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Effect of industrial wastewater irrigation and NP Fertilizers on yield and yield components of Bread wheat (Triticum aestivum L.) under greenhouse condition

Amare Tadesse[1], Dawit Habte[1], Kassu Tadesse[1] and Wubengda Admasa

[1,] Ethiopia Institute of Agricultural Research, Kulumsa Agriculture Research Center
Corresponding Author's email: amare.ashu22@gmail.com, kasstad96@yahoo.com

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In order to study the effects of Barley washed out wastewater with different levels of inorganic fertilizers on growth, Yield and Yield Components of Bread Wheat (*Triticum aestivum* L.), Pot experiment was conducted during February–July, 2014 under greenhouse condition at Kulumsa Agricultural Research Center. Factorial combination of five levels of irrigation water and four levels of NP fertilizers rate were used as treatments and laid out in CRD design with three replication. Analysis of variance illustrated that the use of barley washed out wastewater (blended water) for irrigation purpose resulted better growth, yield and yield component in comparison with natural water irrigation. The main effect of irrigation water was showed highly significant (p<0.01) effect on all measured growth, yield and yield components of bread wheat. Likewise; application of different levels of NP fertilizers rate bring about significant variation on most yield and yield attributer data, except PH, TKW and HI. The combined effect of irrigation water and NP fertilizers rate was significant on most growth, yield and yield components, except TKW and HI of bread wheat. The highest number of tiller per pot, spike length, number of seed per spike, biological and grain yield were obtained from 50% affluent + 50% natural irrigation water with application of 67% RNP fertilizer rate. Therefore, we conclude that application 50% affluent water + 50% natural irrigation water with 67% RNP fertilizer rate provide better yield and yield attributes.

Key words: Bread wheat, Fertilizers, Irrigation, Greenhouse and Waste water

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INTRODUCTION

The demand for water is continuously increasing in arid and semi-arid countries. Therefore, water of higher quality is preserved for domestic use while that of lower quality is recommended for irrigation. The use of industrial or municipal wastewater in agriculture is a common practice in many parts of the world (Ensink *et al*., 2002; Kiziloglu *et al*., 2008). Domestic wastewater rich in organic materials and plant nutrients are finding agricultural use as a cheap way of disposal. Use of domestic wastewater in agriculture may contribute considerable to alleviate the pressure in using fresh water resources. Wastewater from different sources contains considerable amount of organic matter and plant nutrients (N, P, K, Ca, S, Cu, Mn & Zn) and has been reported to increase the crop yield (Tavassoli A. *et al* 2010).

Kulumsa Agricultural Research Center is working on generation of technologies mainly for grain crops. However, the development and supply of technologies to users is low enough to meet the increasing demand for improved technologies, as all of the research and seed multiplication activities are done during the main rainfall season only. In order to improve the speed of generation and distribution of improved technologies on major crops, irrigation project was developed with the strategic aim to continue the research and seed multiplication activities through the off-season.

The Research Center is endowed with an opportunity with respect to availability of water for both supplementary and full irrigation from the existing Assela Malt Factory (AMF) and an intermittent river flow that originate from Kulumsa watershed. After the completion of construction of reservoir and line canals and installation of sprinkler system, irrigation works started. Initial laboratory analysis of the waste water, malt extract, conducted before pot experimentation indicated that it contained no harmful substances for plant growth.

According to Kuforidgy (1994), the general feature of malt extract is a multi- component and balanced system of physiologically active substances of metabolic origin, harmless to environment. However, it is not only the nature of chemical species in affluent water that determines its suitability for irrigation; but also the level of concentration of chemical substances. Salt accumulations in soils from poor quality irrigation water reduce availability of water to crops. Certain ions (sodium, chloride or boron) from soil or water accumulate in a sensitive crop to toxic levels to cause crop damage and reduce yields. Excessive accumulation of essential nutrients from any source can cause damage to crop growth and yield (Jones, 2012). Therefore, a pot experiment was conducted with the objective to evaluate the effect of various proportions of barley washed-out waste water in irrigation and determine optimum irrigation water and fertilizer rate for better growth, yield and yield components of bread wheat.

MATERIALS AND METHODS

Description of experimental site

Pot experiment was conducted at Kulumsa Agricultural Research Center (KARC), Arsi zone during February–July, 2014 under greenhouse condition. The site lies at $08^0$01’10’’North latitude, $39^0$09’11’’East longitude and an altitude of 2250 m.a.s.l. It was received mean annual rain fall of 840 mm, with most of the rain falling between June and September. The average monthly minimum and maximum temperature of 8.5 to 11.9 ^{0}C and 22.7 to 24.9 ^{0}C temperature range, respectively. The dominant soil is Haplic Luvisols (Ethio-Italian Development Cooperation, 2002).

Treatment and design

Factorial combination of five levels of irrigation water such as (100% fresh water, 25% affluent + 75 natural, 50% affluent +50% natural, 75% affluent+ 25% natural, and 100% affluent water) and four levels of NP fertilizers rate (No fertilizer, 33% RNP, 67% RNP, 100% RNP) were used as treatments and laid out in CRD design with three replication. The recommended nitrogen and phosphorus (RNP) fertilizer rate is 100 kg/ha urea + 150 kg/ha DAP. Sixty pots of size 24.5 cm top and 21cm bottom diameter and height of 25cm were arranged in 3 rows; and about 9 kg of soil air dried and passed through 10mm sieve was added to each. A total of 16 seeds of bread wheat (variety, Kekeba) randomly placed in each pot were buried to a depth of about 4 cm by hand. Fertilizer treatments, both N and P from urea and DAP sources, were applied once during planting and mixed with the soil. Water treatments were given at 0.5 L/ pot at interval of 4 days for a total of 134 days.

All pots were made free from weeds throughout the growing period by using hand weeding. For the control of rust disease a triazole fungicide (48% Propiconazole) was used.

Data collection

Growth data such as Plant height(cm), Seedling density, number of tillers per plant, number of spike per pot, spike length(cm) and number of seed per spike were collected at appropriate time Hundred culm weights (G100C and B100C) were collected from 10 plants per pot, slashed from close to the soil surface.

Grain yield determined by hand threshing of all plants harvested/pot. Yield adjustments were made based on 12.5% moisture content. Above ground biomass yields determined based on data of hundred culm weights and harvest index (HI). TKW determined by weighing 250 grains and multiplying by 4. The NSPS determined by averaging hand counts of grains from 7 spike samples. Grain moisture content determined using Grain Moisture Analyzer (HOH-EXPRESS HE 50). Harvest index was calculated as the ratio of grain yield to above ground biomass per pot multiplied by 100 at harvest from the respective treatments. Information on disease and pest incidences and lodging was also collected.

Table 1. Main effects of irrigation water and fertilizer rates on the growth components

Sources of Variation	Growth parameters					
	SDPP	PH (cm)	NSPP	NTPP	SPL cm)	NSPS
100% NW	16.17[c]	78[c]	13.29[d]	16.83[c]	7.17[b]	34.72[c]
25%AW:75%NW	18.67[a]	92[ab]	28.92[b]	32.33[a]	7.58[ab]	37.58[b]
50%AW:50%NW	17.83[ab]	92.25[a]	30.75[a]	31.5[a]	7.83[a]	43.83[a]
75%AW:25%NW	17[ab]	86.42[b]	23.5[c]	26.83[b]	7.33[b]	38.13[b]
100% AW	14.83[d]	69[d]	14.17[d]	16.75[c]	6.16[c]	31.83[d]
LSD	0.95	5.77	1.32	01.2	0.49	2.18
FR1 (0/0)	15.93[c]	81.5	19.77[c]	23.13[c]	6.93[bc]	34.59[c]
FR2 (16.5/ 23)	17.46[b]	84.6	23.6[b]	26.47[b]	7.27[b]	38.44[b]
FR3 (33/46)	18.47[a]	85.8	27.2[a]	28.67[a]	7.93[a]	40.76[a]
FR4 (46/69)	15.73[c]	82.2	17.93[d]	21.13[d]	6.73[c]	35.1[c]
LSD	0.84	ns	1.18	1.07	0.44	1.95
D*F	**	*	**	**	**	**
CV	6.7	8.3	7.2	5.8	8.3	7.1

AW=Affluent water, NW=Natural water, and F1, F2, F3, F4 stand for fertilizer rates of 0%, 33%, 67%, and 100%, SDPP=Seedling density/pot, PH=Plant height (cm), NSPP=No of Spikes/ pot, NTPP=No of tillers/ plant, SPL=Spike length (cm) and NSPS=No of seeds/ spike

Data Analysis

Analysis of variance on growth, yield and yield component data were statistically analyzed using SAS statistical computer package program to determine the treatment effects (SAS, 2002). The means separation was carried out by Duncan's multiple range test (LSD) at $p<0.05$.

Result and Discussion

Main effects of irrigation water and fertilizer rates on the growth components

The main effect of irrigation water (blended water) was showed highly significant ($p<0.01$) effect on all measured growth parameters of bread wheat (Table 1). Analysis of variance revealed that the use of barley washed out wastewater for irrigation purpose resulted better growth performance in comparison with natural water irrigation. The highest amount of Number of spike per plant (30.75), Number of tiller per pot (31.5) , Spike length per plant (7.83cm) and Number of seed per spike (43.83) was obtained from 50% affluent (wastewater) +50% natural water (Table 3) which are statistically significant with control treatment. The increase of growth parameters of wheat could be related to the amount of enough nutritious elements (such as N, P and K) in wastewater. Similar research finding reported by Alizadeh et al. (2001) who reported that irrigation treatment with wastewater in all the growth stages cause the most biological yield of corn to be achieved.

Likewise; application of different levels of NP fertilizers rate bring about significant variation on most growth parameters, except PH. The main effect of NP fertilizers rate on SDDP, NSPP, NTPP, SPL and NSPS was showed highly significant ($p<0.01$) effect (table 2). The highest amount of Number of spike per plant (27.2), Number of tiller per pot (28.67) , Spike length per plant (7.93cm) and Number of seed per spike (40.76) was obtained from plot received 67% RNP (Table 1) which are statistically significant with control treatment.

Main effects of irrigation water and fertilizer rates on Yield and yield component parameters

Analysis of variance revealed that the use of barley washed out wastewater for irrigation purpose resulted better Yield and yield components performance in comparison with natural water irrigation. Application of blended water was showed highly significant ($p<0.01$) effect on all measured yield and yield components of bread wheat (Table 2). The highest amount of Biomass yield (0.08kg/pot) and Grain yield (0.036kg/pot) was obtained from 50% affluent (wastewater) +50% natural (Table 2) which are statistically significant with control treatment.

Table 2. Main effects of irrigation water and fertilizer rates on the Yield and yield components

Sources of Variation	**Yield and yield component parameters**			
	GY kg/pot	BY kg/pot	TKW gm/pot	HI
100% NW	0.026^{bc}	0.057^{bc}	37.5^{ab}	43.84^{ab}
25%AW:75%NW	0.03^{b}	0.065^{b}	40.33^{a}	45.6^{a}
50%AW:50%NW	0.036^{a}	0.08^{a}	40^{a}	46.31^{a}
75%AW:25%NW	0.025^{c}	0.058^{bc}	36^{b}	43.27^{ab}
100% AW	0.023^{c}	0.052^{c}	36.67^{ab}	39.49^{b}
LSD	0.004	0.012	3.96	4.91
F1 (0/0)	0.023^{c}	0.049^{c}	38	44.28
F2 (16.5/ 23)	0.028^{b}	0.064^{b}	37.87	44.03
F3 (33/46)	0.037^{a}	0.081^{a}	39.2	44.48
F4 (46/69)	0.025^{cb}	0.057^{cb}	37.33	41.91
LSD	0.004	0.01	ns	ns
D*F	**	**	ns	ns
CV	17.05	23.69	12.62	13.63

AW=Affluent water, NW=Natural water, and F1, F2, F3, F4 stand for fertilizer rates of 0%, 33%, 67%, and 100%, GY= grain yield, BY= biological yield, TKW=1000 kernel weight, HI= harvest index

Table 3: Interaction effect of ration of AM: NW ratios in (blended water) and fertilizer rates

Ratios of AW:NW	Grain yield (kg/pot)				Biomass yield (kg/pot)			
	F1	F2	F3	F4	F1	F2	F3	F4
100% NW	0.02^{bc}	0.02^{bc}	0.03^{abc}	0.04^{bc}	0.04^{bc}	0.05^{bc}	0.06^{abc}	0.07^{bc}
25%AW:75%NW	0.02^{bc}	0.02^{b}	0.05^{ab}	0.02^{bc}	0.05^{bc}	0.06^{b}	0.11^{ab}	0.05^{bc}
50%AW:50%NW	0.02^{ac}	0.04^{ab}	0.06^{a}	0.03^{abc}	0.04^{ac}	0.08^{ab}	0.12^{a}	0.07^{abc}
75%AW:25%NW	0.02^{c}	0.03^{bc}	0.02^{bc}	0.02^{bc}	0.05^{bc}	0.08^{ab}	0.06^{abc}	0.05^{bc}
100% AW	0.03^{c}	0.02^{bc}	0.02^{bc}	0.02^{abc}	0.06^{c}	0.05^{bc}	0.05^{bc}	0.04^{bc}

Where: AW=Affluent water, NW=Natural water, and F1, F2, F3, F4 stand for fertilizer rates of 0%, 33%, 67%, and 100% of the recommended fertilizer (N/ P_2O_5).

The increase of yield and yield component of wheat could be related to the amount of enough nutritious elements (such as N, P and K) in wastewater. Similar research finding reported by Munir (2007) on forage crops who reported that irrigation with wastewater for two years was caused increasing of barley biomass. The same way; application of different levels of N and P fertilizers rate bring significant ($p<0.01$) variation on biomass and grain yield but not TKW and Harvest index (table 2). The highest (0.081kg/pot), (0.037 kg/pot) and lowest (0.023kg/pot), (0.049 kg/pot) amount of Biomass and grain yield were obtained from plot treated with 67% RNP and control, respectively.

Interaction effects of irrigation water and fertilizer rates on major Yield and yield components

The interaction effect of the two factors was show highly significant effect on all measured yield and yield components, except TKW and HI, (table 3). Positive responses to fertilizer rates were obtained from 33% to 67 % RNP, with water ratios of 25% affluent to 75% natural water and 50% affluent to 50% natural water (table 3). The data in table 3 clearly indicate that the interaction effects highly influenced the yield and yield components. Any treatment factor combinations with water ratios above 50% affluent to 50% natural water and fertilizer rates above 67% reduced the responses. At ratio of 50% affluent to 50% natural water, grain increased by

66 and 138% as the fertilizer application increased from 0 to 33 and 67% RNP, respectively. These results indicate that chemical fertilizers N and P alone can increase yields. But the increase in yield of wheat to chemical fertilizer NP is low when compared to the combined effect of the two treatment factors. Generally, the yield and yield component responses were positively affected by the intermediate combinations of the two factors, indicating the presence of net contributions of various nutrient elements in the affluent water. Aziz (2010) reported that irrigation with wastewater and foliar application with Mn and Zn caused increasing the biological yield in millet.

CONCLUSION AND RECOMMENDATIONS

In order to study the effects of treated barley washed out wastewater with different levels of NP fertilizers on growth, Yield and Yield Components of Bread Wheat (Triticum aestivum L.), Pot experiment was conducted during February–July, 2014 under greenhouse condition at Kulumsa Agricultural Research Center. The above mentioned result concluded that use of barley washed out wastewater for irrigation purpose resulted better growth, yield and yield components in comparison with natural water irrigation. The same way; application of different levels of N and P fertilizers rate bring significant ($p<0.01$) variation on biomass and grain yield but not TKW and Harvest index. The interaction effect of the two factors revealed that highly significant effect on all measured yield and yield components, except TKW and HI.

Positive responses to fertilizer rates were obtained from 33% to 67 % RNP, with water ratios of 25% affluent to 75% natural water and 50% affluent to 50% natural water. The highest number of tiller per pot, spike length, number of seed per spike, biological and grain yield were obtained from 50% affluent water + 50% natural irrigation water with application of 67% RNP fertilizer rate. Therefore, we conclude that application 50% affluent water + 50% natural irrigation water with 67% RNP fertilizer rate provide better yield and yield attribute. Generally, there is a need for further work under field conditions to validate the pot experiment results. Yet, the information obtained could be used as guide for the current irrigation management.

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