**Biomass Partitioning and Yield Performance of Wheat Genotypes as Influenced by Different Irrigation Levels**

**Abstract**

**Aim:** To find out the most suitable genotype and irrigation level to obtain higher productivity of wheat crop.

**Methodology:** A field experiment was conducted during *Rabi* season of2022-23 with three main plot treatments consisting of irrigation levels (One irrigation at CRI stage, two irrigations at CRI and heading stage, irrigations at recommended growth stages) and ten sub plot treatments as genotypes viz. P 13320, P 13779, P 13787, P 30004, P 30005, P 30013, P 30007, P 30012, P 30015 and WH 1142 are laid out in split plot design with three replications.

**Results:** It was found that normal irrigated wheat recorded significantly higher dry weight of all plant parts compared to wheat irrigated with one and two irrigations. One (CRI) and two (CRI and heading) time irrigated wheat resulted in reduction of 93.1 and 65.5 percent in dry weight per plant at harvest compared to normal irrigation, respectively. Among genotypes, P 13320 and P 30013 recorded significantly higher and lower dry weights of all plant parts, respectively. Normal irrigated wheat produced significantly higher grain yield (5832 kg/ha), which was 172.5 and 76.1 percent higher over one irrigation (CRI) and two irrigations (CRI and heading), respectively.

**Interpretation:** The wheat growers may be advised to obtain higher yield of wheat, genotype P 13320 followed by P 30005 be taken with normal irrigations (at all recommended growth stages).

**Keywords**: Wheat, Irrigation level, Genotype, Biomass partitioning

**Introduction**

Wheat (*Triticum aestivum* L.) is the most important cereal crop in the world. It is a major staple food crop that provides 20% of food calories for 30% of the human population (Kesh *et al.,* 2022). India has experienced impressive growth in wheat production and productivity, enabling the country to become not only self-sufficient but also capable of exporting surplus wheat (Singh *et al.,* 2024). Rising temperatures with global warming has further reduced water availability which severely affects global wheat production (Sharma *et al.*, 2024). To cope with the limitation of water and the high demand for food crop production, improving crop water productivity will be a major solution to the current problems (Sagar *et al*., 2025; Dhaliwal *et al*., 2020).

Presently we are having sufficient wheat production but there is a pressing need to further boost production to meet the demands of a rapidly growing population, maintain sufficient buffer stocks, and cater to the requirements of processing industries. FAO estimated that global need for wheat grain will increase by 198 million tonnes additionally by 2050 and estimates that this future demand can only be fulfilled with the increase in yield by 2.5% per annum (Sharma *et al.*, 2015). Water is one of the most precious and scarce resource on earth, therefore efficient and judicious use of every drop of water in crop production is the need of hour. Water stress impacts not only the plant's morphology but also significantly disrupts its metabolic processes (Kamboj *et al.*, 2024; Joy *et al.*, 2021; Kumar *et al.*, 2019).

Wheat shows a strong positive response to irrigation. Irrigation at sensitive stages in wheat has been found to be very crucial to improve yield (Singh *et al.*, 2015). Lower growth rates and high yield decline in wheat have been reported by several researchers when drought was imposed at various growth stages such as tillering, booting, ear head emergence, anthesis and grain development stages (Mandal *et al.*, 2024). The overall effect of moisture stress depends on intensity and length of stress. Partitioning of total dry matter into different plant parts gives a better indication of different functions contributed by plant parts to final yield (Kamal *et al.*, 2024; Monika *et al.*, 2024)

Different responses of wheat genotypes to moisture stress are well documented. It is observed that all varieties exhibit different responses to the same amount of water because of their genetic behavior; some varieties are drought resistant, while others do not (Dhaka *et al.*, 2023). Wheat crop is highly susceptible to water stress, so it is essential to select wheat varieties that can mature and deliver higher yields even with a limited water supply. Thus, the current field research experiment was designed and conducted with the prime objective to seeing the influence of irrigation levels applied at various growth stages on the biomass partitioning and yield performance of ten wheat genotypes.

**Materials and Methods**

The field experiment was conducted in the drought micro plots (6 x 1 x 2 m) at Agronomy research area of CCS Haryana Agricultural University, Hisar, Haryana, India (29°10′N latitude, 75°46′E longitude and altitude of 215.2 m above the mean sea level). The soil at the research site has a sandy texture, slightly alkaline in reaction (pH-7.7), low in organic carbon (0.08 %), available nitrogen (72 kg/ha) and phosphorus (19 kg/ha) and medium in potash (188.0 kg/ha). The climate information was collected from the meteorological observatory at CCS Haryana Agricultural University, Hisar. During the crop season from sowing to harvesting in the study year 2022-23, the average maximum and minimum temperatures were 22.9°C and 8.8°C, with morning and evening relative humidity of 93.9% and 63.2%, respectively. The wind speed averaged 3.2 km/hr, bright sunshine hours were 5.5, pan evaporation was 1.9 mm, and total rainfall and rainy days recorded were 21.7 mm and 5, respectively. The weather conditions throughout the crop study period were generally favorable for wheat growth.

The crop was sown on 17th November 2022 and harvested on 26th March 2023. 150 kg N + 60 kg P2O5 + 30 kg K2O/ha basis were given using DAP, Urea and MOP. The experiment was conducted in split plot design, replicated thrice with three main plot treatments consisting of irrigation levels (One irrigation at CRI stage, two irrigations at CRI and heading stage, Normal irrigations at recommended growth stages i.e., CRI, Tillering, Jointing, Booting, Heading and Maturity) as genotypes as subplot treatments viz. P13320, P13779, P13787, P30004, P30005, P30013, P30007, P30012, P30015 and WH 1142. Irrigations were given as per treatments. Standard nutrient and weed management practices, as recommended by CCS HAU, were followed uniformly.

To assess dry matter accumulation and partitioning, three plants from each treatment (three replicates) were sampled to record dry matter, yield attributes, and yield at different growth stages (60 days after sowing; DAS, 90 DAS, and maturity). The height of the main shoot was recorded from the ground level to the top of the plant using a meter rod (cm) to determine plant height. Three plants from each replication were carefully uprooted, and their roots were washed gently with a water jet to remove sand. The root length of these plants was measured in centimeters with a meter rod, and the average length for each treatment was calculated and expressed in cm. Shoot and root were separated and their dry weight and length were directly determined to compute root:shoot ratio on length and weight basis. For dry weight determination, the shoot and roots were dried in hot air oven at 65 °C for 48 h and weighed. Canopy temperature and chlorophyll content were measured on the third fully expanded leaf from the top at the heading stage. Canopy temperature was measured using infra-red thermometer (ModelAG-42 Tele-temp Corp, California, USA). Chlorophyll content was determined by SPAD 502 plus instrument by measuring the absorbance of the leaf in two wavelength regions (Blue 400-500 nm and Red 600-700 nm). The Normalized Difference Vegetation Index (NDVI) sensor is the instrument used to measure the NDVI at heading. The total tillers per meter row length (mrl), effective tillers/mrl, spike length, number of spikelets per spike and 1000 seed weight (g) was recorded after the final harvest at maturity. The harvested plants were sun dried for 5 days to obtain total biomass and seed yield.

The experimental data were analyzed using the online Statistical Analysis Package (OPSTAT, Computer Section, CCS Haryana Agricultural University, Hisar, India) and tested for statistical significance with the appropriate critical difference (CD) at a 5% probability level (Gomez and Gomez, 1984).

**Results and Discussion**

**Root and shoot length**

Root and shoot length were significantly affected by irrigation levels and genotypes (Table 1). Irrespective of irrigation levels and genotypes the root length was increased up to 90 DAS and declined thereafter up to harvest. Shoot length was increased consistently up to harvest. Maximum increase in root and shoot length of wheat was recorded during initial 60 DAS duration and 60-90 DAS duration, respectively. At 60 DAS stage non-significant variation among irrigation levels was recorded regarding root length, while at 90 DAS and harvest stage less irrigated wheat (one irrigation at CRI) recorded significantly higher root length compared to two time and normally irrigated wheat. Genotype P 13320 followed by P 30015 recorded significantly higher root lengths at all stages of observation, while check variety WH 1142 recorded lowest root length. Normally irrigated wheat recorded significantly higher shoot length over one and two time irrigations at all stages of observation. Wheat genotype P 30015 followed by P 30007 recorded significantly higher shoot length, while P 30005 was found with minimum shoot length at all stages of observations. The differences in plant height could be attributed to the genetic variation among various cultivars, which is consistent with the findings of Sarwar *et al*. (2010).

**Root: Shoot (Length and weight basis):**

Irrigation levels and genotypes had shown significant effect on Root: Shoot (Table 1). Growth pattern of root and shoot under different irrigations and genotypes was also reflected in Root: Shoot observation trend. Declining trend was recorded in Root: shoot (length and weight basis) from 60 DAS up to harvest. Significantly higher Root: Shoot (length basis) was recorded with less irrigated wheat (one irrigation at CRI) compared to two time and normally irrigated crop at all stages of observation. Normally irrigated wheat had shown significantly higher Root: Shoot (weight basis) at all stages of observation except 60 DAS stage. Among genotypes, P 30012 at 60 and 90 DAS stage, P 13320 at harvest stage recorded significantly higher Root: Shoot (length basis), while significantly higher Root: Shoot (weight basis) was recorded with P 30015, P 30005 and P 30004 at 60 DAS, 90 DAS and at harvest stage, respectively.

**Dry weight:**

The dry weight accumulated in various wheat plant parts was significantly influenced by both irrigation levels and genotypes at every stage of observation (Table 2). Regardless of irrigation levels and genotypes, the total dry weight and the dry weight accumulated in various plant parts, except the roots, exhibited a continuous increasing trend up to the harvest stage. The most notable rise in dry weight occurred between 90 DAS and the harvest stage. Among irrigation levels, normally irrigated wheat followed by two times irrigated wheat had shown higher dry weight accumulated by different plant parts. Total plant dry weight recorded with normally irrigated wheat was 40.5, 48.5 and 93.1 percent higher over one time irrigated wheat at 60 DAS, 90 DAS and harvest, respectively. The increased dry weight observed with normal and two irrigations, as opposed to one irrigation, could be due to improved vegetative growth and effective biomass distribution resulting from a favorable water balance in these treatments. Similarly, higher dry weight in crops irrigated during all crucial growth stages, as compared to those experiencing moisture stress, has also been documented by Kamboj *et al.*, 2024; Dhaka *et al.*, 2023; Ibrahim *et al.,* 2017; Summy *et al*., 2015.

Among wheat genotypes, P 13320, followed by WH 1142, recorded significantly higher total dry weight, while genotype P 30013 recorded minimum total dry weight of plant at all stages of observation. Significantly higher dry weights of different plant parts viz. root, stem, leaf and ear head were also found higher in P 13320 genotype at all stages of observation. The notable differences in dry weight among genotypes could be due to their varying capacity to utilize resources, along with differences in biomass allocation and genetic variation. The significantly higher dry weight observed in P 13320 can be attributed to its longer root length, greater number of leaves, and a higher count of fruiting parts compared to other genotypes. Such variations in dry weight among genotypes were also confirmed by the research of Moghaddam *et al*. (2012).

**Yield and harvest index:**

The data on yield and its component traits as influenced by irrigation levels and genotypes were presented in Table 4.Normally irrigated wheat resulted with significantly higher effective tillers/mrl (124.7), spike length (9.36 cm), spikelets/spike (16.1) and 1000 seed weight (38.5 g), which were 11.9/24.8, 3.6/17.5, 14.1/27.7 and 3.8/5.2 percent higher over two irrigations/one irrigation, respectively. One irrigation at CRI stage resulted with 11.5, 13.4, 11.9 and 1.4 percent lower effective tillers/mrl, spike length, spikelets/spike and test weight than two irrigations at CRI and heading stage, respectively. The significantly higher yield attributes observed in normally irrigated wheat, as compared to other irrigation levels, can be attributed to enhanced vegetative and reproductive growth, effective biomass distribution among plant parts, and improved grain filling under favourable water conditions. Yield (Seed, straw and biological) and harvest index were significantly affected by Irrigation levels and genotypes (Table 4). Among Irrigation levels, normal irrigation followed by two irrigations recorded significantly higher yield and harvest index. Normal irrigation recorded 76.1/172.5, 71.9/159.0 and 69.1/150.2 percent higher seed, biological and straw yield compared to two irrigations/one irrigation, respectively. One irrigation at CRI stage resulted with 54.7, 50.6 and 47.9 percent lower seed, biological and straw yield over two irrigations at CRI and heading stage, respectively. A similar trend was evident in the harvest index. The higher yield achieved with normal irrigation (at recommended growth stages) could be attributed to improved water availability, leading to efficient biomass partitioning, enhanced yield attributes, better grain filling, and overall superior growth and development compared to other irrigation levels. These results are in line with the findings of Dhaka *et al.*, 2023; Wang *et al.,* 2012; Tadayon *et al.,* 2012.

Yield attributes except spike length and yield varied significantly among genotypes. Among genotypes, P 13320 closely followed by P 30005 recorded significantly higher seed yield (4281 kg/ha), effective tillers/mrl (128.6) and test weight (41.7 g). Wheat genotype P 13320 was found statistically at par with P 30005 and WH 1142 regarding seed and biological yield, total tillers/mrl and spikelets/spike. The significantly higher seed and biological yield obtained with P 13320 followed by P 30005 might be attributed to significantly higher yield attributes and better growth compared to other genotypes. P 30015 recorded maximum harvest index (42.5%), which was statistically at par with other genotypes except WH 1142. Relatively higher yield attributes in P 13320 and P 30005 might be credited to their genetic constitution and better biomass partitioning over other genotypes. High heritability and genetic advance linked to these traits is an indication that they can easily be transferred to succeeding generations and will remain stable under different eco-environments. The genotypes as a whole showed plenty of genetic variability to be exploited in a breeding programme. These results corroborate the findings of Ahmad and Kumar (2015); Ngwako and Mashiqa (2013); Mushtaq *et al.* (2011); Sarwar *et al.* (2010); Dhaka *et al.* (2006).

**Chlorophyll content and Canopy Temperature**

SPAD Chlorophyll content, NDVI index and canopy temperature showed significant variation among irrigation levels (Table 4). Among irrigation levels, normally irrigated wheat recorded 12.4 and 8.6 percent lower canopy temperature compared to one irrigation (CRI) and two irrigations (CRI and heading), respectively might be due to higher internal water status. Similarly, normal irrigation had resulted with 14.8/5.0, 17.7/8.8 and 20.9/7.8 percent higher chlorophyll at heading, chlorophyll 15 days after heading and NDVI index over one irrigation/ two irrigations, respectively. Water stress increases the production of harmful oxygen molecules in plants, which reduces chlorophyll content. This decrease might also happen because water stress blocks the process of making chlorophyll. Such a decrease in total chlorophyll content due to drought stress was also reported by Ibrahim *et al.* (2017) and Lalinia *et al*. (2012). The significantly higher cool canopy and chlorophyll content observed in irrigated environments compared to non-irrigated ones could be due to improved internal water balance, which supported proper physiological processes and created a cooler microclimate. Increasing leaf temperature due to water stress is possibly related to decreasing stomatal conductance and transpiration. Similar variations in CTD were also reported by Summy *et al*. (2015).

SPAD Chlorophyll content, NDVI index and canopy temperature were significantly affected by genotypes. Among genotypes, P 13320 closely followed by P 30005 recorded significantly lower canopy temperature (21.1 °C), significantly higher chlorophyll at heading (51.2), chlorophyll at 15 days after heading (50.0) and NDVI index (0.712). Similar variations in chlorophyll content among crop plants were also reported by Savaliya *et al*. 2019. The significant differences among genotypes for chlorophyll content and canopy temperature could be attributed to their genetic potential to utilize resources efficiently and maintain internal water balance, along with regulating key physiological processes such as photosynthesis, respiration, and transpiration. Water deficit may lead to chlorophyll degradation and inhibit its synthesis.

**Conclusions**

Based on the findings of the above investigation, the wheat growers may be advised to obtain higher yield of wheat, genotype P 13320 followed by P 30005 be taken with normal irrigations (at all recommended growth stages).

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Table 1: Effect of Irrigation levels on Root and shoot length and their ratio of wheat genotypes

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Treatments** | **Root length (cm)** | **Shoot length (cm)** | **Root: Shoot** **(Length basis)** | **Root: Shoot** **(Weight basis)** |
| **60****DAS** | **90****DAS** | **At harvest** | **60****DAS** | **90****DAS** | **At harvest** | **60****DAS** | **90****DAS** | **At harvest** | **60****DAS** | **90****DAS** | **At harvest** |
| **A) Irrigations** |  |  |  |  |  |  |
| One irrigation at CRI stage | 77.2 | 93.0 | 79.0 | 35.2 | 73.4 | 80.4 | 2.19 | 1.27 | 0.98 | 5.00 | 1.42 | 0.93 |
| Two irrigations at CRI and heading stage | 75.4 | 90.7 | 75.3 | 37.7 | 77.6 | 85.6 | 2.00 | 1.17 | 0.88 | 5.28 | 1.27 | 0.85 |
| Normal irrigations at recommended growth stages | 73.9 | 88.6 | 74.7 | 39.5 | 79.2 | 88.9 | 1.87 | 1.12 | 0.84 | 3.08 | 1.91 | 1.81 |
| SEm+ | 0.9 | 0.6 | 0.5 | 0.6 | 0.7 | 0.6 | 0.03 | 0.01 | 0.01 | 0.26 | 0.04 | 0.05 |
| CD (P=0.05) | NS | 2.4 | 2.2 | 2.7 | 2.8 | 2.6 | 0.13 | 0.03 | 0.06 | 1.06 | 0.18 | 0.20 |
| **B) Genotypes** |  |  |  |  |  |  |
| P 13320 | 85.0 | 98.2 | 93.1 | 38.6 | 79.2 | 87.7 | 2.20 | 1.24 | 1.06 | 4.25 | 1.68 | 1.14 |
| P 13779 | 75.1 | 92.3 | 75.7 | 35.4 | 75.4 | 82.6 | 2.12 | 1.22 | 0.92 | 2.96 | 1.57 | 1.40 |
| P 13787 | 71.0 | 87.0 | 72.0 | 35.4 | 73.3 | 80.3 | 2.01 | 1.19 | 0.90 | 4.34 | 1.13 | 1.43 |
| P 30004 | 77.6 | 92.5 | 77.5 | 38.2 | 78.0 | 85.0 | 2.03 | 1.19 | 0.91 | 4.84 | 1.37 | 1.75 |
| P 30005 | 70.2 | 85.7 | 70.4 | 34.8 | 68.0 | 80.0 | 2.02 | 1.26 | 0.88 | 5.14 | 2.16 | 1.14 |
| P 30013 | 73.6 | 88.5 | 74.2 | 37.3 | 77.0 | 83.5 | 1.97 | 1.15 | 0.89 | 3.80 | 1.39 | 1.22 |
| P 30007 | 75.0 | 91.3 | 75.5 | 38.8 | 79.7 | 88.7 | 1.93 | 1.15 | 0.85 | 3.57 | 1.40 | 0.98 |
| P 30012 | 78.0 | 92.8 | 79.6 | 35.3 | 68.7 | 80.3 | 2.21 | 1.35 | 0.99 | 3.80 | 1.48 | 1.17 |
| P 30015 | 84.0 | 94.5 | 78.8 | 40.7 | 84.7 | 92.1 | 2.06 | 1.12 | 0.86 | 4.86 | 1.76 | 1.24 |
| WH 1142 | 65.7 | 84.8 | 67.7 | 39.8 | 83.4 | 89.5 | 1.65 | 1.02 | 0.76 | 4.29 | 1.71 | 1.39 |
| SEm+ | 1.1 | 0.9 | 1.5 | 0.8 | 1.6 | 1.4 | 0.03 | 0.02 | 0.01 | 0.62 | 0.07 | 0.12 |
| CD (P=0.05) | 3.1 | 2.6 | 4.3 | 2.3 | 4.8 | 3.9 | 0.09 | 0.05 | 0.05 | 1.77 | 0.19 | 0.35 |

DAS- Days after sowing

Table 2: Effect of Irrigation levels on dry weight (g/plant) of different plant parts at 60 DAS, 90 DAS and harvest of wheat genotypes

|  |  |  |  |
| --- | --- | --- | --- |
| **Treatments** | **Dry weight at 60 DAS** | **Dry weight at 90 DAS** | **Dry weight at harvest** |
| **Root** | **Stem** | **Leaf** | **Total** | **Root** | **Stem** | **Leaf** | **Earhead** | **Total** | **Root** | **Stem** | **Leaf** | **Earhead** | **Total** |
| **A) Irrigations** |
| One irrigation at CRI stage | 1.55 | 0.31 | 0.51 | 2.37 | 5.43 | 3.82 | 1.98 | 0.75 | 11.98 | 4.73 | 5.11 | 2.28 | 6.51 | 18.63 |
| Two irrigations at CRI and heading stage | 1.69 | 0.32 | 0.59 | 2.60 | 5.87 | 4.61 | 2.5 | 0.93 | 13.91 | 5.02 | 5.92 | 3.14 | 7.66 | 21.74 |
| Normal irrigations at recommended growth stages | 1.85 | 0.6 | 0.88 | 3.33 | 9.16 | 4.79 | 2.79 | 1.06 | 17.80 | 13.92 | 7.71 | 3.73 | 10.62 | 35.98 |
| SEm+ | 0.03 | 0.02 | 0.02 | 0.02 | 0.48 | 0.05 | 0.05 | 0.03 | 0.73 | 0.44 | 0.16 | 0.12 | 0.19 | 0.86 |
| CD (P=0.05) | 0.13 | 0.09 | 0.06 | 0.10 | 1.93 | 0.22 | 0.21 | 0.13 | 2.95 | 1.79 | 0.66 | 0.49 | 0.78 | 3.48 |
| **B) Genotypes** |
| P 13320 | 2.38 | 0.56 | 0.80 | 3.74 | 9.11 | 5.43 | 2.80 | 1.51 | 18.85 | 10.53 | 9.23 | 4.74 | 11.34 | 35.84 |
| P 13779 | 1.48 | 0.5 | 0.61 | 2.59 | 6.39 | 4.08 | 2.59 | 0.75 | 13.81 | 7.84 | 5.60 | 2.85 | 6.40 | 22.69 |
| P 13787 | 1.65 | 0.38 | 0.74 | 2.77 | 5.93 | 5.25 | 2.30 | 0.54 | 14.02 | 7.81 | 5.47 | 3.41 | 8.01 | 24.70 |
| P 30004 | 1.79 | 0.37 | 0.64 | 2.80 | 6.08 | 4.45 | 2.44 | 1.39 | 14.36 | 8.24 | 4.71 | 3.06 | 9.20 | 25.21 |
| P 30005 | 1.8 | 0.35 | 0.75 | 2.90 | 7.6 | 3.52 | 2.55 | 1.29 | 14.96 | 7.51 | 6.56 | 2.99 | 9.84 | 26.90 |
| P 30013 | 1.33 | 0.35 | 0.51 | 2.19 | 5.58 | 4.01 | 2.15 | 0.62 | 12.36 | 6.48 | 5.3 | 2.64 | 7.11 | 21.53 |
| P 30007 | 1.57 | 0.44 | 0.69 | 2.70 | 6.09 | 4.35 | 2.51 | 0.76 | 13.71 | 7.22 | 7.34 | 2.69 | 6.25 | 23.50 |
| P 30012 | 1.33 | 0.35 | 0.56 | 2.24 | 5.92 | 4.01 | 2.30 | 0.58 | 12.81 | 6.34 | 5.43 | 2.50 | 7.32 | 21.59 |
| P 30015 | 1.70 | 0.35 | 0.77 | 2.82 | 7.38 | 4.20 | 2.33 | 0.54 | 14.45 | 7.64 | 6.14 | 3.03 | 8.46 | 25.27 |
| WH 1142 | 1.93 | 0.45 | 0.52 | 2.90 | 8.12 | 4.75 | 2.26 | 1.17 | 16.30 | 9.28 | 6.68 | 2.62 | 8.70 | 27.28 |
| SEm+ | 0.09 | 0.05 | 0.04 | 0.06 | 0.53 | 0.11 | 0.09 | 0.06 | 0.86 | 0.66 | 0.57 | 0.24 | 0.78 | 1.93 |
| CD (P=0.05) | 0.26 | 0.14 | 0.10 | 0.18 | 1.50 | 0.33 | 0.26 | 0.17 | 2.46 | 1.87 | 1.64 | 0.69 | 2.22 | 5.50 |

 DAS- Days after sowing

Table 3: Effect of Irrigation levels on percent contribution of different plant parts to total dry weight at 60,90 DAS and harvest of wheat genotypes

|  |  |
| --- | --- |
| **Treatments** | **Percent contribution to total plant weight**  |
| **60 DAS** | **90 DAS** | **At harvest** |
| **Root** | **Stem** | **Leaf** | **Root** | **Stem** | **Leaf** | **Earhead** | **Root** | **Stem** | **Leaf** | **Earhead** |
| **A) Irrigations** |
| One irrigation at CRI stage | 65.4 | 13.1 | 21.5 | 45.3 | 31.9 | 16.5 | 6.3 | 25.4 | 27.4 | 12.2 | 34.9 |
| Two irrigations at CRI and heading stage | 65.0 | 12.3 | 22.7 | 42.2 | 33.1 | 18.0 | 6.7 | 23.1 | 27.2 | 14.4 | 35.2 |
| Normal irrigations at recommended growth stages | 55.6 | 18.0 | 26.4 | 51.5 | 26.9 | 15.7 | 6.0 | 38.7 | 21.4 | 10.4 | 29.5 |
| SEm+ | 0.4 | 0.1 | 0.5 | 0.7 | 0.5 | 0.4 | 0.1 | 0.5 | 0.1 | 0.2 | 0.2 |
| CD (P=0.05) | 1.6 | 0.4 | 2.1 | 2.7 | 1.9 | 1.7 | 0.4 | 1.9 | 0.5 | 0.7 | 1.0 |
| **B) Genotypes** |
| P 13320 | 63.6 | 15.0 | 21.4 | 48.3 | 28.8 | 14.9 | 8.0 | 29.4 | 25.8 | 13.2 | 31.6 |
| P 13779 | 57.1 | 19.3 | 23.6 | 46.3 | 29.5 | 18.8 | 5.4 | 34.6 | 24.7 | 12.6 | 28.2 |
| P 13787 | 59.6 | 13.7 | 26.7 | 42.3 | 37.4 | 16.4 | 3.9 | 31.6 | 22.1 | 13.8 | 32.4 |
| P 30004 | 63.9 | 13.2 | 22.9 | 42.3 | 31.0 | 17.0 | 9.7 | 32.7 | 18.7 | 12.1 | 36.5 |
| P 30005 | 62.1 | 12.1 | 25.9 | 50.8 | 23.5 | 17.0 | 8.6 | 27.9 | 24.4 | 11.1 | 36.6 |
| P 30013 | 60.7 | 16.0 | 23.3 | 45.1 | 32.4 | 17.4 | 5.0 | 30.1 | 24.6 | 12.3 | 33.0 |
| P 30007 | 58.1 | 16.3 | 25.6 | 44.4 | 31.7 | 18.3 | 5.5 | 30.7 | 31.2 | 11.4 | 26.6 |
| P 30012 | 59.4 | 15.6 | 25.0 | 46.2 | 31.3 | 18.0 | 4.5 | 29.4 | 25.2 | 11.6 | 33.9 |
| P 30015 | 60.3 | 12.4 | 27.3 | 51.1 | 29.1 | 16.1 | 3.7 | 30.2 | 24.3 | 12.0 | 33.5 |
| WH 1142 | 66.6 | 15.5 | 17.9 | 49.8 | 29.1 | 13.9 | 7.2 | 34.0 | 24.5 | 9.6 | 31.9 |
| SEm+ | 1.0 | 0.5 | 0.7 | 1.1 | 0.7 | 0.5 | 0.3 | 0.8 | 0.6 | 0.4 | 0.7 |
| CD (P=0.05) | 3.0 | 1.5 | 2.2 | 3.2 | 2.3 | 1.3 | 0.9 | 2.4 | 1.8 | 1.1 | 2.0 |

DAS- Days after sowing

Table 4: Effect of Irrigation levels on yield, component parameters and physiological parameters of wheat genotypes

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Treatments** | **Yield (kg/ha)** | **HI (%)** | **Total tillers/mrl** | **Effective tillers/mrl** | **Spike length (cm)** | **Spikelets/Spike** | **1000 seed weight (g)** | **CT (°C)** | **SPAD chlorophyll**  | **SPAD chlorophyll at 15 DAH** | **NDVI**  |
| **Seed** | **Biological** | **Straw** |
| **A) Irrigations** |  |  |  |
| One irrigation at CRI stage | 2140 | 5376 | 3235 | 40.0 | 105.0 | 99.9 | 7.96 | 12.6 | 36.6 | 24.0 | 43.8 | 40.0 | 0.605 |
| Two irrigations at CRI and heading stage | 3311 | 8098 | 4786 | 41.6 | 120.7 | 111.4 | 9.03 | 14.1 | 37.1 | 22.1 | 47.9 | 43.3 | 0.679 |
| Normal irrigations at recommended growth stages | 5832 | 13926 | 8094 | 41.8 | 129.2 | 124.7 | 9.36 | 16.1 | 38.5 | 21.4 | 50.3 | 47.1 | 0.732 |
| SEm+ | 183 | 427 | 250 | 0.36 | 0.64 | 4.36 | 0.19 | 0.23 | 0.34 | 0.17 | 0.31 | 0.12 | 0.002 |
| CD (P=0.05) | 739 | 1724 | 1009 | 1.46 | 2.59 | 17.6 | 0.78 | 0.94 | 1.39 | 0.71 | 1.26 | 0.49 | 0.008 |
| **B) Genotypes** |  |  |  |
| P 13320 | 4281 | 10459 | 6177 | 40.9 | 129.7 | 128.6 | 9.77 | 16.2 | 41.7 | 21.1 | 51.2 | 50.0 | 0.712 |
| P 13779 | 3596 | 8602 | 5005 | 41.9 | 117.3 | 108.2 | 8.33 | 13.8 | 35.2 | 22.5 | 45.6 | 41.4 | 0.671 |
| P 13787 | 3870 | 8996 | 5126 | 42.2 | 118.6 | 110.6 | 8.55 | 14.3 | 38.8 | 22.4 | 49.3 | 44.3 | 0.701 |
| P 30004 | 3701 | 9055 | 5353 | 40.8 | 119.0 | 108.4 | 8.88 | 14.2 | 36.4 | 22.7 | 46.5 | 43.4 | 0.571 |
| P 30005 | 4038 | 9620 | 5581 | 41.2 | 121.3 | 128.0 | 9.11 | 15.6 | 40.6 | 21.3 | 51.1 | 47.5 | 0.711 |
| P 30013 | 3290 | 7750 | 4459 | 43.0 | 103.3 | 97.5 | 8.11 | 13.0 | 33.3 | 22.9 | 44.5 | 40.7 | 0.638 |
| P 30007 | 3644 | 8881 | 5237 | 42.1 | 117.5 | 108.4 | 8.44 | 14.1 | 36.0 | 23.3 | 46.8 | 42.0 | 0.666 |
| P 30012 | 3485 | 8492 | 5007 | 40.9 | 114.4 | 106.0 | 8.22 | 13.2 | 35.1 | 23.2 | 44.8 | 42.4 | 0.708 |
| P 30015 | 3921 | 9147 | 5226 | 42.5 | 119.5 | 114.4 | 9.00 | 14.7 | 38.8 | 22.1 | 50.5 | 47.4 | 0.667 |
| WH 1142 | 3787 | 10333 | 6545 | 35.8 | 122.4 | 109.7 | 9.44 | 14.3 | 38.5 | 22.8 | 43.1 | 35.7 | 0.676 |
| SEm+ | 194 | 411 | 259 | 0.93 | 3.04 | 5.39 | 0.39 | 0.66 | 0.46 | 0.17 | 0.61 | 0.34 | 0.008 |
| CD (P=0.05) | 552 | 1168 | 738 | 2.65 | 8.64 | 15.38 | NS | 1.89 | 1.31 | 0.49 | 1.75 | 0.97 | 0.022 |

HI- Harvest Index (%); mrl- meter row length; CT- Canopy temperature (°C); SPAD- Soil plant analysis development; DAH- Days after heading; NDVI - Normalized difference vegetation index