

Effect of Irrigation Schedules, Nitrogen rates and Weeding regimes on Harvest Index, Water use Efficiency and Protein Content of Triticale (*Triticale tritico-secale wittmack*)

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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 determine the Effect of irrigation schedules, nitrogen rates and weeding regimes on Harvest Index, Water use Efficiency and Protein Content of Triticale (*Triticale tritico-secale Wittmack*). Treatment were irrigation interval at (5, 7 and 9 days), nitrogen levels (0, 60, 90 and 120 kg N ha⁻¹) and weeding regimes (No weeding, one weeding at 20 days after sowing (DAS) and two weeding at 20 and 40 DAS) which were arranged in a split plot design with three replications. Irrigation intervals were allocated to main plot while factorial combinations of nitrogen levels and weeding regimes were the sub-plots. Data collected were subjected to analysis of variance. Significantly higher harvest index, protein content and more water use efficiency were observed at 5 days irrigation interval, 120 kg N ha⁻¹ and weeding done twice at 20 and 40 DAS throughout the period of the research. The interaction between irrigation interval and weeding regime on harvest index and water use efficiency of triticale at Saulawa in 2014 - 2016 dry seasons were found to be significant at $P \leq 0.05$. In 2014 dry season, when the crop was not weeded there was no significant difference between the irrigation schedules. When the crop was weeded once however, irrigation at 7 and 9 days interval was statistically similar. In 2015/2016 dry season, irrigation intervals were statistically similar when weeding was done once. The results obtained revealed that irrigation at 5 days interval, 120 kg N ha⁻¹ and two weeding done at 20 & 40 DAS produced significantly highest harvest index, protein content and maximum water use efficiency.

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INTRODUCTION

Triticale (*Triticale tritico-secale* Wittmack) been a hybrid cereal crop developed by crossing wheat (*Triticum turgidum* or *Triticale aestivum*) and rye (*Secale cereale*) pollen. The yields and grain qualities of Wheat are better than rye, but rye has better disease resistance and tolerance to

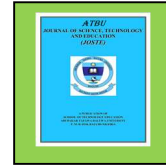
environmental stress. Triticale has similarities with wheat but varies significantly in plant height, larger inflorescence, high grain yield, resistance to biotic and abiotic stresses and valuable grain composition (Zecevic *et al.*, 2010) when compared with wheat. Despite these features, triticale grain is mainly used as a fodder crop for livestock feed,

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it can be used for making porridge, bread, pasta, pastry and beer (Amaya and Pena, 2011). According to FAO (2019), the sown area 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 14,060,433 t ha⁻¹ and yield of 36,927 kg ha⁻¹. The important primary producers of triticale are Poland, Germany, Belarus, France and Russia.

Proper irrigation scheduling is essential for the efficient use of water, energy and other production inputs. Water needs of crop are of paramount importance in determining the time of irrigation during the crop-growing season (Passioura, 2007). Proper irrigation interval has been identified to significantly increase tiller production in wheat (Lado *et al.*, 2005). According to Baloch *et al.* (2014) in a field trial, wheat crop irrigated five times resulted maximum plant height, number of grains spike⁻¹, biological yield, grain yield and harvest index as compared to four irrigations and three irrigations. Increase in irrigation regime increased days to maturity, and decreased water use efficiency (Onyibe 2004). Ngwako (2013) reported that irrigating winter wheat throughout the growing stages increased number of tillers, number of grains per spike, grain yield, and harvest index and grain protein.

Nitrogen is one of the most important mineral nutrients for Poaceae plants influencing growth, development, yield, and protein content of grains (Kousar *et al.*, 2015). Narolia (2013) reported that increasing nitrogen from 60 to 90 kg ha⁻¹ significantly enhanced plant height, yield attributes and yields, harvest index, grain protein concentration and net returns of malting barley.

Pandey *et al.* (2000) also reported highest harvest index in weed free condition is due to less competition with weeds. Hoque *et al.* (2011) reported that grain yield, straw yield, biological yield and harvest index were significantly affected by weeding regime. Rafiquddaula (1999) reported that lowest spikelets spike⁻¹ from no weeding and the highest from weed free regime. Competition between triticale and weeds for essential nutrients and

water was lower in case of two weeding compared to no weeding as reported by Hoque *et al.* (2011). Weeding improved highest plant height which might be due to the availability of more nutrients from a weed free environment as reported by Nano (2016) and due to less competition Dadari *et al.*, (2000). Kabir *et al.* (2014) observed a reduction in weight of grain spike⁻¹ due to weed competition. Pandey *et al.* (2000) who reported that the highest harvest index in weed free condition was due to less competition with weeds. Therefore, the objectives of the study was to investigate the effect of irrigation schedules, nitrogen levels and weeding regimes on harvest index, water use efficiency and protein content of triticale.

MATERIALS AND METHODS

Field experiment was conducted during the 2014 - 2015 and 2016 dry seasons under irrigation from November- March at the Saulawa Irrigation Site in Bindawa Local Government of Katsina State, located in the Sudan savanna agro-ecological zone of Nigeria (Latitude 12° 40' N and longitude 7° 48' E at an altitude of 465m above sea level) (Google Earth, 2017). 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. Long term mean 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°C to 38°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 weedings 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.

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The land was cleared manually and then ploughed, harrowed, leveled and made into appropriate plots. Basins were constructed manually and the borders were raised to 10 cm height to minimize seepage. Plots were marked out with 1.0 m irrigation channels. Gross plot size was 6 x 1.38 m (9.28 m²) and net plot size was 5 x 0.92 m (4.60 m²). 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 between rows and 5 cm from plant to plant 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.

Harvest Index (HI)

The ratio of grain yield to total biological yield for each plot was calculated using the formula of Harper (1983) and expressed in per cent.

$$\text{Harvest index \%} = \frac{\text{Grain yield (t/ha)}}{\text{Total biological yield (t/ha)}} \times 100$$

Water Use Efficiency (WUE)

Water use efficiency is defined as the unit of yield produced per unit of available water (Sinclair, *et al.*, 1984).

$$\text{Water Use Efficiency} = \frac{\text{Grain yield (kg/ha)}}{\text{Irrigation water used (l)}}$$

Protein Content (%)

The nitrogen content in triticale grain was estimated by modified microjeldal method. The protein content (PC) was calculated from the N content in whole grain by multiplying the nitrogen content with the factor (6.25) as described by Tai and Young, 1974 with the following formula:

$$\text{PC (g Kg}^{-1}\text{)} = \text{N (g Kg}^{-1}\text{)} \times 6.25$$

Data generated from the experiment were subjected to analysis of variance using whole model statistical software and means were separated and compared using Tukey's Studentized Range Test (HSD) as described by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Harvest Index

Table 1 shows the effect of irrigation intervals, nitrogen levels and weeding regimes during 2014 to 2016 dry seasons. Harvest index increased significantly with decreased in irrigation interval in all the three years of experimentation. Irrigation interval of 5 days produced the highest HI, which was higher than 7 days interval and the least was recorded in the control plot.

The effect of nitrogen levels on harvest index (HI) was highly significant. Highest harvest index was recorded from 120 kg N ha⁻¹ (23, 21 and 23%) and the least was obtained from the control plot. Nitrogen level applied at 90 and 120 kg ha⁻¹ were statistically similar in 2014/2015 and 2015/2016 dry seasons.

Weeding regime was highly significant in all the trials. Two weedings done at 20 and 40 DAS recorded significantly the highest harvest index which was followed by one weeding at 20 DAS and the least HI was recorded from the control plots.

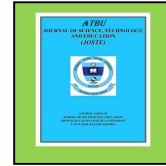
These results are similar to those of Ngwako and Mashiqa (2013) who found reduced values of harvest index under water stress conditions the harvest index indicates the distribution of photosynthesis materials between the economic and other reservoirs of the plant. The reason of harvest index reduction probably is the fact the

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translocation of assimilates to the grain has decreased due to lack of moisture and leads to a reduction in grain yield. It also reported that harvest index decreased under drought stress due to the effect of drought stress on grain yield. The result of many researchers showed that drought stress at different stages of growth of wheat lead to a reduction in the yield of biomass, grain yield, harvest index and grain yield components of wheat Gooding *et al.*, 2003; Garcia *et al.*, 2003; and Parvaneh *et al.*, 2014). Van den Boogaard *et al.* (1996) reported reduced values of harvest index under water stress conditions.

The interaction between irrigation interval and weeding regime on harvest index of triticale at Saulawa in 2013/2014- 2015/2016 dry seasons was significant ($P \leq 0.05$; Table 2). When the crop was weeded once or twice, increase in irrigation interval significantly increased the harvest index in 2013/2014. But when the crop was not weeded there was no significant difference between 7 and 9 days irrigation interval. In 2014/2015 increase in irrigation interval from 5 to 7 days had no significant effect on HI when the crop was not weeded or it was weeded once. When the crop was weeded twice however, HI was significantly decreased with increase in irrigation interval. In 2015/2016 increase in irrigation intervals did not significantly affected the HI when the crop was not weeded. However, when the crop was weeded once or twice irrigation at 5 and 7 days interval was statistically similar.

Protein Content (%)

The data on protein content (PC) as affected by irrigation intervals, nitrogen fertilizer levels and weeding regimes is presented in Table 3. Irrigation has no effect on PC in 2013/2014 dry season. However, significant difference was recorded in 2014/2015 trial. Irrigation interval at 5 days recorded significantly higher PC which was statistically similar with 7 days interval in 2015/2016 dry season. However, irrigation at 9 days interval produced the least PC.

Nitrogen levels had significant ($P \leq 0.01$) effect on PC in all the dry seasons. Nitrogen applied at 120 kg ha⁻¹ recorded the maximum PC

which was significantly similar with 90 kg N ha⁻¹ in 2015/2016 trial. The PC increases with increase in nitrogen rate. The least PC was recorded in the control plot.

Weeding regimes had significant ($P \leq 0.01$) effect on PC. Two weedings at 20 and 40 DAS recorded higher PC, while the least was recorded in the control plot. The interactions among the treatment factors on PC were not significant in all the seasons.

Water Use Efficiency (WUE)

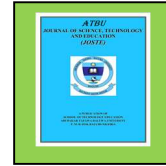
Table 4 shows the effect of irrigation intervals, nitrogen levels and weeding regimes on water use efficiency for the three years. Irrigation intervals had no significant effect on WUE in 2013/14 dry season. Crops irrigated at 5 and 7 days intervals recorded similar WUE in 2014/15 and 2015/16 dry seasons, which were significantly higher than that irrigated at 9 days intervals. Nitrogen levels had significant ($P \leq 0.01$) effect on WUE. Nitrogen applied at 120 kg ha⁻¹ recorded the highest WUE except in 2015/16 dry season that was statistically similar with 90 kg ha⁻¹, the least WUE was obtained in the control plot. The effect of weeding regime on WUE differs significantly in all the trails. Weeding done twice at 20 and 40 DAS recorded significantly higher WUE, this was followed by one weeding while the least was obtained in the control plot. Bhat *et al.* (2006) reported that water use varied with application of different nitrogen levels with enhancement of rate from 90 to 120 kg N ha⁻¹. Gajri *et al.* (1997) also observed that WUE increased with increasing N rates from 0-120 kg ha⁻¹ in wheat. . Bhat *et al.* (2006) obtained higher WUE by 3.64 kg grain ha⁻¹ cm⁻¹ in wheat irrigated at 65mm CPE over the control. Higher water use efficiency was obviously due to higher yield accompanied by saving irrigation water as reported by Singh and Singh (2004). The interactions between irrigation intervals and weeding regimes on WUE during 2015 and 2016 were significant ($P \leq 0.05$; Table 5). In 2014 dry season, when the crop was not weeded there was no significant difference between the irrigation intervals. When the crop was weeded once however, irrigation at 7 and 9

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days interval was statistically similar. In 2015/2016 dry season, irrigation intervals were statistically similar when weeding was done once.

CONCLUSION

From the finding of this investigation, it could be concluded that irrigation at 5 days interval, 120 kg N ha⁻¹ and two weeding at 20 &

40 DAS produced significantly highest harvest index, protein content and maximum water use efficiency, it may be recommended that applying 120 kg N ha⁻¹, two weeding done at 20 & 40 days After Sowing and 5 days irrigation interval was suggested for triticale production in Saulawa area of Sudan savanna ecological zone of Nigeria.

Table 1: Response of Triticale to Irrigation intervals, Nitrogen levels and Weeding regimes on

Treatments	Harvest Index (%)		
	2014	2015	2016
Irrigation intervals (days)			
5	25a	22a	23a
7	20b	19b	21b
9	16c	15c	16c
Level of Significance	**	**	**
SE±	0.420	0.421	0.501
Nitrogen levels (kg ha ⁻¹)			
0	19c	17c	18c
60	20bc	18bc	19bc
90	22b	19ab	21ab
120	23a	21a	23a
Level of Significance	**	**	**
SE±	0.422	0.422	0.612
Weeding regimes (DAS)			
No weeding	17c	14c	14c
20	20b	18b	19b
20 & 40	26a	25a	26a
Level of Significance	**	**	**
SE±	0.401	0.401	0.521
Interactions			
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 5% level of probability using Tukey HSD. NS = Not significant; ** = Significant at 1% level of probability.

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Table 2: Irrigation intervals x weeding regimes Interaction on Triticale Harvest Index (%)

Treatments	Irrigation intervals (days)		
	5	7	9
Weeding regimes (DAS)			
2013/2014			
No weeding	18d	15e	12e
20	25b	20cd	15e
20 & 40	34a	25b	22c
SE±	0.601		
2014/2015			
No weeding	15de	14ef	12f
20	19c	18cd	14ef
20 & 40	30a	26b	18cd
SE±	0.601		
2015/2016			
No weeding	16cd	13d	13c
20	24b	20bc	14b
20 & 40	31a	30a	21b
SE±	0.902		

Means followed by similar letter (s) were not statistically different at 5% level of probability using Tukey HSD.

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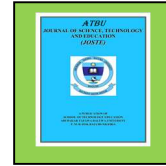


Table 3: Response of Triticale to Irrigation intervals, Nitrogen levels and Weeding regimes on Protein Content (%)

Treatment	2014	2015	2016
Irrigation intervals (days)			
5	12.69	12.91a	13.17a
7	12.63	12.84b	13.11a
9	12.60	12.42c	12.26b
Level of Significance	NS	**	NS
SE±	0.062	0.071	0.091
Nitrogen levels (kg ha ⁻¹)			
0	12.09d	12.19d	12.30c
60	12.45c	12.55c	12.67bc
90	12.79b	12.88b	13.00ab
120	13.22a	13.28a	13.40a
Level of Significance	**	**	**
SE±	0.071	0.082	0.112
Weeding regimes (DAS)			
No weeding	11.23c	11.33c	11.45c
20	12.52b	12.62b	12.74b
20 & 40	14.16a	14.24a	14.36a
Level of Significance	**	**	**
SE±	0.061	0.071	0.092
Interaction			
I * N	NS	NS	NS
I * W	NS	NS	NS
N * W	NS	NS	NS
I * N * W	NS	NS	NS

Means 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.

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Table 4: Response of Triticale to Irrigation intervals, Nitrogen levels and Weeding regimes on Water Use Efficiency

Treatment	2014	2015	2016
Irrigation intervals (days)			
5	1.96	1.88a	2.03a
7	1.94	1.77a	1.89a
9	1.83	1.55b	1.67b
Level of Significance	NS	**	**
SE±	0.042	0.042	0.051
Nitrogen levels (kg ha ⁻¹)			
0	1.66c	1.51c	1.634c
60	1.83c	1.65bc	1.727bc
90	1.99b	1.80b	1.938ab
120	2.19a	2.00a	2.156a
Level of Significance	**	**	**
SE±	0.042	0.053	0.062
Weeding regimes (DAS)			
No weeding	1.30c	1.20c	1.213c
20	1.84b	1.65b	1.785b
20 & 40	2.62a	2.35a	2.592a
Level of Significance	**	**	**
SE±	0.042	0.042	0.053
Interaction			
I * N	NS	NS	NS
I * W	NS	**	**
N * W	NS	NS	NS
I * N * W	NS	NS	NS

Means followed by similar letter (s) were not statistically different at 5% level of probability using Tukey HSD.
** = Significant at 1% level of probability; NS = Not significant;

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Table 5: Irrigation intervals x weeding regimes Interaction on Triticale Water Use Efficiency

Treatments	Irrigation intervals (days)		
	5	7	9
Weeding regimes (DAS)			
2013/2014			
No weeding	1.02e	2.24de	1.33de
20	1.39d	1.79c	1.74c
20 & 40	2.22b	2.60a	2.22b
SE±		0.062	
2015/2016			
No weeding	1.03e	1.18de	1.42d
20	1.69c	1.94c	1.72c
20 & 40	2.29b	2.94a	2.53b
SE±		0.062	

Means in columns or rows followed by similar letter (s) were not statistically different at 5% level of probability using Tukey HSD.

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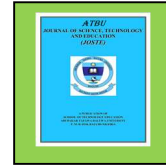
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