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## Influence of nitrogen and phosphorus levels on phenology, growth and yield of bed planted wheat under varying irrigation levels in semi-arid conditions

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### Abstract

A field study was conducted in a semi-arid climate to assess the effect of nitrogen and phosphorus on timely sown bed planted wheat under varying irrigation levels. The soil of the field was sandy loam, having 0.36% organic carbon and pH 8.2. It was low in available N (132 kg/ha), medium in available P (11.6 kg/ha) and rich in available K (325 kg/ha). The experiment consisted of sixteen treatment combinations of four levels of irrigation (Two, three, four and five irrigations) in main plots and four fertilizer levels (80, 90, 100 and 110% of recommended N and P i.e., 150 kg N and 60 kg P<sub>2</sub>O<sub>5</sub>/ha) in sub-plots, laid out in split-plot design with three replications. Application of five irrigations recorded a significant increase in plant height, dry matter accumulation, leaf area index, grain (5022kg/ha) and straw yield (8578 kg/ha) and net returns over two, three and four irrigations. The increased doses of NP significantly increased the growth parameters, grain and straw yield and net returns up to 110% recommended dose of NP.

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### Introduction

Wheat (*Triticum aestivum* L.) is one of the major cereal crops grown around the world and one of the important staple food of majority of the world population. Globally wheat was grown in around 215.58 million hectares during 2019-20, holding the highest position in acreage among all other crops with yearly production of 762.37million tonnes and productivity of 3540 kg/ ha (USDA 2022).India, being blessed and enriched with

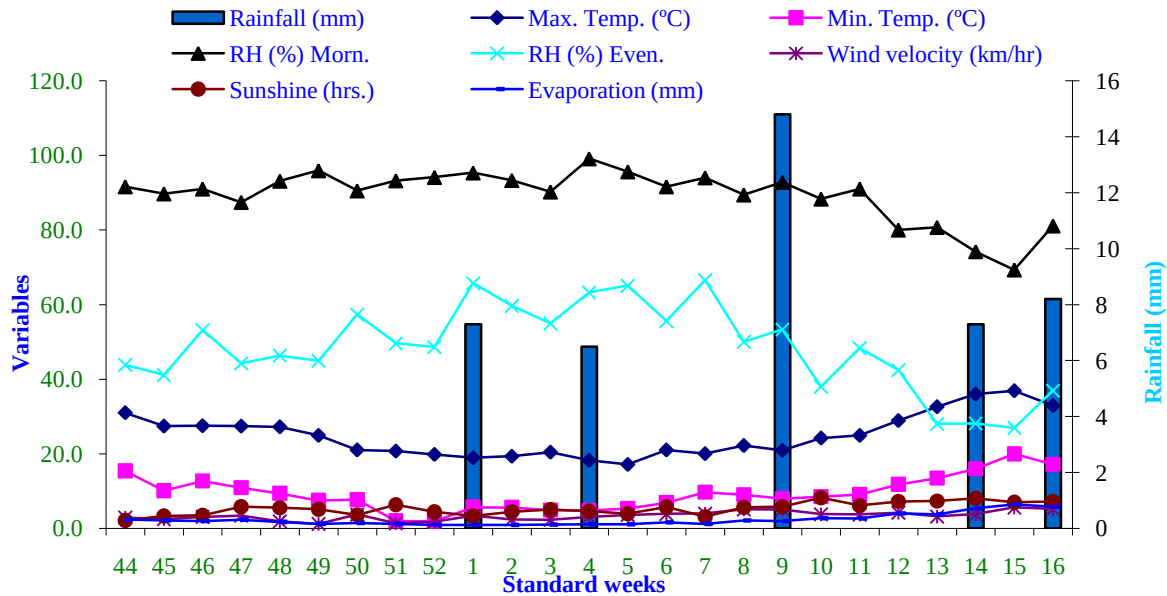
diverse agro-ecological conditions, is the second largest producer of wheat worldwide, ensuring food and nutrition security to a majority of the Indian population through production and balanced supply predominantly in the recent past. The wheat crop being a *Rabi* season crop, normally sown during October-November and harvested in April, in India has been under cultivation in about 29.32million hectares to produce

103.60 million tonnes of wheat with productivity rate of 3530 kg/ha (USDA 2022). Traditional flat wheat planting with surface irrigation is an ancient and common practice in South Asia's Indo-Gangetic Plains. Surface flood irrigation has low application efficiency due to a variety of issues including infiltration, soil properties, field undulation, intake discharge and run-off. The development of crop-specific design can increase the application efficiency of available irrigation water and fertilisers (Kumar & Dhillon 2014). Sowing of crops under FIRBS is a relatively new technology in India, in which the crop is sown in 2 rows or 3 rows on the top of raised beds (about 70 cm wide, with 40 cm top and 30 cm furrow) and water is applied in the furrows. One of the most efficient surface water application technologies is bed planting and furrow irrigation. Wheat planted on beds results in lower runoff and soil erosion, a higher rate of soil organic matter increase, and improved soil structure in top soil (Kumar & Dhillon 2014). Irrigation is a fundamental determinant of agricultural output as its shortcomings are the most powerful limitations on increased productivity. Irrigation was once seen as a protective measure against the vagaries of rainfall and drought in traditional agriculture. However, the use of high-yielding cultivars, chemical fertilisation and multiple cropping increasingly necessitates the use of regulated irrigation to boost output. Fertilizer is the most

important input in achieving a variety's hereditary potential in terms of final grain output. In bed planted the behaviour of nutrient and water distribution in the root zone soil and its use by wheat crop may be different than that of conventional flat sowing and flood irrigation method, so information of nitrogen and phosphorus management along with irrigation scheduling is needed for better growth and yield of wheat under bed planting system.

### Materials and Methods

The field experiment was conducted during *Rabi* 2018-19 at Agronomy Research Farm of CCS Haryana Agricultural University, Hisar, Haryana (India) situated at 29°10' N latitude and 75° 46' E longitude at an elevation of 215.2 m above mean sea level in a semi-arid climate with the average annual rainfall of around 450 mm, of which 70-80 percent is received during monsoon period i.e., July to September and the rest is received in the form of showers of cyclic rains during the winter and spring seasons. The soil of the field was sandy loam, having 0.36% organic carbon and pH 8.2, low in available N (132 kg ha<sup>-1</sup>), medium in available P (11.6 kg ha<sup>-1</sup>) and rich in available K (325 kg ha<sup>-1</sup>). The mean weekly meteorological data during the crop seasons of 2018-19 recorded at meteorological observatory located at Research Farm of CCS Haryana Agricultural University, Hisar are given in (Figure 1).



**Figure 1.** Mean weekly value of weather parameters during crop season of 2018-19

The experimental treatments consisted of combination of four levels of irrigation (Two, three, four and five irrigations in main plots) and four fertilizer levels (80, 90, 100 and 110 per cent of recommended N and P, i.e., 150 kg N and 60 kg  $P_2O_5$ /ha) in sub-plots, laid out in split-plot design with three replications. Nitrogen doses were applied as per treatments in the form of DAP and urea, half dose as basal dose and remaining half as top dressing after first irrigation. Full dose of phosphorus as per treatments was applied in the form of DAP and uniform dose of 60 kg  $K_2O$ /ha was applied as basal dose. Wheat variety HD 2967 was sown on 5<sup>th</sup> November 2019 with the help of bed planter with two rows per bed per bed (70 cm wide having 40 cm top and 30 cm furrow) maintaining 20 cm spacing between the two rows and 10 cm on both sides of the top, using recommended seed rate of 100 kg ha<sup>-1</sup>. Irrigations were applied as per treatments based on critical stages approach and irrigation water was

measured with the help of current meter. Days taken to achieve a particular stage by 50% plant population in the plots was considered as number of days taken to achieve that phenological stage. Plant heights of five tagged plants in each net plot were measured at 30, 60, 90, 120 DAS and at physiological maturity. Dry matter accumulation was measured by harvesting the crop sample from outer area, drying samples in oven at 65°C to achieve constant weight and converting the values in g/m<sup>2</sup>. Green leaf area was measured at 30, 60 and 90 DAS with the help of leaf area meter (L1 3000 Area meter LICOR Ltd. Nebraska, USA). The leaf area index was calculated by the following formula:

$$LAI = \frac{\text{Leaf area (cm}^2\text{)}}{\text{Land area (cm}^2\text{)}}$$

The biomass obtained for individual net plot after threshed, cleaned and grain obtained were converted into kg/ha. The plot wise straw yield was obtained by subtracting grain

yield from biological yield and converted into kg/ha. Attraction index was calculated by dividing the grain yield by straw yield and multiplied by 100 (Donald, 1962)

$$\text{Attraction index (\%)} = \frac{\text{Grain yield}}{\text{Straw yield}} \times 100$$

## Results and Discussion

### Phenology

Irrigation and fertilizer levels had significant effect on phenology of bed planted wheat (Table 1). Among irrigation levels application of five irrigations significantly delayed days to attain flag leaf (67.3), anthesis (111.7), milking (125.1) and physiological maturity (157.0) over the crop irrigated three and two times, whereas, the application of

five irrigation was statistically at par with four irrigations regarding days to attain flag leaf, anthesis, milking and physiological maturity stages. The delay in attainment of different phenological stages by wheat under higher levels of irrigation may be attributed to continuous availability of moisture to the crop owing to frequent irrigations as the water stress forces the plant to complete its life cycle rapidly and hence early flowering takes place while optimum moisture regime is favourable for better plant growth. Under higher levels of irrigation, the longer reproductive phase of crop growth and longer crop duration has been also reported by Kumar et al. (2018).

**Table 1.** Effect of irrigation and fertiliser levels on the period to attain phenological stages in bed planted wheat

| Treatments                | Days to attain phonological stages |           |           |          |         |          |
|---------------------------|------------------------------------|-----------|-----------|----------|---------|----------|
|                           | Emergence                          | Tillering | Flag leaf | Anthesis | Milking | Maturity |
| Irrigation levels         |                                    |           |           |          |         |          |
| Two                       | 8.2                                | 32.0      | 65.5      | 108.9    | 121.8   | 154.0    |
| Three                     | 8.1                                | 32.2      | 66.0      | 109.9    | 123.6   | 155.0    |
| Four                      | 8.3                                | 32.5      | 67.0      | 111.0    | 124.3   | 155.9    |
| Five                      | 8.1                                | 32.6      | 67.3      | 111.7    | 125.1   | 157.0    |
| SE(m) ±                   | 0.2                                | 0.3       | 0.2       | 0.4      | 0.4     | 0.5      |
| C.D.(p=0.05)              | NS                                 | NS        | 0.8       | 1.5      | 1.4     | 1.7      |
| Fertiliser levels ( % NP) |                                    |           |           |          |         |          |
| 80% NP                    | 7.8                                | 31.7      | 65.1      | 109.6    | 122.8   | 154.0    |
| 90% NP                    | 8.1                                | 32.1      | 65.3      | 109.7    | 123.0   | 155.3    |
| 100% NP                   | 8.3                                | 32.6      | 67.4      | 110.9    | 124.2   | 156.0    |
| 110% NP                   | 8.5                                | 33.0      | 68.0      | 111.3    | 124.7   | 156.6    |
| SE(m) ±                   | 0.2                                | 0.4       | 0.5       | 0.3      | 0.4     | 0.4      |
| C.D.(p=0.05)              | NS                                 | NS        | 1.6       | 0.8      | 1.1     | 1.2      |

Higher fertilizer levels also significantly delayed the phenological stages of crop

growth, however, the effect of fertilizer levels was non-significant at days to attain

emergence and tillering (Table 1). Among fertilizer levels, application of 110% NP resulted in maximum days to attain different phenological stages of crop growth, which was statistically at par with application of 100% NP and significantly higher than other levels of fertilizers, whereas, minimum days to attain different phenological stages were recorded with application of 80% NP. The possible reason is that application of higher levels of fertilizer especially with increase in nitrogenous fertilizer increases vegetative growth and increased light use efficiency of crop, as a result delay in crop maturity. The result has conformity with the finding of Kumar et al. (2018) and Wang et al. (2018) who reported that higher level of nitrogen increases cell division and enlargement which develop new tissue in the younger leaves, as a result development of phenological stages slowed down and finally the process of senescence slowed down, therefore, maturity was delayed.

### Growth

Growth parameters such as plant height (Table 2), dry matter accumulation (Table 3) and leaf area index (Table 4) were significantly influenced by different irrigation and fertilizer levels. Among irrigation levels, application of five irrigations produced the tallest plants (18.3, 51.3, 89.8, 105.8 and 113.3 cm), maximum dry matter accumulation (4.1, 56.0, 178.5, 237.5 and 252.6 g/metre row length) at 30, 60, 90, 120 DAS and at

physiological maturity and highest leaf area index (0.62, 3.10 and 4.61) at 30, 60 and 90 DAS, respectively. Water being the solvent and carrier of nutrients is the most important factor for proper and healthy production of crops, hence, deeply impacts photosynthesis, respiration, absorption, translocation and utilization of mineral nutrients, cell division and many other vital processes, which was readily available with frequent application of irrigation. The results are in line with that of Kumar et al. (2017) Kumar et al. (2014) and Sachin et al. (2019). Among fertilizer levels, application of 110% NP recorded maximum plant height (18.4, 52.1, 89.9, 106.0 and 114.0 cm) and dry matter accumulation (4.1, 56.0, 166.5, 228.0 and 248.3 g/metre row length) at 30, 60, 90, 120 DAS and at harvest, respectively being significantly higher than 80% and 90% NP, but statistically at par with 100% NP. Application of 110% NP recorded significantly higher leaf area index (0.64, 3.12 and 4.54) over 80% and 90% NP at 30, 60 and 90 DAS, while at 90 DAS application of 110% NP was significantly superior over all the other fertilizer levels. This might be due to appropriate supply of nutrients ideal for the nutrient uptake and nutrient utilization towards protein synthesis, which helps in increasing vertical and lateral growth of the plant ultimately and increased the area of leaves (Leghari et al. 2016). The result has similarity with the results of Kumar et al. (2016) and Kumar & Dhillon (2014).

**Table 2.** Effect of irrigation and fertiliser levels on plant height of bed planted wheat

| Treatments | Plant height (cm) |        |        |         |             |
|------------|-------------------|--------|--------|---------|-------------|
|            | 30 DAS            | 60 DAS | 90 DAS | 120 DAS | At maturity |

|                           |      |      |      |       |       |
|---------------------------|------|------|------|-------|-------|
| Irrigation levels         |      |      |      |       |       |
| Two                       | 17.5 | 46.9 | 85.4 | 101.9 | 110.0 |
| Three                     | 18.1 | 49.6 | 87.2 | 103.7 | 111.0 |
| Four                      | 18.2 | 50.3 | 88.3 | 105.3 | 112.0 |
| Five                      | 18.3 | 51.3 | 89.8 | 105.8 | 113.3 |
| SE(m) $\pm$               | 0.18 | 0.82 | 0.44 | 0.47  | 0.55  |
| C.D. (p=0.05)             | NS   | 2.90 | 1.55 | 1.65  | 1.92  |
| Fertiliser levels ( % NP) |      |      |      |       |       |
| 80% NP                    | 17.5 | 46.0 | 84.8 | 101.7 | 108.9 |
| 90% NP                    | 17.9 | 48.7 | 86.9 | 103.1 | 110.4 |
| 100% NP                   | 18.1 | 51.3 | 89.0 | 105.7 | 112.9 |
| 110% NP                   | 18.4 | 52.1 | 89.9 | 106.0 | 114.0 |
| SE(m) $\pm$               | 0.21 | 0.38 | 0.39 | 0.44  | 0.47  |
| C.D. (p=0.05)             | 0.62 | 1.12 | 1.15 | 1.30  | 1.39  |

**Table 3.** Effect of irrigation and fertiliser levels on dry matter accumulation of bed planted wheat

| Treatments                | Dry matter accumulation (g/m.r.l.) |        |        |         |             |
|---------------------------|------------------------------------|--------|--------|---------|-------------|
|                           | 30 DAS                             | 60 DAS | 90 DAS | 120 DAS | At maturity |
| Irrigation levels         |                                    |        |        |         |             |
| Two                       | 3.6                                | 44.3   | 129.6  | 190.4   | 218.3       |
| Three                     | 3.6                                | 48.0   | 142.4  | 212.5   | 226.7       |
| Four                      | 3.7                                | 54.3   | 152.4  | 222.7   | 235.9       |
| Five                      | 4.1                                | 56.0   | 178.5  | 237.5   | 252.6       |
| SE(m) $\pm$               | 0.1                                | 1.1    | 4.9    | 2.4     | 2.2         |
| C.D. (p=0.05)             | NS                                 | 4.0    | 17.3   | 8.5     | 7.6         |
| Fertiliser levels ( % NP) |                                    |        |        |         |             |
| 80% NP                    | 3.4                                | 45.8   | 131.5  | 199.2   | 219.2       |
| 90% NP                    | 3.6                                | 48.2   | 142.5  | 212.0   | 222.8       |
| 100% NP                   | 3.9                                | 52.5   | 162.3  | 223.9   | 243.2       |
| 110% NP                   | 4.1                                | 56.0   | 166.5  | 228.0   | 248.3       |
| SE(m) $\pm$               | 0.1                                | 1.8    | 2.8    | 2.5     | 4.0         |
| C.D. (p=0.05)             | 0.3                                | 5.3    | 8.2    | 7.2     | 11.7        |

**Table 4.** Effect of irrigation and fertiliser levels on leaf area index of bed planted wheat

| Treatments                       | Leaf area index |        |        |
|----------------------------------|-----------------|--------|--------|
|                                  | 30 DAS          | 60 DAS | 90 DAS |
| <b>Irrigation levels</b>         |                 |        |        |
| Two                              | 0.57            | 2.47   | 3.61   |
| Three                            | 0.58            | 2.79   | 4.06   |
| Four                             | 0.61            | 2.89   | 4.29   |
| Five                             | 0.62            | 3.10   | 4.61   |
| SE(m) $\pm$                      | 0.02            | 0.07   | 0.08   |
| C.D. (p=0.05)                    | NS              | 0.24   | 0.27   |
| <b>Fertiliser levels ( % NP)</b> |                 |        |        |
| 80% NP                           | 0.56            | 2.44   | 3.80   |
| 90% NP                           | 0.58            | 2.68   | 4.04   |
| 100% NP                          | 0.59            | 3.00   | 4.18   |
| 110% NP                          | 0.64            | 3.12   | 4.54   |
| SE(m) $\pm$                      | 0.01            | 0.07   | 0.08   |
| C.D. (p=0.05)                    | 0.04            | 0.21   | 0.24   |

### Yield

The differences in grain and straw yield among the irrigation levels were observed to be significant (Table 5). The maximum grain (5022kg ha<sup>-1</sup>) and straw yield (8578 kg ha<sup>-1</sup>) was found with application of five irrigations, which was statistically significant over two, three and four irrigations in terms of grain yield, but was statistically significant over two and three irrigations in terms of straw yield. The differences in attraction index were not found significant. The possible reason for increase in grain and straw yield under higher irrigation levels is increase in yield attributes, which directly increase the grain and straw yields. Similar finding were observed by Kumar et al. (2014) and Sagaret al. (2018). Among fertilizer levels significantly higher grain (4765 kg ha<sup>-1</sup>) and straw yield (8134 kg ha<sup>-1</sup>) was recorded under application of 110% NP, which was statistically at par with application of 100% NP (4606 and 7934 kg

ha<sup>-1</sup>, respectively), whereas, the lowest grain (4093 kg ha<sup>-1</sup>) and straw yield (7362 kg ha<sup>-1</sup>) was produced under application of 80% NP. Fertilizer levels had no significant effect on attraction index. Grain and straw yield was higher under higher dose of fertilizers because of sufficient amount of available nutrients, as the crop plants had good growth and as a result produced higher yield attributes, which directly contributed in the increase of grain and straw yield of wheat (Kumar & Dhillon 2014; Wang et al. 2018; David Israel Mansingh & Suresh 2019). These findings are in corroboration with the results of Noonari et al. (2016).

### Economics

Application of five irrigations achieved the highest gross return (Rs. 131504 ha<sup>-1</sup>) due to increased grain and straw yields. The net returns also followed the same trend, highest (Rs. 77432ha<sup>-1</sup>) was achieved with the application of five irrigations, followed by

four irrigation (Table 6). This increase in net returns was due to better growth of the crop with frequent application of irrigation, ultimately resulting in better grain yield. Similar results were reported by Kumar et al. (2019). Among the fertilizer levels, the highest gross return (Rs. 124748ha<sup>-1</sup>) was recorded under the application of 110% NP

because of higher grain and straw yields. Maximum net returns (Rs. 73024 ha<sup>-1</sup>) was also obtained by application of 110% NP due to better growth resulting in grain and straw yield, whereas, the minimum (Rs. 58542ha<sup>-1</sup>) was recorded under the application of 80% NP. The results have conformity with the result of Raskar et al. (2013).

**Table 5.** Effect of irrigation and fertiliser levels on yield, harvest index and attraction index of bed planted wheat

| Treatments                | Grain yield (kg/ha) | Straw yield (kg/ha) | Attraction index (%) |
|---------------------------|---------------------|---------------------|----------------------|
| Irrigation levels         |                     |                     |                      |
| Two                       | 3851                | 6924                | 55.62                |
| Three                     | 4278                | 7494                | 57.17                |
| Four                      | 4670                | 7989                | 58.52                |
| Five                      | 5022                | 8578                | 58.62                |
| SE(m) ±                   | 91                  | 168                 | 0.77                 |
| C.D.(p=0.05)              | 322                 | 591                 | NS                   |
| Fertiliser levels ( % NP) |                     |                     |                      |
| 80% NP                    | 4093                | 7362                | 55.55                |
| 90% NP                    | 4357                | 7554                | 57.63                |
| 100% NP                   | 4606                | 7934                | 58.12                |
| 110% NP                   | 4765                | 8134                | 58.62                |
| SE(m) ±                   | 76                  | 168                 | 0.90                 |
| C.D.(p=0.05)              | 222                 | 492                 | NS                   |

**Table 6.** Effect of irrigation and fertiliser levels on Economics of bed planted wheat

| Treatments               | Gross return (Rs/ha) | Returns on variable cost (Rs/ha) | B:C  |
|--------------------------|----------------------|----------------------------------|------|
| Irrigation levels        |                      |                                  |      |
| Two                      | 102407               | 54455                            | 2.11 |
| Three                    | 112859               | 62867                            | 2.26 |
| Four                     | 122338               | 70306                            | 2.35 |
| Five                     | 131504               | 77432                            | 2.43 |
| SE(m) ±                  | 2320                 | 2320                             | -    |
| C.D. (p=0.05)            | 8187                 | 8187                             | -    |
| Fertilizer levels (% NP) |                      |                                  |      |
| 80% NP                   | 108843               | 58542                            | 2.15 |

|               |        |       |      |
|---------------|--------|-------|------|
| 90% NP        | 114605 | 63828 | 2.26 |
| 100% NP       | 120914 | 69666 | 2.35 |
| 110% NP       | 124748 | 73024 | 2.40 |
| SE(m) $\pm$   | 1982   | 1982  | -    |
| C.D. (p=0.05) | 5820   | 5821  | -    |

### Conclusion

The maximum plant height, dry matter accumulation, leaf area index and yield of bed planted wheat were recorded with five irrigations along with 110% recommended dose of NP. Gross returns and net returns maximum with five irrigations and 110% recommended dose of NP. Based on the findings, it can be concluded that sowing of crop with five irrigations with 110% recommended dose of NP is profitable to get the maximum productivity of bed planted wheat under semi-arid conditions of Haryana.

### References

- David Israel Mansingh M & Suresh S. 2019. Effect of difference sources and levels of lime application on yield, nutrient availability and uptake of rice in acidic soils. *Journal of Agriculture and Ecology*, 7: 73-87.
- Donald C.M 1962. In search of yield. *Australian Institute of Agricultural Science*, 28: 171-178.
- Kumar A, Nand V and Kumar R 2016. Effect of different levels of irrigation under integrated nutrient management (INM) on wheat (*Triticumaestivum* L.) for central plain agro climatic zone of utar Pradesh, India, *Plant Archives*, 16(1): 395-398.
- Kumar M, Pannu RK and Singh B 2018. Effect of irrigation regimes and nitrogen levels on phenology and grain yield of late sown wheat. *Wheat and Barley Research*, 10(1): 15-19.
- Kumar N, Kumar S, Kakraliya SK and Singh M 2017. Growth and quality parameters of bed planted barley cultivars in relation to planting geometry and moisture regimes. *Annals of Biology*, 33(1): 64-68.
- Kumar S and Dhillon SS 2014. Growth and yield of bed planted timely sown wheat as influenced by nitrogen levels and methods of application, *Haryana Journal of Agronomy*. 30(1): 85-88.
- Kumar S, Dhindwal AS, Kumar P and Sehwal M 2014. Shoot and root growth of wheat succeeding mungbean and sorghum in relation to planting methods and irrigation scheduling. *Haryana Journal of Agronomy*, 30(2): 176-183.
- Kumar S, Sharma PK, Yadav MR, Sexena R, Gupta KC, Kumar R, Garg NK and Yadav HL 2019. Effect of irrigation levels and moisture conserving polymers on growth, productivity and profitability of wheat, *Indian Journal of Agricultural Sciences*, 89(3): 509-514.
- Noonari S, Kalhor SA, Ali A, Mahar A, Raza S, Ahmed M, Shah SFA and Baloch SU 2016. Effect of Different Levels of Phosphorus and Method of Application on the Growth and Yield of Wheat. *Natural Science*, 8: 305-314.
- Raskar SS, Sonani VV and Patil PA 2013. Study of Economics of Maize as influenced by different levels of Nitrogen, Phosphorus and Zinc, *International Journal of Scientific and Research Publications*, 10(3): 1-3.
- Sachin AS, Sivakumar T, Krishna Surendar K & Senthivelu M. 2019. Influence of plant growth regulators and nutrients on biometric, growth and yield attributes in



- Blackgram (*Vigna mungo*L.). *Journal of Agriculture and Ecology*, 7: 55-63.
- Sagar VK, Naresh RK, Sagar PK, Kumar V, and Thaneshwar 2018. Water Productivity and Water Use Pattern in Bed Planted Wheat (*Triticumaestivum* L.) under Varying Irrigation Schedules, *International Journal of current Microbiology and applied Science*, 7(2): 873-882.
- USDA. 2022. World Agricultural Production. Foreign Agricultural Service, United States Department of Agriculture (USDA). *Circular Series*, WAP 4-22, April 2022.
- Wang L, Palta JA, Chen W, Chen Y and Deng X 2018. Nitrogen fertilization improved water-use efficiency of winter wheat through increasing water use during vegetative rather than grain filling, *Agricultural Water Management*, 197: 41-53.
-