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Effect of sowing dates and varieties on the nutrient uptake and economics of Wheat crop (*Triticum aestivum* L.) under changing climate

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Abstract
A field experiment was conducted to assess the effect of sowing dates and varieties on the nutrient uptake and economics of Wheat crop (*Triticum aestivum* L.) under the changing climate in *Rabi* season (November-April) 2017-18. The experiment was conducted at Crop Research Station Masodha, Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhaya (U.P) during Rabi season. The experiment was carried out for four dates of sowing (05th November, 25th November, 15th December, 05th January) in the main plot against six varieties (HD-3086, HS-562, HI-1544, WR-544, MACS-6222, and HD-2967) in the subplot with three replication. Available nitrogen (195.3) and phosphorus (17.25) is low and potassium (285.0) is found medium in the soil. The soil was found silty loam having neutral pH and organic carbon with a value of 0.35, EC (0.25). The soil was moderate for the cultivation of the wheat crop. The present study was taken to generate information about the effect of different sowing dates and varieties on the growth of the Wheat crop. The optimum dates of sowing are evaluated in this experiment because of the increase in seasonal temperature. Among the varieties, HD-3086 on 25th November provides the best results. Protein content in grain, and nitrogen, phosphorus and potassium content of grain and straw as well as their uptake by grain and straw was significantly higher with sowing of HD-3086 on 25th November. Maximum net return was found with sowing of HD-3086 on 25th November.

Keywords: Economics, sowing dates, wheat varieties, nutrient, protein

Introduction
Wheat (*Triticum aestivum* L.) belongs to the family Poaceae and is a very important crop as it contributes a major portion of staple food for the world's population and provides more calories and protein in the world's diet than any other cereals. It is a C3 plant primarily grown in temperate regions and also at higher altitudes under tropical climatic areas in the winter season. Wheat is the major Rabi crop in India and is sensitive to various biotic and abiotic stresses like weather and inter-seasonal climatic variability (in terms of changes in temperature, rainfall, sunshine hours, etc.), soil condition, and agricultural inputs like irrigation, fertilizer, and pesticides. Most recent and extensive research on climate change effects predicts marked increases in both rainfall and temperature, with temperature projected to rise by as much as 3-4^0 C by the end of the century in South Asia. Ben *et al.* (2021) [1] reported that elevated [CO_2] stimulates grain production (through larger grain numbers) and starch accumulation but negatively affects nutritional traits such as protein and mineral content. Predicted effects on wheat production include minimum grain yield over most of India, with the greatest impacts in the lower potential areas. The introduction of high-yielding crop varieties, fertilizers, assured irrigation, and improved agronomic practices are the main reason for the meteoric success of food production in India over the years; it is mainly due to increased production and productivity of the wheat crop. Efforts ought to be made to minimize the effect of temperature variation caused due to changed sowing dates by choosing appropriate wheat varieties which can synchronize its temperature requirement.
The sowing date is one of the most important factors affecting grain production and quality (Ferrise *et al*., 2010) [5]. The optimum sowing date depends on rainfall and temperature (Jackson *et al*., 2000) [8] to maintain high grain yields. It has been realized that the average yield of wheat in this region, sown during November, is well comparable to the state average, but the declining trend in wheat yield has been noticed with delayed sowing i.e. in December and January. It is mostly due to the shorter growth period available to late sown wheat coupled with high temperature and hot winds during the reproductive growth period, which leads to forced maturity and ultimately poor grain yield. In addition to this, improper selection of

varieties in this region also affects the crop yield. At present, there is tremendous scope for increasing the yield of wheat with the use of multi-character high yielding varieties. The huge reduction in yield due to delayed sowing prompted us to evaluate the optimum time of sowing for different varieties for maximum production.

Global warming has significantly impacted agricultural production and has been the focus of many researchers (Sun *et al*., 2015; Ding *et al*., 2015) [19, 4]. Ideally, the best temperature regime during the wheat crop season is 20-22 °C at sowing, 16-22 °C at tillering to the grain filling, and the slow rise of temperature to 40° C at harvesting (Sharma, 2000) [16]. However, the seed can germinate in the temperature range of 3.5C-35 °C. A sudden increase in temperature for a period of 4-5 days at any stage of the wheat crop can adversely affect the crop yield and even a one-day abnormal increase in temperature at grain formation and filling stage can result in large grain losses. The effect of date of sowing on Wheat was recorded on the uptake of the nutrients in the grain and straw along with the protein content in the plant

Improper selection of varieties also affects crop yield because performance of varieties vary correspondingly with their genetic potential and adaptable environment, so there is scope for increasing yield of wheat with cultivation of climate resilient varieties (Hussain *et al*., 2012) [7]. W heat yield can be increased 10 to 80% through proper selection of sowing time and suitable cultivars (Coventry *et al*., 2011) [3]. Mukherjee (2012) [11] reported higher gross return, net return and B: C with early sowing as compared to late sown crops. Taub *et al*. (2008) [20] reported that in the grain crops wheat, the reduction in protein mediated by elevated [CO_2] was reported to be 10%. Shortening of the critical phenological period, as a key factor in determining the photoperiod and productivity of crops, may further explain the poor performance under delayed sowing (Ferrise *et al*., 2010; Sattar *et al*., 2010) [5, 15].

Environmental factors significantly affected the grain yield of wheat that was sown late. Global wheat production is estimated to fall by 6% for each °C of further temperature increase and become more variable over space and time. The huge reduction in yield due to delayed sowing prompted us to evaluate the optimum time of sowing for different varieties for maximum production. Sowing date plays vital role in yield potential of wheat production. The environment being the foster parent of every plant plays an indispensable function in its development, as do hereditary factors which have transmitted to it from biological parents. The growth and development of a plant are thus result of coordinated interplay of the hereditary and environmental conditions. Ouda *et al*., (2005) [12] reported that delay in sowing resulted in reduction of grain yield because of exposure of crop to high temperature which reduces length of growing duration sowing time in relation to GDD accumulation.

Changes in seasonal temperature affect the grain yield, mainly through the phenological development process. The delayed sowing caused poor vegetative growth probably due to low temperature during the early vegetative stage and due of high-temperature exposure during reproductive stages; thereby reducing growing season length and causing a reduction in wheat yields. The objective of the present study is to find out the impact of climate-changing on the growth of wheat varieties. The negative effects of delayed sowing were caused by environmental limitations including adverse weather factors such as low temperature during vegetative growth, shortened duration of various phases of crop development, and increased temperature during the grain-filling period. Wang *et al*. (2013) and He *et al*. (2015) [21, 6] recorded that climate variables such as temperature and precipitation can significantly impact wheat harvest. The rise in temperature could also accelerate the growth of crops, while a longer growing cultivars or late sowing date could lead to delayed growth. Warming alone caused similar rates of yield declines in sites and crop varieties under baseline precipitation (5−7 percent at 1 °C) (Pirttioja *et al*. 2015) [14].

Methods and Materials

The experiment was conducted at Crop Research Station Masodha, Narendra Deva University of Agriculture and Technology Kumarganj Ayodhaya 224229 (U.P.) which is geographically situated between 26.47ºN latitude to 82.12ºE longitude and at an altitude of 113 m above mean sea level. The experiment comprised of 24 treatment combinations was planned in a split-plot design replicated thrice. Dates of sowing were kept in the main plot and varieties in the sub-plot. The experiment was laid out in split-plot design with six varieties (HS-562, HD-2967, HD-3086, HI-1544, MACS-6222, and WR-544) and four date of sowing (05th November, 25th November, 15th December, and 05th January) with three replications. The experimental field was divided into 72 plots. Each gross plot size was 2.40 m×6.0 m =14.40 m^{-2} and the net plot size 2.0 m×5.0 m =10.00 m^{-2} and row to row distance was maintained 20 cm. Nitrogen, phosphorous and potassium at the rate of 150 kg N, 60 kg P2O5 and 40 kg K2O ha-1 were applied to crop. Nitrogen, phosphorous and potassium were applied through Urea (46% N), Di-ammonium Phosphate (46% P2O5 and 18% N) and Muriate of Potash (60% K2O), respectively. 1/3rd dose of nitrogen and full dose of phosphorous and potassium were applied as basal and remaining 2/3rd of nitrogen was applied in two equal splits, i.e. 1/3rd nitrogen after first irrigation and 1/3rd after second irrigation. The various observations were recorded from randomly selected plants in each plot. The experiment was conducted under irrigated conditions and five irrigation (Including one pre-sowing irrigation) was applied. The crop was first irrigated at the Crown root initiation (CRI) stage (21-25 DAS) in all the treatments and remaining irrigations were given whenever it was required by the crop.

Result and Discussion

Crop yield is the final output of the interaction between the genetic composition of the crop plant population and the external environment including soil, which varied in nature. These external factors influence the agronomic practices and thereby constitute a major problem in crop production. Although with the advent of short duration semi-dwarf and dwarf varieties of wheat yield has been increased tremendously, hence a new horizon in their economic requirement has been opened up. Wheat has been occupying the major share of cultivated land and production has been increased many folds but the productivity of this crop in eastern U.P. is measurably low mainly because of delayed sowing and improper varietal selection. The present investigation entitled “Effect of sowing dates and varieties on the nutrient uptake and economics of Wheat crop (*Triticum aestivum* L.) Under changing climate” was carried out during Rabi season 2017-2018. Each crop requires an optimum temperature, rainfall, humidity, and other related weather conditions, which are necessary for higher yield. However, such ideal conditions seldom prevail and the plant grows satisfactory within a definite range around their optimum point. If the fluctuations are too wide plants may fail to adjust their rhythm of growth and development and finally, the poor yield is achieved. The season during the experiment was normal, the incidence of pests and diseases was not noticed which provided an opportunity for proper growth and development. Nutritional quality is also negatively influenced by the changing climate, which will impact human health. Similar to drought, heat stress decreases starch content but increases grain protein and mineral concentrations (Ben *et al.*, 2021) [1].

Nitrogen, phosphorous and potassium content

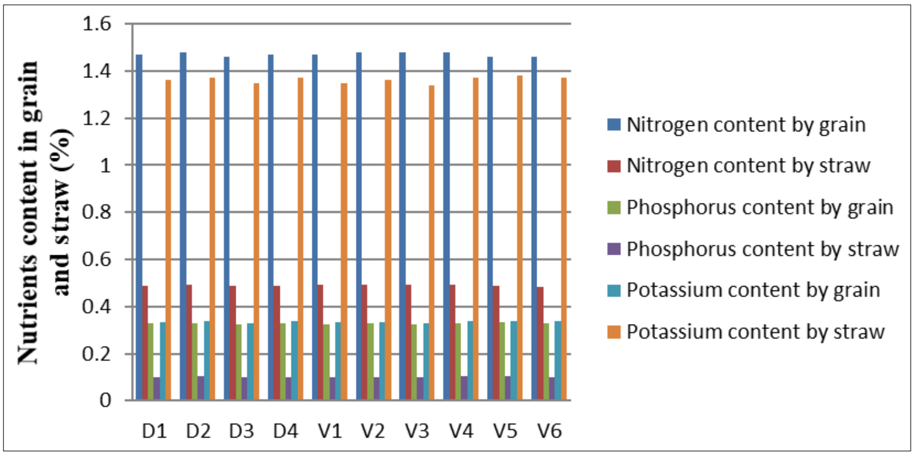

Fig 1: Effect of dates of sowing and wheat varieties on the content of nitrogen, phosphorus and potassium.

Nitrogen content (%)

The data on nitrogen content in grain and straw as affected by different treatments has been depicted in Fig. 1. It was clearly indicated that the date of sowing did not significantly influenced the nitrogen content in grain and straw. However, maximum nitrogen content in grain (1.48) and straw (0.494) recorded with 25th November sowing. Varieties also showed non-significant difference for nitrogen content in both grain and straw. However, maximum nitrogen content in grain (1.48) and straw (0.494) recorded HI-1544 variety.

Phosphorous content (%)

The data of phosphorous content in grain and straw as affected by different treatments have been depicted in Fig. 1. It was clearly indicated that the date of sowing did not significantly influenced the phosphorus content in grain and straw. However, maximum phosphorus content in grain (0.329) and straw (0.102) recorded with 25th November sowing. Varieties also showed non-significant difference for phosphorus content in both grain and straw. However, maximum phosphorus content in grain (0.329) and straw (0.102) recorded in HI-1544 variety.

Potassium content (%)

The data related to potassium content in grain and straw as affected by different treatments have been depicted in Fig.1. It was clearly indicated that the date of sowing did not significantly influenced the Potassium content in grain and straw. However, maximum Potassium content in grain (0.336) and straw (1.37) recorded with 25th November sowing. Varieties also showed non-significant difference for Potassium content in both grain and straw. However, maximum Potassium content in grain (0.336) and straw (1.37) recorded in HI-1544 variety.

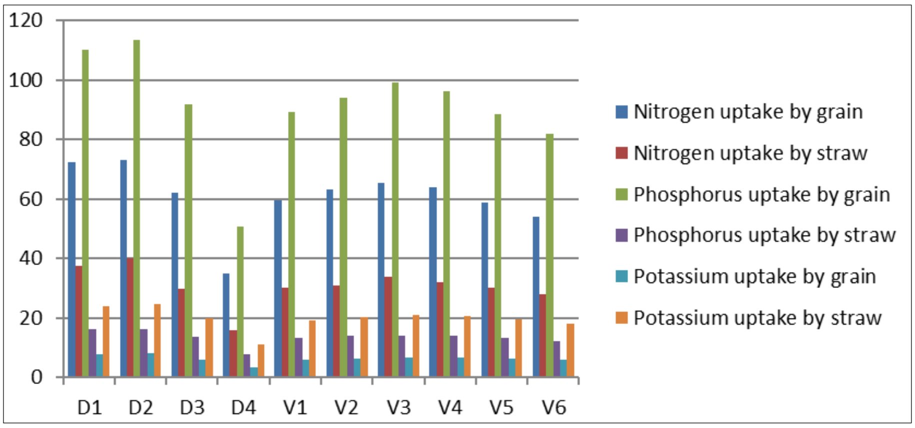

Fig 2: Effect of sowing dates and various varieties on uptake of nitrogen, phosphorus and potassium.

Nitrogen uptake (kg ha^{-1})

The data pertaining to nitrogen uptake in grain and straw as affected by different treatments have been depicted in Fig. 2. Different sowing dates influenced the nitrogen uptake by grain and straw and on the total nitrogen uptake. Among the different dates of sowing 25th November recorded highest uptake of nitrogen which was at par with 05th November and significantly higher than rest of the sowing dates. Total uptake of nitrogen recorded maximum with 25th November sowing which was remained at par with 05th January sowing and significantly superior than rest of the sowing dates. Varieties had also significant effect on nitrogen uptake in grain, straw and total uptake. Maximum uptake by grain (65.34) and total nitrogen uptake (99.13) recorded in HD-3086 which was significantly higher than rest of varieties while at par with HD-2967 and HI-1544. In straw nitrogen uptake HD-3086 (33.79) which was at par with HI-1544 and significantly higher than rest of the varieties. Yin *et al*., (2018) [22] reported that wheat plants with delayed sowing can use N more efficiently by optimizing crop N status. There exists potential for improvement in NUE by combining delayed sowing and reduced N fertilizer rates that meet but do not exceed crop N requirements.

Phosphorus uptake (kg ha^{-1})

The data regarding to phosphorus uptake in grain and straw as affected by different treatments have been presented in Fig. 2. There was significant effect of different dates of sowing on phosphorus uptake by grain and straw as well as on total phosphorus uptake. Highest uptake of phosphorus by grain was recorded on 25th November (16.28 kg ha^{-1}) which was at par with 05th November sowing and significantly higher than rest of the sowing dates. Total uptake of phosphorus recorded maximum with 25th November sowing which was remained at par with 05th January sowing and significantly superior than rest of the sowing dates. Varieties had also significant effect on uptake of phosphorus in grain, straw and total uptake. Maximum uptake by grain (14.21) and total phosphorus uptake (21.01) recorded in HD-3086 which was significantly higher than rest of varieties while at par with HD-2967 and HI-1544. In straw phosphorus uptake HD-3086 (6.80) which was at par with HI-1544 and significantly higher than rest of the varieties. Singh *et al*. (2021) [17] reported that the uptake of N, P and K in grain and straw was recorded higher with November 28 sown crop followed by November 18. The higher uptake with November sown crop was mainly attributed due to higher grain and straw yield. Variety DBW-187 recorded lower content (%) of N, P and K but the uptake of N, P and K through grain and straw was recoded highest followed by HD-2967.

Potassium uptake (kg ha^{-1})

The data on potassium uptake in grain and straw as affected by different treatments have been depicted in Fig. 2. There was significant effect of different dates of sowing on potassium uptake by grain and straw as well as on total potassium uptake. Highest uptake of phosphorus by grain was recorded on 05th November (16.46 kg ha^{-1}) which was at par with 25th November sowing and significantly higher than rest of the sowing dates, whereas maximum potassium uptake was recorded with 25th November sowing was significantly higher than rest of the sowing dates. Total uptake of potassium recorded maximum with 25th November sowing which was remained at par with 05th January sowing and significantly superior than rest of the sowing dates. Varieties had also significant effect on uptake of potassium in grain, straw and total uptake. Maximum uptake by grain (14.52) and total potassium uptake (106.26) recorded in HD-3086 which was significantly higher than rest of varieties while at par with HD-2967 and HI-1544. In straw potassium uptake HD-3086 (92.04) which was at par with HI-1544 and significantly higher than rest of the varieties.

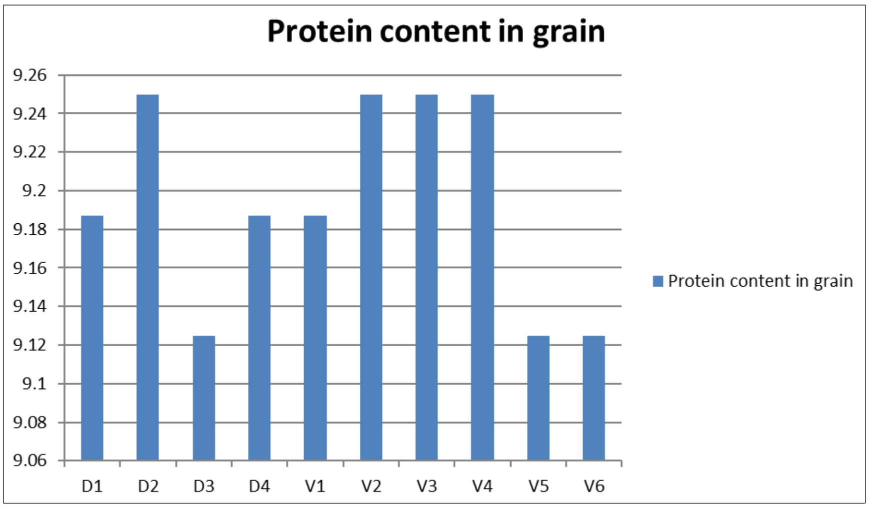

Fig 3: Effect of sowing dates and various varieties on protein content in grain.

Protein Content (%): The data on protein content in grain as affected by different treatments have been summarized in Fig.3. Protein content in grain was remained unaffected by sowing time. However, maximum protein (9.25%) content recorded with 25th November sowing. Varieties did not influence the protein content significantly. However, maximum protein content (9.25) recoded in HD-3086, HI-1544(9.25%) and HD-2967(9.25%). Singh *et al.* (2010) [18] also revealed that delayed sowing associated with high temperature during grain filling resulted in an overall increase in total grain protein. WR 544 in higher protein content (12.6%) as compared to rest of the varieties. While comparing the interaction of varieties with date of sowing, HI 1544 produced significantly higher grain higher yield (6007 kg ha^{-1}) of wheat sown at 5th November which was statistically at par with WH 1105 (5833 kg ha^{-1}) and HD 3086 (5616 kg ha^{-1}) at same date of sowing. Jat *et al.* (2013) [9] also reported higher amount of total protein with late sowing, due to higher temperature during grain filling period which induced higher nitrogen accumulation than photosynthates.

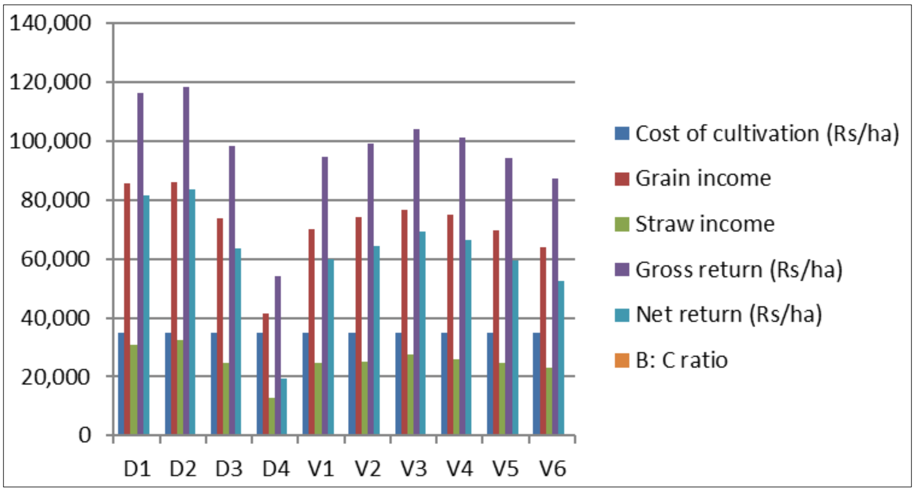

Fig 4: Effect of dates of sowing on economics of wheat varieties

Economics of the treatments

The data on economics of wheat cultivation as affected by different treatments is presented in Fig.4. The cost of cultivation of all the treatments was same, as there was no input variable. It is evident from the data that highest net return (Rs/ha 83,579.00) and benefit cost ratio (2.40) was obtained under the crop sown on 25th November which was closely with the crop sown on 5th November (Rs/ha 81,385.00 and B: C Ratio 2.33). Varieties also exhibited difference in their economics. The highest net return (Rs/ha 69,285.00) and benefit cost ratio (1.99) was obtained in HD-3086, which was close to the variety HI-1544 net return (Rs/ha 66,226.00 and B: C Ratio 1.90), HD-2967 net return (Rs/ha 64,449.00 and B:C Ratio 1.85. Singh *et al.* (2021) [17] found out that the highest net return (Rs.105081 ha^{-1}) and benefit: cost ratio (2.64) was obtained on November 28th and in case of varieties highest net return (Rs.102581 ha^{-1}) and benefit: cost ratio (2.46) was obtained in DBW 187. This was due to the increase in grain yield because of timely sowing and better genetic characters of variety.

Conclusion

From the result it may be concluded that the best treatment combination response on the available nutrients content and nutrient uptake after harvest of the crop and highest economic return was found in Hd-3086 variety along with the sowing date 25th November in comparison to early (November 5th) and too late condition (January 5th).

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