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Influence of different Dates of Sowing and Varying Integrated Nutrient Management Practices on Growth, Yield and Economics in Wheat (*Triticum aestivum* L.)

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ABSTRACT: A field experiment was conducted to assess the "Influence of different dates of sowing and varying integrated nutrient management practices on growth, yield and economics in wheat (*Triticum aestivum* L.)" during the *rabi* seasons of 2020-2021 and 2021-2022. It included three sowing dates *viz.,* 10 November, 25 November and 10 December as well five integrated nutrient management practices, including 100% RDF through inorganic fertilizer, 75% RDN through inorganic fertilizer + 25% N through FYM, 50% RDN through inorganic fertilizer + 50% N through FYM, 75% RDN through inorganic fertilizer + 25% N through Vermicompost, 75% RDN through inorganic fertilizer + 25% N through Poultry manure. When compared to 10 December, the wheat sown on November 25 had the highest plant height, tillers per square metre, dry matter accumulation (g/running m), LAI, yield-attributing characters, grain yield, straw yield and B-C ratio, while remaining noticeably on par with 10 November. The 50% RDN through chemical fertilizer + 50% N through FYM nutrient management treatment had the highest values for growth characteristics, yield characteristics, grain yield, straw yield, net return and B-C ratio over the rest the treatments.

Keywords: Wheat, integrated nutrient management, dates of sowing, growth, yield and economics.

INTRODUCTION

Wheat (*Triticum aestivum* L.), is one of the most important staple food crop of India and occupy a notable position among the food grain crops not only in terms and production but also in its elasticity in fulfillment to a wide range of agro climatic conditions. The area, production and productivity of wheat in India were 29.8 million ha,111.32 million tonnes and 3371 kg/ha during 2020-2021 (Anonymous 2021). It is a native of South West Asia and is referred as the "king of cereals". Wheat is grown in at least 43 countries worldwide. The top countries worldwide for wheat cultivation are China, India, Thailand, Indonesia, and the United States. Wheat makes up about 35% of the country's food supply. It is widely used to make chapattis, pasta, bread, cakes, biscuits and sweet dishes.

After the green revolution, production of crops had increased to a great extent due to the use of chemical fertilizers but their indiscriminate use had led to soil sickness, ecological hazards and depletion of other sources of energy. The recent energy crisis, high fertilizer cost and low purchasing power of the farming community have made it necessary to re-think alternatives (Patyal *et al.,* 2022). Under these situations, INM was a good option and helps in mitigating the multiple nutrient deficiencies. Judicious use of FYM with chemical fertilizer improves soil physical, chemical and biological properties and improves the crop productivity. Application of organic manure may also improve availability of native nutrients in soil as well as the efficiency of applied fertilizers (Tripathi *et al.,* 2022). The wide spread use of fertilizer in modern agricultural production systems has undoubtedly enhanced grain productivity in several nations during the past 20 years. But in the intensive cropping system, continued use of chemical fertilizers also resulted drop in crop yields and soil fertility. In order to meet public demand, farmers employ synthetic inorganic fertilizers and pesticides at a staggering rate every day. Both humans and animals can suffer from a variety of health problems. Due to the continued usage of such inorganic fertilizer sources, the health and fertility of the soil were also compromised and in some places, barren soil has been seen. INM treatment could be used to determine the potential wheat crop yield and benefit-cost ratio (Kumar *et al*., 2019).

Sowing time is related to temperature dependent, the optimum temperature requirement of the crop in different stages should be optimized for higher yield and productivity (Meleha *et al.,* 2020). Timely sowing of wheat provides optimum environment for crop growth to accumulate more biomass and finally higher grain yield. Under late sown condition wheat crop exposed to low temperature at the germination, which delayed the crop emergence and to higher temperature at the reproductive phase leads to force maturity and resulted in reduction of the yield and yield attributes (Gupta *et al.,* 2017). While too early sowing produced weak plants with poor root system which ultimately affected growth, yields attributes and yield of the crop adversely (Yusuf *et al.,* 2019). Singh *et al.* (2018) reported that under timely sown condition, wheat crop experienced prolonged favorable growth environment which resulted in higher accumulation of carbon photo synthates and ultimately enhanced the yield attributes positively. Also, the ideal sowing period affects the crops accessibility to heat, light and water (Silva *et al*., 2014). Although it can grow at lower temperatures of 3 to 4°C or higher temperatures of 30 to 32°C, the optimum temperature for growing wheat is frequently between 15 and 25°C. High temperatures during anthesis and grain maturity considerably inhibited wheat grain development when compared to plants cultivated in optimal conditions.

MATERIALS AND METHODS

Growing environment. The field experiment was carried out at the Agronomy research farm, Sangam University, Bhilwara, Rajasthan, which is located at 25°26″N latitude, 74°62″E longitude at an altitude of 421 m above mean sea level, in wheat during the *rabi* seasons of 2021-21 and 2021-22. In the years 2020-21 and 2021-22, respectively, the weekly mean maximum temperature ranged from 21.7 to 37.3°C with an average of 28.73°C and 21.53 to 36.18°C with an average of 27.57°C. In 2020-21 and 2021-22, respectively, the crop period saw total rainfall of 14.7 mm and 76.3 mm. during the crop season, there were a total of 4 wet weeks in 2020–21 and 8 in 2021–22. The weekly mean maximum relative humidity in 2020-21 ranged from 54 to 75% with an average of 63.48%, whereas it ranged from 56.65 to 80.1% with an average of 67.16% in 2021-22.

The soil in the experimental field was silty loam in texture, deep, well-drained, with EC values of 0.11 and 0.19 dSm^{-1}, pH values of 8.1 and 7.95 (1:2.5 soil: water), low levels of organic carbon (0.39% and 0.48%), low levels of available nitrogen (228.79 and 243.71 kg/ha) (Subbiah and Assja 1956), medium levels of available phosphorus (23.0 and 24.10 kg/ha) (Olsen *et al.,* 1954) and medium in available K (270.67 and 276.32 kg/ha) (Jackson, 1973) during 2020-21 and 2021-222, respectively.

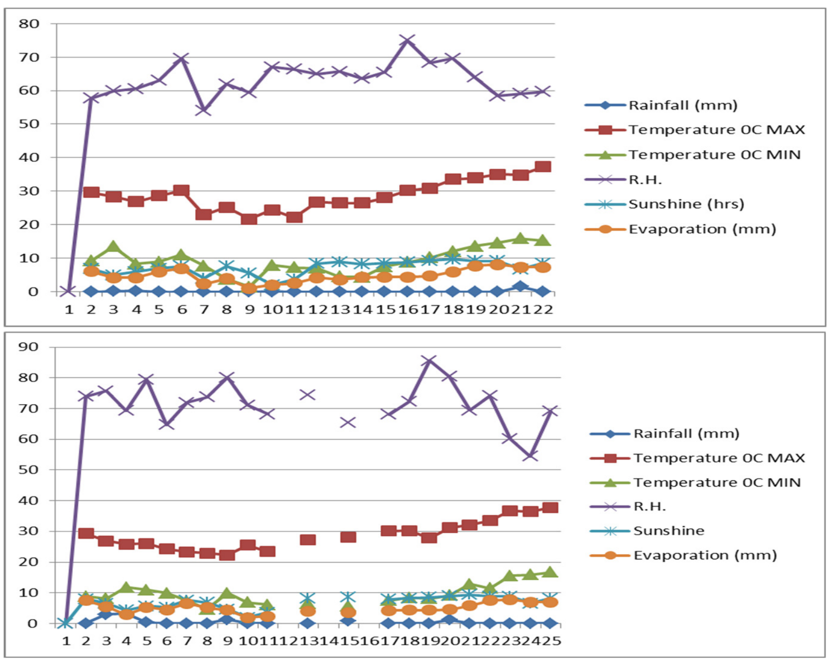

Fig. 1. Mean weekly meteorological data of 2020-21 and 2021-222 during crop season.

Treatments and experimental design. The experiment was carried out in split-plot design with three replications. The dates of sowing were subjected to main plots while integrated nutrient management in sub plots. A treatment combination of 3 dates of sowing , *viz.,* S_1-10 Nov, S_2-25 Nov, S_3-10 Dec and 5 INM treatments *viz.,* T_1-100% RDF through inorganic fertilizer, T_2-75% RDN through inorganic fertilizer +25% N through FYM, T_3-50% RDN through inorganic fertilizer +50% N through FYM, T_4-75% RDN through inorganic fertilizer + 25% N through Vermicompost, T_5- 75% RDN through inorganic fertilizer + 25% N through Poultry manure. The experimental field was ploughed with tractor drawn MB plough followed by discing, dry weeds and stubbles were removed before sowing of wheat seeds. After applying fertilizer and manures plot-wise and incorporating them into the soil one day before to the sowing of wheat, the cultivar "Raj-4079" was manually seeded with the aid of a hoe at a spacing of row 22.5 cm. The recommended fertilizers doses of urea (46% N), di-ammonium phosphate (46% P_2O_5 and 18% N) and muriate of potash (60% K_2O) were used to apply the recommended doses of nitrogen (140 kg/ha), P_2O_5 (60 kg/ha), and K_2O (40 kg/ha). The remaining 50% of the needed N was applied in two split doses as top dressing five days after the first irrigation and third irrigation, together with the 100% recommended doses of P_2O_5 and K_2O from organic and inorganic sources. For the purpose of documenting biometrical observations and yield, standard procedures were used. Plant height, tillers, leaf area index, dry matter accumulation, chlorophyll content, number of green leaves/plant yield (grain and straw yield), N, P, and K uptake were the growth characteristics that were recorded.

RESULTS AND DISCUSSION

Growth parameters. The key growth-related characteristics include plant height, tillers per square meter, dry matter accumulation, leaf area index and chlorophyll content performed significantly better in sowing date of 25 Nov as compared to 10 Dec. However, it was determined statistically at par with the dates of sowing of Treatment S_1 (10 November).One of the most noticeable traits of agricultural plants is growth. It describes the development, expansion and maturation of cells as a result of an increase in volume and weight. Growth metrics are substantially impacted by the sowing date. A late-sown wheat crop has a shorter life span because it takes longer to achieve different phenophases as a result of the sowing delay. The findings from Gupta *et al.* (2017); Madhu *et al*. (2018) are close agreement with these results.

In terms of integrated nutrient management, T_3 (50% RDN through inorganic fertilizer + 50% N through FYM) had significantly superior plant height, tillers per square meter, accumulation of dry matter, leaf area index, and chlorophyll content. Growth characteristics result from the absence of growth-restraining variables like nutrients. In treatments where nutrients were supplemented with 50% N by FYM, the integration of several sources of nutrients may have slowed down the availability of nutrients. The results closely align with Borse *et al*. (2019).

Yield. When compared to the sowing dates for Treatments S_3 (10 December) and S_1 (10 November), the sowing date for Treatment S_2 (25 November) had significantly higher grain and straw yields. It might be because of better growth and development of the plant in terms of maximum number of tillers, which in turn led to more effective ears/m^2, length of ears, and number of grains/ear with the availability of efficient resources as well as favorable soil and environmental conditions. Praveen *et al.* (2018) also discovered outcomes that were similar.

N_3 (50% RDN through inorganic fertilizer + 50% N through FYM) produced significantly greatest grain and straw yields among the various integrated nutrient management treatments. The combination of applying nutrients through fertilizers and organic nutrient sources may have helped in balancing the availability of nutrients at all growth stages of the crop. Nutrients are important components of plants and when supplied adequately stimulate net photosynthesis and more dry matter accumulation. Higher values of growth and yield attribute in N_3 (50% RDN through inorganic fertilizer + 50% N through FYM), provide strong support for the conclusion which produced the highest yield of grain and straw Kumar *et al.* (2019) likewise came to a similar conclusion.

Interaction effects on grain yield. In comparison to the other treatment combinations, the integration of N_3 (50% RDN through inorganic fertilizer + 50% N through FYM) and dates of sowing of Treatment S_2 (25 November) showed a significantly maximum grain production. This could be as a result of the treatment combination S_2N_3 dates of sowing of Treatment S_2 (25 November) and N_3 (50% RDN through inorganic fertilizer + 50% N through FYM)having improved growth and yield potentials.

Table 1: Influence of different dates of sowing and varying integrated nutrient management practices on growth attributes in wheat.

Treatment	Plant height (cm)				Number of tillers/m^2				Dry matter accumulation (g running/m)				LAI		Chlorophyll content (mg/gm)	
	60 DAS		At harvest		60 DAS		At harvest		60 DAS		At harvest		60 DAS		60 DAS	
	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022
Date of sowing																
10 November	55.06	55.82	80.74	81.61	521.08	537.20	568.39	574.45	108.06	108.50	445.46	446.15	1.93	1.99	0.77	0.78
25 November	61.49	62.52	90.01	91.15	580.08	597.71	636.45	643.30	112.57	113.02	464.47	465.07	1.99	2.05	0.80	0.81
10 December	44.35	45.84	64.88	65.50	417.93	430.55	457.92	462.18	88.76	89.14	365.95	366.52	1.47	1.51	0.59	0.60
SEm±	1.998	1.777	3.027	3.309	20.161	21.037	22.022	23.225	5.438	5.402	22.467	22.422	0.060	0.065	0.023	0.023
CD (P=0.05)	7.84	6.98	11.89	12.99	79.16	82.60	86.47	91.19	21.35	21.21	88.22	88.04	0.24	0.25	0.09	0.09
Integrated nutrient management																
100% RDF through inorganic fertilizer	51.56	51.48	75.51	76.35	486.80	501.66	532.84	538.34	81.70	82.03	337.00	337.47	1.28	1.31	0.51	0.52
75% RDN through inorganic fertilizer + 25% N through FYM	53.29	54.16	78.05	78.92	503.16	518.52	550.74	556.43	91.43	91.83	376.91	377.52	1.60	1.64	0.64	0.65
50% RDN through inorganic fertilizer + 50% N through FYM	55.84	57.44	81.78	82.69	527.20	543.29	577.06	583.02	131.52	132.04	542.47	543.22	2.24	2.30	0.91	0.92
75% RDN through inorganic fertilizer + 25% N through Vermi-compost	53.88	55.42	78.90	79.78	508.67	524.20	556.77	562.52	110.06	110.50	453.96	454.59	1.96	2.02	0.78	0.80
75% RDN through inorganic fertilizer + 25% N through Poultry manure	53.79	55.13	78.79	79.66	505.99	521.44	553.85	559.57	100.94	101.36	416.13	416.77	1.90	1.96	0.76	0.77
SEm±	0.034	0.330	0.063	0.057	0.497	0.550	0.323	0.401	3.056	3.035	12.648	12.617	0.085	0.088	0.034	0.033
CD (P=0.05)	0.10	0.96	0.18	0.17	1.45	1.61	0.94	1.17	8.92	8.86	36.92	36.83	0.25	0.26	0.10	0.10

Economics. Among variable dates of sowing, Treatment S_2 (25 November) recorded maximum gross returns, net returns and benefit cost ratio during both the years. This is mainly due to higher grain and straw yields with lesser weather stress among crop plants due to optimum dates of sowing under this treatment which led to maximum net return and benefit cost ratio. This is in agreement with the finding of Chauhan *et al*. (2020).

Assessment of data on economics of various integrated nutrient management methods revealed that the higher net returns and B-C ratio was obtained with N_3 (50% RDN through inorganic fertilizer + 50% N through FYM). The increase in net returns and benefit-cost ratio were, because of maximum grain and straw yield, maximum grain and straw yield were due to slower but longer availability of nutrients from the soil. Similar results were also found by Fazily and Hunshal (2019).

Table 2: Influence of different dates of sowing and varying integrated nutrient management practices on yields, harvest index, Net return and B: C Ratio in wheat.

Treatment	Grain yield (kg/ha)		Straw yield (kg/ha)		Harvest Index (%)		Net return (`/ha)		Benefit: Cost ratio	
	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022
Date of sowing										
10 November	3462.27	3565.98	5442.00	5623.22	38.82	38.74	65943.5	79815.8	1.46	1.68
25 November	3560.47	3667.00	5446.13	5627.89	39.50	39.42	67916.0	81897.9	1.50	1.72
10 December	3164.93	3259.30	4892.80	5055.20	39.26	39.18	55677.5	67955.9	1.22	1.42
SEm±	5.995	9.920	11.889	18.056	0.046	0.046	195.4	371.3	0.004	0.008
CD (P=0.05)	23.54	38.95	46.68	70.90	0.18	0.18	767.3	1457.8	0.02	0.03
Integrated nutrient management										
100% RDF through inorganic fertilizer	2952.89	3040.83	4708.89	4865.51	38.55	38.47	55498.4	67410.8	1.37	1.59
75% RDN through inorganic fertilizer + 25% N through FYM	3006.78	3096.39	4726.67	4883.94	38.90	38.82	55418.3	67363.9	1.33	1.54
50% RDN through inorganic fertilizer + 50% N through FYM	3830.22	3944.59	5773.44	5965.88	39.88	39.79	79814.0	95020.8	1.90	2.15
75% RDN through inorganic fertilizer + 25% N through Vermi-compost	3651.33	3760.53	5602.56	5789.02	39.46	39.38	63534.2	77594.7	1.19	1.38
75% RDN through inorganic fertilizer + 25% N through Poultry manure	3538.22	3644.78	5490.00	5672.83	39.19	39.11	61630.1	75392.3	1.18	1.38
SEm±	13.254	15.325	12.320	14.701	0.094	0.094	309.9	402.5	0.007	0.008
CD (P=0.05)	38.69	44.73	35.96	42.91	0.27	0.27	904.5	1174.9	0.02	0.02

Price 2021-22: Wheat grain=1975 rs/q (Department of Agriculture and cooperation, Directorate of Economics and statistics)
Wheat straw=800 rs/q (Local market)
Price 2022-23: Wheat grain=2015 rs/q (Department of Agriculture and cooperation, Directorate of Economics and statistics)
Wheat straw=1000 rs/q (Local market)

Table 3: Interaction effect of integrated nutrient management and date of sowing on grain yield in Wheat.

Integrated Nutrient Management	Date of sowing					
	2021			2022		
	S_1	S_2	S_3	S_1	S_2	S_3
100% RDF through inorganic fertilizer	3059.33	3150.67	2648.67	3150.57	3243.84	2728.07
75% RDN through inorganic fertilizer + 25% N through FYM	3041.00	3220.33	2759.00	3132.24	3315.64	2841.30
50% RDN through inorganic fertilizer + 50% N through FYM	4007.67	4082.33	3400.67	4127.68	4204.48	3501.61
75% RDN through inorganic fertilizer + 25% N through Vermi-compost	3665.00	3708.33	3580.67	3774.83	3819.70	3687.05
75% RDN through inorganic fertilizer + 25% N through Poultry manure	3538.33	3640.67	3435.67	3644.58	3751.31	3538.46
	SEm±	**CD at 5%**		**SEm±**	**CD at 5%**	
T at same levels of S	22.957	67.01		26.544	77.48	
S at same or different levels of T	21.391	64.01		25.731	78.82	

CONCLUSIONS

Based on a two year study, it was concluded that the combined use of 50% RDN through inorganic fertilizer + 50% N through FYM with timely sowing (25 Nov) performed significantly better in terms of growth parameters, yield parameters and also performed economically well as compared to other treatments. The treatment is recommended gives maximum profit to the farmers.

FUTURE SCOPE

Integrated nutrient management is currently considered as an approach that helps smallholder farmers to alleviate many issues such as poverty and food insecurity through enhancing the amount and quality of food and improving soil fertility.

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Conflict of Interest. None.

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