Effect of Sowing Date and Irrigation Frequency on Wheat (*Triticumaestivium* L) Production in Southern Niger Republic

ABSTRACT

The objective of this study was to find out the optimum sowing date and irrigation frequency for better performance of the wheat variety ''NORMAN'' in Niger.
The study was carried out at Djirataoua(13°25'59''N, 7°8'12''E) in the southern part of Niger republic during the dry season 2015-2016.
Three sowing dates (15-Nov, 30-Nov and 15-Dec) and three irrigation frequencies (5, 10 and 15 days) were tested in a Split Plot Design with 3 replications. The wheat variety used in this study was "Norman". Data were recorded on yield and yield components as well as on some growth and phenological parameters.
Results showed that sowing date on 15-Nov and 30-Nov took respectively 78 and 75 days to heading while the late planting (15-Dec) achieved heading in 71 days. The irrigation interval of 5 days gave the highest number days to heading (78 days). Physiological maturity was achieved at 109 and 102 days for 15-Nov and 30-Nov and decreased to 96 days when sowing was on 15-Dec. At 5 days interval of irrigation the number of days to maturity was 107 days and dropped to 101 and 99 days for 10 and 15 days interval of irrigation. Plant height was greatest (98 and 96 cm) for planting at 15-Nov and 30-Nov respectively, and became lower (90 cm) with 15-Dec. The highest plant height (103 cm) was achieved with 5 days interval of irrigation. Also the highest yield (5545 kg/ha) was achieved at 5 days interval of irrigation while the planting date on 15-Nov gave 4395 kg/ha.The thousand kernel weight was greatest (38.68 g and 39.02 g) with sowing date on 15-Nov and 30-Nov respectively and was lowest (31.43 g) when planting was delayed to 15-Dec. But the weight of thousand grains was statistically similar (39.12 g; 36.53 g and 33.48 g) for the three irrigation intervals. The interaction between the two factors was not significant for all parameters.
This study was relevant for the determination of the right planting window and irrigation interval for best performance of wheat in the study area. However further studies with more options of irrigation regime are needed to evaluate the irrigation water cost in order to achieve an optimum and economic yield.

Keywords: wheat; sowing date; irrigation frequency; Niger republic

1. INTRODUCTION

Niger is a dry country that is predicted to get drier with climate change. In 2021, the irrigation potential of Niger was estimated at 10 942 568 hectares in terms of surface water and groundwater. The population of Niger republic is estimated at25 million inhabitants in 2023. The cereals requirements would increase from about 3 million tons in 2005 to 4, 2 million tons in 2015 [1].
Limited wheat is grown in Niger republic, with a total annual production of about 5,700 tons, versus a total demand of about 194,858 tons in 2022. Wheat is cultivated under irrigation with an average grain yield of 1.8 – 2.6 ton ha^{-1} [2].
Wheat production in the country is failing to keep pace with growing demand. Demand for wheat in the past was not very high in Niger, because the nutritional habit of the majority of

the population was based mainly on millet and sorghum. At present wheat consumption has notably increased (Figure 1). The country is therefore becoming increasingly dependent upon imports for wheat. Over 73000 tonsof wheat were imported in Niger in 2022. [2].This may be due to the increase of wheat consumption. Therefore it is urgent to reduce the large gap between production and importation of wheat in Niger through the development of new high yielding and heat tolerant varieties as well as the best management of agronomic practices such as sowing time, irrigation, fertilization etc.

Sowing date is one of the most important agronomic factors involved in producing high yielding small grain cereal crops, which affects the timing and duration of the vegetative and reproductive stages [3]. Correctly matching the time at which growth stages occurwith the wheat plant's environmental requirements is key of maximizing wheat yield. Thus, producers have to choose the appropriate variety for a specific sowing date for the optimum flowering time and, thereby, the highest possible yield [4]. Sowing at inappropriate time may cause drastic reduction in wheat yield. Generally, wheat crop sown during November results in better yield and any delay in sowing reduced tillers, seed index and grain yield that resulted in reduced yield. This was found by [5] whose results revealed that maximum grain yield could be achieved with wheat planted in first fortnight of November and any delay in wheat sowing might reduce wheat yield.Early planted wheat yielded maximum grains per spike (44.14 grains), plant height (79.81 cm), 1000-grain weight (39.17 g) grain yield (4165.7 kg ha^{-1}) and straw yield (6814.2 kg ha^{-1}) [6].

Irrigation plays an important role in wheat plant development at any critical stage from seed germination to plant maturation. Earlier studies have shown that moisture stress to wheat crop at spike emergence and antithesis stages reduced yield from 7 to 3.3 tons per hectare [7].Excessive irrigation increases evapotranspiration and decreases water use efficiency and may also reduce grain yield [8]. Limited irrigation is an important constraint for wheat production in tropical, arid, and semi-arid regions. Plant height, spike length, number of tillers per square meter, number of spikelets per spike, 1000 grains weight, biological yield and grain yield were significantly affected by irrigation regime [9].

The recommended number of irrigations at the vegetative and the reproductive stages need to be applied properly and timely for better yields. Given the soil water holding capacity, it is important to decide the number of irrigations and interval between successive irrigations so that crop may not suffer from water stress. Proper timing and frequency of supplementary irrigation in relation to crop yield are crucial in irrigation scheduling for the most effective use of available water in optimizing wheat production [10]. Longer intervals of irrigation (21days) during the insensitive growth stages of wheat could help in reducing the pressure imposed by crops on water demand and labor. Highest grain yield was achieved from watering every 14 days until the boot stage and 10 days thereafter [11].The highest water use efficiency was obtained when crop was irrigated at one week interval in Pakistan [12, 17-20]. [13] have carried out an experiment on wheat irrigation in semi-arid Sudan, and concluded that irrigation every 7 and 10 days gave the highest protein content, grain and straw yield and field water use efficiency. But for economic reason irrigation every 10 days is recommended.

2. MATERIAL AND METHODS

The experimentation was carried out during the dry-season 2015-2016 on the irrigated perimeter of Djirataoua in southern Niger republic: 13°25'59''N, 7°8'12''E, at an altitude of 350 m above sea level. The site is located along the Goulbi'nMaradi Valley with an average rainfall is 490 mm per year. The soil texture is loamy (Appendix 1).

2.1 factors of the study

Two factors were involved in this study:

The first factor was the sowing date.Three sowing dates were tested:

- D1 = 15th November
- D2 = 30th November
- D3 = 15th December

The second factor was Irrigation frequency.Three levels of irrigation were evaluated:

- 5 days interval
- 10 days interval
- 15 days interval

The sowing dates as well as the irrigation treatments were chosen based on previous studies conducted in northern Nigeria, having similar climatic conditions with the study area, where 10 days irrigation interval was found more efficient.

The experimental design was a Split-plot with three replications. The irrigation frequency was placed on main plot while the sowing date was put on sub-plot.

2.2Implementation of the experiment

2.2.1 Plant material

The plant materialused in this study was the wheat variety ''Norman''. This variety was developed by CIMMYT-Mexico with a potential yield of 6 tons/ha.

2.2.2 Planting operation

The seed were treated with the chemical Calthio at the rate of 10 g kg^{-1} of seed before sowing. The sowing was done by means of single row hand drill at the rate of 120 kg ha^{-1}. Wheat grains were drilled in 6 rows with 30 cm inter-row spacing on sub-plots.

2.2.3 Cultural practices

Irrigation was done according to the treatment plan using flooding method through ground canal with borders raised at 20 cm height to prevent water seepage. The quantity of water applied was calculated at 30 mm per irrigation during the whole growing season. The fertilization was based on the three major nutrients (Nitrogen, Phosphorus and Potassium) were applied in the form of NPK (15-15-15), SSP (0-18-0) and Urea (46-0-0) fertilizers. The Nitrogen, Phosphorus and Potassium fertilizers were applied at the constant rate of 120 kg/ha, 60 kg/ha and 40 kg/ha respectively. The NPK and the SSP were applied at the time of sowing and the Urea was be top-dressed in two split applications ½ at tillering and ½ at jointing stages. One weeding was done by hoe at tillering stage before fertilizer application. The harvesting was done at physiological maturity stage. The three central rows were harvested tomeasure the parameters of study.

2.3Data analysis

Data collected were analyzed using the Statistical package GENSTAT 18th Edition. Analysis of variance (ANOVA) was performed and the means of the different parameters were compared by the Bonferroni Test through the Least Significant Difference (LSD).

3. RESULTS AND DISCUSSION

3.1 Effect of sowing date and irrigation frequency on different parameters

3.1.1 Number of days to heading

The sowing date as well as the irrigation frequency significantly affected the number of days to heading (Table 1). The number of days to heading was higher (77.78 days and 78.44 days) when the sowing date was on 15 Nov and the irrigation frequency of five (5) days interval (Table 2 and Table 3). The number of days to heading became lower (71 days and 72 days respectively) when the time of sowing was delayed to 15 December and the irrigation frequency applied at 15 days interval (Table 2 and Table 3). This may be due to the change in temperature as reported by [6], because when the temperature increased plants are stressed and consequently shortened their time of heading. The interaction of sowing date by irrigation frequency on the number of days to heading was not significant. Sowing date on 15 Nov with irrigation frequency at 5 days interval took 82 days while the late sowing date of 15 Dec with the longer interval of irrigation of 15 days took only 70 days to achieve heading of plants (Table 4 and Figure 1).

3.1.2Number of days to Maturity

The physiological maturity followed the same trend like the number of days to heading because the two parameters are very closely related. For instance, the plants took 109 days to mature when planted earlier (15 Nov) but only 96 days were required by plants to be mature when the sowing was delayed to 15 Dec (Table 2). When the irrigation frequency was applied at 5 days interval the physiological maturity was achieved at 106 days; the number of days was significantly reduced to 101 and 99 days when the irrigation interval was respectively 10 and 15 days. The result is in agreement with the findings of [14]who observed a significant hastening of physiological maturity of wheat plants submitted to deficit irrigation in comparison to the well watered plants. Irrigation at short intervals reduced the shortening of the grain-filling duration, thereby allowing the crop to sustain photosynthetic production of biomass and seed yield.The interaction of the two parameters on the time of physiological maturity was not significant; though some differences can be noticed (Figure 1).

3.1.3Plant Height

The data analysis (Table 1) indicated that sowing date significantly affected the plant height. The plant height decreased progressively with the delaying of the time of planting. Plants achieved 98 cm when sown on 15 November whereas these sown on 15 December were only 89.78 cm of height (Table 2). Sowing date influences the plant height as reported by [3]and [6]. The data (Table 1) showed no significant difference of plant height due to the difference in irrigation frequency; the plant height was thus statistically similar. The interaction of the two factors was also not significant (Table 1).

3.1.4Thousand kernel weight

Effect of sowing date was highly significant (Table 1) on thousand kernel weight (TKW) of wheat; the 1000 grains of crops planted on 15 November and 30 November achieved respectively 38.68 g and 39.02 g, while only 31.43 g was recorded with the delayed planting date of 15 December. This might be explained by the heat stress of late sowing resulting in reduction of grain weight. This result is in agreement with[15] who found higher values of TKW with earlier sowing time than late sowing in Sudan. But no significant difference for thousand kernel weight was recorded with regards to irrigation frequency and the interaction between the two factors was also not significant. But, a maximum thousand kernel weight of 42.23 g was achieved when wheat crop was planted on 15 November and irrigated each 5 days (Table 4)

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Table 1: ANOVA table with mean square values of different parameters studied

Irrig&SowDate	DF	Heading(Days)	Maturity(Days)	Plant_Height(cm)	T.kernel.wght(g)	Grain.Yield(kg/ha)
Replication	2	2.481	4.333	54.11	63.521	3909090
Irrigation freq.	2	95.370**	140.444**	565.78 ns	71.848 ns	21325104**
Sowing date	2	90.704***	368.111***	150.11 **	165.288***	7414334***
Irrig*Sowing Date	4	1.759 ns	3.222 ns	44.22 ns	4.516 ns	408784 ns

Error	26	16.199	42.94	95.38	28.75	2968629

Table 2: Mean values of different parameters for sowing date

Sowing Date	Heading(Days)	Maturity(Days)	Plant_Height(cm)	T.kernel.wght(g)	Grain.Yield(kg/ha)
Nov. 15	77.78 a	108.67 a	97.67 a	38.68 a	4395 a
Nov. 30	75.00 b	101.78 b	95.56 ab	39.02 a	4259 a
Dec. 15	71.44 c	95.89 c	89.78 b	31.43 b	2759 b
(LSD)	1.144	1.927	4.538	2.557	578.6

Table 3: Mean values of different parameters for irrigation frequency

Irrigation freq.	Heading(Days)	Maturity(Days)	Plant_Height(cm)	T.kernel.wght(g)	Grain.Yield(kg/ha)
5 Days	78.44 a	106.56 a	103.44 a	39.12 a	5545 a
10 Days	73.44 b	100.78 b	90.56 a	36.53 a	3244 ab
15 Days	72.33 b	99.00 b	89.00 a	33.48 a	2623 b
(LSD)	3.080	3.914	15.049	4.798	1661.1

Table 4: Effet of SowingDate x Irrigation interaction on the different parameters

Irrig&SowDate	Heading(Days)	Maturity(Days)	Plant_Height(cm)	T.kernel.wght(g)	Grain.Yield(kg/ha)
Nov.15 x 5Days	82.33 a	114.00 a	103.33 a	42.23 a	6389 a
Nov.15 x 10Days	76.3 abc	106.33 ab	94.33 a	37.27 abc	3653 ab
Nov.15 x 15Days	74.7 bcd	105.67 b	95.33 a	36.53 abc	3144 ab
Nov.30 x 5Days	78.7 ab	105.33 b	104.33 a	41.77 ab	6235 a
Nov.30 x 10Days	73.7 bcde	100.67 bc	90.67 a	39.73 ab	3611 ab
Nov.30 x 15Days	72.7 bcde	99.33 bc	91.67 a	35.57 abc	2931 c
Dec.15 x 5Days	74.33 cde	100.33 bc	102.67 a	33.37 bc	4012 b
Dec.15 x 10Days	70.33 de	95.33 cd	86.67 a	32.60 abc	2469 c
Dec.15 x 15Days	69.67 e	92.00 d	80.00 a	28.33 c	1796 c
(LSD)	3.088	4.168	14.808	5.245	1652.7

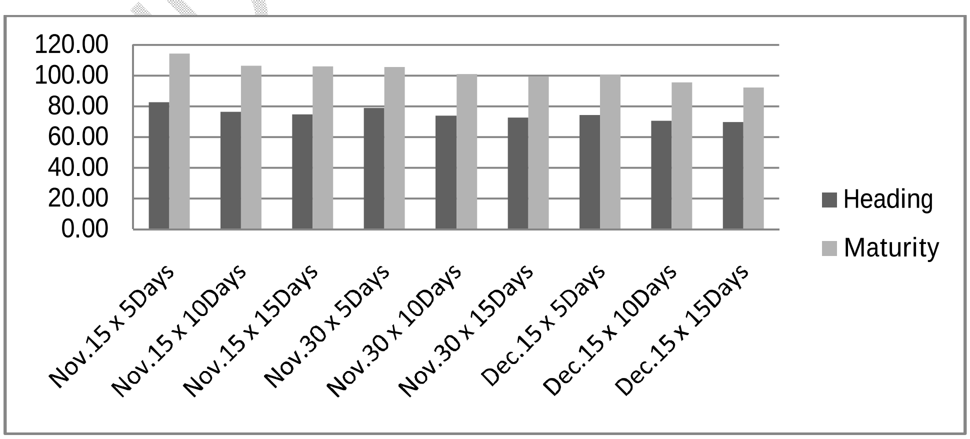

Figure 1:Effect of interaction sowing date by irrigation frequency on number of days to heading and maturity

3.1.4 Grain Yield

Both sowing date and irrigation frequency significantly influenced the grain yield (Table 1). The sowing dates 15 November and 30 November, statistically similar, produced respectively 4395 kg/ha and 4259 kg/ha. Grain yield drastically dropped to 2759 kg/ha when the sowing was delayed to 15 December (Table 2). That correlation between the sowing date and the grain yield has been reported by [5], [6] and other researchers.

A high yield of 5545 kg/ha was achieved with 5 days interval of irrigation (Table 3); and then the grain yield significantly dropped to 3244 kg/ha and 2623 kg/ha when plants were irrigated 10 and15 days respectively. A similar result was reported by [16]. However the interaction of the two factors was not significant; although the highest yield (6389 kg/ha) was achieved with the combination of early planting (15 November) of wheat and the shortest interval of irrigation (5 days). A grain yield of6235 kg/ha was obtained with 30 November sowing date x 5 days irrigation interval (Table 4 and Figure 2). But a more realistic yield of 3653 kg/ha is more affordable by farmers with an early planting time of 15 November combined with a reasonable irrigation frequency of 10 days interval (Table 4 and Figure 2). The sowing date of 15 December associated with a 15 days interval of irrigation resulted in a very low yield of 1796 kg/ha corresponding to a loss of 71.88 % from the highest value of yield achieved.

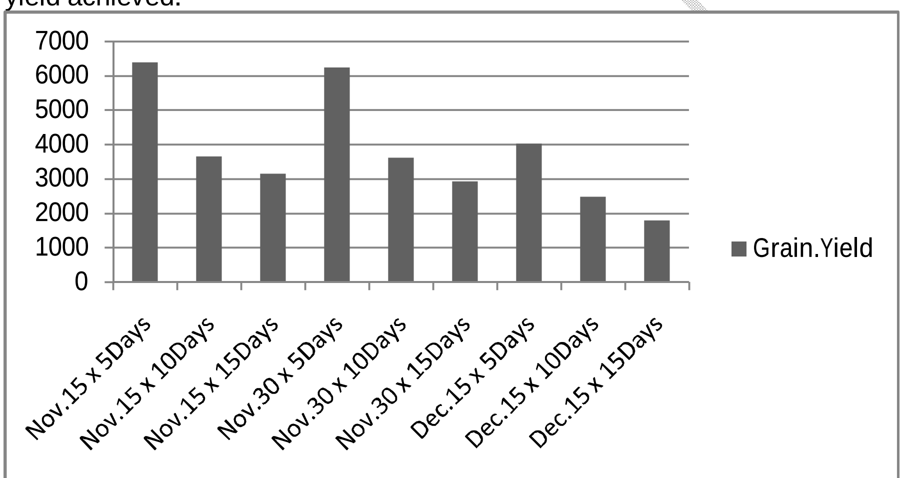

Figure 2: interaction effect of sowing date and irrigation frequency on grain yield

4. CONCLUSION

This study has highlighted how critical are the sowing date and the irrigation frequency in wheat production in Southern Niger republic. Earlier sowing (15 to 30 November) of wheat made the plants to take sufficient time to grow and develop during the vegetative and the reproductive stages by increasing the number of days to heading, the number of days to maturity, the plant height, the weight of thousand kernels and all put together resulted in higher grain yield. As well, the irrigation frequency showed the key role that it plays in the achievement of high yield in wheat production. The irrigation at 5 days interval gave the highest yield more than 10 and 15 days interval. However the irrigation each 5 days from planting to harvesting will definitely result in high cost of production due to excessive water use. Further researches, including economical evaluation should be carried out to determine the appropriate irrigation schedule which will lead to an optimum and economic yield. In agronomic view, the interval of 7 days and 10 days should be properly evaluated in the future.

APPENDICES

Appendix 1: Physical properties of the soil of the experimental site of Djirataoua

Particle size distribution	
Sand (g kg-1)	510.6
Silt (g kg-1)	327.7
Clay (g kg-1)	161.6
Texture	Loamy
Water Holding Capacity (%)	57.2

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