed at comparing the direct, residual and cumulative effects of different combinations of organic manures (FYM) and biofertilizers to find out the effect of different combinations of organic manures (FYM) and biofertilizers on yields, NPK uptake, gross and net returns of wheat under organic farming. Biofertilizer is the living cell of microorganisms on solid and liquids carriers. Such products having numerous functional properties such as nitrogen fixing, nutrient solubilization and nutrient mobilization to improve plant growth and productivity of crops and to maintain soil health and fertility. Over 95% of the bacteria existing near plants rhizosphere or in the plant roots help in nutrients uptake from soils. Also, it was determined how the application of these beneficial bacterial strains, a bio-inoculant shaped the rhizosphere and root associated bacterial communities under stress. Nitrogen supplementation is essential to the yield and quality of wheat. The impact of N- deficiency on wheat at seedling stage has been previously reported. Nitrogen uptake and N utilization in plants are also known to be influenced by the seeding rate. Plant N accumulation was highest at the optimum seed rate, and when seed rates were lower or higher than the optimum they failed to increase N accumulation in wheat **(Blankenau & Olfs, 2001)**.

Phosphorus is a vital element which also needed for the producti on of energy from photosynthesis and transportation of carbohyd rates **(Rngothama,1999).** Phosphorus helps in improving growth of roots and cell turgidity by maintaining the high leaf water potential which in turn increases the stomata conductance and photosynthetic rate **(Waraich *et.al*. 2011).** Phosphorus fertilization has great influence on wheat yield by increasing number of tillers per plant and it's deficiency has been reported as one of the main resources for reduction in number of tillers per plant. Potassium is a macro-nutrient, which plays an important role in plant growth and development it takes part in different physiological and biochemical processes in plants such as protein synthesis, carbohydrate metabolism and activation of several enzymes Nutrient deficiency adversely impacts plant growth and physiological processes, including photosynthetic function, respiration etc. Therefore, an experiment was conducted to evaluate the performance of different seed rate and INM practices on yield and uptake of late sown wheat.

MATERIAL AND METHOD

The field research was carried out at Agronomy farm, Acharya Narendra Dev University of Agriculture and Technology during winter *(Rabi)* season of 2023-2024 and 2024-2025. The latitude and the longitude of the research station was 26.54"N and 81.83"E respectively, with an altitude of 113 m above the mean sea level. The study aimed to evaluate the performance of wheat under different seed rate and integrated nutrient management using inorganic, organic and Bio-fertilizers.

The experimental field soil had a silty loam texture and low organic carbon (0.26%) low in available N (189.6 kg ha^{-1}), low in available phosphorus (17.04 kg ha^{-1}) and available potassium (201.25 kg ha^{-1}) with normal Ph range (8.02) and EC (0.383 ds/m). The research was organized according to split plot design. The wheat variety "DBW 187" with 3 replications, comprising of 4 treatment in main plot of seed rate i.e. S_1 -100 kg ha^{-1} , S_2 -125 kg ha^{-1}, S_3 -150 kg ha^{-1} and S_4 -175 kg ha^{-1} Five different nutrient management practices in sub plot N_1 -100% RDF, N_2 -FYM 10 t ha^{-1}, N_3 -100% RDF + FYM 10 t ha^{-1}, N_4 -75% RDF + FYM 10 t ha^{-1} + Biofertilizer consortium 5 kg ha^{-1} and N_5 50% RDF + FYM 10 t ha^{-1} + Biofertilizer consortium 5 kg ha^{-1}. The experimental unit area 20 m^{-2} and a distance of 20 cm row spacing with seed rate. The recommended dose of N-P-K fertilizer for late sown wheat crop was 80:40:30 kg ha^{-1}. After field preparation basal application of NPK by urea, di ammonium phosphate and muriate of potash was applied according to the treatment and FYM is incorporated in soil 15 days before sowing, seeds are treated with liquid biofertilizer consortium @ 250 ml in 3 litre water /kg seed rate as per the treatment and then mixed with FYM in 2:1 ratio to protect the seed from picking by birds. The crop received two uniform irrigations at tillering and booting stage and was harvest at 15 and 16 April, respectively in first and second year of experimentation. The following traits were studied

1- LAI (leaf area index)
2- Yield attributing characters.

A. LAI (leaf area index)

Five plants' leaves were taken at 30, 60, and 90 days after sowing in order to estimate the dry matter in the samples. The leaf area was then measured using a leaf area meter. Following the measurement of leaf area, these leaves were once more combined with the examples of dry matter estimation. Leaf area per plant was calculated by averaging the leaf area for each sample that was thus recorded. The following relationship was used to calculate LAI at each stage based on land area per plant (Watson, 1958).

$$LAI=\frac{\text{Area of leaves (cm2)}}{\text{Area of land (cm2)}}$$

B. Yield attributes

1. Number of Spike m^{-2}

When the sampling unit reached maturity, the number of spikes bearing tillers was counted, and the data was expressed as the number of effective tillers m^{-2}.

2. Spike Length (cm)

Five spikes, or ears, will be chosen at random, and their lengths will be measured. The average spike length will be calculated by adding the figures for each of the five spikes and dividing the total by 5. It will be noted in centimeters.

3. Number of grain per spike

Ten spikes were chosen at random from each plot, and the average number of grains per spike calculated by counting the number of filled grains per ten spikes.

4. 1000-grain weight

A weight measurement in grams was made of one thousand full grains from the net plot's yield.

5. Weight of grain spike^{-1}

Five spikes, or ears, will be randomly selected from each net plot, and the average weight of grain per spike will be calculated.

RESULT AND DISCUSSION

According to Table no. 1 Data revealed leaf area index of late sown wheat crop as influenced by different seed rates and nutrient management practices. A perusal of data indicates that seed rates and nutrient management has significant effect on leaf area index of late sown wheat crop during both the years of experimentation. Data further revealed that maximum plant leaf area index recorded under 175 kg ha^{-1} at 30, 60 and 90 days of sowing (0.38 and 0.39) (2.59 & 2.62) and (3.06 & 3.09) which was at par with 150 kg ha^{-1} seed rate while significantly higher over rest of the treatments during 2023-24 and 2024-25, respectively. Similarly nutrient management practices 75% RDF+ 10 t ha^{-1} FYM+5 kg ha^{-1} biofertilizer consortium recorded maximum leaf area index at 30, 60 and 90 days of sowing (0.39 and 0.40) (2.80 & 2.83) and (3.35& 3.26) which was significantly higher over rest of the treatments during both the years. This might be due to more plant population and leaves per unit area. Leaf area index increases up to 90 DAS thereafter decrease in LAI. During later stages because of the leaf's senescence photosynthesis decreased drastically and as consequences increase in height and number of tillers recorded. Maximum leaf area index in these treatments was due to adequate supply of nutrients at active growth stages resulted in maximum leaf area index. Similar finding also was reported by Chopra and Chopra (2012).

Number of spike m^{-2}

Data as regard to number of spike m^{-2} late sown wheat crop as influenced by different seed rates and nutrient management has been given in Table no. 2. A perusal of data indicated that seed rates and nutrient management has significant effect on late sown wheat crop during both the years of experimentation. Data further revealed that maximum number of spike m^{-2} recommended under 150 kg ha^{-1} (298.57 and 300.22 m^{-2}) which was at par with 125 kg ha^{-1} seed rate while significantly higher over the rest of the treatments during 2023-24 and 2024-25 respectively.

Among nutrient management practices 75% RDF + 10 t ha^{-1}+FYM + 5 kg ha^{1}+ biofertilizer consortium recorded maximum number of spike m^{-2} (303.32 and 305.15 m^{-2}) which was significantly higher over rest of the treatments during 2023-24 and 2024-25 respectively. Maximum number of spike m^{-2} in these treatments were due to adequate supply of nutrients at active growth stages resulted in maximum number of spike m^{-2}, Similar finding also was reported by Kumar *et al.* (2022).

Spike length

Data recorded on spike length of late sown wheat crop as influenced by seed rate and nutrient management has been given in Table no. 2. A perusal of data indicates that seed rates and nutrient management had non-significant effect on spike length of late sown wheat crop during both the years of experimentation. Highest spike length recorded under 150 kg ha^{-1} (9.00 and 9.04 cm) however there were no significant effect in spike length under different seed rate during 2023-24 and 2024-25 respectively.

Among nutrient management practices 75% RDF+ 10 t ha^{-1} FYM+5 kg ha^{-1} biofertilizer consortium recorded highest spike length which was (9.02 and 9.06 cm) however there were no significant effect in sike length under different nutrient management practices during 2023-24 and 2024-25 respectively. Maximum length of spike in these treatments were due to adequate supply of nutrients at active growth stages resulted in maximum length of spike. Similar finding also was reported by Singh *et al.* (2007).

Number of grains spike^{-1}

Data pertaining to number of grain spike^{-1} of late sown wheat crop as influenced by seed rate and nutrient management has been given in Table 2. A perusal of data indicates that seed rates and nutrient management has significant effect on number of grain spike^{-1} of late sown wheat crop during both the years of experimentation. Data further revealed that maximum number of grain spike^{-1} recorded under 150 kg ha^{-1} (41.26 and 45.35) which was at par with 125 kg ha^{-1} seed rate while significantly higher over the rest of the treatments during 2023-24 and 2024-25 respectively. Among nutrient management practices 75% RDF+ 10 t ha^{-1} FYM+5 kg ha^{-1} biofertilizer consortium recorded maximum number of grains per spike (45.65 and 50.66) which was significantly higher over rest of the treatments during 2023-24 and 2024-25 respectively. Maximum number of grains spike^{-1} in these treatments were due to adequate supply of nutrients at active growth stages resulted in maximum number of grains spike^{-1}. Similar finding also was reported by Pandey *et al. (*2009).

1000-gain weight (g)

Data regarding test weight of late sown wheat crop as influenced by seed rates and nutrient management has been given in Table 2. A perusal of data indicates that seed rates and nutrient management has significant effect on test weight of late sown wheat crop during both the years of experimentation. Data further revealed that maximum test weight recorded under 150 kg ha^{-1} (40.30 and 41.13 g) which was at par with 125 kg ha^{-1} seed rate while significantly higher over the rest of the treatments during 2023-24 and 2024-25 respectively.

Among nutrient management practices 75% RDF+ 10 t ha^{-1} FYM+5 kg ha^{-1} biofertilizer consortium recorded maximum test weight which was (40.81and 42.53 g) which was at par with 100% RDF + FYM 10 t ha^{-1} during 2023-24 and 2024-25 respectively. This might be due to adequate supply of nutrients at active growth stages resulted in maximum test weight. Similar finding also were reported by Verma *et al. (*2010) and Singh and Singh (2018).

Weight of grain spike^{-1}

Data pertaining to weight of grain spike^{-1} of late sown wheat crop as influenced by seed rates and nutrient management has been given in Table 2. A perusal of data indicated that seed rates and nutrient management did not have significant effect on weight of grain spike^{-1} of late sown wheat crop during both the years of experimentation. Data revealed maximum weight of grain spike^{-1} recorded under 150 kg ha^{-1} (1.84 and 1.87) however there were no significant effect in weight of grain spike^{-1} under different seed rate during 2023-24 and 2024-25 respectively. Among nutrient management practices 75% RDF+ 10 t ha^{-1} FYM+5 kg ha^{-1} biofertilizer consortium recorded maximum weight of grain spike^{-1} which was (1.86 and 1.89) however, there were no significant effect in weight of grain spike^{-1} under nutrient management during 2023-24 and 2024-25 respectively. Maximum grain weight spike^{-1} in these treatments were due to adequate supply of nutrients at active growth stages resulted in maximum grain weight spike^{-1}. Similar findings have been reported by Aatif *et al.* (2017) and Kumar *et al.* (2017).

CONCLUSION

Based on findings of the experiment conducted for two years, it may be concluded that application of seed rate 175 kg ha^{-1} and 75% RDF + FYM (10 t ha^{-1}) + Biofertilizer consortium 5 kg ha^{-1} achieve highest leaf area index but 150 kg ha^{-1} and 75% RDF + FYM (10 t ha^{-1}) + Biofertilizer consortium 5 kg ha^{-1} is best practice to record highest yield attributing characters during the research period.

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Table 1. Effect of application of different seed rates and nutrient management on LAI at 30,60 and 90 DAS.

Treatments	Leaf area Index (LAI)					
Seed rates	30 DAS		60 DAS		90 DAS	
	2023-24	2024-25	2023-24	2024 -25	2023- 24	2024-25
100 kg ha^{-1}	0.31	0.31	2.44	2.46	2.88	2.91
125 kg ha^{-1}	0.34	0.32	2.47	2.49	2.90	2.93
150 kg ha^{-1}	0.37	0.38	2.56	2.58	3.03	3.07
175 kg ha^{-1}	0.38	0.39	2.59	2.62	3.06	3.09
SEM±	***0.00***	***0.02***	**0.03**	**0.04**	**0.03**	**0.05**
CD at 5%	***0.01***	***0.05***	**0.09**	**0.10**	**0.11**	**0.12**
Nutrient Management						
100%RDF	0.35	1.41	2.45	2.47	2.97	3.09
FYM 10 t ha^{-1}	0.28	1.21	2.28	2.29	2.59	2.69
100% RDF + FYM 10 t ha^{-1}	0.37	1.53	2.63	2.65	3.16	3.08
75% RDF + FYM (10 t ha^{-1}) + Biofertilizer consortium 5 kg ha^{-1}	0.39	1.63	2.80	2.83	3.35	3.26
50% RDF + FYM 10 t ha^{-1} + Biofertilizer consortium 5 kg ha^{-1}	0.32	1.32	2.42	2.44	2.77	2.89
SEM±	***0.01***	***0.03***	**0.05**	**0.04**	**0.06**	**0.07**
CD at 5%	***0.02***	***0.08***	**0.14**	**0.15**	**0.16**	**0.17**

Table 2. Effect of application of different seed rates and nutrient management on yield attributes on late sown wheat

Treatments	Yield attributes									
Seed rates	Number of grain spike^{-1}		Test weight (g)		Spike length(cm)		Number of spike m^{-2}		Weight of grain spike^{-1}	
	2023-24	2024-25	2023-24	2024 -25	2023-24	2024-25	2023-24	2024-25	2023-24	2024-25
100 kg ha^{-1}	38.10	41.85	37.80	38.56	8.88	8.89	249.36	250.32	1.80	1.82
125 kg ha^{-1}	40.40	43.92	40.19	40.83	8.96	8.97	295.46	296.48	1.83	1.85
150 kg ha^{-1}	41.26	45.35	40.30	41.13	9.00	9.04	298.57	300.22	1.84	1.87
175 kg ha^{-1}	39.44	42.91	39.07	40.58	8.92	8.93	259.37	260.43	1.81	1.83
SEM±	**0.43**	**0.47**	**0.44**	**0.45**	**0.10**	**0.10**	***3.14***	***3.15***	**0.02**	**0.02**
CD at 5%	**1.59**	**1.62**	**1.53**	**1.55**	**NS**	**NS**	***10.87***	***11.10***	**NS**	**NS**
Nutrient Management										
100%RDF	35.60	43.44	39.77	40.69	8.93	8.95	270.63	271.56	1.83	1.85
FYM 10 t ha^{-1}	37.68	36.72	37.56	36.66	8.85	8.86	251.19	252.23	1.76	1.79
100% RDF + FYM 10 t ha^{-1}	42.16	46.35	39.90	41.78	8.97	9.00	286.70	287.64	1.84	1.86
75% RDF + FYM (10 t ha^{-1}) + Biofertilizer consortium 5 kg ha^{-1}	45.65	50.66	40.81	42.53	9.02	9.06	303.32	305.15	1.86	1.89
50% RDF + FYM 10 t ha^{-1} + Biofertilizer consortium 5 kg ha^{-1}	37.89	40.36	38.67	39.71	8.90	8.92	266.61	267.74	1.79	1.81
SEM±	**0.76**	**0.82**	**0.73**	**0.75**	***0.17***	***0.31***	***5.21***	***5.55***	**0.01**	**0.01**
CD at 5%	**2.19**	**2.37**	**2.11**	**2.15**	***NS***	***NS***	***15.00***	***16.10***	**NS**	**NS**