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Water Use and Productivity of Different Agricultural and Horticultural Crops and Rice and Maize-based Cropping Systems in an Intensively Cultivated Sub-watershed of Peninsular India

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A B S T R A C T

The crop water requirement of different agricultural and horticultural crops (16 crops) was assessed during different season's viz., *kharif, rabi* and summer for four successive years (2008-12) in farmers field conditions. The water utilized and water productivity of rice –rice and maize – vegetable cropping systems were studies at Wargal, *Kothakunta* sub -watershed, in Siddipet district, Telangana. The mean water used and water productivity of crops was estimated for *kharif* rice (13299 m3/ha and 0.457 kg m^{-3}), *rabi* rice (14298 m3/ha and 0.463 kg m^{-3}), maize (3472m3/ha and 1.607 kg m^{-3}), sweet corn (3378 m3/ha and 1.812 kg m^{-3}), cotton (5421m3/ha and 1.61 kg m^{-3}), sunflower (9209 m3/ha and 0.051 kg m^{-3}), tomato (drip irrigation) (5162 m3/ha and 1.544 kg m^{-3}), tomato (surface irrigation) (11665 m3/ha and 1.376 kg m^{-3}), bhendi (surface irrigation) (9302 m3/ha and 0.464 kg m^{-3}), green chillies (surface irrigation) (7597 m3/ha and 2.22 kg m^{-3}), French bean (surface irrigation) (*kharif*- 3704 m3/ha and 0.99 kg m^{-3}, *rabi*-2846 m3/ha and 0.94 kg m^{-3} and summer- 4972 m3/ha and 0.887 kg m^{-3}), French bean (drip irrigation) (2626 m3/ha and 1.347 kg m^{-3}), French bean (after paddy) surface irrigation (2751 m3/ha and 2.456 kg m^{-3}), bush bean (surface irrigation) (6069 m3/ha and 0.62 kg m^{-3}), bush bean (drip) (6088 m3/ha and 1.005 kg m^{-3}), bush bean surface irrigation (after paddy field) (2404 m3/ha and 0.349 kg m^{-3}), vegetable cow pea (drip irrigation) *rabi* (9713 m3/ha and 0.696 kg m^{-3}), vegetable cow pea (drip irrigation) summer (4040m3/ha and 1.19 kg m^{-3}), ridge gourd (drip irrigation) (5334 m3/ha and 1.413 kg m^{-3}), cabbage (surface irrigation) (6802 m3/ha and 11.92 kg m^{-3}),), cucumber ((drip irrigation) (*kharif*-3304 m3/ha and 1.599 kg m^{-3}, *rabi*-2241 m3/ha and 2.67 kg m^{-3} and summer- 10048 m3/ha and 0.782 kg m^{-3}), onion (surface irrigation) (2136 m3/ha and 2.676 kg m^{-3}), potato (surface irrigation) (4386 m3/ha and 2.396 kg m^{-3}), potato (drip irrigation) (4621 m3/ha and 3.509 kg m^{-3}).The rice crop consumed a higher quantity of water than other crops. The cabbage cultivated during *rabi* 2009-10 under surface irrigation recorded the highest water productivity, while the lowest water productivity was recorded in sunflower during *rabi* 2011-12.Rice equivalent yield was worked out using prevailing crop market prices during 2009-12. Mean water productivity of different rice-rice and maize based cropping systems was found to be rice -rice (0.38 kg m^{-3}), maize -potato (0.76 kg m^{-3}), maize - tomato (0.86 kg m^{-3}), maize- fallow –French bean (0.89 kg m^{-3}), maize - vegetable cow pea (0.57 kg m^{-3}), maize- fallow –bush bean (1.33 kg m^{-3}) and maize - cabbage (2.31 kg m^{-3}). The water productivity of maize – vegetable cropping system was three times higher than that of rice – rice cropping system. Therefore, from the present study maize – vegetable cropping system was found to be the most viable cropping system under Wargal, *Kothakunta* sub -watershed for conservation of available water resources.

Introduction

In India more than 80% of the water resources are used for agriculture. The agriculture sector uses a higher quantity of water and in the coming years it has to compete with other sectors like domestic, industry and power generation and the share of water available for agricultural production is getting reduced day by day. The groundwater contributes more than 60% of the irrigated area in India. To meet the food grain requirement of people, it is assumed that the overall irrigation efficiencies will be in the order of 50% for surface water systems and 72% for groundwater systems, compared to the level of 35-40% in 2010 (FAO, 2010). For feeding the growing population with decreased water allocation for agriculture, that is, to increase agricultural water productivity. The water productivity (WP) is a measure of the ability of agricultural systems to convert water into food (Kijne *et al.,* 2003). It can be measured as physical and economic WP, irrigation and rainwater productivity (Simon Cook *et al.,* 2006).In general, the WP in farmer's fields is low as compared to experimental sites indicating the need for more efforts to transfer water-saving technologies (Yadvinder-Singh *et al.,* 2014). With scientific data on crop water requirements in different seasons and for producing targeted yields, the regional planning of water resources could be achieved. In Wargal, *Kothakunta* sub watershed, 206 bore wells irrigate 192.91 ha and the crops cultivated under bore wells are paddy, maize, vegetables, cotton and sunflower. The major area is under rice. Rice consumes a large quantity of water and the productivity is lower than any irrigated dry crop. Alternatives for increasing water productivity can be applied at the crop, farm system and basin levels (Molden *et al.,* 2001). The knowledge of water resources availability, crop water requirement and water productivity is necessary for its improvement especially in groundwater extracted areas. Hence, an attempt was made during 2008 to 2012 to assess the water productivity of different agricultural and horticultural crops and rice –rice and maize – vegetable based cropping systems in *Kothakunta* sub watershed in Siddipet district of Telangana, India that helps to suggest alternative agronomic measures for increasing the water productivity.

Materials and Methods

The Wargal village is located at latitude 17^0 41'19.4'' N, longitude 78^0 29'24.0'' E and an elevation of 576-590 m above sea level in Siddipet district of Telangana. Wargal village is having 2618 ha of geographical area with 1460 ha rain-fed, 167 ha under tank irrigation and 235 ha under irrigation of 206 bore wells. The major crops cultivated under bore wells include paddy, maize, vegetables (bhendi, beans, potato, ridge guard, onion and cowpea), cotton and sunflower. Though the village is having red chalka (Red sandy/sandy clay loams – Alfisols, 2336 ha) and black cotton soils (Vertisols, 280 ha), the watershed area (about 15 sq km) consists of mostly red soils. The area is having a slope of 1-5 %, with shallow to medium soil depth and coarse to medium in soil texture. The soil is having a pH range of 6.5 to 7.5, low in available N, low to high in available phosphorus and medium to high in available K. The major amount of rainfall is received during the South-West monsoon and the normal rainfall is 773 mm. The land holdings indicate that 25%, 47% and 28% of the farmers belonged to marginal, small and large (Vijayakumari *et al.,* 2012).

The water use and water productivity of different agricultural and horticultural crops were assessed during *kharif, rabi* and summer seasons for four successive years. The water used and water productivity of rice –rice and

maize – vegetable based cropping systems were worked out. The crops were grown with groundwater irrigation in Wargal sub-watershed. The popular rice varieties like BPT 5204, JGL 384, Kaveri and Prabhala 1101 and hybrid maize and high yielding vegetable varieties were grown during *kharif* and *rabi* seasons. Data was recorded on the quantity of water used and yield of the different crops from the farmer's fields. Growing the crops with surface irrigation was prevalent in the watershed area. Drip irrigation facility was provided to four farmers of the village and crop water requirement under drip irrigation was recorded along with surface irrigation. The irrigation water given to crops was measured by fixing water meters to water delivery pipe and the quantity of water applied at each irrigations was recorded.

Amount of rainfall received differed considerably year to year. It was 662 mm, 489 mm, 1081 mm and 570 mm during 2008, 2009, 2010 and 2011 year, respectively. The rainfed crops grown during *kharif* crops were given supplemental irrigations and the rice in kharif and rabi and rabi irrigated dry crops were cultivated with groundwater of bore wells. The total water received for each crop was estimated by adding the irrigation water given through bore well and the effective rainfall. The rice equivalent yield was calculated by estimating the total value of different crops and back converting to paddy based on the prevailing prices of the product during the crop season viz., rice (*kharif*) Rs 12.4 kg^{-1}, rice (*rabi*) Rs 8.8 kg^{-1}, maize Rs 8.8 kg^{-1}, sweet corn Rs 13 kg^{-1}, tomato Rs 3.43 kg^{-1}, potato Rs 5.48 kg^{-1}, cabbage Rs 1.70 kg^{-1}, green chilli Rs 11.8 kg^{-1}, beans Rs 10.2 kg^{-1}, cucumber (*rabi*) Rs 2.36 kg^{-1}, cucumber (summer) Rs 6.41 kg^{-1}, ridge gourd Rs 13.6 kg^{-1}, bhendi Rs 7.5 $kg^{-1}$and vegetable cowpea Rs 5.6 kg^{-1}.Water productivity (WP) (kg grain m^{-3} of water) was calculated for individual crops and rice equivalent yield as shown below:

1. Water productivity = (for individual crops) $\frac{\text{Yield (kg ha}^{-1})}{\text{Amount of water used (m}^3)}$

2. Water productivity (for rice equivalent yield) = $\frac{Y}{(IR + R)}$

Where

Y = rice equivalent yield (kg ha^{-1}) and
IR = Irrigation water (mm or m^3)
R = Effective rain fall (mm or m^3)
(IR + *R*) = total water input
IR= irrigation water
R= effective rainfall

Effective rainfall data was arrived using CRIWAR software.

3. Rice equivalent yield (kg/ha) = $\frac{\text{Yield of the particular crop (kg/ha) x price of the crop(Rs/kg)}}{\text{Price of rice (Rs/kg)}}$

Results and Discussion

Yield, water use, water requirement and water productivity of different agricultural and horticultural crops cultivated in *Kothakunta* sub watershed is presented in Table 1 and Fig. 1.

Rice

The grain yield of rice ranged from 4987 to 6093 kg/ha with a mean of 5442kg/ha during *kharif* and 5982 to 6085 kg/ha with a mean of 6034 kg/ha during *rabi* (2008-10). The rice crop grown during *rabi* (6034 kg/ha) recorded 6 % higher yield than *kharif* crop (5442 kg/ha). The highest water consumption and water requirement was recorded in rice crop. The water used by the rice crop ranged from 8388 to 17032 m3/ha with a mean of 13299 m3/ha during *kharif* and 11612 to 16983 m3/ha with a mean of 14298 m3/ha during

rabi. The water requirement of rice crop ranged from 1631 to 2833 L/kg with a mean of 2188 L/kg during *kharif* and 1842 to 2611 L/kg with a mean of 2160 L/kg during *rabi*. The water productivity of rice ranged from 0.353 to 0.613 kg/m3 with a mean of 0.457 kg/m3 during *kharif* and 0.383 to 0.543 kg/m3 with a mean of 0.463 kg/m3 during *rabi*.

Maize

The yield of maize grown during *kharif* varied from 2589 to 7250 kg/ha with a mean of 5420 kg/ha. The water used by the maize ranged from 1840 to 4230 m3/ha with a mean of 3472 m3/ha, whereas its water requirement ranged from 515 to 739 L/kg with a mean of 597L/kg. The water productivity of maize varied from 1.353 to 1.942 kg/m3 with a mean of 1.607 kg/m3.

Maize (Sweet corn)

The sweet corn was cultivated during *kharif* and its grain yield ranged from 3125 to 7261 kg/ha with a mean of 5193 kg/ha. Its fresh weight was 10161 kg/ha. The maize sweet corn used water ranging from 2516 to 4240 m3/ha with a mean of 3295m3/ha and its water requirement ranged from 308 to 1357 L/kg with a mean of 670L/kg. Its water productivity ranged from 0.737 to 3.246 kg/m3 with a mean of 2.289kg/m3. Among cereals rice crop grown during *rabi* consumed higher quantity of water and sweet corn cultivated during *kharif* recorded higher water productivity.

Cotton

Cotton was cultivated during *kharif* and recorded a yield of 2425 kg/ha. The water requirement of cotton was 621 L/kg and it used 5421 m3/ha water. It recorded a water productivity of 1.61 kg/m3.

Sunflower

The seed yield of sunflower grown during *rabi* was 471 kg/ha. The sunflower used 9209 m3/ha water and its water requirement was 19608 L/kg. The water productivity of sunflower was 0.051 kg/m3.

Vegetables

In *Kothakunta* sub-watershed, data was recorded for vegetables cultivated under surface irrigation and drip irrigation.

Tomato

The tomato cultivated under drip irrigation during *rabi* recorded a fresh fruit yield of 6498 kg/ha. The fresh fruit yield of tomato cultivated under surface irrigation during *rabi* was 16053 kg/ha. The water used by the tomato cultivated under drip irrigation was 5162 m3/ha and its water requirement was 648 L/kg. The tomato cultivated under surface irrigation used 11665 m3/ha water and its water requirement was 727 L/kg. The tomato cultivated under drip irrigation recorded 6 % higher water productivity than surface irrigation.

Bhendi

The yield of bhendi cultivated under surface irrigation during *kharif* was 4317 kg/ha. The water used and water requirement of the bhendi was 9302 m3/ha and 2155 L/kg, respectively. The water productivity of bhendi was 0.464 kg/m3.

Green chillies

Green chillies cultivated during summer to *kharif* under surface irrigation recorded fresh green chillies yield ranging from 6402 to 24986 kg/ha with a mean of 15694 kg/ha. Green chillies water used ranged from 6791 to

8403 m3/ha with a mean of 7597 m3/ha and its water requirement ranged from 272 to 1312 L/kg with a mean of 450 L/kg. Green chillies recorded water productivity ranging from 0.762 to 3.679 kg/m3 with a mean of 2.22 kg/m3.

French bean

The French bean cultivated under surface irrigation during *kharif* recorded fresh pod yield of 3667 kg/ha. The fresh pod yield of French bean ranged from 1663 to 2340 kg/ha with a mean of 2001 kg/ha during *rabi* and 3057 to 5000 kg/ha with a mean of 4029 kg/ha during summer. However, the fresh pod yield of French bean cultivated under drip irrigation during summer was 3537 kg/ha and French bean grown after paddy under surface irrigation during *rabi* was 6757 kg/ha. The water used by the French bean under surface irrigation was 3704 m3/ha during *kharif* and ranged from 1662 to 4031 m3/ha with a mean of 2846 m3/ha during *rabi.* The water requirement of the French bean was 1010 L/kg during *kharif* and ranged from 770 to 1721 L/kg with a mean of 1245.5L/kg during *rabi*. During summer French bean recorded water usage of 3960 to 5984 m3/haand a water requirement of 792 to 1957 L/kg with a mean of 4972 m3/ha and 1127 L/kg, respectively. However, water used by the French bean cultivated under drip irrigation during summer was 2626 m3/ha with a water requirement of 742 L/kg. French bean grown after paddy under surface irrigation during *rabi* used water of 2751 m3/ha with a water requirement of 407 L/kg. The water productivity of French bean was 0.99 kg/m3 during *kharif* and ranged from 0.581 to 1.299 kg/m3 with a mean of 0.94 kg/m3during *rabi*. It recorded water productivity ranging from 0.511 to 1.263 kg/m3with a mean of 0.887 kg/m3during summer. The water productivity of French bean cultivated under drip irrigation during summer was 1.347 kg/m3 and French bean grown after paddy under surface irrigation during *rabi* was 2.456 kg/m3.

Bush bean

The fresh pod yield of bush bean cultivated under drip irrigation during summer ranged from 4019 to 7635 kg/ha with a mean of 5827 kg/ha. The yield of bush bean grown under surface irrigation during summer ranged from 2186 to 5500 kg/ha with a mean of 3843 kg/ha. The yield of bush bean was higher under drip irrigation than surface irrigation. The bush bean grown after paddy during summer recorded a yield of 840 kg/ha. The water used by the bush bean cultivated under surface irrigation ranged from 5757 to 6380 m3/ha with a mean of 6069 m3/ha and its water requirement ranged from 1161 to 2639 L/kg with a mean of 1613L/kg. The water used by the bush bean grown under drip irrigation ranged from 5384 to 6791 m3/ha with a mean of 6088 m3/ha and its water requirement ranged from 705 to 1689 L/kg with a mean of 995L/kg. The bush bean grown after paddy used 2404 m3/ha water with a water requirement of 2865 L/kg.The water productivity of bush bean under drip irrigation ranged from 0.592 to 1.418 kg/m3 with a mean of 1.005 kg/m3. The water productivity of bush bean under surface irrigation ranged from 0.379 to 0.861 kg/m3 with a mean of 0.62 kg/m3. Therefore, the water productivity of bush bean was 24 % higher under drip irrigation than surface irrigation. The bush bean grown after paddy recorded a water productivity of 0.349 kg/m3.

Vegetable cowpea

The fresh pod yield of vegetable cowpea grown during *rabi* under drip irrigation was 6764 kg/ha. Vegetable cowpea cultivated during summer recorded fresh pod yield of 4809 kg/ha. The water used by the vegetable cowpea grown during *rabi* was 9713 m3/ha

and water requirement was 1437 L/kg. During summer its water usage was 4040 m3/ha, whereas its water requirement was 840L/kg. The water productivity of vegetable cowpea was 0.696 kg/m3 during *rabi* and 1.19 kg/m3 during summer.

Table.1 Yield, water used, water productivity and water requirement of different crops grown in farmer's field conditions at *Kothakunta* Watershed, Wargal, Medak district

Sl. No.	Crops	Season / Year	Yield (kg ha^{-1})	Water used (m^3 ha^{-1})	Water Productivity (kg m^{-3})	Water Productivity (kg mm^{-1})	Water requirement (litres kg^{-1})
1	**RICE (*Kharif*)**						
	1	*Kharif*, 2008	6093 (4)	17032 (4)	0.390 (4)	3.9	2564
	2	*Kharif* 2009	5148 (4)	15805 (4)	0.353 (4)	3.53	2833
	3	*Kharif* 2010	5538 (4)	11970 (4)	0.471 (4)	4.71	2123
	4	*Kharif 2011*	4987 (3)	8388 (3)	0.613 (3)	6.13	1631
		Mean	5442 (15)	13299 (15)	0.457(15)	4.57	2188
	RICE (*Rabi*) (Grain yield)						
	5	*Rabi* 2008-09	6085 (4)	11612 (4)	0.543(4)	5.43	1842
	6	*Rabi* 2009-10	5982 (2)	16983 (2)	0.383 (2)	3.83	2611
		Mean	6034 (6)	14298 (6)	0.463 (6)	4.63	2160
2	**MAIZE (*Kharif*) (Grain yield)**						
	7	*Kharif* 2008	7082 (4)	3716 (4)	1.942 (4)	19.42	515
	8	*Kharif* 2009	4919 (3)	4101 (3)	1.353 (3)	13.53	739
	9	*Kharif* 2010	7250 (2)	4230 (2)	1.727 (2)	17.27	579
	10	*Kharif 2011*	2589 (2)	1840 (2)	1.407 (2)	14.07	711
		Mean	5420 (11)	3472 (11)	1.607 (11)	16.07	597
3	**MAIZE (SWEET CORN) (Grain yield)**						
	11	*Kharif* 2009	7261 (1)	2516 (1)	2.886 (1)	28.86	347
	12	*Kharif* 2010	3125 (1)	4240 (1)	0.737 (1)	7.37	1357
	13	*Kharif 2011* (Fresh weight)	10161 (1)	3130 (1)	3.246 (1)	32.46	308
		Mean		3295 (3)	2.289 (3)	22.89	670
4	**COTTON**						
	14	*Kharif 2011*	2425 (1)	5421 (1)	1.61 (1)	6.54	621
5	**SUNFLOWER (DRIP)**						
	15	*Rabi* 2011-12	471 (1)	9209 (1)	0.051 (1)	0.51	19608
	VEGETABLES						
6	**TOMATO (Fresh Fruit yield)**						
	16	*Rabi* 2008-09 (Drip)	6498 (3)	5162 (3)	1.544 (3)	15.44	648
	17	*Rabi* 2009-10 (SI)	16053 (1)	11665 (1)	1.376(1)	13.76	727
7	**BHENDI (SI)**						
	18	*Kharif 2011*	4317 (1)	9302 (1)	0.464 (1)	46.4	2155
8	**GREEN CHILLIES (SURFACE IRRIGATION)(Fresh green chillies yield)**						
	19	Summer 2010 to *Kharif* 2010	6402 (1)	8403 (1)	0.762 (1)	7.62	1312
	20	Summer 2011 to *Kharif* 2011	24986 (1)	6791 (1)	3.679 (1)	36.79	272
		Mean	15694 (2)	7597 (2)	2.22 (2)	22.2	450

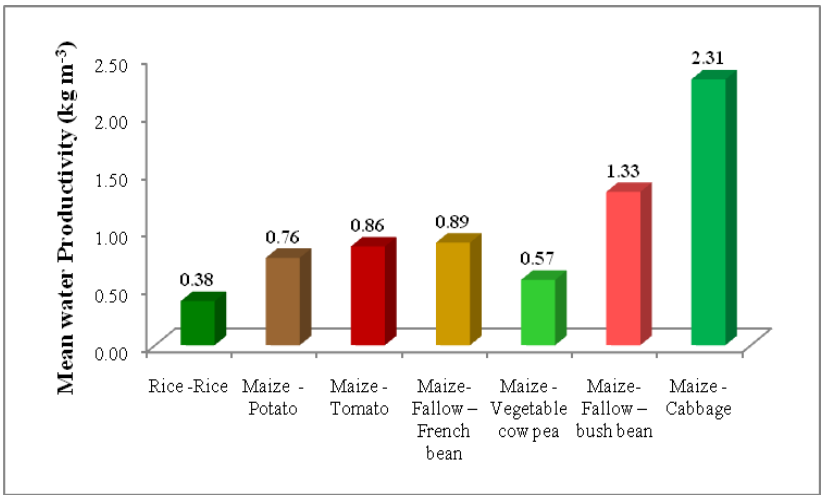
9	**FRENCH BEAN (SURFACE IRRIGATION) (Fresh Pod yield)**						
	21	*Kharif 2011*	3667 (1)	3704 (1)	0.990 (1)	9.9	1010
	22	*Rabi* 2010-11	2340 (1)	4031 (1)	0.581 (1)	5.81	1721
	23	*Rabi* 2011-12	1663 (3)	1662 (3)	1.299 (1)	12.99	770
		Mean	2001	2846	0.94	9.4	1245.5
	24	Summer 2009	5000 (1)	3960 (1)	1.263	12.63	792
	25	Summer 2010	3057 (1)	5984 (1)	0.511	5.11	1957
		Mean	4029 (2)	4972 (2)	0.887 (2)	8.87	1127
	FRENCH BEAN (DRIP) (Fresh pod yield)						
	26	Summer 2010	3537 (1)	2626 (1)	1.347 (1)	13.47	742
	FRENCH BEAN (AFTER PADDY) SURFACE IRRIGATION						
	27	*Rabi* 2011-12	6757 (1)	2751 (1)	2.456 (1)	24.56	407
10	**BUSH BEAN (SURFACE IRRIGATION) (Fresh pod yield)**						
	28	Summer 2010	2186 (2)	5757 (2)	0.379 (2)	3.79	2639
	29	Summer 2011	5500 (2)	6380 (2)	0.861 (2)	8.61	1161
		Mean	3843 (4)	6069 (4)	0.62 (4)	6.2	1613
	BUSH BEAN (DRIP) (Fresh pod yield)						
	30	Summer 2009	4019 (1)	6791 (1)	0.592 (1)	5.93	1689
	31	Summer 2010	7635 (1)	5384 (1)	1.418 (1)	14.18	705
		Mean	5827 (2)	6088 (2)	1.005 (2)	10.05	995
	BUSH BEAN (SURFACE IRRIGATION) (Fresh pod yield) (After paddy field)						
	32	Summer 2011	840 (1)	2404 (1)	0.349	3.49	2865
11	**VEGETABLE COW PEA (DRIP) (LOWA) (Fresh pod yield)**						
	33	*Rabi* 2009-10	6764 (1)	9713 (1)	0.696 (1)	6.96	1437
	34	Summer 2009	4809 (1)	4040 (1)	1.19 (1)	11.9	840
12	**RIDGE GOURD (DRIP)**						
	35	Summer 2011	7537 (1)	5334 (1)	1.413 (1)	14.13	708
13	**CABBAGE (SURFACE IRRIGATION) (Fresh cabbage yield)**						
	36	*Rabi* 2009-10	81050 (1)	6802 (1)	11.92 (1)	119.2	84
14	**CUCUMBER (DRIP) (Salad) (Fresh cucumber yield)**						
	37	*Kharif 2011*	5285 (1)	3304 (1)	1.599 (1)	15.99	625
	38	*Rabi* 2011-12	5983 (1)	2241 (1)	2.67 (1)	26.7	375
	39	Summer 2011	7859 (1)	10048 (1)	0.782 (1)	7.82	1279
15	**ONION (SI)**						
	40	*Kharif 2011*	5714 (1)	2136 (1)	2.676 (1)	26.76	374
16	**POTATO (SURFACE IRRIGATION) (Tuber yield)**						
	41	*Rabi* 2008-09	4809 (1)	4000 (1)	1.202 (1)	12.02	832
	42	*Rabi* 2009-10	3034 (2)	7417 (2)	0.514 (2)	5.14	1946
	43	*Rabi* 2010-11	9750 (1)	1754 (1)	5.559 (1)	55.59	180
	44	*Rabi* 2010-11	10095 (1)	4371 (1)	2.309 (1)	23.09	433
		Mean	6922 (5)	4386 (5)	2.396 (4)	23.96	417
	POTATO (DRIP IRRIGATION) (Tuber yield)						
	45	*Rabi* 2009-10	2298 (1)	8473 (1)	0.271 (1)	27.1	3690
	46	*Rabi* 2010-11	14750 (3)	2639 (3)	7.802 (3)	78.02	128
	47	*Rabi* 2011-12	6757 (1)	2751(1)	2.456 (1)	24.56	407
		Mean	7935 (5)	4621 (5)	3.509 (5)	35.09	285

Figures in parentheses indicate the number of farmers

Table.2 Rice equivalent yields (kg/ha), water used and water productivity of different cropping systems of *Kothakunta* sub watershed, Wargal, Siddipet district, Telangana

Sl. No.	Cropping system	Rice equivalent yield (REY) of system, Kg/ha				Mean Water consumed by system m^3/ha				Water Productivity of the system, REY kg/m^{-3}
2008-09										
		Kharif	*Rabi*	Summer	Total	*Kharif*	*Rabi*	Summer	Total	
1	Rice - rice	6093	6085	-	12178	17032	11612	-	28644	0.43
2	Maize -potato	5077	2995	-	8072	3716	4000	-	7716	1.05
3	Maize -Tomato	5077	2533	-	7610	3716	5162	-	8878	0.86
4	Maize- Fallow – French bean	5077	-	4113	9190	3716	-	3960	7676	1.20
5	Maize- Fallow – bush bean	5077	-	3306	8383	3716	-	6791	10507	0.80
2009-10										
1	Rice -rice	5148	5982	-	11130	15805	16983	-	32788	0.34
2	Maize -potato	3527	1889	-	5416	4101	7417	-	11518	0.47
3	Maize- Fallow – French bean	3527	-	2515	6042	4101	-	5984	10085	0.60
4	Maize - vegetable cow pea	3527	4304	-	7831	4101	9713	-	13814	0.57
5	Maize- Fallow – bush bean	3527		6280	9807	4101	-	5384	9485	1.03
6	Maize- Cabbage	4577	11112		15689	4101	-	6802	10903	2.31

Fig.1 Mean water productivity of different cropping systems (REY kg/m^3) in Wargal, Siddipet district, Telangana, during 2008-09 and 2009-10



Ridge gourd

The ridge gourd cultivated under drip irrigation during summer recorded 7537 kg/ha yield. The ridge gourd used 5334 m3/ha water and its water requirement was 708 L/kg. Water productivity of ridge gourd was 1.413 kg/m3.

Cabbage

The fresh cabbage yield cultivated under surface irrigation during *rabi* was 81050 kg/ha. The water used by the cabbage was 6802 m3/ha and its water requirement was 84 L/kg. The water productivity of cabbage was 11.92 kg/m3.

Cucumber

The yield of cucumber cultivated under drip irrigation during *kharif* was 5285 kg/ha, *rabi* was 5983 kg/ha and summer was 7859 kg/ha. The water usage and water requirement of the cucumber during *kharif* was 3304 m3/ha and 625 L/kg, *rabi* was 2241 m3/ha and 375 L/kg and summer was 10048 m3/ha and 1279 L/kg, respectively. The water productivity of cucumber during *kharif* was 1.599 kg/m3, *rabi* was 2.67 kg/m3 and summer was 0.782 kg/m3.

Among different vegetables cabbage (11.92 kg/m3) cultivated under surface irrigation recorded the highest water productivity and bush bean (0.349 kg/m3) cultivated under surface irrigation after paddy recorded the lowest water productivity. The water productivity of the vegetables grown under drip irrigation was higher than surface irrigation. Under drip irrigation potato cultivated during *rabi* recorded the highest water productivity (3.509kg/m3).

Onion

The onion cultivated under surface irrigation during *kharif* recorded a yield of 5714 kg/ha. The onion used 2136 m3/ha water and its water requirement was 374 L/kg. It recorded a water productivity of 2.676 kg/m3.

Potato

The tuber yield of potato cultivated under drip irrigation during *rabi* ranged from 2298 to 14750 kg/ha with a mean of 7935 kg/ha, whereas the yield of potato grown under surface irrigation during *rabi* ranged from 3034 to 10095 kg/ha with a mean of 6922 kg/ha. Therefore, potato cultivated under drip irrigation (7935 kg/ha) recorded higher tuber yield than surface irrigation (6922 kg/ha). The potato cultivated under drip irrigation used water ranging from 2639 to 8473 m3/ha and its water requirement ranged from 128 to 3690 L/kg with a mean of 4621 m3/ha and 285L/kg, respectively. The potato cultivated under surface irrigation used water ranging from 1754 to 7417 m3/ha and its water requirement ranged from 180 to 1946 L/kg with a mean of 4386 m3/ha and 417L/kg, respectively. The water productivity of potato cultivated under drip irrigation ranged from 0.271 to 7.802 kg/m3 with a mean of 3.509 kg/m3, whereas the water productivity of potato under surface irrigation ranged from 0.514 to 5.559 kg/m3 with a mean of 2.396 kg/m3. Therefore, potato cultivated under drip irrigation (3.509 kg/m3) recorded 18 % higher water productivity than surface irrigation (2.396 kg/m3).

Rice-rice and maize –vegetable based cropping systems

Rice equivalent yield (REY)

For comparison, the yields of different crops were converted to rice equivalent yield (REY). The REY of the rice –rice cropping system was 12178 kg/ha in the first year (2008-09) and11130kg/ha in the second year (2009-10) (Table 2). During the first year of

study, the maize –fallow-French bean recorded higher REY of 9190kg/ha followed by maize –fallow-bush bean (8383kg/ha), maize –potato (8072kg/ha) and maize – tomato (7610kg/ha). During the second year of study, the maize –cabbage recorded higher REY of 15689kg/ha, while the lower REY was recorded by maize –potato cropping system (5416kg/ha).

Water use of different cropping systems

The total quantity of water consumed during both years was the highest in rice –rice cropping system (28644 m3/ha and 32788m3/ha). In the first year water consumed in rice –rice cropping system was 32.99 %, 31.16 %, 33.06 %, 28.59 % higher than maize- potato, maize – tomato, maize – fallow-French bean and maize –fallow-bush bean, cropping system respectively. In the second year water consumed in rice –rice cropping system was 24.01 %, 25.63 %, 21.42 %, 26.3 % and 24.7 % higher than maize-potato, maize –fallow-French bean, maize-vegetable cowpea, maize –fallow-bush bean and maize –cabbage cropping system, respectively (Table 2). However, during second year water used by rice – rice cropping system was higher than that of rice – rice cropping system in first year.

Water productivity of different cropping systems

Among different cropping systems, the lowest water productivity was recorded in rice -rice cropping system during both the years. In first year, maize –fallow-French bean recorded higher water productivity of 1.20kg/m3 followed by maize –potato (1.05kg/m3) (Table 2). The maize –tomato and maize – fallow-bush bean cropping systems recorded lower water productivity than the former two maize – vegetable cropping systems. In second year, the maize – cabbage cropping system recorded higher water productivity(2.31kg/m3) than other systems. The mean water productivity of maize – vegetable cropping system was higher than that of rice – rice cropping system (Table 2 and Fig. 1). In general, the rice crop water productivity increases with short duration (Tuong, 1999) and increase in the ratio of photosynthesis to transpiration (Peng *et al.*, 1998). Further, extensive variability in crop water productivity in a region will occur due to many non-climate related parameters which can be managed.

In conclusion the mean water productivity indicated that among cereal crops sweet corn had the highest water productivity. Among vegetables water productivity of cabbage was highest. During *kharif* sweet corn recorded the highest water productivity, while during *rabi* cabbage recorded the highest water productivity and during summer green chillies recorded the highest water productivity. In general, crops under drip system recorded higher water productivity than under surface irrigation. The water productivity of the maize – vegetable cropping system was three times greater than that of rice – rice cropping system. In intensively groundwater irrigated area of water-shed, it is advisable to follow maize-based irrigated dry crops rather than rice – rice cropping system for groundwater sustainability in peninsular India where rainfall is an uncertainty and groundwater recharge fluctuates greatly from year to year.

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