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Performance of wheat (*Triticum aestivum* L.) under different sowing date and nutrient management in calcareous soil of Bihar

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Abstract
An experiment was conducted during Rabi seasons of 2022 at the crop research centre of RPCAU, Pusa (Samastipur), Bihar with 3 sowing dates and 4 nutrient management treatments. The experiment laid out in Split Plot Design with 3 replications revealed that sowing on 22nd November with N4 treatments of nutrient management i.e., 125% NPK (150:75:50 Kg/ha) + 1 Tonne Poultry Manure, application gave significantly higher grain yield (4.44 t/ ha) and net return (Rs. 62301/ha). Result also prove that the optimum date sowing (22 November) revealed maximum yield attributes, plant height (90.40cm), spike length (8.84cm), grains/ear (49.90) and test weight (38.27g) which were significantly higher than all other sowing dates. But in terms of B:C ratio which which was highest with N2 treatment of nutrient management i.e., 125% NPK (150:75:50 Kg/ha).

Keywords: Crop production, nutrient management, sowing dates, wheat

Introduction
Wheat (*Triticum aestivum* L.) is not only a major source of food, but it is also an important crop for national food security because of its significant contribution to food grain buffer stock. It plays a crucial role in national food grain adequacy, which has stabilised the country food grain production at increasing levels. After rice, it is India second most important food grain crop. Wheat occupies 31.6 million hectares area in India, its production is 109.59million tonnes and average yield of 3.42 tonnes/ha While in Bihar, total cultivated area is about 2.15 million hectares and 5.58 million tonnes of total production with an average yield of 2.6 tonnes/ha (DAC 2021) [1].

A timely wheat planting offers the right conditions for crop growth, leading to better biomass accumulation and ultimately higher grain production. In late-sown conditions, wheat crops were exposed to temperatures that were lower at germination, delaying crop emergence, and temperatures that were too high during the reproductive phase causing plants to mature too quickly and reducing yield and yield attributes (Gupta *et al*. 2017) [2]. According to Nahar *et al.* (2010) [6], too early planting led to frail plants with a weak root system, which eventually had a negative impact on the crops growth, yield characteristics, and yield.

In comparison to a crop planted on 6th December, Verma (2015) [9] found that the crop planted on 11th November had longer spikes, more grains per spike, and heavier test weights. Singh *et al.* (2018) [14] reached the following conclusion under timely seeded conditions, wheat crop achieved longer favourable growing environment that led to larger accumulation of carbon photosynthates and ultimately improved the yield characteristics. When compared to late- sown crops, early and timely-sown crops have been known to achieve low temperatures before blooming, which results in less cell division and a lesser concentration of structural protein, according to Torbica *et al.* (2008) [8]. However, high temperatures during the grain filling stage led to a larger collection of starch and a reduced accumulation of protein, which is negatively associated to carbohydrate storage. According to Kaur *et al.* (2010) [9], wheat grain protein content increased when it was sown later than it should have, but the weight per hectoliter increased when it was sown on 15th November.

For sustainable production and sustaining soil health, the integrated use of organic manures and inorganic fertilisers has gained enormous importance. Over the past three decades, intensive agriculture in India has resulted in a significant loss of soil nutrients due to the use of labor intensive, high-yielding wheat varieties. The condition of the soil has also been harmed by farmers unbalanced use of chemical fertilisers. With the advent of high yielding varieties after the mid-sixties, their production has increased dramatically. Adopting the idea of integrated nutrient management is necessary to stop this downward trend in production. For India's food and nutritional security, improving and preserving soil quality is crucial to growing and sustaining agricultural production. Although India currently produces 200 Mt of food grains annually, it will need an extra 7-9 Mt of food grains annually if the trend of expanding population continues. Use of organic resources and fertilisers can be increased and made more effective to address this difficulty. For food and nutritional security in Indian agriculture, it is crucial to implement integrated plant nutrient supply and management systems to improve soil quality, input usage effectiveness, and crop yield (Swarup, 2010) [7].

Recent years have seen an emphasis placed on supplementing chemical fertilisers with less expensive nutrient sources like organics and biosources due to the decline in soil health caused by the global energy crisis and the rise in fertiliser prices (Kumar and Dhar, 2010) [4]. A higher level of output can be achieved by using chemical fertilisers more frequently, but this may cause pollution issues and a deterioration in the soil's properties, which can only be sustained at a sustainable level by the application of organic manures. Farmyard manure is one of the more common and traditional organic manures that farmers have utilised since the dawn of time. Maintaining soil fertility and production involves adding organic material to the soil, such as farmyard manure. The soil microflora derives its energy from organic matter, and the amount of organic carbon in the soil is regarded as a measure of its health.

Integrated nutrient management (INM) is a flexible strategy to maximise nutrient efficiency and farmer profit while minimising the usage of artificial sources of nutrients. The main element of INM is fertilisers, organic manures, and bio fertilisers. No one plant nutrient source can satisfy all of the nutrient requirements of the crops in modern agriculture; instead, it must be applied consistently in accordance with a management system that is commercially feasible, socially acceptable, and environmentally sound. As organic and inorganic fertilisers were used together, root-shoot dry matter increased dramatically, and the pace of growth was enhanced as compared to inorganic fertiliser application. (Ghosh *et al*., 2003) [3].

Materials and Methods

The field experiment was conducted during rabi season of 2022 at Crop Research Centre, DRPCAU, Pusa, Bihar. It is situated 52.3 m above mean sea level on the southern bank of the Burhi Gandak river, with a latitude and longitude of 25.590 N and 84.400 E, respectively. The research field was connected to the main irrigation channel, which was connected to the farm tube well for reliable and timely watering and had a constant topography and textural make- up. Drainage system setups were accessible during the research time to get rid of extra water. During the crop growing season, there was 19.8 mm of rainfall, maximum temperatures varied from 25 to 39 °C with a mean of 24.77 °C and lowest temperatures ranged from 7.6 to 22.7 °C with a mean of 13.8 °C. The maximum relative humidity (RH) reading was 99% from 1st January to 11th January and the lowest reading (RH) of 39% occurred from 14th April to 27th April with a mean wind speed of 3.64 km/h. The experiment was executed in split-plot and replicated thrice consisted of three sowing dates i.e., D1-22 November, D2-02 December and D3-12 December were treatments of the main plot and four Nutrient management i.e., N1-100% NPK (RDF:: 120:60:40 Kg/ha), N2-125% NPK (150:75:50 Kg/ha), N3-100% NPK (120:60:40 Kg/ha) + 1 Tonne Poultry Manure, and N4- 125% NPK (150:75:50 Kg/ha) + 1 Tonne Poultry Manure are treatments of the subplot. The cultivar used as a test was HD 2967. The experimental plot soil had a sandy loam texture, with an alkaline reaction (pH 8.6), and only modest amounts of accessible N (155 kg/ha), P2O5 (20.23 kg/ha), and K2O (120 kg/ha). The grain and straw yield was recorded from 10 m2 area and converted into hectare. Data was analysed using the OPSTAT software.

Results and Discussion

Wheat plants cultivated with sowing date (D1) showed maximum plant height (90.40 cm) at harvest, which was substantially better than sowing date at D2 i.e., 02 December (82.28 cm) and D3 i.e., 12 December (68.65 cm). At harvest, the plant height (90.83 cm) was highest at N4 (125% NPK + 1 Tonne Poultry Manure), which was statistically comparable to N2 (125% NPK) but significantly superior to N1 (100% NPK) and N3 (100% NPK + 1 Tonne Poultry Manure. The trends in plant height were comparable at 60, 90, and 120 DAS and at harvest.

Plants sown at D1, i.e., 22 November, generate maximum tillers meter-1 row length (83.91) at 60 DAS, which was statistically comparable to D2 (76.37), i.e., 02 December, but much better than D3, i.e., 12 December (63.72). Similar patterns in the number of tillers meter-1 row length were seen at 90 DAS and at harvest. Plants grown with nutrient management at 125% NPK (150:75:50 Kg/ha) + 1 Tonne poultry manure i.e. N4 produce maximum number of tillers meter-1 row length at 60 DAS (84.31) when compared to other treatments which was significantly better than N1 i.e. 100% NPK (65.46) and N3 i.e. 100% NPK + 1 Tonne poultry manure (71.13) but was statistically at par with N2 i.e. 125% NPK (77.78) When comparing the number of tillers meter-1 row length at 90 and at harvest, similar trends could be noticed.

Maximum dry matter accumulation (909.56 g m-2) was observed during harvest at D1, i.e., 22 November. This value was statistically comparable to D2 (823.36 g m-2), i.e., 02 December but much higher than D3 (678.68 g m-2) i.e., 12 December. From 60 to 120 DAS, the resultant quantity of dry matter followed a similar pattern. At harvest, plants grown with nutrient management at 125% NPK (150:75:50 Kg/ha) + 1 Tonne poultry manure, i.e., N4 produced maximum dry matter than other treatments (914.08 m-2), which was superior to N1 (698.53 g m-2) and N3 (763.37 g m-2), but N4 was statistically at par with N2 (839.49 g m-2), i.e., 125% NPK. Similar trends were seen for several growth phases from 60 to 120 DAS.

The highest crop growth rate (10.08 g m-2 day-1) was reported at 90-120 DAS at D1 (22 November), which was statistically on par with D2 (9.17 g m-2 day-1) i.e., 02 December but significantly better than sowing at D3 (7.65 g m-2 day-1) on 12 December. Similar trends in crop growth rate were seen at harvest times of 30-60, 60-90, 90-120, and 120- harvest. While in sub plot, treatment of N4 (125% NPK + 1 tonne poultry manure), crop growth rate was maximum that is 10.13 g m-2 day-1 between 90 and 120 DAS, which was significantly higher than N1 (7.86 g m-2 day-1) i.e., 100% NPK and N3 (8.54 g m-2 day-1) i.e., 100% NPK +1 Tonne poultry manure. But in terms of statistical perspective, it was similar to N2 (9.34 g m-2 day-1), i.e., 125% NPK. Similar trends in crop growth rate were seen at harvest times of 30-60, 60-90, 90-120 DAS and 120- harvest.

Plants sown at D1, i.e., 22 November, produce the highest number of tillers m-2 (331.66 m- 2), largest ear length (8.84 cm), highest number of grains ear-1 (49.90 grains ear-1), and highest test weight across the different sowing dates (37.43 g), much more than those sown at D3, i.e., 12 December. However, plants sown at D2, i.e., 02 December, are statistically equivalent to those sown at D1. When compared to other treatments, plants grown with nutrient management with 125% NPK + 1 Tonne poultry manure i.e., N4 produced the highest number of tillers m-2 (333.22 m-2), largest spike length (8.88 cm), maximum number of grain ear-1 (50.14 grains ear-1), highest test weight (38.27g) and performed significantly better than N1 i.e., 100% NPK and N3 i.e., 100% NPK + 1 Tonne poultry manure, but was statistically on par with N2 i.e., 125% NPK.

The plant sown at D1 i.e., 22 November, gave the highest grain and straw yield that is 4.44 t ha-1 and 5.42 t ha-1, respectively, which was statistically equal to D2, i.e., 02 December that is 4.04 t ha-1 and 4.93 t ha-1, respectively, but significantly higher than D3, i.e., 12 December that is 3.37 t ha-1 and 4.11 t ha-1 respectively While in case of nutrient management, grain and straw yield that is 4.46 t ha-1 and 5.42 t ha-1 respectively was maximum at N4 i.e., 125% NPK (150:75:50 Kg/ha) + 1 Tonne Poultry manure which was significantly superior to N1 i.e., 100% NPK (RDF::120:60:40 Kg/ha) and N3 i.e., 100% NPK (120:60:40 Kg/ha) + 1 Tonne poultry manure but was statistically at par with N2 (125% NPK) i.e. 4.12 t ha-1 and 5.02 t ha-1 respectively.

Table 1: Effect of date of sowing and nutrient management on growth parameters of wheat

Treatments	Plant height (cm) at harvest	Tiller/meter row length at 60 DAS	Dry matter accumulation (g/m2) at harvest
Sowing Dates(D)			
D1 – 22 Nov	90.40	83.91	909.56
D2 - 02 Dec	82.28	76.37	823.36
D3 – 12 Dec	68.65	63.72	678.68
S.Em(±)	2.76	2.56	29.32
CD (*p*= 0.05)	9.56	8.87	101.45
Nutrient Management(N)			
N1 - 100% NPK (RDF::120:60:40 Kg/ha)	70.52	65.46	698.53
N2 - 125% NPK (150:75:50 Kg/ha)	83.80	77.78	839.49
N3- 100% NPK + 1 Tonne Poultry Manure	76.63	71.13	763.37
N4- 125% NPK + 1 Tonne Poultry Manure	90.83	84.31	914.08
S.Em(±)	2.60	2.42	27.64
CD (*p*= 0.05)	7.81	7.25	82.88

Table 2: Effect of date of sowing and nutrient management on yield parameters of wheat

Treatments	Effective tiller/m2	Spike length (cm)	Grains/ear	Test weight (g)	Grain yield (t/ha)	Straw yield (t/ha)	Harvest index (%)	Net return (Rs/ha)	B:C ratio
Sowing Dates(D)									
D1 – 22 Nov	331.66	8.84	49.90	37.43	4.44	5.54	44.48	62301	1.28
D2 - 02 Dec	301.87	8.04	45.42	34.06	4.04	5.06	44.39	52318	1.07
D3 – 12 Dec	251.86	6.71	37.90	30.42	3.37	4.42	43.26	35563	0.72
S.Em(±)	10.13	0.27	1.52	1.14	0.14	0.17	0.42	3395	0.07
CD (*p*= 0.05)	35.07	0.93	5.28	3.96	0.47	0.57	NS	11749	0.25
Nutrient Management(N)									
N1 - 100% NPK	258.72	6.89	38.93	29.86	3.46	4.51	43.41	41245	0.91
N2 - 125% NPK	307.44	8.19	46.26	35.36	4.12	5.11	44.63	55812	1.18
N3- 100% NPK + 1 Tonne Poultry Manure	281.13	7.49	42.30	32.39	3.76	4.72	44.33	43754	0.87
N4- 125% NPK + 1 Tonne Poultry Manure	333.22	8.88	50.14	38.27	4.46	5.51	44.73	59430	1.14
S.Em (±)	9.55	0.25	1.44	1.08	0.13	0.16	0.36	3201	0.07
CD (*p*= 0.05)	28.65	0.76	4.31	3.23	0.38	0.47	NS	9598	0.20

Maximum gross return, net return and B:C ratio was obtained at D1 i.e., 22 December that is 111127 ₹/ha, 62306₹/ha and 1.28 respectively, which was statistically equal to D2 i.e., 02 December that is 101144 ₹/ha, 52323₹/ha and 1.07 respectively but was significantly better than D3 i.e., 12 December that is 84389 ₹/ha, 35568₹/ha, and 0.72 While in terms of nutrient management Gross return and net return that is 111650 ₹/ha and 62306₹/ha respectively was highest at N4 i.e., 125% NPK (150:75:50 Kg/ha) + 1 Tonne Poultry Manure, which was statistically equal to N2 (125% NPK) i.e.,103012 ₹/ha and 55812 ₹/ha, respectively but was substantially better than N1 i.e., 100% NPK (RDF::120:60:40 Kg/ha) and N3 i.e., 100% NPK + 1 Tonne poultry manure. Maximum B: C ratio (1.18) was found at N2 i.e., 125% NPK (150:75:50 Kg/ha) which was statistically equivalent to N4 (125% NPK + 1 Tonne Poultry Manure) i.e., 1.14 but significantly better than N1 i.e., 100% NPK (RDF: 120:60:40 Kg/ha) and N3 i.e., 100% NPK (120:60:40 Kg/ha) + 1 Tonne Poultry Manure.

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