



GROWTH AND GRAIN YIELD OF TRITICALE AS INFLUENCED BY IRRIGATION INTERVALS, NITROGEN RATES AND WEEDING REGIMES

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ABSTRACT

Field experiment was conducted during 2014, 2015 and 2016 dry seasons at Saulawa (Latitude 12°40'11"N and Longitude 7°48'19"E) in Katsina State to study the response of triticale (*Triticale tritico-secale* wittmack) to irrigation intervals, nitrogen rates and weeding regimes. The treatments consisted of 3 irrigation intervals (5, 7 and 9 days), 4 nitrogen rates (0, 60, 90 and 120 kg N ha⁻¹) and 3 weeding regimes (No weeding, one weeding at 20 days after sowing (DAS) and two weeding at 20 and 40 DAS). These were factorially combined and arranged in a split plot design with three replications. Irrigation intervals were allocated to main plot while nitrogen rates and weeding regimes were allocated to the sub-plots. Data were collected on Leaf area index, Crop growth rate, Net assimilation, 1000 grain weight and Grain yield. All data collected were subjected to analysis of variance (ANOVA) and Duncan's Multiple Range Test (DMRT) was adopted in separating the means. Results of the experiment revealed a significant ($P \leq 0.05$) difference among the treatments throughout the study period. The result further showed that, growth and yield of triticale were significantly ($P \leq 0.05$) higher at 5 days irrigation interval with the application of 120 kg N ha⁻¹ and weeded twice at 20 and 40 DAS. Irrigation interval beyond 5 days significantly ($P \leq 0.05$) decreased triticale growth and yield. Application of 120 kg N ha⁻¹ significantly ($P \leq 0.05$) influenced growth and yield of the crop. Similarly, two weeding at 20 and 40 DAS significantly ($P \leq 0.05$) increased yield and most of the growth characters. Based on the result of this findings, growing triticale under 5 days irrigation interval with the application of 120 kg N ha⁻¹ and two weeding at 20 and 40 DAS influenced growth and yield of the crop and is therefore recommended for better yield in the study area.

Key words: Triticale, NAR, CGR, Nitrogen

INTRODUCTION

Triticale (*Triticale tritico-secale* wittmack) is a hybrid cereal crop developed by crossing wheat (*Triticum turgidum* or *Triticale aestivum*) and rye (*Secale cereale*) pollen. The objective of making wheat/rye crosses was to capture the best traits of each species. Wheat yields and grain qualities are better than rye. But rye has better disease resistance and better tolerance to environmental stress. The area under cultivation of triticale (both winter and spring cultivars) in the world increased from 2.49 million ha. in 2000 to 3.81 million ha in 2019 growing at an average annual rate of 2.47%. The world production of triticale was however, 14,060,433 t ha⁻¹ and yield of 36,927 kg ha⁻¹. Triticale is a newly introduced crop in Nigeria and grown under irrigation condition. The primary producers of triticale are however, Poland, Germany, Belarus, France and Russia (FAO 2019).

Irrigation water is in short supply and thus it is more important that water must be judiciously used in a way that crop growth does not suffer (Aremu and Chari, 1987). Nitrogen is an essential nutrient, and often the most yield limiting for cereal production. High cost, scarcity and poor distribution of fertilizer has however, made the commodity not always easily



available to resource poor farmers. Traditional manual weeding is the most popular method of weed control in Nigeria. This is however, time consuming, tedious and labour intensive, strenuous and generally expensive as such beyond farmers (Joshua and Gworgwor, 2000). This study is therefore carried out to assess the influence of irrigation interval, nitrogen fertilizer and weeding frequency on growth and yield of triticale.

MATERIALS AND METHODS

The experiment was conducted during 2014, 2015 and 2016 dry seasons under irrigation from December- March at the Saulawa Irrigation Site in Bindawa Local Government of Katsina State, located at Latitude $12^{\circ} 40' N$ and longitude $7^{\circ} 48' E$ at an altitude of 465m above sea level (Google Earth, 2017) in the Sudan savanna agro-ecological zone of Nigeria. The area has a long dry season that is characterized by cool dry air during harmattan from November to February and hot dry air during hot season from March to May. Rainfall in the area lasts for 4-5 months in a year, starting from late May or early June to September/October. The average annual rainfall in the area is reported to be 600 mm. Potential evapo-transpiration is about 1700-1800 mm per annum and the mean annual temperature ranges from $14^{\circ}C$ to $38^{\circ}C$ (Google Earth, 2017).

The treatments consisted of three irrigation intervals (5, 7 and 9 days), four nitrogen levels (0, 60, 90 and 120 kg N ha^{-1}) and three weeding regimes (No weeding, one hoe weeding at 20 days after sowing [DAS] and two hoe weeding at 20 and 40 DAS). The experiment was laid out in split-plot design with three replications. Irrigation was allocated to main plot while factorial combinations of nitrogen levels and weeding regimes were allocated in the sub-plots. The land was cleared manually and then ploughed, harrowed, leveled and made into appropriate plots. Basins were constructed manually and the boarders were raised to 10 cm height to minimize seepage. Plots were marked out with 1.0 m irrigation channels. Gross plot size was $6 \times 1.38 \text{ m}$ (9.28 m^2) and net plot size was $5 \times 0.92 \text{ m}$ (4.60 m^2). Distance of 0.5 m between subplots and 2 m between main plots and between blocks was maintained throughout the trial period.

In each season, spring triticale seeds variety 'Abase' obtained from the Department of Agronomy, Bayero University, Kano were sown on 15th November each year by drilling at 2 cm depth at the seed rate of 120 kg ha^{-1} . A spacing of 23 cm inter row and 5 cm intra row was maintained. There were six rows in each sub-plot. Irrigation was carried out by surface flooding in which each plot is filled to capacity using channels from tube- well. For the first two weeks after sowing, irrigation was carried out at five days interval, thereafter the irrigation treatment was imposed accordingly. Nitrogen was applied in form of NPK 15:15:15 and urea. Half of the N in form of NPK was applied at sowing while the remaining half was applied at 40 DAS using urea 46% N. data were collected on leaf area index using LI- 3000 portable leaf meter, crop growth rate, net assimilation rate, 1000 grain weight and grain yield. All data collected were subjected to analysis of variance (ANOVA) using SPSS (2.0) and Duncan's Multiple Range Test (DMRT) was adopted in separating the means.

RESULTS

Leaf Area Index

The result of the response of leaf area index (LAI) to irrigation intervals, nitrogen levels and weeding regimes is presented in Table 1. The result revealed a significant ($P \leq 0.05$) effect of irrigation intervals on LAI throughout the periods under consideration. The result further indicated that, irrigation at 5 days interval recorded significantly ($P \leq 0.05$) higher LAI followed by 7 days and the least was obtained at 9 days irrigation interval, with the exception of 2015



where irrigation at 5 days and 7 days interval were statistically ($P \leq 0.05$) similar. The result of the effect of nitrogen levels on LAI showed that, except at 2014 dry season where application of 120 kg N/ha proved to be significantly ($P \leq 0.05$) better, no significant ($P \leq 0.05$) difference was recorded in 2015 and 2016. The result also showed that, weeding frequency had no significant ($P \leq 0.05$) effect of LAI of triticale throughout the study period.

The result of the interaction of irrigation intervals and weeding regimes on leaf area index during 2014 dry season (Table 2) revealed that, irrigating the crop at 5 days interval with twice weeding at 20 and 40 DAS significantly ($P \leq 0.05$) increased the LAI better than the other treatments considered.

Table 1: Response of Triticale to Irrigation intervals, Nitrogen levels and Weeding regimes on Leaf Area Index (LAI) at 90 DAS during 2014, 2015 and 2016 Dry Seasons

Treatment	Leaf Area Index		
	2014	2015	2016
Irrigation intervals (days)			
5	2.42a	3.11a	3.02a
7	2.19b	3.05a	2.69b
9	2.11c	2.59b	2.52c
Level of Significance	**	**	**
SE \pm	0.021	0.052	0.042
Nitrogen levels (kg ha⁻¹)			
0	2.20b	2.87	2.72
60	2.20b	2.91	2.73
90	2.21b	2.92	2.74
120	2.35a	2.94	2.76
Level of Significance	**	NS	NS
SE \pm	0.023	0.052	0.042
Weeding regimes (DAS)			
0	2.21	2.87	2.70
1	2.24	2.94	2.75
2	2.25	2.94	2.78
Level of Significance	NS	NS	NS
SE \pm	0.022	0.052	0.042
Interaction			
I * N	NS	NS	NS
I * W	**	NS	NS
N * W	NS	NS	NS
I * N * W	NS	NS	NS

Means on the same column followed by similar letter (s) were not statistically different by DMRT.

** = Significant at 1% level of probability, SE \pm = standard error.



Table 2: Interaction of irrigation intervals and weeding regimes on Leaf Area Index during 2014

Treatments	Irrigation Intervals (days)		
	5	7	9
Weeding Regimes (DAS)			
No weeding	2.02 ^e	2.15 ^d	2.06 ^e
20	2.36 ^b	2.21 ^c	2.11 ^{de}
20 & 40	2.54 ^a	2.21 ^c	2.15 ^d
LS		**	
SE±		0.026	

Means on the same column followed by similar letter (s) were not statistically different by DMRT.

** = Significant at 1% level of probability, SE± = standard error, LS = Level of significance.

CROP GROWTH RATE (CGR)

Crop growth rate as affected by irrigation interval, nitrogen level and weeding regimes in 2014, 2015 and 2016 dry seasons is presented in Table 3. The result revealed a significant ($P \leq 0.05$) difference among the treatments throughout the study period. The result further indicated that, CGR was significantly ($P \leq 0.05$) affected by irrigation intervals for the period under consideration. CGR decreased with increase in irrigation interval. Irrigation at 5 and days interval recorded the highest CGR and the least CGR was obtained at 9 days interval throughout the period under study. The result also showed that, nitrogen application significantly ($P \leq 0.05$) influenced CGR for the periods under consideration. The result further indicated that CGR significantly ($P \leq 0.05$) increased with increase in nitrogen levels. However, in 2015 and 2016 nitrogen applied at 90 and 120 kg N ha⁻¹ were statistically ($P \leq 0.05$) similar. The response of CGR to weeding regimes was observed to be significant ($P \leq 0.05$) for the period under consideration. The result showed that CGR increased with increase in weeding frequency except in 2015 and 2016 dry seasons where weeding at 20 DAS and two weeding at 20 and 40 DAS were found to be statistically ($P \leq 0.05$) the same. Control plot on the other hand, the recorded the least CGR.



Table 3: Response of Triticale to Irrigation Intervals, Nitrogen Levels and Weeding Regimes on Crop Growth Rate in 2014, 2015 and 2016 Dry Seasons.

Treatment	Crop Growth Rate ($\text{g m}^{-1} \text{day}^{-1}$)		
	2014	2015	2016
Irrigation intervals (days)			
5	12.23 ^a	15.55 ^a	12.99 ^a
7	11.13 ^b	14.67 ^b	11.03 ^b
9	10.18 ^c	11.91 ^c	9.78 ^c
Level of Significance	**	**	**
SE \pm	0.080	0.201	0.172
Nitrogen levels (kg ha^{-1})			
0	10.59 ^c	13.35 ^b	10.64 ^b
60	11.01 ^b	13.94 ^{ab}	11.19 ^{ab}
90	11.47 ^a	14.32 ^a	11.54 ^a
120	11.64 ^a	14.56 ^a	11.69 ^a
Level of Significance	**	**	**
SE \pm	0.091	0.232	0.222
Weeding regimes (DAS)			
No weeding	10.72 ^c	13.67 ^b	10.98 ^b
20	11.24 ^b	13.97 ^{ab}	11.08 ^b
20 & 40	11.58 ^a	14.50 ^a	11.72 ^a
Level of Significance	**	*	**
SE \pm	0.082	0.201	0.171
Interaction			
I * N	NS	NS	NS
I * W	NS	NS	NS
N * W	NS	NS	NS
I * N * W	NS	NS	NS

Means on the same column followed by similar letter (s) were not statistically different by DMRT.

** = Significant at 1% level of probability, SE \pm = standard error, NS = Not significant,

Net Assimilation Rate (NAR)

Table 4 shows result of the effect of irrigation intervals, nitrogen levels and weeding regimes on net assimilation rate (NAR). The result as presented in Table 4 indicated significant ($P \leq 0.05$) response of NAR to irrigation interval in all the sampling periods. The result further revealed that, irrigation at 5 days intervals recorded the highest NAR, though statistically ($P \leq 0.05$) similar with 7 days during 2014 and 2016 dry seasons but significantly ($P \leq 0.05$) better than 9 days throughout the study period. The application of nitrogen was found significantly ($P \leq 0.05$) influenced NAR with highest response recorded under 120 kg ha^{-1} though statistically ($P \leq 0.05$) similar with 90 kg N ha^{-1} but significantly ($P \leq 0.05$) better than the other rates throughout the study period. The response of NAR to weeding regimes was found to be significantly ($P \leq 0.05$) different with two weeding at 20 and 40 DAS taken the lead, except in 2016 dry season where one and two weeding were statistically ($P \leq 0.05$) similar but significantly ($P \leq 0.05$) better than the control.



Table 4: Response of Triticale to Irrigation Intervals, Nitrogen Levels and Weeding Regimes on Net Assimilation Rate during 2014, 2015 and 2016 Dry Seasons

Treatments	Net Assimilation Rate ($\text{g dm}^{-2} \text{ day}^{-1}$)		
	2014	2015	2016
Irrigation interval (days)			
5	4.91 ^a	3.67 ^a	4.510 ^a
7	4.73 ^b	3.44 ^b	4.322 ^a
9	4.58 ^c	3.34 ^b	3.921 ^b
Level of Significance	**	**	**
SE \pm	0.032	0.032	0.060
Nitrogen levels (kg ha^{-1})			
0	4.54 ^c	3.29 ^b	4.049 ^b
60	4.69 ^b	3.50 ^a	4.140 ^b
90	4.79 ^b	3.55 ^a	4.407 ^a
120	4.94 ^a	3.58 ^a	4.408 ^a
Level of Significance	**	**	**
SE \pm	0.032	0.041	0.062
Weeding regimes			
No weeding	4.44 ^c	3.35 ^b	4.020 ^b
20	4.83 ^b	3.54 ^a	4.299 ^a
20 & 40	4.94 ^a	3.55 ^a	4.432 ^a
Level of Significance	**	**	**
SE \pm	0.032	0.031	0.060
Interaction			
I * N	NS	NS	NS
I * W	NS	NS	NS
N * W	NS	NS	NS
I * N * W	NS	NS	NS

Means on the same column followed by similar letter (s) were not statistically different by DMRT.

** = Significant at 1% level of probability, SE \pm = standard error, NS = Not significant,

Grain Yield

The influence of irrigation intervals, nitrogen levels and weeding regimes on grain yield of triticale in 2013/2014, 2014/2015 and 2015/2016 is presented in Table 10. Irrigation interval had highly significant ($P \leq 0.01$) effect on grain yield in all the three years trials. Grain yield significantly decreased with increase in irrigation interval in all the trials. Irrigation intervals of 5 days recorded the maximum grain yield which was higher than 7 days interval and the least grain yield was obtained at the 9 days irrigation interval throughout the experimentation periods.

Nitrogen levels had significant effect on triticale grain yield in all the trials. Application of 120 kg N ha^{-1} significantly produced higher grain yield and the least grain yield was obtained in the control plots.

Weeding regimes had significant effect on triticale grain yield in all the trials. Two weeding done at 20 and 40 DAS produced significantly higher grain yield. This was followed by one weeding done at 20 DAS and the least was obtained in the control plot.



The interaction between irrigation intervals and weeding regimes on grain yield of triticale at Saulawa in 2013/2014 to 2015/2016 dry season was significant ($P \leq 0.05$; Table 11). In 2013/2014 there was no significant effect on grain yield in kg ha^{-1} between 7 and 9 days irrigation interval when the crop was not weeded. But when the crop was weeded once or twice there were significant differences between 7 and 9 days irrigation interval. In 2014/2015 there was no significant difference between 5 and 7 days irrigation interval when the crop was weeded once or twice. Grain yield was however, significantly decrease with increased in irrigation interval when the crop was weeded twice. Similarly, in 2015/2016 when the crop was not weeded increase in irrigation interval had no significant effect on grain yield ha^{-1} .

Table 5: Response of Triticale to Irrigation intervals, Nitrogen levels and Weeding regimes on Grain Yield (t ha^{-1}) at Saulawa in 2013/14, 2014/15 and 2015/2016 Dry Seasons.

Treatment	Grain Yield t ha^{-1}		
	2013/2014	2014/2015	2015/2016
Irrigation intervals (days)			
5	1.65a	1.40a	1.51a
7	1.30b	1.24b	1.34b
9	1.06c	0.95c	1.02c
Level of Significance	**	**	**
SE \pm	0.023	0.025	0.033
Nitrogen levels (kg ha^{-1})			
0	1.16d	1.04c	1.13c
60	1.27c	1.14bc	1.19bc
90	1.38b	1.25b	1.33b
120	1.52a	1.36a	1.49a
Level of Significance	**	**	**
SE \pm	0.262	0.295	0.389
Weeding regimes (DAS)			
No weeding	0.90c	0.82c	0.83c
20	1.29b	1.13b	1.25b
20 & 40	1.82a	1.64a	1.79a
Level of Significance	**	**	**
SE \pm	0.230	0.255	0.337
Interaction			
I * N	NS	NS	NS
I * W	**	**	**
N * W	NS	NS	NS
I * N * W	NS	NS	NS

Means in columns or rows followed by similar letter (s) were not statistically different at 1% level of probability using Tukey HSD.

NS = Not significant

** = Significant at 1% level of probability

Table 6: Irrigation Interval x Weeding Regime Interaction on Grain Yield ($t\ ha^{-1}$) of triticale at Saulawa in 2013/2014- 2015/2016 Dry Seasons.

	Irrigation intervals (days)		
Treatment	5	7	9
Weeding regimes (DAS)			
		2013/2014	
No weeding	1.10e	0.90ef	0.72f
20	1.60bc	1.31d	0.92e
20 & 40	2.31a	1.71b	1.52c
SE±		0.041	
		2014/2015	
No weeding	0.92d	0.82de	0.72e
20	1.26c	1.19c	0.94d
20 & 40	2.01a	1.72b	1.20c
SE±		0.044	
		2015/2016	
No weeding	0.93c	1.37b	0.77c
20	1.52b	1.28b	0.93c
20 & 40	2.06a	1.94a	0.79c
SE±		0.058	

Means in columns or rows followed by similar letter (s) were not statistically different at 1% level of probability using Tukey HSD.

DISCUSSION

The result indicated that irrigation at 5 days interval resulted in higher LAI in all the treatments while irrigation at 9 days interval resulted in lower LAI. These higher LAI at 5 days irrigation interval indicates increased ability of plant canopy to intercept photosynthetically active radiation and it is generally acknowledged that growth rate of a plant is a function of its LAI (Baloch *et al.* (2014).

Bishnupriya *et al.* (2018) reported that leaf area index (LAI), crop growth rate (CGR) and grain yield of wheat significantly increased with increase in nitrogen level up to $150\ kg\ N\ ha^{-1}$. Amanullah *et al.* (2017) in their work on wheat, rye, barley and oats had reported significant variations in AGR, CGR and NAR among the four crops at different growth stages and NPK source. The leaf area index, crop growth rate, and grain yield of wheat were significantly increased except 1000-grain weight with increase in nitrogen level up to $150\ kg\ N\ ha^{-1}$. Akram (2011) had reported that moisture stress at different crop growth stages reduced LAI, CGR and NAR significantly as compared to that of the fully irrigated plants.

Water stress significantly reduced the grains spike $^{-1}$, 1000 grain weight and grain yield. Ghanbari and Abolfazl (2013) reported that the lowest amount of yield components was achieved from without irrigation treatment (dry farming) and without consumption of nitrogen fertilizer. Djukie *et al.* (2010) reported the highest triticale grain yield with application of $180\ kg\ N\ ha^{-1}$. Tababtabaei *et al.* (2012) had reported that the highest grain yield of triticale ($6.1\ ton\ ha^{-1}$) was obtained with application of $160\ kg\ N\ ha^{-1}$.

Iqbal and Hussain (2012) reported that 120 and $150\ kg\ ha^{-1}$ levels of nitrogen fertilizer significantly increased the 1000-grain weight and grain yield. Maqsood *et al.* (2010) reported that weight of spike $^{-1}$ and 1000-grain weight significantly increased with increasing nitrogen



levels. Mahdi *et al.* (2016) reported that wheat yield increased by increasing nitrogen rate from 50 to 75 kg N ha⁻¹ from 2.44 to 2.48 t ha⁻¹ respectively.

Abebe and Manchore (2016) reported that application of different levels of nitrogen significantly affected grain yield of wheat in farmers' field. This is because well balanced supply of nitrogen at optimal amount, resulted in higher NAR and increased grain yield. Amjed *et al.* (2011) reported that 1000-grain weight and grain yield significantly increased by increasing the nitrogen. Excessive use of nitrogen fertilizer however, leads to an increase in the growth period, production of more vegetative organs and ultimately decreases grain yield and increase of the number of infertile grains (Basso & Ritchie, 2005). Abdo (2009) had similarly, reported that excessive N fertilizer application however, had toxic effect on crop and resulted for less grain yield.

Turk *et al.* (2003) reported the highest number of grain spikes⁻¹ and grain yield of barley under 120 kg N ha⁻¹. Higher weight of grain spike⁻¹ and grain yield in wheat was however, reported by Javaid *et al.* (2012) at nitrogen level of 125 kg ha⁻¹. Similarly, Narolia (2013) reported that increasing nitrogen from 60 to 90 kg ha⁻¹ significantly enhanced yield attributes and yield of malting barley.

The influence of weeding regimes on grain weight spike⁻¹ was significant in all the three trials. Maximum weight of grain spike⁻¹ was obtained from plots that received two weeding at 20 and 40 DAS. Competition between triticale plants and weeds for essential nutrients and water was lower in case of two weeding compared to one weeding and the control trials. Under two weeding condition, plants got maximum nutrients, light and water, which is in conformity with the earlier results of Lado *et al.* (2004) who reported that the highest grain yield was produced from weed free plot as a result of less competition of weeds.

This interaction was earlier reported by Matsunaka *et al.* (1992) who stated that optimum irrigation increased nitrogen absorption by the crop; leading to a greater number of tillers, larger leaves and a greater yield because soil moisture conditions affected nutrient availability to the crops. Maqsood *et al.* (2002) had reported a significant interaction between irrigation interval and nitrogen levels as they affected number of grains per spike⁻¹. Bradford (1994) showed that application of nitrogen in water stress condition led to improvement of 1000-seed weight. Imam *et al.* (2009) reported that water stress and nitrogen deficit led to severe decrease of yield. The 1000-grain weight and grain yield increased significantly due to increase in nitrogen fertilizer levels up to 210 kg ha⁻¹ under well-watered and up to 105 kg ha⁻¹ under post flowering drought stress conditions (Moukhtar, 2010). Benin *et al.* (2012) also observed higher response to nitrogen application when the water regime was suitable to crop growth. Kobata *et al.* (1992) showed that drought stress and nitrogen fertilizer deficit led to seed yield decrease. In this research, it was generally observed that supplying of enough moisture and suitable amounts of nitrogen fertilizer increased growth and grain yield of triticale.

Higher growth parameters and yield were recorded under irrigation at 5 days interval and weed free plots because fewer weeds were observed in two weeding which resulted in increased nutrient, water, space and light supply to the triticale crop due to absence of crop-weed competition. This in turn might have resulted in greater photosynthesis and hence better translocation of photosynthates beside larger sink and stronger reproductive phase. Similarly, longer irrigation interval and un-weeded plots recorded poor crop growth which might be due to higher weed competition that reduces the availability of soil moisture and nutrients to the crop plants resulted significantly to lower grain yield of triticale and this was in conformity with the report of Singh *et al.* (2013), Chhoker, *et al.* (2013) and Verma *et al.* (2014).



CONCLUSION AND RECOMMENDATION

The result indicated that each increase in irrigation interval beyond 5 days significantly decreased LAI, CGR, NAR, grain weight spike⁻¹, 1000 grain weight and grain yield. Application of 120 kg N ha⁻¹ significantly increased all the parameters similarly, weeding done twice at 20 & 40 DAS produced the best in growth parameters and grain yield.

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