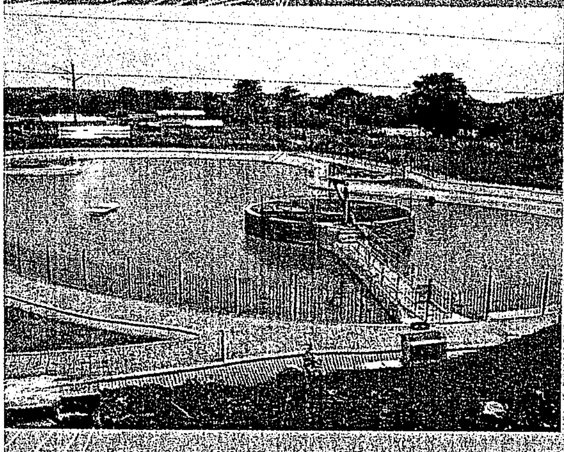
United Nations
Educational, Scientific and
Cultural Organization

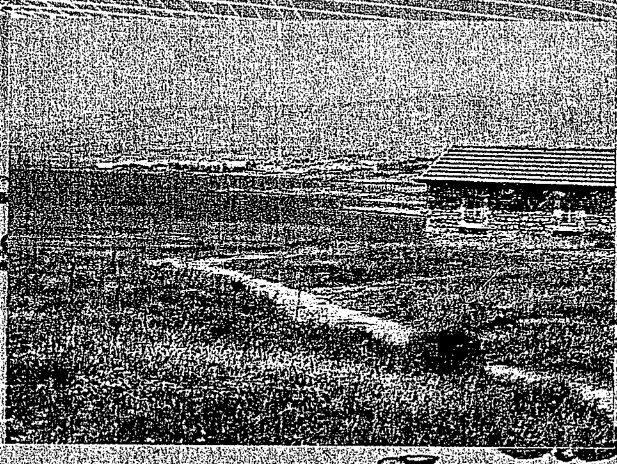
International
Hydrological Programme

WATER HARVESTING

Brining Green Revolution to Rainfed Areas

VOLUME-I





Editors
Dr. Arumugam Kandiah
Dr. K. Ramaswamy
A. Sampathrajan

UNESCO, New Delhi
Tamil Nadu Agricultural University

WATER HARVESTING

Brining Green Revolution to Rainfed Areas

Proceedings of the International Symposium
Held on 23 to 25 June 2008
at the Tamil Nadu Agricultural University

Editors

Dr. Arumugam Kandiah
Visiting Professor, TNAU

Dr. K. Ramaswamy
Professor, TNAU
Regional Programme Specialist, UNESCO

and

A. Sampathrajan
Dean, Agricultural Engineering College and Research Institute, TNAU

Volume – I

Published Jointly by

Tamil Nadu Agricultural University, Coimbatore
and
United Nations Educational, Scientific and Cultural Organization,
New Delhi Office, New Delhi

July 2008

5

Conservation of Rainwater and Sustenance of Productivity Through Improved Land Management and Cropping System in a Vertisol of Central India

K.M. Hati, A.K. Misra, K.G. Mandal, A.K. Tripathi, A. Subba Rao, R.K. Singh, S.P. Wani, P. Singh and P. Pathak

Introduction

For sustainable crop production system under rainfed condition, the conservation of rainwater and its efficient recycling are imperative. The rainwater can be conserved either *in-situ* i.e. in the soil itself or *ex-situ* in natural or man made structures wherefrom it can be used for supplemental irrigation. *In-situ* rainwater conservation can be carried out either though tillage or landform management (Singh *et al.*, 2000). Among the various landform management practices like raised and sunken bed, ridges and furrow etc. developed for Vertisols, broad-bed and furrow (BBF) system is very promising in controlling surface runoff, reducing the soil loss through erosion and increasing infiltration (Pathak et al. 1985; Singh et al. 1999). The BBF landform management system reduces the velocity of runoff water and thus increases opportunity time for water to infiltrate and reduces sediment losses. Further, during the period of heavy rainfall the furrows allow excess water to drain safely from the plots and thus avoid water congestion to the crop (Kampen, 1982). There is an urgent need to manage the water resources of Vertisols of Central India to control soil erosion and to improve use efficiency of the rainfall for sustaining crop production. This is possible through adoption of improved land management practices, which will decrease runoff and soil erosion and concomitantly improve crop yield in deep Vertisols.

Stagnation of productivity of soybean based production systems due to erratic distribution of monsoonal rain and incidence of new insect-pests and diseases is leading to under-utilization of land, water, nutrient and climatic resources. Under this situation the crop diversification in the rainy season can be a viable option for stabilizing and enhancing productivity of the system. In winter season, it has been found that chickpea performs better than high water and nutrient requiring wheat crop. In addition, harvesting of run off water in storage pond and its efficient utilization through supplemental irrigation to the rainy season crop in case of early withdrawal of monsoon and pre-sowing irrigation to the winter crop holds the promise for increasing the total system productivity and stability. In fact, insufficient attention on rain water harvesting and its recycling hampers efficient utilization of nutrients by crops. In order to ensure a pay-off from nutrients, all round augmentation of water resource with watershed as a unit of development is imperative. In this back drop, an experiment was conducted with the following objectives, (i) to assess the effect of landform treatments on loss of rain water through runoff and loss of soil through erosion, (ii) to study soil water dynamics, and (iii) to evaluate the productivity of five soybean and maize based sole and intercropping systems in a vertisol.

Materials and methods

A field experiment was conducted for four years from 2003-04 to 2006-07 on broad bed and furrow (BBF) and flat on grade (FOG) land treatments with five different cropping systems viz. Soybean- chickpea, maize- chickpea, soybean/ maize intercropping– chickpea, soybean/ pigeon pea intercropping and maize/ pigeon pea intercropping and two irrigation levels on a micro-watershed at the experimental farm of Indian Institute of Soil Science, Bhopal, Madhya Pradesh (23°18' N, 77°24' E, 485m above mean sea level). Soil of the experimental site was deep heavy clay (Typic Haplustert). The climate of the experimental site was hot subhumid type with a mean annual rainfall of 1130 mm and potential evapo-transpiration of 1400 mm. The BBF landform was prepared with the help of a tractor drawn BBF former along the key lines drawn based on a topographic survey. The width of the broad bed was 1.0m with 0.5m wide furrows on either side of the bed. In the first year (2003-04) pigeonpea monocrop was taken in lieu of maize/pigeon pea intercropping. In rainy season crops were grown rainfed while in winter season chickpea was grown with two irrigation levels, (i) one pre-sowing (PS) irrigation to chickpea (I_1) and (ii) one PS + one irrigation to chickpea at flowering stage (I_2). The irrigation was provided from the water harvesting pond of the watershed. Recommended doses of NPK fertilizer were applied to each crop and farmyard manure (FYM) @ 5 t ha^{-1} was applied once in a year to the rainy season crop. The N:P:K doses for soybean, maize, pigeonpea and chickpea were 30:26:25, 120:26:33, 30:26:33, 30:26:33 kg ha^{-1}, respectively. Crops were harvested manually at their physiological maturity and grain yield was recorded from net plot harvest.

Runoff from each landform treatment was measured with automatic runoff recorder (Thalimedes) installed on a H-flume constructed at the lowest contour point. The height of the water passing through the H-flume was continuously recorded by a float operated shaft encoder with digital data logger which was later interpreted in terms of runoff volume associated with each rainfall event (Pathak, 1999). Automatic pumping sediment sampler fabricated at International Crop Research Institute for Semi-Arid Tropics (ICRISAT), Hyderabad, India was used to monitor the temporal changes in sediment losses from each runoff events. The samplers collected runoff water with suspended sediments passing through the H-flume and stored in plastic collection bottles at 20 minutes interval. The sediment was flocculated by adding 10 N HCl. Then these were dried in oven to estimate the suspended particle content. The sediment concentration obtained from each bottle was used for the calculation of total sediment losses associated with each runoff events. Soil water content up to a depth of 90 cm at 15 cm interval was determined thermo-gravimetrically at regular interval during the crop growth period in 2003 and 2004. The water content of individual soil depth determined on weight basis was multiplied with corresponding bulk density and depth of the soil layer to obtain the profile water storage. Analysis of variance (ANOVA) was carried out using split plot design (Gomez and Gomez, 1984) for comparing means of main and interaction effect using least significant difference with 5% significant level.

RESULTS AND DISCUSSION

Seasonal Rainfall, Runoff, and Soil Loss

The amount of rainfall received during the four years of experimentation was highly variable. Total rainfall received during the rainy season of 2003 between June to October was 1058 mm, which was slightly higher than the long-term average rainfall of 1005 mm for this season, while in 2006, the rainfall received during the rainy season was 1513 mm, which was 50% higher than the average rainfall. During the rainy season of 2004 and 2005 seasonal rainfall was lower than the long-term average rainfall. In 2004, the distribution of rainfall was also not uniform during the season. In the month of June, rainfall was only 8.5% whereas, July and August received 83% and September and October received very less rain. Thus the performance of soybean crop was adversely affected because of the soil moisture deficit during the pod development stage of the crop. Moreover, the soybean crop was heavily infested by the insect-pests and yield reduced drastically. In 2005, the onset of monsoon was very late; the month of June received only 26.7 mm i.e. 2.8% of the seasonal total rainfall and most of the rain was received in the month of July (55.7%) whereas the share of August was only 18.4% of the seasonal total in the year.

Runoff and soil losses from the field area under broad-bed and furrow (BBF) and flat on grade (FOG) landform treatments were monitored during the *kharif* seasons. In all the every year, seasonal runoff from the BBF plot was less than that from the FOG (Table 1). This might be attributed to the reduced speed of runoff from BBF plot due to uniform slope, which have resulted in higher opportunity time for water to infiltrate in BBF than FOG treatment. The runoff was 15.4-33.2% and 20.3-57.7% of seasonal rainfall from BBF and FOG landform treatments. The run off under both BBF and FOG was much higher during the rainy season of 2006 because of unusually high rainfall. The soil losses through runoff from BBF and FOG were higher in high rainfall years; the extent of soil loss was to the tune of 1956 and 2837 kg ha^{-1} from BBF and FOG, respectively in 2003 and 3503 and 6365 kg ha^{-1} in the corresponding treatments in 2006. However, the soil losses were relatively less, 657 and 1466 kg ha^{-1} from BBF and FOG, respectively in 2004. BBF landform treatment reduced soil loss to a greater extent (31 to 55%) than its reduction in runoff volume (24 to 32%) as compared with that of FOG over the years. This can be ascribed to lower concentration of sediments in runoff water coming from the BBF than from FOG as velocity of flow of the runoff water was generally lower in BBF. Pathak *et al.* (1985) and Srivastava and Jangwad (1988) have also shown that runoff and soil loss were remarkably reduced in BBF land surface management treatment in a long-term watershed study in Vertisol.

Soil Water Dynamics and Moisture Extraction by Crops

Water storage in the soil profile up to 90 cm depth during rainy season of 2003 and 2004 was determined gravimetrically throughout the crop growth period. The data revealed that the water storage during 2003 ranged between the field capacity and permanent wilting point (PWP) in all plots. This was because of uniform distribution of rainfall in the rainy season. Even in later phase of crop growth moisture storage in the root zone remained higher than the PWP moisture storage. The average moisture storage in the later part of crop growth (after 64 DAS) was higher in BBF than FOG treatment, but this was not conspicuous in the early growth period. After the withdrawal of monsoon a continuous monitoring of soil moisture extraction was made for two weeks to study the moisture depletion pattern during a drying cycle. The results showed that the depletion of soil moisture during the two weeks drying period was considerably higher in the sole pigeon pea and soybean/pigeon pea intercropping treatment compared to sole soybean, sole maize and soybean/maize intercropping treatments (Table 2). Depletion of moisture was maximum (60.4 mm) from the sole pigeon pea treatment on BBF. Similar results were recorded under both BBF and FOG landform treatments. This might be due to higher extraction of moisture by pigeon pea, which was approaching maximum vegetative stage during that period, compared to the other two crops, which were near maturity at that time.

In 2004 water storage in the profile decreased slightly during the first week after sowing and thereafter it increased in all the plots in the month of July with the increase in rainfall. Up to the middle of August, soil water contents remained near field capacity. During this period, treatment effects on water storage were not clear and it followed the rainfall distribution pattern. Among the two land surface management treatments, BBF often retained slightly higher water in the profile than the FOG treatment. This might be due to higher infiltration and better retention of water in BBF than FOG treatment. Singh et al. (1999) also reported higher water storage in BBF during rainy season in soybean-chickpea rotation on a Vertic Inceptisols. After withdrawal of monsoon, from second week of September in 2004, monitoring of profile water at weekly interval was carried out to study the moisture extraction pattern by different cropping systems during this drying period. Like the earlier year the depletion of water during this period was considerably higher in soybean/pigeonpea and maize/pigeonpea intercropping systems compared with sole maize, sole soybean and soybean/maize intercropping systems in both BBF and FOG land management treatments (Table 3). This was due to higher extraction of water from the profile by pigeonpea crop which was near full vegetative stage during that period, while the other two crops viz. maize and soybean were near maturity at that time. Besides this, the deep root system of pigeonpea extracted more water from deeper soil layers than the other crops.

Yield of Rainy Season Crops

The grain yield of soybean in sole soybean treatment varied due to differential rainfall amount and its distribution during the years of experimentation. In 2004, the grain yield of soybean was typically low in both broad bed and furrow (BBF) and flat on grade (FOG) land treatments because of less rainfall. However, results revealed that the grain yield of soybean in sole soybean, soybean/maize intercropping and soybean/pigeon pea intercropping systems under BBF was greater than that under FOG for every year of the experimentation. On an average over four years, BBF registered 12.7-18.0% greater grain yield of soybean than FOG under sole soybean. The soybean yield in sole soybean and soybean/ pigeon pea intercropping was similar, but it reduced in soybean/ maize intercropping. This was mainly due to competition between the crops for light and nutrients in soybean-maize cropping system. But soybean/pigeonpea intercropping the yield of soybean was not affected, as pigeonpea was a slow growing crop compared to maize and soybean and its growth peaked up after harvest of soybean and maize. Thus competition between the intercrops was less. Similar trend was observed in total biomass production of crops for sole and intercropping systems under BBF and FOG land treatments.

Grain yield of maize in sole maize treatment under BBF was 11.8-16.0% greater than the same treatment under FOG land configuration. In soybean/maize and maize/pigeon pea intercropping systems, grain yield of maize was also greater in BBF than FOG. Similar trend was observed in total biomass production of maize for different sole and intercropping systems. In 2003-04, though maize population in soybean/maize intercropping was similar to the sole maize, maize yield was reduced in intercropping by 203 and 244 kg ha^{-1} in BBF and FOG, respectively. For other years, maize yield in soybean/ maize intercropping was lower than the sole maize because of reduced plant population, almost half of the sole maize population. In maize/ pigeonpea intercropping, maize population was imilar to the sole maize, as pigeonpea was intercropped with maize as in the additive series; thus maize yield was not reduced. This trend was observed in every year since 2004-05.

Soybean equivalent yield (SEY) of rainy season crops was higher in BBF than FOG (Table 4). Higher yield of crops in BBF might be ascribed to higher retention of moisture in the grain filling stage, less water congestion, better aeration in the rooting zone. Selvaraju et al. (1999) and Wani et al. (2003) also reported a higher crop yield under BBF land treatment in Vertisols. In 2003-04, SEY of systems were in the order: soybean/pigeon pea intercropping > sole pigeonpea > sole soybean > soybean/maize intercropping > sole maize both in the BBF and FOG. In the year 2004-05, the order was: maize/pigeon pea intercropping > soybean/ pigeonpea intercropping > sole maize > soybean/ maize intercropping > sole soybean, while in 2005-06 and 2006-07, SEY showed the following order maize/ pigeon pea intercropping > soybean/ pigeon pea intercropping > sole maize = soybean/maize intercropping > sole soybean.

Grain Yield and Water Use Efficiency of Chickpea

In the winter season chickpea was grown in three cropping systems where pigeonpea was not included and with two irrigation levels. The grain yield of chickpea was greater in BBF than FOG in all the four years of experimentation (Table 5). In both the land configuration, yield variation of chickpea was not significant among three cropping systems where it was grown. Thus, the residual effect of previous crops on the performance of chickpea was not significant. However, irrigation treatments showed significant variation in the performance of chickpea. The grain yield of chickpea in I_2 (one pre-sowing + one post-sowing irrigation) was significantly greater than I_1 (pre-sowing irrigation) in both the land configuration.

Water use efficiency (WUE) was estimated as grain yield divided by seasonal evapotranspiration (ET). Seasonal ET was estimated by water balance method, assuming water loss through runoff and deep drainage during the crop-growing season as negligible. WUE of chickpea was more under BBF than FOG (Table 6). In the year 2003-04, WUE in BBF was significantly higher in I_1 than I_2 irrigation treatment but in FOG the difference among the irrigation levels was not significant. Residual effect of the previous crop has not shown any significant effect on the WUE of chickpea in both BBF and FOG land configuration. In the years 2005-06 and 2006-07, WUE of chickpea was significantly higher in I_2 than that in I_1 irrigation treatment in BBF. This was probably due to higher increase in seed yield of chickpea compared to corresponding increase in ET with increase in irrigation amount in BBF; however, in FOG irrigation level has not shown any significantly effect on the WUE of chickpea in 2005-06.

Total System Productivity as Soybean Equivalent Yield (SEY)

Irrespective of irrigation to chickpea and cropping systems, results revealed that total system productivity (TSP) as soybean equivalent yield was greater in BBF than FOG; and TSP was higher in I_2 (pre-sowing plus 1 post sowing irrigation) than I_1 (pre-sowing irrigation). Among the 5 cropping systems, there was significant difference in the total productivity of systems (Table 7). Soybean-chickpea system was found to be the least productive except in the first year (2003-04). After 2003-04, system productivity was not favourable for the soybean-chickpea system, because of constantly lower yield of soybean over years, and at the same time maize yield was considerably higher. Consequently, the systems involving maize crop, either as sole or intercrop (as in maize-chickpea, soybean/ maize intercropping-chickpea and maize/ pigeonpea intercropping systems) gave higher productivity than other systems under both BBF and FOG land treatments. Even the TSP was higher in maize/ pigeonpea intercropping systems where there was no subsequent chickpea crop. In the event of non-availability of irrigation water to chickpea, maize/ pigeonpea intercropping is better system than sole soybean. Thus, these three cropping systems viz. maize-chickpea, soybean/ maize intercropping-chickpea and maize/ pigeonpea intercropping i.e., diversification from the sole soybean, hold the promise for increasing productivity in the on-station watershed.

Conclusions

The runoff and soil loss from broad-bed and furrow (BBF) are less than that from flat land treatment. Besides this, BBF also helps in safe drainage of excess rainfall and reduces chance of water congestion to the rainy season crops while it retains higher moisture during the later phase of crop growth after withdrawal of monsoon and produced higher crop yield than the traditional flat land sowing system. Farmers may adopt BBF land configuration for growing of crops like soybean, maize, pigeonpea and chickpea. The study provides an option for crop diversification from the present predominant soybean based cropping systems to cropping systems where maize is a component, either as sole or intercrop for this region. Water lost as surface run-off could be conserved in watershed ponds and used as supplemental or life-saving irrigation.

References

Gomez, K.A. and Gomez, A.A., 1984. Statistical Procedures for Agricultural Research. 2nd ed. Wiley – Interscience. New York.

Kampen, J., 1982. An approach to improved productivity on deep Vertisols. Information Bulletin No. 11, International Crop Research Institute for the Semi-Arid Tropics, Patancheru, A.P., India.

Pathak, P., 1999. Runoff and soil loss measurement. In: Wani, S.P., Singh, P., Pathak, P. (Eds.), Methods and Management of Data for Watershed Research, Technical Manual No. 5, International Crop Research Institute for the Semi-Arid Tropics, Patancheru, A.P., India, pp. 15-40.

Pathak, P., Miranda, S.M., El-Swaify, S.A., 1985. Improved rainfed farming for semi-arid tropics – Implications for soil and water conservation. In: El-Swaify, S.A., Moldenhauer, W.C., Andrew, L. (Eds.), Soil Erosion and Conservation. Soil Conservation Society of America, pp. 338-354.

Selvaraju, R., Subbian, P., Balasubramanian, A., Lal, R., 1999. Land configuration and soil nutrient management options for sustainable crop production on Alfisols and Vertisols of southern peninsular India. Soil Tillage Res. 52, 203-216.

Singh, H.P., Venkateswarlu, B., Vittal, K.P.R., Ramachandran, K., 2000. Management of rainfed agro-ecosystem. In: Yadav, J.S.P., Singh, G.B. (Eds.), Natural Resource Management for Agricultural Production in India. International Conference on Managing Natural Resources for Sustainable Agricultural Production in the 21st Century, New Delhi, February 14-18, 2000, pp. 669-774.

Singh, P., Algarswamy, G., Pathak. P., Wani, S.P., Hoogenboom., G., Viramani, S.M., 1999. Soybean- chickpea rotation on Vertic Inceptisols I. Effect of soil depth and landform on light interception, water balance and crop yields. Field Crops Res. 63, 211-224.

Srivastava, K.L., Jangwad, L.S., 1988. Water balance and erosion rates of Vertisol watersheds under different management. Indian J. Dryland Agric. Res. Develop. 3, 137-144.

Wani, S.P., Pathak, P., Jangawad, L.S., Eswaran, H., Singh, P., 2003. Improved management of Vertisols in the semi-arid tropics for increased productivity and soil carbon sequestration. Soil Use Manage. 19, 217-222.

❑❑❑

Table 1: Seasonal rainfall, runoff, and soil loss from different land configuration, broad-bed and furrow (BBF) and flat on grade (FOG)

Year	*Rainfall (mm)*	*Runoff (mm)*		*Soil loss (kg ha^{-1})*	
		BBF	*FOG*	*BBF*	*FOG*
2003	1058.0	163.0 (15.4%)	214.9 (20.3%)	1956.0	2836.9
2004	798.2	124.0 (15.5%)	183.3 (23.0%)	657.0	1466.0
2005	946.0	177 (18.7%)	246 (26.1%)	1402.0	3123.0
2006	1513.0	502 (33.2%)	873 (57.7%)	3503.0	6365.0

Values within parentheses indicate the percent of seasonal rainfall

Table 2: Depletion of soil moisture during a drying cycle after the withdrawal of monsoon in 2003 as affected by land surface management treatment and cropping system

Cropping systems	*Moisture depletion from 0-90 cm depth (mm)*	
	BBF	*FOG*
Sole soybean	40.8	42.4
Soybean/maize intercropping	37.7	35.6
Sole maize	33.3	35.0
Sole pigeon pea	60.4	57.3
Soybean/pigeon pea intercropping	51.2	55.8
LSD (P=0.05)	11.3	10.5

Table 3: Depletion of soil moisture during a 28 days drying cycle after the withdrawal of monsoon in 2004 as affected by cropping system under BBF and FOG land treatment

Cropping systems	*Moisture depletion from 0-90 cm depth (mm)*	
	BBF	*FOG*
Sole soybean	62.3	59.3
Soybean/maize intercropping	59.0	56.0
Sole maize	55.6	52.6
Maize/pigeon pea intercropping	70.3	76.6
Soybean/pigeon pea intercropping	74.5	71.5
LSD (P=0.05)	6.2	7.5

Table 4: Soybean equivalent yield (SEY) of rainy season crops

Cropping system	*Soybean equivalent yield (SEY) (kg ha^{-1})*							
	BBF				*FOG*			
	2003-04	*2004-05*	*2005-06*	*2006-07*	*2003-04*	*2004-05*	*2005-06*	*2006-07*
Sole soybean	1831b	641e	1527d	1178d	1581b	543e	1337c	1029e
Sole maize	1212c	2072c	3163c	2590c	1084c	1778c	2726b	2325c
Soybean/maize intercropping	1791b	1378d	3244c	2315c	1566b	1194d	2791b	2083d
Soybean/ pigeon pea intercropping	2615a	2369b	3532b	3134b	2262a	2027b	2912b	2778b
Maize/ pigeon pea intercropping*	1907b	3385a	4513a	3951a	1646b	2975a	4112a	3659a

*There was pigeonpea sole crop in the year 2003-04

Table 5: Yield of chickpea as influenced by irrigation and previous crops

Cropping system	Grain yield of chickpea (kg/ha)							
	BBF				FOG			
	2003-04	2004-05	2005-06	2006-07	2003-04	2004-05	2005-06	2006-07
Irrigation								
I_1	1893b	1297b	795b	1087b	1259b	1202b	715b	936b
I_2	2116a	1557a	1203a	1500a	1588a	1397a	980a	1423a
Cropping systems								
Soybean-chickpea	2040a	1468a	1076a	1326a	1340a	1349a	920a	1181a
Maize-chickpea	2062a	1385a	969a	1254a	1453a	1258a	797a	1162a
Soybean/maize -chickpea	1913a	1429a	952a	1301a	1478a	1292a	824a	1195a

Table 6: WUE of chickpea as influenced by irrigation and previous crops

Cropping system	WUE (kg ha^{-1} mm^{-1})							
	BBF				FOG			
	2003-04	2004-05	2005-06	2006-07	2003-04	2004-05	2005-06	2006-07
Irrigation								
I_1	12.38a	9.13a	5.05b	6.75b	8.72a	8.97a	4.74a	6.46b
I_2	10.37b	8.00b	6.06a	7.66a	8.58a	7.65b	4.83a	7.81a
Cropping systems								
Soybean-chickpea	11.56a	8.64a	5.73a	7.32a	8.18a	8.44a	5.13a	7.15a
Maize-chickpea	11.63a	8.40a	5.41a	7.06a	8.88a	8.08a	4.52a	7.20a
Soy/maize intercropping-chickpea	10.92a	8.66a	5.53a	7.24a	8.87a	8.40a	4.71a	7.06a

Table 7: Total system productivity as soybean equivalent yield (SEY)

Cropping system	Total system productivity as SEY (kg ha^{-1})							
	BBF				FOG			
	2003-04	2004-05	2005-06	2006-07	2003-04	2004-05	2005-06	2006-07
Irrigation to chickpea								
I_1	2818b	2747b	3857b	3551b	2257b	2425b	3370b	3165b
I_2	2929a	2903a	4196a	3900a	2422a	2542a	3591a	3576a
Cropping systems								
Soybean-chickpea	3530a	2109d	3019c	3044c	2698a	1894c	2613c	2691c
Maize-chickpea	2931b	3457a	4507a	4354a	2295b	3036a	3832a	3959a
Soybean/maize -chickpea	3385a	2807b	4564a	4145ab	2798a	2485b	3933a	3765b
Soybean/pigeonpea	2615c	2369c	3532b	3134c	2262b	2027c	2912b	2778c
Maize/pigeonpea*	1907d	3385a	4513a	3951b	1646c	2975a	4112a	3659b

*There was sole crop of pigeonpea in the year 2003-04