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Effects of Supplementary Irrigation on Growth and Yield of Spring Wheat (*Triticum aestivum* L.)

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Abstract

A study was carried out in the research farm of Agriculture Faculty at for two seasons 2020/2021. The aim to study the effects of supplementary irrigation on growth and yield of Spring Wheat (*Triticum aestivum* L.), especially to find the effect of limited water in the time of cease rainfall. Randomized Complete Block Design (RCBD) was used and had three repeats. Five irrigation (T1 = control, T2 = one irrigation at tillering, T3 = one irrigation at anthesis, T4 = one irrigation at grain filling, T5 = three irrigation at (tillering, anthesis and grain filling)). The plot size was 1.6 × 3m consisted of 8 rows. The fertilizer dose of Nitrogen (150kg/ha⁻¹) Phosphorus (100kg/ha⁻¹) was applied in the form of Urea and DAP. The variety of wheat used was Lalmi4 #. Data obtained included crop growth and yield parameters of wheat adopted for analyzing the parameters, with the supplemental irrigation treatments as plots. Supplementary irrigation significantly affected the yield, the high yields were obtained from three irrigation in tillering, anthesis and grain filling stages, whereas the lowest was obtained by the no irrigation treatment. There was slight difference effect on growth and yield components. The result of this study showed that supplementary irrigation affected the growth and yield parameters of wheat, and also it was concluded that three supplementary irrigation at (tillering, anthesis and grain filling) gave the highest yield parameter viz. spike length, number of spikelet, number of seed per spike, thousand grain weights, biological yield and grain yield compared to others.

Keywords: Growth, *Triticum sativum*, Yield, Spring wheat, RCBD, Supplementary irrigation, and Wheat.

1. Introduction

Wheat is the main staple crop globally and plays a crucial role in challenging food security, with a total production of 736.1 million tons (Slafer *et al.*, 2014). Its importance has risen due to the frequently experienced food shortages and also its role in world trade. Wheat is significance as a food of mankind; provide meals energy and protein to the people. Increasing wheat production to meet higher demands by growing population is still a challenge in many countries hence greater land is committed

global for manufacturing than any other commercial crops.

The starting place of wheat can be traced again to the Far East, Egypt and Rome as early as 6,700 BC. The grains had been powdered using rocks as water mills seemed solely in 85 BC in Asia Minor. Two a native to southwestern Asia, whole wheat used to be introduced to the Western Hemisphere only in the late 15th century when Christopher Columbus discovered America on his second voyage to the New

World. Wheat (*Triticum* spp. L) is one the important cool season crops originated from the Middle East. It has truly longer cultivation area and less warmness requirement than the other small grain crops; and many population in the world use it as meals in pretty a wide variety such as steamed breads, cookies, cakes, pasta, noodles and couscous. Today wheat is still a basically important product in human nutrition especially due to its protein. Its protein content and yield depend on the weather condition (Johansson *et al.*, 2003; Bedada *et al.*, 2024). Unfavorable moisture and limited water during the main phonological stages can cause variability in yield and in protein content which effect the break making quality (Bonfil *et al.*, 2004). The main purpose that why wheat is called very vital meals grain because it has bread making first rate which is the result of gluten content in wheat grain. Wheat is cultivated all over the world especially, especially in U.S.A, Russia, Australia, Canada, Argentina, Ukraine, Kazakhstani, China, India, Pakistan and Netherland and also the important producing country of wheat are: Russia, UAE, French, German, Chaina, Japan, Nigeria and the Mexico.

Wheat (*T. aestivum* L) is the world's large source of protein and calories. Its provide more than 50% of the human daily meals in developing countries and not less than 20% of the daily food for human consumption, in the well developed countries, Moreover it's a very good source for animals and birds feeding variation. Wheat (*Triticum* spp. L) cultivation area has been down to 8 million ha in recent year. It ranks first among cereal crops provide meal for one third of the world population. Wheat is an important crop of Afghanistan that has calculated 4 million metric tons in 2018. High amount of it is used as bread in Afghanistan; also 75% as bread, 15% in industry and 10% are used in agriculture. Wheat is cold season crop that introduced an important food grain all over the world. It has 12.5% moisture content, 330g calories, 12.3% protein, 1.8% lipids, 71.7% N-free extract, 2.3% fiber, 1.7% ash, 0.52 (mg/100gr) thiamine, 0.12 (mg/100gr) riboflavin, 4.3% niacin also produce 20% energy (FAO/WHO, 1973). Globally, wheat covers 22% area.

Opposite to irrigation, drought is the most serious environmental problem which limit crop production

in rain fed agriculture. Thus water is one of the most important ecological factors which determine crop growth and development (Asaye Zeleke, 2020). The other side the most limiting natural resource. Water is the key constraint for improving agricultural productivity owing to the extreme variability of rainfall, long dry seasons, recurrent droughts, and floods and dry spell in the same season (Carbtree *et al.*, 1985). Also In arid and semi-arid regions the water and rainfall is the main source for food grains production (Monsour soharbi, 2010). High grain yield and quality of wheat are opposite site and are influenced by environmental condition as by variety, soil, fertilizers, and relations between these factors (Rao *et al.*, 1993). As reported by (Debeak *et al.*, 1996; Feil, 1997), yield and quality are negatively related. Also yield and quality depend on whether condition during various developmental stages of spring wheat (Jaohansson *et al.*, 2003). Yield depend on water application time or the amount of water (Ahmad and Aslam, 1999). Due to the importance of water to plant survival and substance, the amount applied during irrigation, time and method of application, water holding capacity of the soil and the water condition of the environment are factors that greatly influence plant growth, yield and general performance of crops (Doorebos and Kassam, 1979). Yield response to water, Irrigation and drainage. Sporadic and scanty pattern of rainwater limits the economical crop production. Moisture stress during critical stage of crop growth usually causes collapse in the crop yield. Improving water productivity can contribute to water saving, which can be used to irrigate additional lands with higher total production to improve sustainability of the existing water resources (Oweis, *et al.*, 2000).

The normal yield under rain fed ecology may be improved by managing the available small quantities of irrigation water in judicious way considering non-sufficient rainfall thus supplementary irrigation be supportive for successful wheat production. And efficient use of limited water resources and better growth under limited water supply are desirable traits for crops in drought environments (Kobata *et al.*, 1992). Wheat can be categorized as winter or spring types according to chilling requirements, winter hardiness and day length sensitivity. Winter wheat requires a cold period or chilling [vernalization] during early growth for normal heading under long days also in early stages show resistance

to frost, whereas spring wheat does not require chilling for heading. However, it is also sensitive to frost. For winter and spring wheat minimum daily temperature for measurable growth is 5°C. Information on optimal scheduling of limited amounts of water to maximize the yields is essential (Al-Kaisi *et al.*, 1997). The crop development stages also sensitive to moisture stress. There for response of plants to water stress depends on several factors such as developmental stage, severity and duration of stress (Boltrano and Marta, 2008). There are critical stages in plant development when water stress or excessive can cause significant decrease in yield. Many plant species don't have the ability to storing water to use in drought periods and need supplemental water during these periods. Thus, defining the appropriate time, amount and method of irrigation for each plant species will increase the efficiency of supplemental water. In recent years, many studies about the effects of supplementary irrigation on growth, yield performance and water use efficiency have shown that proper supplementary irrigation can increase crop yield by significantly improving soil water conditions and their water use efficiency (Deng *et al.*, 2007). Supplementary irrigation is defined as the use a limited amount of water to rainfed crops when precipitation fails to provide the essential moisture stress for normal growth in dry land regions (Tavakoli and Oweis, 2004). Application of limited amount of supplementary irrigation besides increasing yields and can also stabilize yield from year to year in dry land condition (Tahmasebi and Roohi, 2008).

Despite water shortages, waste of irrigation water is common because insufficient methods and not recognize the critical stages may result decrease in water use efficiency (WUE) and profits (Anderson, *et al.*, 1990). Also farmers don't know that how we use limited water and in which growing season may give the best result. Thus may cause reduction in yield so Response or wheat yield to supplementary irrigation is well established but how wheat would response if we use limited amount of water when precipitation fails to provide the essential moisture stress and growing season needs consideration. Wheat has the widest adaptation of all cereal vegetation and is grown in hundred countries around the world. Wheat is a main plant of the world. Wheat is a cultural product in Afghanistan and it is

cultivated about in all states it is the staple food, having more usages than other grains in Afghanistan. Afghanistan has 7910 million hectars cultivated land. The agronomic crops cover approximately 95% area in the world. Wheat, rice and corn just cover the 52% area under cultivation. Wheat is the main staple food as well the major crop in Afghanistan and is grown under 18-22°C. About 70% of total crop area is cultivated; about 60% of wheat area is irrigated (Appendix **Table A** and **B**). Note: Years shown in the table correspond to the calendar year of harvest. Most wheat is planted in November–December and harvested the following April-May.

The share of wheat production obtain from irrigated land is absolutely great through (approximately 80%), since yields on irrigated land were on average three times those on rain fed land (1.8 tons/ha versus 0.6 tons/ha). Other cereals account for 15% of area cultivated. Poppy is grown illegally on about 2% cultivated land (World Bank, 2004). The major wheat growing areas are concentrated in northern (NR), north-eastern (NER), western (WR), and south-western (SWR) regions of the country. Averaged over the period 2005-2012, the NR accounted for 35.9%, NER 23.3%, WR 14.4% and SWR 8.4% of total cultivated area under wheat. Irrigated wheat areas were more concentrated in the northern region accounting for 45.9% and north-eastern 29.5% of the total irrigated wheat area. It accounts for around 70% of total cereal consumption and 60% of the total intake of calories. Per capita consumption of wheat was 186 kilograms per year averaged over the period 2002-2009. Wheat (*T. aestivum* L.) is the major food grain grown in Afghanistan. It is the staple food that plays a vital role in maintaining food and nutrition security of its people. Wheat accounted for 78.5% of annual aggregate production of cereals in Afghanistan averaged over the period 2005-2012. Wheat in Afghanistan ranks first in terms of cultivated area, covered approximately 1635000 hectares in 2019 and total production of 3613300 ton with an average yield of 2210 kg/ha. Of all wheat area in Afghanistan, 45% is irrigated and 55% rainfed. But there are substantial annual fluctuations of wheat area depending on the amount and timing of rainfall the country receives. Wheat production in Afghanistan remains extremely sensitive to variations in precipitation and the aggregate annual production of

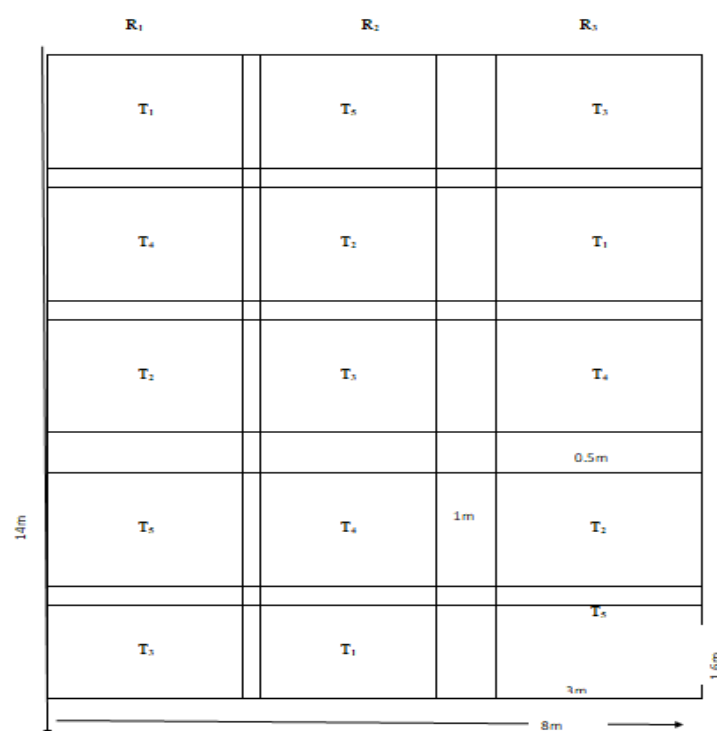
wheat in any given year depends on the performance of the rainfed crop. While irrigated wheat is expected to produce a reasonable yield, the fate of the rainfed crop depends entirely on rainfall and the exposure of critical crop growth stages to extreme temperatures. Hence the research project an entitled “effects of supplementary irrigation on growth and yield of spring wheat” was carried out in the research farm of agriculture faculty, Department of Agronomy, Kabul University Afghanistan to find out the best time of application of supplementary irrigation for Kabul Afghanistan, to find out the effect of supplementary irrigation on growth and yield of spring wheat and to identify the response of Lalmi4 variety spring wheat to supplementary irrigation.

2. Materials and Methods

The experiment was conducted at the Experimental farm of Agronomy department, Agriculture Faculty, Kabul University, and Kabul – Afghanistan, from March, 2020 to July, 2021. Geographically, the

research farm is situated between $33^{\circ}.34'$ North latitude and between $13^{\circ}.69'$ East longitudes. The altitude is about 1791 m above sea level. This area falls under semi - arid climatic zone. Land preparation started at 18/3/2020 for first research and land preparation started for at 7/3/2021 for second research. A local hand tool was used for working the land, constructing the furrows, shaping and levelling of the experimental plot. Land was ploughed and prepared by tractor. Planting started one week after land preparation. Eight lines at each plot, space between every line were 20cm. For optimum seed germination and seedling establishment, a seed rate of 150 kg/ha was adopted. Quantity of seeds actually used for each plot was calculated as seed rate/ plot (gr) = $150000/10000 = 15\text{gr/m}^2 = 15\text{gr} \times 4.8\text{m}^2 = 72\text{gr/plot}$ approx. Total seed rate for research area was 1500gr, seeds were manually drilled and thoroughly covered.

Experimental layout



The composite samples from 0-30cm depth were randomly collected from the experimental field with the help of auger prior to experimentation. All the possible technical precautions as prescribed for standard soil sampling were also taken. Then samples were brought to the laboratory, air-dried and ground, thereafter sieved through 2 mm mesh. The soil samples thus obtained were subjected to various mechanical, physical and chemical analyses

to assess the single value physical and chemical properties of soil. The soil of the experimental plot was slightly alkaline in reaction and was low in available nitrogen, phosphorus and potassium. Climatologically, the Research Farm falls under semi – arid zone with annual rainfall varying from 301 ml in period where research took place. The annual mean maximum temperature is 21.66°C with a range from 6.5°C to 36.6°C . The annual mean

minimum temperature is 8.54 ° c with a range from - 2.3 ° c to 18.6 ° c. The annual mean maximum temperature is 21.66 ° c with a range from 6.5 ° c to 36.6 ° c. The annual mean minimum temperature is 8.54 ° C with a range from -2.3 ° C to 18.6 ° C. The experiment consisting of five treatments combinations based on sources of supplementary irrigation presented in Appendix **Table C**.

The experiment was conducted on spring wheat in medium loam soil, the variety is Lalmi #4 and sowing date of first term is 29/ 3 / 2020 and sowing date of second term experiment is 18/3/2021. Number of rows in plot is 8 and distance between rows are 20 m, space with plant to plant are 7 cm. gross plot size were 2 x 3.5 m, and net area is 1.6 x 3 m. the research design is randomized complete block design (RCBD). There are 5 treatments and 3 replications. The fertilizer dose is 150:100 NP, kg ha⁻¹, applied with broadcast method and K fertilizers

were not applied because there is no need for them in Afghanistan agricultural conditions. The weed competition was determined at 4 weeks after sowing subsequently removed by hand and using implements such as hoe. Analysis of variance (ANOVA) was used to specify the effects of treatments, meanwhile treatment means were compared with least significance difference (LSD) at P<0.05 using SAS software.

3. Results

Plant height is an important parameter which can be used to study the effect of different treatments on crop growth. The data on periodic plant height recorded at 30 DAS, 60 DAS, 90 DAS and their analysis of variance is given in **Table 1**. Showed that averaged over the different treatments the increase in plant height with successive intervals from 30-60 DAS, 60-90 DAS.

Table 1: Analysis of variance for plant height at different growth stage.

Source of variation	DF	30DAS	60DAS	90DAS	HARVEST
		MS	MS	MS	MS
Replication	2	17.0153**	115.376**	1005.42**	939.508**
Treatment	4	0.0270	0.325	1.48	1.276
Error	8	0.0647	0.161	0.56	23.478
Total	14				

The maximum plant height has registered under T5 (85cm) following by T2 (74cm), and T3 (69.26cm) following by T4 (66.6cm) respectively. The minimum plant height (50.6cm) was obtain from T1. Tillers count per unit area is an important parameter for determining the effect of any treatment on

growth and yield of a crop like wheat. The mean data of tillers were counted at 30, 60, 90 DAS and their analysis of variance is given in **Table 1**, The perusal of data revealed that wheat plants produced maximum tillers per m² at 60 DAS and later on tiller per m² decreased with the advancement of crop age.

Table 2: analysis of variance for tiller m⁻² at different plant growth stage.

Source of variation	DF	30 DAS	60 DAS	90 DAS	HARVEST
		MS	MS	MS	MS
Replication	2	664.116**	7358.36**	24729.7*	31073.4*
Treatment	4	2.385	913.80	170.27*	846.5
Error	8	84.576	703.36	98.4	334.9
Total	14				

Table 2 show that T5 produced more tillers followed by T2 and T3 following by T4. T5 recorded maximum tillering at 30, 60, 90, DAS stage and at harvest being significantly higher than all other of treatment. Treatment T3 was with little difference produce more tiller than T4. T1 recorded lowest tillers during the year of study. The leaf area indicates the photosynthetic efficiency of any crop

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field. Data pertaining to leaf area index at 90DAS stages of crop growth were significantly influenced by planting techniques.

Their analysis of variance is given in **Table 3** revealed that significantly highest leaf area index was recorded (4.80) giving supplementary irrigation at (tillering, anthesis and grain filling).

Table 3: Analysis of variance for leaf area index.

Source of variation	DF	F/term	Sec/term	combine
		Mean sum of square	Mean sum of square	Mean sum of square
Replication	2	60.6110*	0.551000*	1.05833**
Treatment	4	0.0000	0.014000	0.00233
Error	8	0.095	0.06500	0.00886
Total	14			

Spike length is directly related to the number of spikelet and grains spike⁻¹ and hence this is an important determinant of grain yield. Spike length may also serve as one of the criteria for assessing the grain yield in cereal crops. The analysis of variance is given in **Table 4** revealed that T5

treatment significantly increased spike length following by T3 over T4 treatment during the year of study. Treatments T1 and T2 statistically at par among themselves with respect to spike length during the year of study.

Table 4: Analysis of variance for length of spike.

Source of	DF	F/research	Sec/research	Combine
		Mean sum of square	MS	MS
Replication	2	8.46948*	9.55015**	16.7220*
Treatment	4	0.15461	0.06652	0.0428
Error	8	0.10865	0.94377	1.8272
Total	14			

Number of spikelet's spike⁻¹ is one of the most yield attribute. The data on the spikelet's spike⁻¹ were influenced by different treatments and their analysis of variance is given in **Table 5** advocated that the

maximum number of spikelet's spike⁻¹ was recorded significantly superior in T5 treatment as compared to all other treatments in the year of study. T1 and T2 were at par with each other.

Table 5: Analysis of variance for number of spikelet's/ spike.

Source of Variation	DF	F/research	Sec/research	Combine
		Mean sum of square	Mean sum of square	Mean sum of square
Replication	2	53*	44.2333**	96.2*
Treatment	4	0.20	10.4667	4.1333
Error	8	0.9500	2.6333	2.3652
Total	14			

Head length is one of the most yield attribute. The data on head length were influenced by different treatments and their analysis of variance is given in **Table 6** advocated that the maximum number of

head length was recorded significantly superior in T5 treatment as compared to all other treatments in the year of study. T1 and T2 were at par with each other.

Table 6: Analysis of variance for head length/cm.

Source of variable	DF	F/research	Sec/research	Combine
		Mean sum of square	Mean sum of square	Mean sum of square
Replication	2	13.3944*	29.2585*	39.9416*
Treatment	4	0.0909**	0.0115	0.0836
Error	8	0.0099	0.2881	2.4084
Total	14			

The weight of individual grain (Appendix **Table D**) calculated from 1000 grain weight (test weight) is an important yield attribute which provides information

regarding the efficiency with grain filling process took place. Thousand grain weight (1000 grain weight), as it is called the test weight of the desired

output, is referred to be considered as one of the most significant agronomic parameters ever trusted that contributes in having a reconnaissance over the possible production of a lot (grain yield). Grain yield (Appendix **Table E**) is a function of various parameters like crop dry matter accumulation, number of tillers, number of grains spike⁻¹ and grain weight etc. Grain yield is the most important criteria for evaluating the effects of applied treatments. Crop productivity is the rate at which a crop accumulate biomass which depends primarily on the photosynthesis and conversion of light energy into chemical energy by green plants. Data revealed in Appendix **Table F** that the significantly highest biological yield (18761.8kg/ha) was obtained with T5 (3 supplement irrigation at tillering, anthesis and grain filling) over all other treatments. Also treatment T4 (17069.3kg/ha) was significantly superior over T3 (16104.5kg/ha) and T2 (13843.3kg/ha) treatments during the year of study. Harvest index is an important parameter indicating the efficiency in partitioning of dry matter to the economic part of crop. Statistically higher harvest index is the economic return of the crop. The data regarding harvest index have been shown which treatment has highest harvest index it shows the maximum yield. Analysis of variance is given in Appendix **Table G**.

4. Discussion

The findings presented in the preceding chapter provided a detailed account of the performance in terms of growth, development, yield and yield contributing characters of wheat as influenced by supplementary irrigation. The phenomenon of growth and development of plants mainly depends on genetic make-up, soil environment and climatic conditions. The relationship between agriculture and soil is better understood than between agriculture and climate. It may not be possible to change the climate but it is possible to adopt particular agriculture practice, which aims at higher and sustainable production of crop under prevailing weather situations. In recent years uncertainties in rainfall, the swings in the onset, continuity and withdrawal pattern of monsoon make crop production more risky (Singh, 2001). For introducing a suitable supplementary irrigation stage, it is necessary to know the critical stage and yield reduction level of plant. Such information is necessary for crop planning based on various agro-

climatic and soil hydrological condition both under un-irrigated and irrigated areas. In addition, it is necessary to optimized yield and water use efficiency through proper tillage practices under irrigated conditions. Since crop growth and yield are determined directly by the plant water stress and only indirectly by the soil water stresses (Pal *et al.*, 2002; Sheikh *et al.*, 2024).

In any crop, the yield per hectare can be analyzed in terms of yield per plant and plant population per hectare. Yield per plant in case of wheat can be resolved into for basic components via, number of spikelet spike⁻¹, spike length (cm), number of grains spike⁻¹ and test weight.. Grain yield then appears to be the result of genetic and physiological potential and higher yield can be reached when high genetic ceiling is combined with high physiological and metabolic potentials and efficient source and sink relationship (Baliyan *et al.*, 1984). Therefore, present study was conducted to find out the “the effect supplementary irrigation on growth and yield of Wheat (*T. aestivum*).

Effect on growth

The growth parameters such as plant height, dry matter accumulation, and number of tillers show a subsequent increase as the crop advanced from the early vegetative stage toward later developmental phases. This improvement is likely the result of favorable environmental conditions prevailing during the season, including adequate rainfall, suitable temperature, and sufficient sunshine hours, which collectively supported better physiological activity and biomass formation. During the early vegetative stage, the effect of the supplementary irrigation on growth attributes was minimal; however, its influence became more evident as the crop reached the later growth stages. The effect of supplementary irrigation becomes more pronounced during the later stages of crop growth because the plant's demand for water increases substantially during key physiological phases such as stem elongation, heading, flowering, and grain filling. At these stages, adequate moisture is critical for sustaining cell expansion, nutrient uptake, biomass accumulation, and grain development. When supplementary irrigation is applied during these high-demand periods, it effectively prevents moisture stress and enables the crop to express its full growth and yield potential, which is why the impact is more

noticeable compared to the early vegetative stage, where water requirements are relatively low.

Among all treatments, T5 consistently recorded significantly higher values for plant height, dry matter, and tiller production, followed by T2. The superior performance under T5 and T2 can be attributed to enhanced soil moisture and improved nutrient availability, which likely facilitated greater nutrient uptake and consequently promoted better vegetative growth. In contrast, T1 showed the lowest values across all growth parameters, reflecting the limitations caused by insufficient moisture supply. Overall, the results clearly demonstrate that supplementary irrigation plays a crucial role in enhancing the growth performance of spring wheat, particularly during the critical later stages of crop development.

Effect on yield attributes

The results demonstrated that grain yield and biological yield were significantly enhanced under improved moisture conditions provided through supplementary irrigation. The increased vegetative growth observed in earlier stages ultimately translated into higher yield attributes - particularly the number of grains per spike and test weight-which collectively contributed to the increase in final grain yield. These findings are consistent with previous reports indicating that moisture stress generally reduces grain yield (Hsiao, 1973), although it may simultaneously elevate certain grain quality traits such as protein content (Guttieri *et al.*, 2000). Furthermore, earlier studies by (Donaldson, 1996; Nazeri, 2005) have shown that water deficit occurring after anthesis shortens the grain-filling period and reduces kernel weight, ultimately leading to lower crop productivity. Among the treatments evaluated, T5 produced the highest grain yield (5488 kg ha⁻¹), followed by T4 (4925.16 kg ha⁻¹). The superior performance of T5 can be attributed to the application of supplementary irrigation at three critical growth stages-tillering, anthesis, and grain filling-ensuring uninterrupted water availability during phases of high physiological demand. Similarly, T4, which received irrigation at the grain-filling stage, also achieved comparatively high yield, highlighting the sensitivity of this stage to moisture supply. Biological yield exhibited a similar trend: T5 recorded the highest biological yield (18,761.83 kg ha⁻¹), followed by T4 (17,069.33 kg ha⁻¹). The

significantly higher grain and biological yields under these treatments can be explained by greater soil moisture availability, which facilitated efficient nutrient absorption, enhanced assimilate production, and improved expression of yield attributes. Overall, the results clearly indicate that timely supplementary irrigation at critical growth stages substantially improves yield components and ultimately maximizes grain and biological yield in spring wheat.

Effect on grain quality

Wheat grain quality is determined by a combination of genetic and environmental factors, including protein content, test weight, and gluten percentage (Johansson, 2002; Johansson *et al.*, 2004). In the present study, absence of supplementary irrigation resulted in lower grain yield but higher protein concentration, reflecting the inverse relationship between yield and protein under moisture-limited conditions.

Supplementary irrigation, particularly in T5, significantly enhanced protein content, test weight, and gluten percentage, likely due to improved moisture availability during critical growth stages, which facilitated nutrient uptake, metabolic activity, and optimal grain development. These results indicate that timely irrigation not only maximizes yield but also maintains superior grain quality.

Effect on protein and gluten contents

In the both trails (2020 and 2021) protein content of T5 were lowest than other treatments because the protein contents of wheat is decreased with supplementary irrigation. Similar result was reported by Saint Pierre *et al.* 2008). T1 produced the high protein content. Also Gooding *et al.* (2003) discussed that high temperatures and water stress may lead to increased grain protein content. Gluten index has been introduced as a better trait for wheat processing quality, rather than the wet gluten content (Deng *et al.*, 2005).

Effect on spike length

Spike length affected by supplementary irrigation, data in **Table 4** revealed that significant increase in spike length shown in T5 (12.87cm), T3 (11.53cm) and T4 (10.28) this may be because of better moisture availability in T5 at the time of spiking and development of spike.

Effect on yield

Water stress had a more dramatic effect on yield after the flowering stage than preflowering. The difference between, T2 and T3, T4, T5 for yield and yield components were always significant and T1 had low values, similar result were recorded by (Heatherly, 1993) in soybean, Westage, (1994) in maize, and Robins and (Domingo, 1956; Maurer *et al.*, 1969; Kemp *et al.*, 1974) in beans.

Limitations

Limited Geographic Scope: The study was conducted in a specific agro-ecological zone, Agriculture Faculty of Kabul University which may not represent the diverse environmental and soil conditions of other wheat-growing regions.

Limited Parameters Studied: While the study focused on growth and yield parameters, it did not explore other important aspects such as water use efficiency, economic returns, or grain quality under different irrigation regimes.

Resource Constraints: Due to limited resources, advanced tools like remote sensing, soil moisture sensors, or modeling techniques were not used, which could have added precision to the findings.

Evaluating on other varieties: This research is carried out just on Lalmi4 variety and we cannot recommend on other varieties it is necessary to conduct on other varieties.

Future Scope of the Research

Multi-Location Trials: Future studies can be conducted across various agro-climatic zones to validate and generalize the findings of supplementary irrigation effects on spring wheat.

Long-Term Studies: Conducting long-term experiments over multiple growing seasons can help in understanding the year-to-year variability and resilience of supplementary irrigation strategies under climate change scenarios.

Integration with Modern Technologies: Future research can incorporate technologies such as drip irrigation, soil moisture sensors, and decision support systems for precise irrigation management.

Economic and Environmental Analysis: Further studies should include cost-benefit analysis and environmental impact assessment of supplementary irrigation to provide more holistic recommendations to farmers and policymakers.

Exploring Other Crop Traits: Additional traits such as disease resistance, grain protein content, and root

development under supplementary irrigation could be explored to improve the overall productivity and quality of wheat.

Evaluating on other varieties: This research is conducted just on Lalmi4 variety; future studies can be conducted on different varieties to compare the differences among them.

5. Conclusion

The field experiment was conducted during spring season of 2020 and 2021 at crop research center of Kabul university on topic (effect of supplementary irrigation on growth and yield of Wheat (*T. aestivum*)). the experiment was laid out in RCBD design with three replications and five treatments. Observation on growth and development, yield and yield contributing characters were recorded. The salient finding of these investigation are summarized below. Crop growth parameters (plant height, number of tillers and leaf area index were influenced by supplementary irrigation. Plant height increased with advancement of age and increase in moisture supply and reached maximum at 90 DAS. The plant height increased significantly with successive increase in moisture and nutrient availability in the year of experimentation. Number of tillers and leaf area also increased with increase due to supplementary irrigation and reached maximum at 60 DAS for number of tillers and at harvest. T5 (3 supplementary irrigation at tillering, a thesis and grain filling) produced significantly higher growth parameters than rest of the treatment. The results of experiment revealed that significantly higher number of grains per spike, test weight, spike length, number of spikelets per spike, and grain straw and biological yield of wheat crop increased with supplementary irrigation at critical stage. The grain yield was significantly increased by T5 (3 supplementary irrigations at tillering, a thesis and grain filling) to the tune of 14.5 and 8.25 over all others treatments respectively. The profile moisture content was highest at the time of sowing and it was lowest at the time of crop maturity in all the treatments during the year of study. The moisture content of (T5) was always higher than T4, T3, T2 and T1 treatment during experimentation. T5 treatment consumed markedly higher water than other treatments during the crop season. T1 consumed the lowest water than all other treatments during the year of the study. T5 (giving 3 supplementary irrigation at tillering, anthesis and grain filling) increased gross income

and net profit because of more increase in grain yield, biological yield and gross income in comparison to increase in cost of cultivation. Among the above treatments the highest net profit was obtained T5 because of giving three supplementary irrigations at critical stages (at tillering, anthesis and grain filling). Based on the results of the study during 2020 and 2021 at Crop Research Centre of Kabul University, (Afghanistan) it can be concluded that among the five treatments T1 (no irrigation), T2 (1 irrigation at tillering), T3 (1 irrigation at anthesis), T4 (1 irrigation at grain filling) and T5 (3 irrigation at tillering, anthesis and grain filling). this study confirmed that the supplementary irrigation affect significantly on grain yield, leaf area, harvest index, thousand grain yield, head length, bundle weight, length of spike, number of spikelet per spike and biological yield. T5 (3 irrigation at tillering, anthesis and grain filling) performed best on grain yield, leaf area, harvest index, thousand grain yield, head length, bundle weight, length of spike, number of spikelet per spike and biological yield according to the below reasons.

- Three supplement irrigation applied for this treatment, so these three supplementary irrigation applied at critical stages of the growth, like in tillering, anthesis and grain filling
- There was no shortage of water during critical stage of the growth.
- There were availability of enough moisture for up taking the nutrients
- There is no limitation of water during growth, development and maturity

T2 (supplementary irrigation at tillering) produced the high tiller per sqm during the year of the study so in this stage giving the supplement irrigation caused the high number of tiller, effect on the growth. T5 (3 irrigations at tillering, anthesis and grain filling) following by T3 (1 irrigation at anthesis) produced high thousand seed weight. T5 (3 irrigations at tillering, anthesis and grain filling) following by T4 (1 irrigation at grain filling) produced high grain yield/ha. Only T1 showed the lowest result over all other treatments. But at every stage T5 was given the maximum yield than all other treatments during the year of the study and T1 was given the lowest result than all other treatments. We also can conclude if water source is limited,

rainfall is distributed irregularly and moisture of soil cannot meet the needs of wheat how can we manage our irrigation? By giving supplementary irrigation at these three critical stages at tillering, anthesis and grain filling we can obtain the best results.

6. Author contributions

Z.Z.: led the study, conceptualized the research, designed and supervised the experiment, analyzed the data, and wrote the manuscript. H.H.: collected the data and A.T.: reviewed the manuscript

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8. Conflicts of Interest

The authors declare no financial, personal, or professional conflicts that could have influenced this research. All aspects of the study were conducted independently, ensuring objectivity, transparency, and adherence to ethical standards.

9. References

- Ahmed, M. A., & Badr, N. M. (2004). Growth and yield attributes of some wheat cultivars in relation to missing an irrigation at different stages of growth in newly cultivated sandy soil.
<https://www.cabidigitallibrary.org/doi/full/10.5555/20063232905>
- Aksoy, M. A., & Beghin, J. C. (Eds.). (2004). Global agricultural trade and developing countries. *World Bank Publications*.
- Al-Kaisi, M. M., Berrada, A., & Stack, M. (1997). Evaluation of irrigation scheduling program and spring wheat yield response in south-western Colorado. *Agricultural Water Management*, 34(2), 137-148.
<https://www.sciencedirect.com/science/article/pii/S0378377497000103>
- Anderson, W. K., & Smith, W. R. (1990). Yield advantage of two semi-dwarf compared with two tall wheats depends on sowing time. *Australian J. of Agricultural Research*, 41(5), 811-826.
<https://doi.org/10.1071/AR9900811>

- Asaye, Z. (2017). Effect of Different Levels of Supplementary Irrigation on Yield and Yield Component of Maize (*Zea mays* L) at Teppi, South West Ethiopia, Doctoral dissertation, Haramaya University.
- Baliyan, R. S., Bhan, V. M., & Mallik, R. K. (1984). Studies on possibilities of zero tillage in cotton-wheat rotation.
<https://www.cabidigitallibrary.org/doi/full/10.5555/19860783051>
- Bedada AF, Akter L, and Alemayehu DY. (2024). Optimum determination of NPSB fertilizer rates on bread Wheat (*Triticum aestivum* L.) varieties. *Int. J. Agric. Vet. Sci.*, **6**(5), 105-118.
<https://doi.org/10.34104/ijavs.024.01050118>
- Beltrano, J., & Ronco, M. G. (2008). Improved tolerance of wheat plants (*Triticum aestivum* L.) to drought stress and rewatering by the arbuscular mycorrhizal fungus *Glomus claroideum*: Effect on growth and cell membrane stability. *Brazilian Journal of Plant Physiology*, **20**, 29-37.
- Bonfil, D. J., Karnieli, A., & Schmilovitch, Z. (2004). Decision support system for improving wheat grain quality in the Mediterranean area of Israel. *Field Crops Research*, **89**(1), 153-163.
- Crabtree, R. H. (1985). The organometallic chemistry of alkanes. *Chemical Reviews*, **85**(4), 245-269.
<https://pubs.acs.org/doi/pdf/10.1021/cr00068a002>
- Deng, X. P., Shan, L., & Inanaga, S. (2002). Sensitivity and resistance of seedling establishment to water stress in spring wheat. *Cereal Research Communications*, **30**(1), 125-132.
<https://link.springer.com/article/10.1007/BF03543399>
- Huang, M. L., Deng, X. P., & Tanaka, K. (2007). Water and nutrient use efficiency in diploid, tetraploid and hexaploid wheats. *J. of Integrative Plant Biology*, **49**(5), 706-715.
<https://doi.org/10.1111/j.1744-7909.2007.00463.x>
- Doorenbos, J., Plusje, J. M. G. A., & Bentvelsen, C. L. M. (1986). Yield response to water (Vol. 192).
FAO Food Balance Sheets (FAOSTAT), 2004. Available from: www.fao.org
- Guttieri, M. J., Ahmad, R., & Souza, E. (2000). End-use quality of six hard red spring wheat cultivars at different irrigation levels. *Crop Science*, **40**(3), 631-635.
<https://doi.org/10.2135/cropsci2000.403631x>
- Hsiao, T. C. (1973). Plant responses to water stress. *Annual review of plant physiology*, **24**(1), 519-570.
- Johansson, E., Prieto-Linde, M. L., & Svensson, G. (2004). Influence of nitrogen application rate and timing on grain protein composition and gluten strength in Swedish wheat cultivars. *Journal of Plant Nutrition and Soil Science*, **167**(3), 345-350.
<https://onlinelibrary.wiley.com/doi/abs/10.1002/jpln.200320332>
- Kobata, T., Palta, J. A., & Turner, N. C. (1992). Rate of development of postanthesis water deficits and grain filling of spring wheat. *Crop science*, **32**(5), 1238-1242.
<https://access.onlinelibrary.wiley.com/doi/abs/10.2135/cropsci1992.0011183X003200050035x>
- Oweis, T., Hachum, A., & Kijne, J. (1999). Water harvesting and supplemental irrigation for improved water use efficiency in dry areas (Vol. 7). IWMI.
- Oweis, T., Pala, M., & Ryan, J. (1998). Stabilizing rainfed wheat yields with supplemental irrigation and nitrogen in a Mediterranean climate. *Agronomy Journal*, **90**(5), 672-681.
- Oweis, T., Zhang, H., & Pala, M. (2000). Water use efficiency of rainfed and irrigated bread wheat in a Mediterranean environment. *Agronomy journal*, **92**(2), 231-238.
- Roohi, E., Tahmasebi, S. Z., & Sioseh, M. A. (2013). Comparative study on the effect of soil water stress on photosynthetic function of triticale, bread wheat, and barley.
https://www.sid.ir/EN/VEWSSID/J_pdf/84820130218.pdf
- Sheikh MR, Abedin MT, and Sayed MA. (2024). Genomic insights into the cultivated common buckwheat: a comprehensive review on genetic diversity, population structure, and marker technologies. *Int. J. Agric. Vet. Sci.*, **6**(3), 60-69.
<https://doi.org/10.34104/ijavs.024.060066>

- Slafer, G. A., Savin, R., & Sadras, V. O. (2014). Coarse and fine regulation of wheat yield components in response to genotype and environment. *Field Crops Research*, **157**, 71-83. https://www.sid.ir/EN/VEWSSID/J_pdf/84820130218.pdf
- Sohrabi, M., Heidari, G., & Yazdanseta, S. (2010). Evaluation of quantitative and qualitative characteristics of yield in dryland wheat cultivars under supplemental irrigation conditions. *J. of Food, Agriculture and Environment*, **8**(2), 400-403.
- Walker, G. K., & Hatfield, J. L. (1979). Test of the stress-degree-day concept using multiple planting dates of red kidney beans. *Agronomy Journal*, **71**(6), 967-971.
- Holmberg, J., Harrington, L., & Peacock, J. (2005). Afghanistan-state building, sustaining growth, and reducing poverty.
- Yano, T., Aydin, M., & Haraguchi, T. (2007). Impact of climate change on irrigation demand and crop growth in a Mediterranean environment of Turkey. *Sensors*, **7**(10), 2297-2315. <https://www.mdpi.com/1424-8220/7/10/2297>

Appendix

Table A: Area, production and yield of wheat in Afghanistan, 1999–2004.

Wheat Area and Production	1999	2000	2001	2002	2003	2004
Wheat Area (thousand hectares)	2027	2029	1779	1742	2294	1766
Irrigated	1196	1189	1156	1045	1059	969
Rainfed	831	840	623	697	1235	797
Wheat production(thousand tons)	2500	1469	1597	2686	4361	2293
Irrigated	1988	1329	1514	2110	3017	1867
Rainfed	512	140	83	576	1345	426
Wheat Yield (ton/ha)	1.2	0.7	0.9	1.5	1.9	1.3
Irrigated	1.7	1.1	1.3	2	2.8	1.9
Rainfed	0.6	0.2	0.1	0.8	1.1	0.5

Source: FAO/WFP Crop and Food Supply Assessments 2003 and 2004.

Table B: Provinces accounting for larger production in wheat production.

No.	Province	Production (tons)		Changes		Changes as % of total reduction
		2009	2011	Value	%	
1	Faryab	361	104	257	71	14.2
2	Balkh	391	158	233	60	12.9
3	Herat	462	243	219	47	12.1
4	Sari-i- Pul	190	47	143	75	7.9
5	Badghis	210	76	134	64	7.4
6	Juzan	264	132	132	50	7.3
7	Takhar	342	219	123	36	6.8
8	Samangan	172	64	108	63	5.9
9	Badakshan	191	83	108	57	5.9
10	Kunduz	316	221	95	31	5.2
11	Baghlan	230	162	68	30	3.7
12	Farah	107	39	68	64	3.7
13	Total	32.36	1548.0	1688.0	52	93.3

Source: FAO/GIEWS country balance sheet.

Table C: Treatment detail.

No	Treatments	Short form
1	T1	No irrigation
2	T2	1 irrigation at tillering
3	T3	1 irrigation at anthesis
4	T4	1 irrigation at grain filling
5	T5	3 irrigation at tillering, anthesis, grain filling

Table D: Analysis of variance for 1000 grain weight (test weight).

Source of variable	DF	F/research	Sec/research	Combine
		Mean sum of square	Mean sum of square	Mean sum of square
Replication	2	83.6560*	115.252*	196.552*
Treatment	4	5.6507*	16.301**	20.017**
Error	8	0.6840	4.678	2.451
Total	14			

Table E: analysis of variance for grain yield kg/hectare.

Source of variable	DF	F/site	Sec/site	Combine
		Mean sum of square	Mean sum of square	Mean sum of square
Replication	2	2473229	201621*	2027563**
Treatment	4	64590	9479	23023
Error	8	57478	3348	449809
Total	14			

Table F: Analysis of variance for biological yield Kg/ha.

Source of variable	DF	F/site	Sec/site	Combine
		Mean sum of square	Mean sum of square	Mean sum of square
Replication	2	16009835	19428464*	33801401*
Treatment	4	16016..467	71443.8	20470.533
Error	8	223494.13	79374.3	612479.27
Total	14			

Table G: Analysis of variance for harvest index.

Source of variable	DF	F/research	Sec/research	Combine
		Mean sum of square	Mean sum of square	Mean sum of square
Replication	2	9.0960	29.6493*	12.9556
Treatment	4	19.1580	1.2835	6.6124
Error	8	4.3405	0.9536	21.1998
Total	14			

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