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Effect of conjunctive use of waste and ground water on yield and crop water productivity of cluster bean

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Abstract

The scarcity of good quality irrigation water is a serious problem in arid and semi- arid zones of the World. The increasing demand for food, fodder and fibre has therefore compelled to explore the possibilities of using wastewater conjunctively for irrigating crops. A study at Agriculture Research Substation Shikarpur was carried out in 2015-16 to evaluate the effect of conjunctive use of waste and ground water irrigation on cluster bean crop (Cyamposis tetragonoloba L). The study comprised of four treatments *i.e.* I_1 (groundwater), I_2 (wastewater 25% + groundwater 75%), I_3 (wastewater 50% + groundwater 50%) and I_4 (wastewater 75% + groundwater 25%). The experiment results revealed that after sowing, soil EC (dSm^{-1}) and sodium adsorption ratio (SAR) were observed to be higher in treatment I_4 as compared to other treatments, whereas pH in treatment I_4 resulted minimum. It was observed that cluster bean when treated 75% wastewater + 25% groundwater (treatment I_4) resulted maximum plant height (75.50cm), weight plant^{-1} (93g), yield plot^{-1} (7.44kg) and yield hactre^{-1} (9725.50). Crop water productivity was also observed to be significantly higher (4.01kgm^{-3}) when treated with 75% wastewater (treatment I_4), which then significantly decreased with decreasing wastewater content. The study concluded that, the conjunctive use of waste and ground water can successfully be adopted for cultivation in water scarce area.

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Introduction

The growth of the World's population with industrial and agricultural activities for growing food supply collective with consecutive droughts in recent years have affected existing water resources in arid and semi-arid countries. In accumulation to conventional resources, non-conventional water resources suggest that alternate supplies can be used to partially alleviate water scarcity in those regions where renewable water resources are extremely limited. Such water resources are related for agricultural and further uses through specialized processes such as desalination of seawater and highly brackish water and collection, treatment, and usage of wastewater (Qadir *et al.*, 2007). The central and south-east zones continue to be regions with severe discrepancies between supply and demand.

This is why wastewater reuse for agriculture is becoming a very imperative water resource in contrast to other nearby countries such as France (Faby *et al.*, 1999). Water is the most essential natural source and it is being used intensively for agriculture, industries, domestic and recreational purposes. However, agriculture is the most important water consuming sector. Approximately 80 percent of the soil surface is enclosed by water. Out of 1011M km^3 of the over-all liquid existing on soil, merely 33,400 cubic meters of water is available for human beings, crop growing and manufacturing purpose (Dara, 1993).

Water incomes are limited due to more population pressure, mechanization and suburbanization. Hence, this is a requirement of the period to find another resources of irrigation water to make certain sustainability of the existing resources (Thawale *et al.*, 2006). Pescod (1992) stated that, wastewater practice can be vital deliberation in arid as well as semi-arid areas. Acceptable nutrient obtainability, mostly nitrogen, to fulfil crop necessities from wastewater has exhilarated growers toward practice of this water in irrigation. Raw wastewater, existence of maximum nutrients becomes rapidly presented toward the plants at a minimum expense (Clemet and Ensink, 2006).

Growers want raw wastewater because it is observed as additionally reliable for irrigation because of its rapid accessibility on minimum price and its maximum nutrient position (Mahmood and Maqbool, 2006). Application of wastewater to crop field and forests is an attractive choice for disposal because it can increase soil physical properties and rise nutrient contents of soils. Wastewater mostly contains applications of organic and inorganic nutrients, *ex.* nitrogen and phosphate, which are essential for crop growth (Khalil and Kakar, 2011).

Conjunctive use of water can be reliable solution for growing cereals in irrigated areas and rising vegetables in urban area. Conjunctive use of water is the combination of waste and fresh water to meet crop water requirement. It is the management of surface and groundwater to improve the productivity, equity and environmental sustainability by instantaneously managing surface and groundwater resources (World Bank, 2005). Conjunctive usage of fresh as well as sewage water can effectively be implemented for crop production (Isaac *et al.*, 2009).

Cluster bean (*Cyamopsis tetragonoloba* L.) is the essential commercial and distributor plant of Pakistan. It is assumed to have created in Africa, but is now grown throughout southern Asia since ancient times, as a vegetable and forage crop. Cluster bean has been cultivated in Pakistan as well as India forages for the usage of its green pods as vegetable, grains as pulse and green plants as fodder and for soil manure purpose (Arain, 2013).

Cluster bean Fruits are rich in food value and each 100 g contains 10.8g carbohydrate, 3.2 protein, 1.4g minerals, 316 IU vitamin-A and 47mg vitamin-C. It is also used as a nutritious fodder for livestock. Mucilaginous seed flour is used for making guar gum (galactomannan) utilized in textile, paper, cosmetic and oil industries throughout the world (Pakissan, 2015).

Keeping in view the facts stated above, the present study was carried out to determine the effect of conjunctive use of waste and ground water on cluster bean crop and its soil properties.

Materials and methods

The research study was carried out at the experimental field of Agriculture Research Sub Station Shikarpur, which is located at Latitude 27°57'N and Longitude 68°39'E at an elevation of about 75m above mean sea level (MSL). The area is within semi and climatic zone. Four level of irrigation treatments applied included, I_1 = groundwater 100% (control) (1:0), I_2 = wastewater 25% + groundwater 75% (1:3), I_3 = wastewater 50% + groundwater 50% (1:1) and I_4 = wastewater 75% + groundwater 25% (3:1). The experimental setup was laid out in complete randomized design (CRD), replicated thrice. Total area of field (11m x 12.7m) was divided into twelve sub plots (3m x 2.55m each). The experimental field was deep ploughed twice and then was pulverized using disc harrow. The furrows and ridges were constructed manually, the length and width of each ridge kept was 3m and 0.60m and furrows 3 m and 0.45m respectively. Each sub plot contained 3 furrows and 2 ridges.

Soil sampling

The soil samples were collected from the experimental field at the depth of 0-20cm, 21-40cm and 41-60cm with the help of auger before sowing and after harvesting of cluster bean crop. The collected soil samples were analysed for soil texture, EC and pH in the Soil and Water Testing Laboratory Shikarpur. The methods adopted are presented in Table 1.

Table 1. Analytical methods for soil and water analysis/determinations.

S. No.	Determinations	Methods adopted	For	Reference
1.	Soil texture	Bouyoucos Hydrometer	Soil	Bouyoucos
2.	Electrical conductivity (dSm^{-1})	Digital EC meter,	Soil & water	USSL, 1954)
3.	pH	Digital pH meter	Soil & water	USSL, 1954

Sodium adsorption ratio (SAR)

Sodium adsorption ratio was calculated using following relation (Rowell, 1994),

$$SAR = \frac{Na^+}{\sqrt{\frac{Ca^{2+} + Mg^{2+}}{2}}}$$

Preparation of irrigation water

Wastewater was collected from municipal drainage line near Agriculture Research Sub Station Shikarpur in buckets. The collected wastewater was poured into plastic drum and then transported to experimental field, which was then blended with groundwater as per design in different ratios.

Sowing of seed and observations recorded

Cluster bean crop was sown in the month of March. The Kaachan variety of cluster bean seed was sown on both sides of ridge at the depth of 2.54 to 3.81cm (Arain, 2013). The plant to plant distance was 10 to 15cm (Majeedano, 2012). After germination of seeds the extra plant was thinned out to maintain the required distance between plants. Observations for plant height (cm), weight of $plant^{-1}$ (g) and yield were calculated (kg $plot^{-1}$), which were then converted into (kg ha^{-1}).

Irrigation

Before the seedbed preparation a pre-soaking irrigation of 7.62cm was applied. Seedbed was prepared (as the soil reached at field capacity). The crop was irrigated to the depth 7.62cm per irrigation at an interval of 15 days (Majeedano, 2012). The quantity of irrigation water was estimated with volumetric method using following relationship, Volume of water (m^3) = Length of furrow x width of furrow x depth of water. The volume of water per furrow per irrigation was calculated as 0.103m^3. There were three furrows in each plot hence total volume of water per plot per irrigation was 0.309m^3 (Table 2).

Table 2. Irrigation water applied.

S.NO	Date of irrigation	Quantity of irrigation water (m^3)	
		Per plot	Per hectare
1	19/03/2015 (soaking dose)	0.309	403.41
2	03/04/2015	0.309	403.41
3	18/04/2015	0.309	403.41
4	03/05/2015	0.309	403.41
5	18/05/2015	0.309	403.41
6	03/06/2015	0.309	403.41
	Total	1.854	2420.46

Manures and fertilizers

13 mds farm yard manure, fertilizer (2-3 bags/acre), DAP (1-2 bag/acre) and potash (1 bag/acre) were applied at the time of last ploughing (Majeedano, 2012).

Crop water productivity (CWP)

Crop water productivity (per hectare) was determined using following relation (Issac *et al.,* 2009):

$$CWP = \frac{Y_h}{TW}$$

Where; Y_h = Total crop yield (kg ha^{-1}) and TW = Total irrigation water used for crop production (m^3 ha^{-1})

Statistical analysis

Analytical software (Statistix ver. 8.1) was used for analysis of variance (ANOVA), the data was analyzed at a significant level of P≤0.05.

Results and discussion

For determination of soil texture, the soil samples were collected at the depth of 0-20, 21-40 and 41-60 cm. The texture of soil was determined to be Clay (Table 3). The average quality of irrigation water applied are presented in Table 4.

Table 3. Texture of soil of the experimental field.

S. No	Treatments	Clay %	Silt %	Sand %	Textural class
1	I_1	60	23	17	Clay
2	I_2	65	25	10	Clay
3	I_3	70	18	12	Clay
4	I_4	74	14	12	Clay

Table 4. Average quality of irrigation water applied to experimental field.

Treatments	EC (dSm^{-1})	pH	SAR	RSC
I_1	1.52	8.3	5.85	Nil
I_2	1.62	8.1	5.93	Nil
I_3	1.76	8.1	6.30	Nil
I_4	1.95	8.1	6.57	Nil

Plant height

Variation in plant height of Cluster bean crop for various irrigation treatments are shown in Fig. 1. The maximum plant height 75.50m was observed under treatment I_4 followed by I_3, I_2 and I_1 respectively with average plant height of 68.38cm. While lowest Plant height of 61.5cm was observed under I_1. Analysis of variance showed that there was a significant (P<0.05) difference in plant height of cluster bean crop among various treatments (Table 5). Maximum Plant height of cluster bean crop under I_4 may be due to maximum supply of sewage water, which contains nutrients for the growth and development of crop. These finding are supported by Issac *et al.* (2009), who observed that plant height significantly increased with simultaneously increase in sewage water. Similarly, Singh et al. (2012) reported that, application of wastewater increased macro and micro nutrients for better plant growth. Likewise Hussain et al. (2002) used wastewater from decades for supplement of essential nutrient for crop growth. Whereas, Breen (1992) stated that raw sewage effluent contained rich mineral nutrients necessary for plant growth (NPK, and micronutrient).

Table 5. Analysis of variance for plant height (cm).

Source	DF	SS	MS	F-value	Prob.
Treatment	3	324.990	108.330	40.3	0.0000
Error	8	21.507	2.688		
Total	11	346.497			

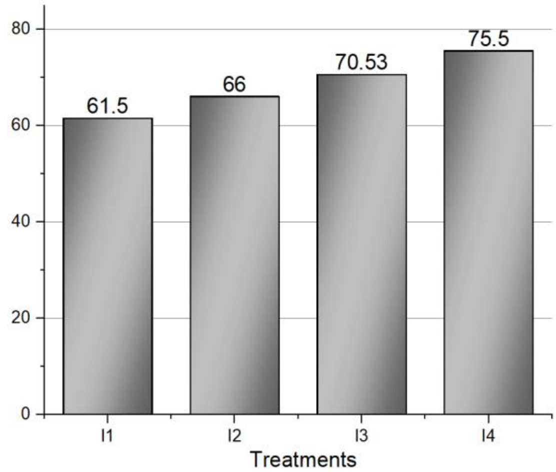

Fig. 1. Plant height (cm) of cluster bean for different treatments.

Weight plant^{-1} of cluster bean crop

Fig. 2 shows the variation in Weight pant^{-1} of Cluster bean crop for various irrigation treatments. The maximum weight plant^{-1} 93.00g was observed under I_4 followed by I_3, I_2 and I_1 respectively with an average weight plant^{-1} of 84.69g. While lowest weight plant^{-1} of 75.70g was observed under I_1. The effect of different irrigation treatments on weight plant^{-1}of cluster bean crop were statistically different from each other (Table 6). Maximum weight plant^{-1} under I_4 may be due to rapid uptake of soil nutrients given by sewage water. The experimental observations were similar to those given by Isacc *et al.* (2009), who stated that crop irrigated with sewage water resulted greater weight plot^{-1}. However, Singh *et al.* (2012) reported that crop irrigated with wastewater resulted significant increase in crop production. Likewise, Boyang *et al.* (2015) showed that application of wastewater significantly increased weight of fresh vegetable when compared with tap water.

Table 6. Analysis of variance for weight plant^{-1}.

Source	DF	SS	MS	F-value	Prob.
Treatment	3	500.796	166.932	74.3	0.0000
Error	8	17.973	2.247		
Total	11	518.769			

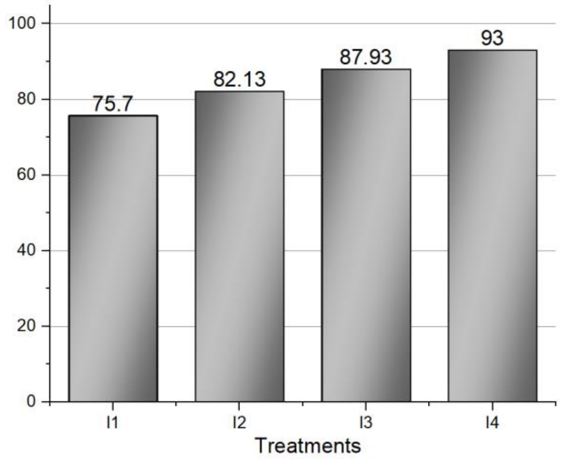

Fig. 2. Average Weight plant^{-1} (gm) for different treatments.

Yield plot^{-1} of Cluster bean crop (kg)

Variation in yield plot^{-1} of Cluster bean crop for various irrigation treatments are illustrated in Fig. 3. The maximum yield plot^{-1} with 7.44kg was observed under I_4 followed by I_3 I_2 and I_1 respectively with an average yield plot^{-1} of 6.77kg. While lowest yield plot^{-1} of 6.05kg was observed under I_1. The effect of different irrigation treatments on yield plot^{-1} of cluster bean crop were statistically different from each other (Table 7).

Table 7. Analysis of variance for yield plot^{-1}.

Source	DF	SS	MS	F-value	Prob.
Treatment	3	3.21536	1.07179	73.2	0.0000
Error	8	0.11713	0.01464		
Total	11	3.33249			

Yield of Cluster bean crop (kg ha^{-1})

Variation in yield (kg ha^{-1}) of Cluster bean crop for various irrigation treatments is shown in Fig. 4. The maximum yield (kg ha^{-1}) 9725.50 was observed under I_4 followed by I_3 I_2 and I_1 respectively with an average yield (kg ha^{-1}) of 8856.63,. While lowest yield (kg ha^{-1}) of 7916.30 was observed under I_1.

The effect of different irrigation treatments on yield (kg ha^{-1}) of cluster bean crop were statistically different from each other (Table 8). Higher yield (kg ha^{-1}) in I_4 was achieved by incorporation of higher levels of sewage water. These findings are matched to those of Issac *et al.* (2009), who evaluated that yield kg ha^{-1} significantly increased when treated with sewage water. Whereas, Singh *et al.* (2012) argued that application of wastewater had positive effect on crop yield as well as grain and straw yield when compared while treating with groundwater. Similarly, pescod (1992) stated that experiment had repeatedly established a maximum crop yield with wastewater. Likewise, Hussain *et al.* (2002) reported that wastewater irrigation may be the source of fertilizer for increased crop yield.

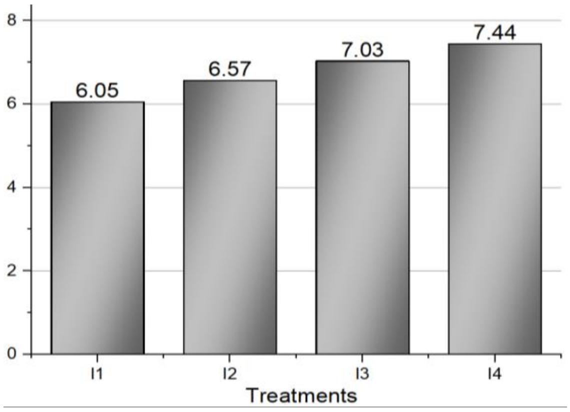

Fig. 3. Average Yield plot^{-1} (kg) for different treatments.

Table 8. Analysis of variance for yield kg ha^{-1}.

Source	DF	SS	MS	F-value	Prob.
Treatment	3	5476697	1825566	74.3	0.0000
Error	8	196555	24569		
Total	11	5673253			

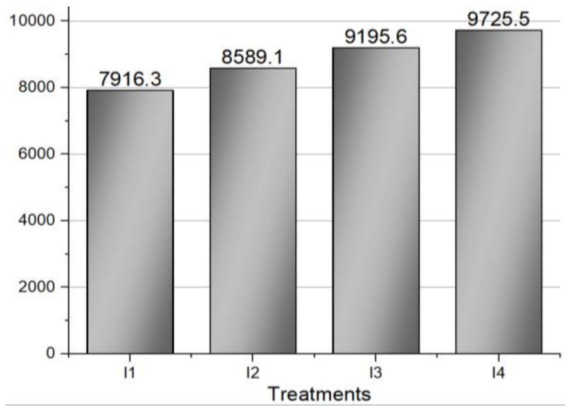

Fig. 4. Average Yield (kg ha^{-1}) for different treatments.

Crop water productivity (kgm-3)

Fig. 5 shows the variation in Crop water productivity of Cluster bean crop for various irrigation treatments. The maximum Crop water productivity (4.01kgm^{-3}) was observed under I_4 followed by I_3 I_2 and I_1 respectively with an average crop water productivity of 3.66kgm^{-3}. While lowest Crop water productivity with 3.27kgm^{-3} which was observed under I_1. Analysis of variance showed that there was a significant ($P<0.05$) effect of different irrigation treatments on Crop water productivity of cluster bean crop (Table 9). These findings are matched with those of Issac *et al.* (2009) who stated that crops irrigated with different treatments had significant influence on Crop water productivity of radish, the crop water productivity was observed to be significantly higher when sewage water was applied. Similarly, CISRO (1995) stated that experiment had repeatedly established a higher productivity of crops when irrigated with wastewater. Whereas, Azaiez (2002) reported that conjunctive use of surface and ground water sources could not only solve the problem of water scarcity, but also can expand the water use efficiency in regional environment of cultivated area.

Table 9. Analysis of variance for crop water productivity.

Source	DF	SS	MS	F-value	Prob.
Treatment	3	0.93514	0.31171	74.5	0.0000
Error	8	0.03348	0.00419		
Total	11	0.96862			

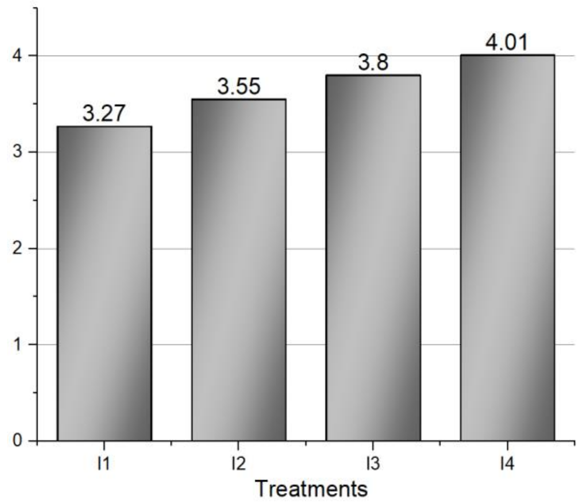

Fig. 5. Average Crop water productivity (kgm^{-3}) for different treatments.

Conclusion

The present study concluded that the conjunctive use of waste with ground water provided significant results. It was in present study observed that treatment I_4 (wastewater 75% + groundwater 25%) resulted maximum for plant height with 75.50 cm, weight plant^{-1} with 93 g, yield plot^{-1} with 7.44kg, yield kg ha^{-1} with 9725.50kg and crop water productivity with 4.01kgm^{-3}, followed by I_3, I_2 and I_1 respectively. Whereas minimum results were observed when treated with groundwater (I_1). The conjunctive use of waste and ground water is therefore suggested to be adopted in water scarce area for successful crop production.

References

Arain GB. 2013. Crop manager agronomy centre pivot irrigation system valley irrigation Pakistan (private), limited. www.valleyirrigation pakistan.com/wp-content/uploads/2012/09/Guar-Cultivation-in-Pakistan.pdf. [Accessed on 04-02-2015].

Azaiez MN. 2002. A model for Conjunctive use of groundwater and surface water with opportunity cost. European Journal of Operational Research **143 (3),** 611-624.

Bo yang X, Kong A, Cui B, Jin D, Deng Y, Zhuang x, G. Zhuang Z. Bai. 2015. Impact of rural domestic wastewater irrigation on the physiochemical and microbiological properties of Pakchoi and Soil. Water **7,** 1825-1839.

Bouyoucos JB. 1962. Hydrometer method for making particle-size analysis of soils. Agronomy Journal **54,** 464-465.

Breen PF. 1992. Artificial wet land for wastewater treatments: A review with particular reference to rural areas. In: CSIRO Division of water resources: Research areas pertinent to intensive rural industry. Waste management (K.H. Bowmer and P. Lunt Eds.) 34-36. divis report, 92/4.

Clemet A, Ensink J. 2006. Farmer driven wastewater treatment: A case study from Faisalabad. Pakistan, www.wedc.lboro.ac.uk/conferences/pdfs/32 /Clemet.Pdf.

CSIRO. 1995. Effluent irrigated plantations: design and management. CSIRO Technical Paper No. 2.

Dara SS. 1993. Water Pollution. In A textbook of environmental chemistry and pollution control. S. Chand and Co. Ltd. Nagar, New Delhi pp. 64-65.

Faby JA, Brissaud F, Bontoux J. 1999. Wastewater Reuse in France Water Quality Standards and Wastewater Treatment Technologies. Water Science and Technology **40 (4-5),** 37-42.

Hussain I, Raschid L, Hanjra MA, Markar F, Van der Hoek W. 2002. Waste water use in agriculture: review of impacts and methodological issues in valuing impacts. Working Paper 37, Colombo, Sri Lanka: International Water Manag Insti.

Isaac RK, Swaroopand N, Kumar JLG. 2009. Effect of conjunctive use of water on yield components and marketable yield of radish crop. Journal of Science and Technology **29(2),** 131-136.

Khali S, Kakar MK. 2011. Agricultural Use of Untreated Urban Wastewater in Pakistan. Asian Journal of Agriculture and Rural Development **1(1),** 21-26.

Mahmood S, Maqbool A. 2006. Impacts of wastewater irrigation on water quality and on the health of local community in Faisalabad. Pakistan Journal of Water Resources **10,** 19-22.

Majeedano HI. 2012. Agro Digest. Agronomy Section, Agriculture Research Institute, Tandojam 45.

Pakissan R. 2015. Cluster bean (Guar) gum product, Physiology, Genetics and cultivation pp. 1-46.

Pescod. 1992. Wastewater treatment and use in agriculture- FAO Irrigation and Drain paper 47, FAO, Rome pp. 125.

Qadir M, Sharma BR, Bruggeman A, Chourkd-Allah R, Karajeh F. 2007. Non-conventional water sources and opportunities for water augmentation to achieve food security in water scarce countries. Agricultural Water Management **87(1),** 2-22.

Rowell DL. 1994. The preparation of saturation extracts and the analysis of soil salinity and sodicity. In Soil Science Methods and Applications. Ed. D.L. Rowell. Longman Group UK

Salinity Laboratory Staff US. 1954. Diagnosis and improvement of saline and alkali `soils. Handbook, No. 60 USDA. US. Govt. Print. Office Washington DC.

Singh PK, Deshbhratar PB, Ramteke DS. 2012. Effects of sewage wastewater irrigation on soil properties, crop yield and environment. Agricultural Water Management **103,** 100-104.

Thawale PR, Jawarkar AS, Kulkarni AB, AA Juwarkar. 2006. Lysimeter studies for evaluation of changes in soil properties and crop yield using wastewater. Inter Journal Tropical Agriculture **17,** 231-244.

World Bank. 2005. Conjunctive use of groundwater and surface water", shaping the future of water for agriculture a sourcebook for investment in Agricultural Water Management. www.siteresources.worldbank.org/INTARD/Resources/Shaping_the_Future_of_Water_for_Agriculture. pdf