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Effect of blended irrigation water quality on soil physico-chemical properties and cotton yield in Middle Awash Basin Ethiopia

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Awash River is the main irrigation water source for mechanized farms and small land farmers established in the Basin for the last few decades. Recently, with the rise of Beseka Lake, the amount of discharging rate into the Awash has been a serious concern to Agricultural Production in the Middle and Lower Awash Areas. This study was conducted to evaluate the effects of Beseka Lake on irrigation water quality, soil physical–chemicals properties and Cotton yield. Seven levels of Awash River and Beseka Lake blended water (8, 10, 15, 20, 25, 30 and 50% of Beseka water) and a control (0% of Beseka water) as a treatment were arranged in randomized complete blocks design with three replications. Yield of cotton showed significant ($p<0.05$) difference among irrigation treatments and maximum yield of 41.393 q/ha was obtained from the control treatment and significantly differed from all other treatments. Blended irrigation water had impact on soil properties which decreased yield with increasing blending ratio. Soil properties, such as electrical conductivity (EC) (1.18), exchangeable sodium percentage (ESP) (12.95), as well as pH (8.66), increased due to blending effect of Beseka water. Blended irrigation water treatment ratio of 8% gave the highest yield (39.143 q/ha) and reduced yield by 5% as compared to the control treatment (41.39q/ha).

Key words: Irrigation water quality, blended irrigation water, Beseka lake, soil properties, cotton yield, awash river.

INTRODUCTION

Background and justification

Water is critical for sustainable livelihoods and is impossible for a single life to live without it. Water is vital to the survival of ecosystems, and plants and animals that live in them, and in turn ecosystems, help to regulate the quantity and quality of water (Rosegrant et al., 2002). Over 97% of the world's water resources is in the oceans and seas and is too salty for most productive uses. Two thirds of the remainder is locked up in ice caps, glaciers,

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permafrost, swamps, and deep aquifers (Seckler et al., 1998). At global level, the withdrawal ratios are 70% agricultural, 11% municipal and 19% industrial (Food and Agricultural Organization (FAO), 2014).

Agriculture is the main stay of Ethiopia's economy, providing the livelihood base for nearly 83% of the population, contributing over 50% of gross domestic product, and accounting for about 90% of foreign exchange earnings (Fassil, 2009). Based upon the various river basin master plans, net irrigation potentials of Ethiopia have been estimated as 2.6 million hectares and the gross irrigation potential is about 3.7 million hectares (Seleshi and Mokonnen, 2011).

Awash River basin has a catchment area of 112,696 km^2 and originates from Central West part of Ethiopia, flowing 1200 km long, and provides a number of benefits to Ethiopia. Relatively, the most utilized river basin and the only river entirely in the country. The total mean annual flow from the river basins is estimated to be 4.9 billion cubic meters (Awulachew et al., 2007).

Recently, the river faces a great environmental concern; mainly the saline water of Beseka lake expansion affects the surface and ground water dynamics and soil properties of the region and the condition is specifically dangerous for the sustainability of Matahara Sugar Estate and Matahara town in particular, and the Awash river basin in general (Megersa et al., 2009). This would be disastrous, as the quality of the river water will be deteriorated such that agricultural development downstream (such as in Amibara Irrigation scheme) would be at risk (Eleni, 2009).

The expanding Beseka lake is in less than 3 km from the River Awash, which is the source of drinking water and irrigation for millions of people downstream. If the lake continues to expand at the current rate and other influencing factors remain the same, the lake will cross the natural water divide and invade the town of Addis Ketema and join the River Awash. This would be disastrous, as the quality of the river water will be polluted and agricultural development downstream (such as in Amibara Irrigation scheme) would be at risk (Eleni, 2009; Megersa et. al., 2009). Hence it was decided to discharge water of Beseka lake into Awash River and reduced its volume to certain level. The blending proportion is fixed to 2% of the Awash River flow rate, during peak flow, which was studied by the Water Resource Authority as harmless. Thus the study identifies effect of blended irrigation water for cotton yield and soil physical and chemical properties, for sustainable use of the water resource, thereby improving the appropriate use of blended irrigation water for agricultural production.

METHODOLOGY

Climatic data

Amibara irrigation scheme, particularly the study area (Werer), falls within the semi-arid agro-climatic zone. Thus, agricultural practices depend on the abstraction of water from the Awash River. The long-term (1972 to 2012 G.C) WARC climatic data indicate the mean and annual rainfall as 560 mm and ET_0 3000 mm/year. Average minimum and maximum temperatures ranged from 14.7°C on December to 37.9°C in June. Relative humidity ranges from 58% in August to 39% in June. Wind speeds were highest in June and July, at about 180 km/day. Daily sunshine hours vary from 7.2 in July to 9.6 h in November. Reference evapotranspiration (ET_0) ranges from 4.1 mm/d in December to 6.8 mm/day in June.

Agricultural practices

The major crops grown in the study area are cotton, maize, sesame, banana and vegetables. Crop production by the state farm and two large private enterprises (Amibara Farm Development and Africa Private farm) is entirely for commercial purposes, while small holders/agro-pastoralists cultivate cotton, sesame and vegetables for cash income and maize for subsistence. The large and medium enterprises practice mono-cropping that is cotton. Banana used to be grown in the former Melka Sedi banana unit, which was later replaced by cotton between 2001 and 2002 (Gedion, 2009). Very recently, the cotton farmland has been replaced by sugarcane plantation.

Experimental design

The samples (amount of water) applied were 8, 10, 15, 20, 25, 30, 50 and control (0% of Lake Beseka) water blended with Awash River water (Table 1). The seven blended irrigation water samples and a control (0% beseka water) were arranged in a randomized complete block design (RCBD) in three replications. Accordingly, the samples including the control treatment were assigned randomly to the experimental units within a block. The amount of water applied to the field was based on Werer Research Center recommended schedule for cotton which was 75 mm every two weeks interval with twice 125 mm pre-irrigation and measured using 3'' Parshal flume.

Experimental layout

The experimental plot sizes were 5*5 m^2 dimensions with recommended plant spacing 25 cm * 80 cm for Cotton. Each plot consisted of 5 rows of 5 m in length and spaced 25 cm apart. A total of 24 plots were arranged in RCBD in three replicationsand Agronomic management was done according to local recommendation.The adjacent blocks and plots were separated by 1.6 m wide-open space and 0.8 m blank rows; respectively.

Data collection

Soil samples were taken before and after harvesting and analyzed for soil chemical and physical properties such as pH, electrical conductivity (EC), exchangeable cation and anion, field capacity (FC), infiltration rate, permanent wilting point (PWP), texture, bulk density (BD). The water samples collected from Awash river (upstream and downstream of lake Beseka) and Lake Beseka were analyzed at WARC laboratory before the experiment period. Agronomic data (yields, and yield parameters) of the cotton were collected according to quality standards such as plant height, stand count, boll number and lint yield set by Ethiopian Institute of Agricultural Research.

Table 1. Fresh river water mixing ratio of Beseka water.

Treatment (T)	Awash water (%)	Beseka Lake water (%)
Treatment 1	92	8
Treatment 2	90	10
Treatment 3	85	15
Treatment 4	80	20
Treatment 5	75	25
Treatment 6	70	30
Treatment 7	50	50
Treatment 8 (control)	100	0

All ratio of mixing irrigation water are on volume basis.

Soil and water sampling and analysis

Soil sampling and preparation

Composite soil samples were taken from the plots up to 0.9 m depth with 0.3 m interval. A total of 45 soil samples were collected before sowing and for the chemical analysis 24 samples were taken from each plot at a depth of 30 cm interval composite into eight (8) after harvesting (Table 4). The soil samples were bagged and properly labeled. Then, soil samples were air dried, grounded and sieved with 2 mm sieve for laboratory characterization and analyzed.

Soil physical and chemical analysis

The soil samples were analyzed for physico-chemical soil properties at Werer Research Soil Laboratory following standard test procedures. Soil texture (particle size distribution), bulk density, and water holding capacity at field capacity and permanent wilting point are some of the physical properties which were determined. Similarly, the soil chemical properties analyzed were soil pH, electrical conductivity (EC), cation exchange capacity (CEC), exchangeable bases (Ca, Mg, K and Na), soluble bases (Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}), anions (Cl^{-}, HCO_3^{-},CO_3^{2-}), sodium absorption ratio (SAR) and Exchangeable sodium percentage (ESP).

Particle size distribution was determined in the laboratory by the modified Bouyoucos hydrometer method (Bouyoucos, 1962) using sodium hexametaphosphate as dispersing agent. Then, the soil textures were determined using the United States Department of Agriculture (USDA) textural triangle. In the field, soil infiltration measurement was made for the identified fields/plots using double ring infiltrometer. Soil bulk density from the undisturbed soil samples were determined following the procedures described in Blake (1965). Soil pH were measured potentiometrically using a digital pH-meter in the supernatant suspension of 1:2.5 soils to distilled water mixture and 1:2.5 (on volume basis) soils to KCl solution in the bathing solution with glass electrode (Baruah and Barthakur, 1997). The EC values measured at the prevailing temperature were converted to EC at 25°C temperature.

Exchangeable bases (Ca^{2+}, Mg^{2+}, K^{+} and Na^{+}) of the soils were extracted by excess ammonium acetate (1 M NH_4OAc at pH 7) solution. Exchangeable Ca^{2+} and Mg^{2+} in the extracts also determined by atomic adsorption spectrophotometer while exchangeable K^{+} and Na^{+} in the extracts were measured by flame photometer (Okalebo et al., 2002). CEC (cmol (+)/kg) of the soils were determined from the ammonium acetate saturated samples through distillation and measurement of ammonium using the modified Kjeldahl procedure as described by Okalebo et al. (2002). Finally, ESP was computed as the percentage of the sum of exchangeable bases and exchangeable Na to the CEC of the soil as follows:

$$\mathbf{ESP(\%)} = \frac{\textbf{Sodium Exchangeable } (\mathbf{Na^{+}})}{\textbf{CEC}} * \mathbf{100} \quad (1)$$

Where concentrations are in cmol(+)/kg of soil.

Basic cations (Ca, Mg, Na, and K) and anions (Cl^{-}, SO_4^{2+}, HCO_3^{-}, $CO_3^{2-}$and NO_3^{-}) were measured on a 1:5 soil water ratio extract following the methods described by the US Salinity Laboratory Staff (Richards, 1954). Soluble Ca and Mg were read using AAS while that of Na and K using flame photometer. Chloride was determined by titrating the extract against 0.1 N $AgNO_3$ solution using potassium chromate as an indicator. The CO_3^{2-} and HCO_3^{2-} ions were also determined by titrating with sulfuric acid (H_2SO_4) to phenolphthalein and methyl orange end points, respectively. Nitrate (NO_3^{-}) content was analyzed as per the methods outlined by Okalebo et al. (2002). Sodium adsorption ratios (SAR) of the soil solution were calculated from the concentrations of soluble Na, Ca and Mg as follows:

$$\mathrm{SAR} = \frac{Na^{+}}{\sqrt{Ca^{2+} + Mg^{2+}}} \quad (2)$$

Then, the soils were classified to the different salinity soil classes based on the criteria established by the USSLS (1954).

Water sampling and analysis

Location of sampling sources and water sampling sites: Water samples were collected from the existing surface irrigation water sources (irrigation canals) and pollution contributing sources such as Lake Beseka along the Awash River. The samples were collected from Beseka Lake at blending point and Werer Research Center Pump Site (MWPS) (Table 2).

Water sampling and preparation: Water samples were collected from 2 sampling sites from March to August, 2014 (Table 7). The water sampling was conducted once per month and lasting to six months. A 35 of total water samples were collected by mixing several portions (sub-samples) taken at 5 min interval in order to obtain representative samples using a grab method. Acid washed polyethylene bottles (2 L) were used to collect irrigation water samples from all the sample sites. The samples were transported to

Table 2. Location of water sampling sites at Awash River.

Site	Sampling site	Northings	Eastings	Elevation
1	Beseka	08° 53" 55'	039° 54" 22'	946.00
2	M.W.P.S	09° 20" 39'	040° 10" 20.6'	749.00

MWPS (Werer Research Center Pumping Site).

the laboratory in dark boxes containing water from the same source to maintain the temperature of the samples close to that of the *in situ* temperature and analyzed for their physical and chemical composition immediately. Generally, the collection and handling of irrigation water samples were done in accordance with the procedure outlined by Richards (1954) and the USSLS (1954). Each of the water sampling points was also registered using global positioning system (GPS).

Water analysis: The collected water samples were subjected for the analysis of pH, EC, dissolved cat ions (Ca, Mg, Na and K), alkalinity (HCO_3^- and CO_3^{2-}) and Cl^- contents in the laboratory. Total dissolved salts (TDS), SAR and residual sodium carbonate (RSC) were estimated from the measured parameters. EC and pH of the water samples were measured in the laboratory within 24 h using conductivity meter and a digital pH meter, respectively (Richards, 1954) with appropriate conversion factors for temperature. Alkalinity (HCO_3^- + CO_3^{2-} ions) was determined by titrating with standard acid (pH of 4.5) within 12 to 24 h of sample collection. Chloride was measured by the mercuric nitrate titrimetric methods outlined by Okalebo et al. (2002) and EIAR quality manual (2013). Ca and Mg ions were measured using atomic absorption spectrophotometer, while Na and K was analyzed using flame photometer. Irrigation water salinity, as total dissolved salts (TDS), was determined by summing the concentration of the individual ions (EIAR Quality Manual, 2013). Moreover, the TDS (mg/l or ppm) can be obtained by multiplying the EC value expressed in mmhos/cm by 640. The SAR value was calculated using equation of SAR with the concentrations expressed in meq/L. The RSC (Equation 3) was determined using from the concentrations of HCO_3^-, CO_3^{2-}, Ca^{2+} and Mg^{2+} ions as follows:

$$\mathbf{RSC} = [(\mathbf{HCO_3^-}) + (\mathbf{CO_3^{2-}}) - (\mathbf{Ca^{2+}}) + (\mathbf{Mg^{2+}})] \quad (3)$$

Where concentrations are expressed in meq/l (USSLS, 1954).

Adjusted RNa (adj. RNa), which is recommended by Suarez (1981) as more acceptable than adjusted SAR and represents the true picture of the SAR was calculated as:

$$\mathbf{Adj.R_{Na}} = \frac{(\mathbf{Na^+})}{\sqrt{\frac{\mathbf{Ca_X^{2+} + Mg^{2+}}}{2}}} \quad (4)$$

Where Na^+ is the concentration of sodium in the irrigation water expressed in meq/L. Ca_X is a modified Ca value set by FAO (1985b). Ca_X represents Ca in the irrigation water but modified due to salinity of the water (EC), its HCO_3/Ca ratio (HCO_3 and Ca in meq/l) and the estimated partial pressure of CO_2 in the top surface of soil is P_{CO2} = 0.0007 atmospheres, and Mg is the concentration of Mg in the irrigation water expressed in meq/L. Finally, the water was classified to the different suitability classes as per the criteria established by FAO (1985b).

Statistical data analysis

Analysis of variance (ANOVA) was used for agronomic and irrigation based experiments. Irrigation water quality data were interpreted and compared with descriptive statistics and applied to all physico-chemical parameters. Results of yields and yield parameters were analyzed using the statistical software analysis (SAS) window 9.0 version.

RESULT AND DISCUSSION

The effects of different blended irrigation water applications on soil physical and chemical properties, cotton crop yield, and blended irrigation water quality studied were presented in subsequent section.

Soil analysis before planting

The result of soil physical parameters analyzed for soil samples taken before planting is shown in Table 3. Based on the observation of the study as indicated in Figure 1, the soil of the field was dominated by silt size fractions. The analytical results indicated that the textural class of the experimental site has a proportion of 31.5% clay, 52.8% silt and 15.7% sand. The results in general, indicated that soil physical properties infiltration rate, water-holding capacity, and bulk density show no change after application of the blended water. This is due to the physical properties nature of soil, it indicated that the effect of blended water on the soil will need further experiment and assessment.

pH

Mixed Beseka and Awash water irrigation treatments applied to the field showed increased soil pH in the experiment site (Figure 2). Soil pH increased after cotton harvest involving Awash water as the first pre irrigation, and fluctuated around (8.5 to 8.9) values attained during the experimentation.

Lower proportion 8,10 and 15% blended water application and intervening higher rainfall might have also helped to reduce the soil pH after harvesting in treatments T1 (8.50), T2 (8.70) and T3 (8.60). Maximum soil pH was found in T5 (8.9) treatments involving a blended water with mixed ratio (30%) except T8 (8.7) which has nearly the same pH before planting. This could mainly be attributed to the fact that the maximum ratio of Beseka water will affect fresh water quality of Awash River. The pH values in treatments T3 (8.60), T2 (8.70)

Table 3. Soil chemical properties of experimental field before sowing.

Depth (cm)	PH	EC (dS/m)	Water soluble cations and ions					Exchangeable cations			SAR	CEC	ESP%
			(Ca+Mg)	Na	CO_3^{2-}	HCO_3^-	Cl^-	Ca+Mg	Na	K			
0-30	8.8	0.8	6.3	1.6	Nil	8	6.8	55.0	1.15	0.25	1.08	56.4	2.0
30-60	8.1	0.82	4.3	1.4	Nil	7	7.7	48.8	1.26	0.17	0.98	50.2	2.3
60-90	8.3	1.69	9.3	1.4	Nil	7	16.5	55.7	2.17	0.37	0.69	58.2	3.73

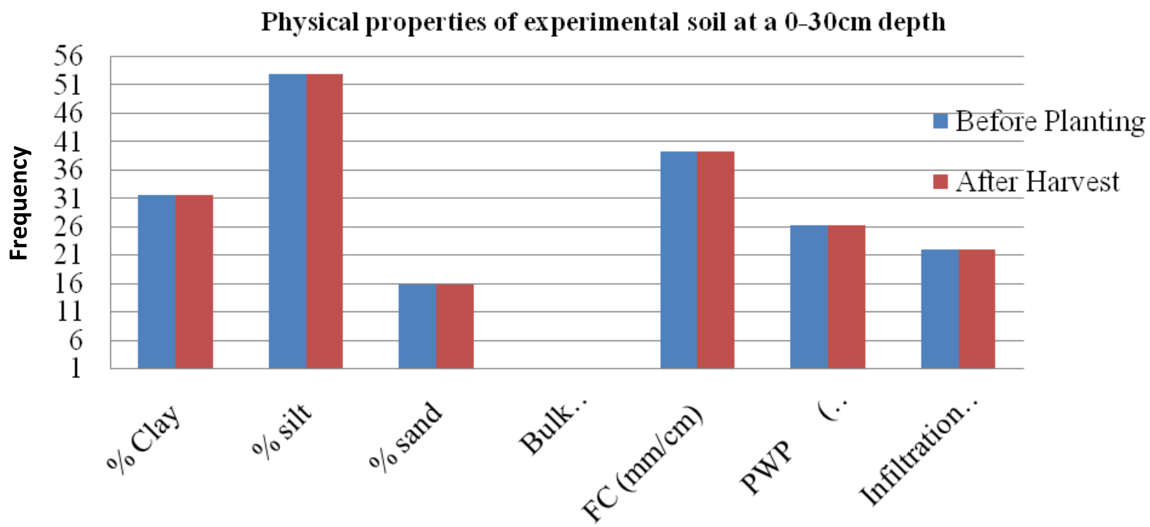

Figure 1. Experimental field soil characteristic of the study area.

and T1 (8.50) tended to be closer to the pH of T8 (8.70) treatment. Other treatments such as T4 (8.7), T6 (8.6) and T5 (8.9) were higher (4 to 8.0) as per the standard of FAO (1985) and the pH increased due to poor irrigation quality. This is due to high bicarbonate and carbonate levels in water which can cause calcium to precipitate from the soil: this reduces the soil's exchangeable calcium content and increases soil sodicity. Magnesium can also be lost in this way. The loss of soil calcium and magnesium will affect plant growth. This demonstrates the use of the blended waters of different ratio which negatively affects the soil and yields of cotton. A similar result was stated that increasing soil pH due to saline irrigation water reduced cotton yield (Chemura. et al., 2011; Chauhan et al., 2007; Anna et al., 2006; Minhas and Gupta, 1993). According to USSSL (1954) soils that have a pH values 7 to 9 are categorized under saline and hinders yield. FAO (1985b) reported that the preferable pH ranges for most crops and productive soils are from 4 to 8. The pH (8.84) result shows nearly saline nature of the soil. Thus, the pH of the experimental soil was within the range of unproductive soils. Thus, results clearly indicate that if Beseka water is diluted to Awash River at a rate higher than

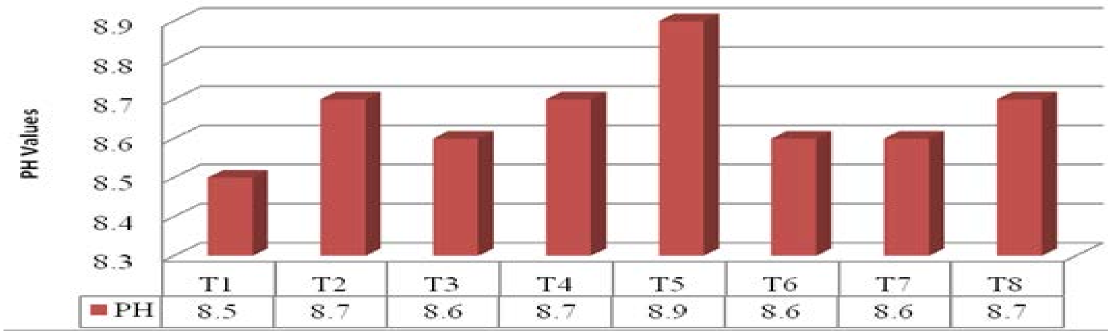

Figure 2. Soil pH values of experimental field.

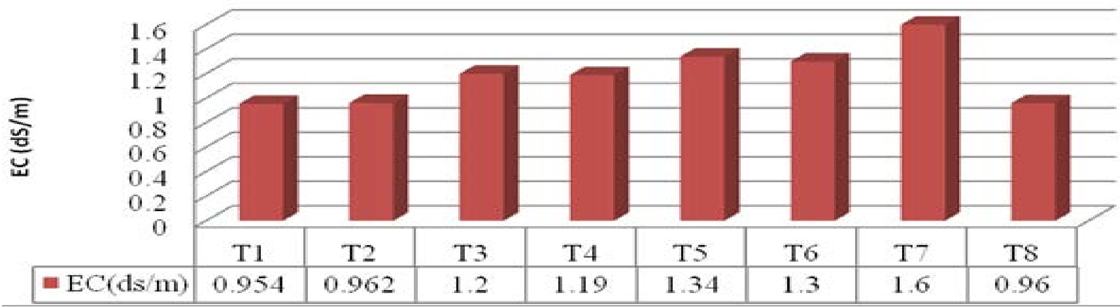

Figure 3. Composite EC (dS/m) values of experimental field after harvesting.

currently in use, which is 2% it will affect the cotton yield and soil quality.

Electrical conductivity (EC)

Electrical conductivity of the soil obtained in irrigation treatments T7 (1.60 dS/m), T6 (1.30 dS/m) and T5 (1.34 dS/m) were higher than other treatments (Figure 3). When Beseka was blended with Awash water, there was increment in EC which remained higher at the end of cropping period. EC values after harvest remained much higher than before planting. The trend in all treatments throughout the soil showed slight increase in EC at 30 cm depth after harvest (Table 4). The EC increased with the increasing salinity of irrigation water, especially in the surface soil (Chauhan et al., 2007).

Electrical conductivity of soil at experiment site before planting was 0.81, 0.83 and 1.92 dS/m at 0 to 30, 30 to 60 and 60 to 90 cm depth, respectively. The EC of the soil increased at harvesting time as compared to the before planting. In general, EC of soil values remained much lower than threshold level of salinity for cotton crop (4.8 dS/m) (Maas, 1987; Maas and Hoffman, 1977).

Blended water with an EC of 12 to 14 dS/m can be used as part of the irrigation water during the last stages of wheat growth even though a yield reduction of about 15% may occur as compared to fresh irrigation water (Dougherty and Hall, 1995; Minhas and Gupta, 1993).

This indicates application of high mixed water aggravate excess salts contained in the root zone, which limits the crop development. Results of this research are similar to findings of Chauhan et al., (2007). Choudhary et al., (2006) and Minhas and Gupta (1993) showed that plants are sensitive to salinity at the beginning of the growth stage. Therefore, according to FAO classification the values of EC of the soil are grouped to be suitable for cotton production with no reduction in yield.

Exchangeable sodium percentage (ESP)

Exchangeable sodium percentage of experiment soil values were obtained in a range (11.10 to 15.13 %) at a depth of (0 to 0.3 m). A soil in T8 (Awash River without mixed Beseka water) showed a value for exchangeable sodium percentage of 12.61 (Figure 4) which was much higher than threshold limit. Irrigation treatments involving the use of mixed Beseka with Awash water increased ESP with increasing mixing ratio T7 (15.13%) and T5 (13.86%), and the same results were obtained in T2 (12.61%), T3 (12.61%), T4 (12.61%) and T6(12.61%) with that of T8 (11.61%) having 100% Awash water as full irrigation cycle throughout growing period. This could

Table 4. Soil chemical properties of experimental field (0 to 0.3 m) after harvesting.

Irrigation Treatment	Mixing ratio (%) (Awash:beseka)	pH	EC (dS/m)	Water soluble cations and ions						Exchangeable basic cation			SAR	CEC	ESP%
				Ca+Mg	Na	K	Cl^-	CO_3^-	HCO_3^-	Ca+Mg	Na	K			
T1	92:08	8.50	0.95	3.95	0.59	0.16	7.75	trace	5.75	59.5	8.13	2.38	0.42	70.01	11.6
T2	90:10	8.70	0.96	4.95	0.74	0.20	7.00	trace	5.75	53.5	8.03	2.14	0.47	63.67	12.6
T3	85:15	8.60	1.20	4.50	0.68	0.18	8.25	trace	6.25	55.5	8.33	2.22	0.45	66.05	12.6
T4	80:20	8.70	1.19	4.45	0.67	0.18	8.25	trace	5.75	55.5	8.33	2.22	0.45	66.05	12.6
T5	75:25	8.90	1.34	4.95	0.74	0.20	10.75	trace	5.85	57.5	9.63	2.30	0.47	69.43	13.8
T6	70:30	8.60	1.30	5.95	0.89	0.24	9.50	trace	6.25	62.5	9.38	2.50	0.52	74.38	12.6
T7	50:50	8.60	1.60	5.45	0.82	0.22	10.25	trace	7.25	56.5	10.48	2.26	0.50	69.24	15.1
T8	100:00	8.70	0.96	2.95	0.44	0.12	7.00	trace	5.75	55.5	8.33	2.22	0.36	66.05	12.6

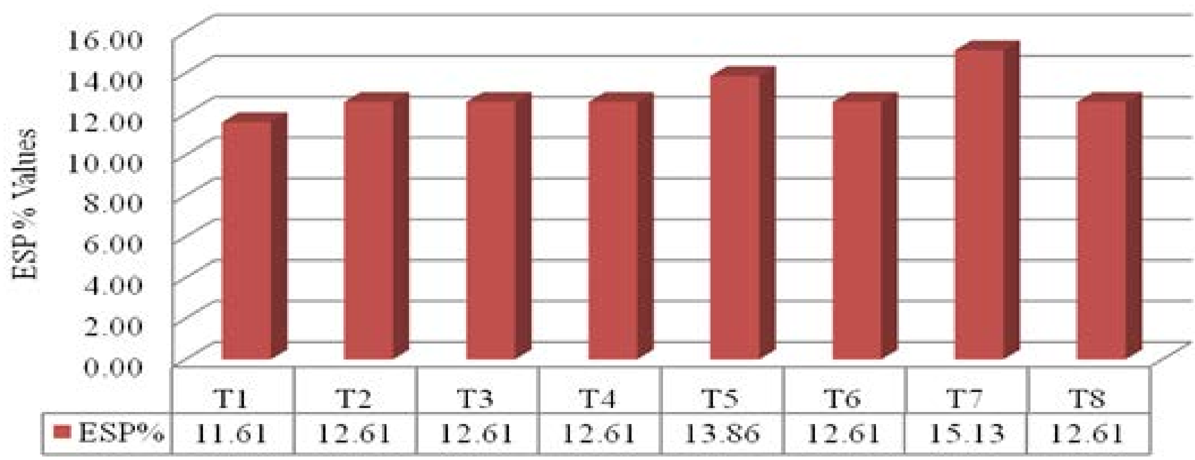

Figure 4. Exchangeable sodium percentage (ESP %) of composite soil after harvesting.

be mainly due to rainfall, and leaching downward might be the case. On the other hand, the ESP had higher values in the top layer of soil experiment field because the exchangeable sodium was less soluble than the sodium in the soil solution (Minhas and Gupta, 1992; Bajwa and Josan, 1989).

Cotton yield

Awash irrigation water alone produced significantly ($p < 0.05$) higher yield than mixed Awash and Beseka blended irrigation water. Awash water T8 gave the highest cotton yield (42.2 q/ha) and significantly different to all other treatment. The lowest blended ratios T1 gave the highest average yield (39.143 q/ha) among the blended water and significantly different to all other treatments (Table 5). Comparing the control treatment with other blended irrigation water 5 to 40% of yield reduction was observed under mixed percentage of 50, 30, 25 and 20%. Hence, this

Table 5. Cotton yield and yield parameters analysis.

Irrigation treatment	Mixed ratio (%)	Stand count	Average plant height (cm)	Boll number	Yield (Q/ha)
T1	92:08	26.6667[a]	69.333[a]	11.0000[ba]	39.143[b]
T2	90:10	24.3333[b]	69.333[a]	11.6667[a]	36.450[c]
T3	85:15	26.0000[ba]	69.333[a]	11.0000[ba]	34.497[dc]
T4	80:20	25.3333[ba]	63.333[a]	10.0000[bc]	33.403[d]
T5	75:25	25.0000[ba]	59.000[a]	8.6667[dc]	29.657[e]
T6	70:30	26.0000[ba]	74.333[a]	8.6667[dc]	28.233[e]
T7	50:50	26.3333[a]	72.333[a]	8.0000[d]	25.243[f]
T8	100:00	25.3333[ba]	71.000[a]	11.3333[ba]	41.393[a]
Mean	-	25.666	67.708	33.502	25.666
LSD(0.05)	-	1.827	17.759	1.351	2.218
CV (%)	-	4.066	14.977	7.683	3.781

indicated that increasing Beseka water ratio gradually decreased cotton yield.

Poor irrigation water can reduce 10% to 25% cotton yield potential (FAO, 1985b; Josan et al., 1998; Grattan and Oster, 2003).Therefore, in this study, blended irrigation water reduced cotton yield by 5 to 40%. The lowest yield was found in treatment (T7) that were subjected to irrigation with high blended ratio during the whole irrigation cycle and significantly different to all other treatments. Although, applied awash water early in the growth season (sensitive stage) and mixed with Beseka water (8, 10, and 20%) in later stages (relatively tolerant) after maturity gave optimum yield (10%) when it was compared with cotton grower farmers at Amibara irrigation scheme. However, blended irrigation water had a similar effect on yield and may be advantageous only with water of low to moderate salt content. The EC higher than 1.367 dS/m in irrigation water resulted in more than 50% reduction in final shoot dry weight of cotton crop (Dougherty and Hall, 1995). These results were similar from those reported by other authors that observed reduction in yield of maize plant (Chemura et al., 2011; Chauhan et al., 2007; Minhas, 1996; Shalhavet, 1984; Minhas and Gupta, 1993).

Chemical properties of irrigation treatments/blended water

pH of blended irrigation water

A six month result shows high values of pH occurred in May (9.88) and low value was obtained at March (8.80). The result found in June (9.12), July (9.23) and August (9.13) were decreasing, in fact this might be due to high flood during rainy season. Generally, results indicate that the value of pH increased after Beseka water blending point. Considering monthly results (Table 7), maximum pH (9.88) value was obtained in May which is dry and low flow period of River Awash decreased with high flooding season, comparatively showing lower pH. It may be due to decrease in the water level and presence of suspended particulate matter and low rainfall. Similarly, results of the data shows high pH ranges from 7.8 to 9.2 were obtained after blending of Beseka water and from 8 to 8.5 at Awash River before joining Beseka which indicates that the value of pH has increased after Beseka blending point. High pH values above 8.5 are often caused by high bicarbonate (HCO_3^-) and carbonate (CO_3^{2-}) concentrations, known as alkalinity (Bauder et al., 2004).

Electrical conductivity (EC) of blended irrigation water

Results have shown the EC value of blended (Awash and Beseka) irrigation water of the study area ranges from 1.606 to 2.97 dS/m. Maximum EC of Blended irrigation water obtained from treatment (T7, 50%) was 2.97 dS/m and all Blended irrigation treatments were increased with increasing mixed ratio as shown in Table 6. In the same way a six month (Table 7) result showed that high values of EC occurred in August (2.16 dS/m) and low was obtained in April (1.90 dS/m). The result found in March (2.60), May (1.92), June (1.98) and July (2.03) were decreasing; in fact this might be due to high flood during rainy season. It is easily presumable from the result shown in Table 7 that in terms of EC value, all the mixed irrigation water treatments were suitable for irrigation purpose. According to FAO (1985) standard, EC value of treatment (T8, 100%) falls within ‘permissible’ irrigation water quality classification standard. In terms of the ‘degree of restriction on use’, EC values of all treatments are categorized under ‘slight to moderate’ according to UCCC (1974). On the other hand, in terms of salinity and sodicity, hazard classification treatments such as T1,T2 and T3 fell under C2 (medium) and T4,T5 and T6 fell C3 (High) but exceptionally, T7 fell under C4 (very high).

Table 6. Chemical parameters of blended water over six months.

Parameters	T1	T2	T3	T4	T4	T6	T7	T8
EC ds/m	1.61	1.68	1.84	1.98	2.15	2.32	2.98	1.44
PH	9.12	9.14	9.23	9.29	9.49	9.50	9.59	9.12
TDS mg/L	1028	1072	1174	1267	1375	1487	1905	1026
Ca + Mg	1.67	1.62	1.66	1.78	1.43	1.67	1.53	1.68
Na^+	4.77	3.43	4.39	4.93	4.45	5.22	6.20	4.17
K^+	0.38	0.25	0.16	0.17	0.16	0.18	0.27	0.24
CO_3^{2+}	2.56	2.84	2.95	3.43	3.84	4.30	6.28	2.59
HCO_3^-	10.65	11.54	12.25	13.53	15.00	16.17	19.59	10.65
Cl^-	3.96	4.28	4.80	4.92	5.32	5.64	7.05	4.00
SAR	1.61	1.68	1.84	1.98	2.15	2.32	2.98	1.44
RSC	9.12	9.14	9.23	9.29	9.49	9.50	9.59	9.12

Table 7. Chemical and Physical parameters of blended water over six months.

Parameters	March	April	May	June	July	August
EC ds/m	2.06	1.90	1.92	1.98	2.03	2.10
PH	8.80	9.50	9.88	9.33	9.23	9.13
TDS mg/L	1382.76	1237.82	1226.58	1292.72	1297.66	1315.88
Ca + Mg	1.26	1.63	1.42	1.95	1.90	1.62
Na^+	3.00	5.39	2.55	5.74	5.77	5.73
K^+	0.28	0.15	0.40	0.15	0.19	0.20
CO_3^{2+}	4.31	3.51	4.10	2.95	3.09	3.63
HCO_3^-	14.69	12.72	13.26	13.58	13.67	14.10
Cl^-	5.31	4.81	4.81	5.03	4.99	5.02
SAR	3.93	6.01	3.02	5.95	6.05	6.37
RSC	17.75	14.60	15.94	14.65	14.87	16.11

Sodium adsorption ratio (SAR) of blended irrigation water

Low value of SAR in T1 was found to be 3.45 meq/L and maximum were obtained in T7 (7.24) as shown in Table 6. According to the UCCC (1974), the studied water samples fell in class 2 (medium sodium hazards) except Blended water of T7 (50%) which had an SAR value of 7.24 and fell in the S3 class (high sodium hazards). The result indicated that rating of sodicity hazards based on SAR values for all Blended water treatments were of medium hazards (S2) except treatment T7 (50% ratio) water which was high sodium hazards (S3). As a result, Blended Irrigation water ratio such as 50, 30, 25, and 20% Beseka with Awash in terms degree of restriction, fell under slightly moderate category and can be used for irrigation.

Residual sodium carbonate (RSC) of blended irrigation water

In all irrigation treatments RSC values were above 2.5 meq/lit (Table 6) and very high at month of March during study season (Table 7). According to the RSC data presented in Table 7, the classification of different water samples for irrigation in the studied area indicate that all of the studied samples are above 2.5 meq/l and classified as class 4 and hence very RSC hazards (unsafe water), this indicates that blended water is unsuitable for irrigation, USSLS (1954). So water of mixed Beseka and Awash River can be considered unsafe for irrigation purpose according to USSLS considerations.

Conclusion

From the study it can be concluded that the discharge rate of Beseka water into Awash River will affect its quality and aggravate the soil salinity and reduce cotton yield. Moreover the result revealed that Beseka lake is a great source of pollution for down streams agricultural farm and it is a great environmental concern than need immediate attention.

Conflict of Interests

The authors have not declared any conflict of interests.

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