



Assessment of Crop Water Productivity in an Intensively Cultivated Watershed of Peninsular India

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ABSTRACT

Background: India is facing high water stress and it is amongst those with the most fragile and uncertain water resource countries in the world. Crop productivity depends on quality of input supply including seeds, fertilizers, pesticides and supported by irrigation facilities. In India, ground water irrigates more than 61% of net cropped area and much of water being used for irrigating rice crop. The disproportionate water uses for crop production results in poor water productivity. The planning of water resources could be achieved by knowing the crop water requirements in different seasons and productivity of water. Hence, study was taken up to assess the water use and productivity of crops under intensively ground water irrigated watershed.

Methods: A study conducted to assess the water use and productivity of different crops grown in *Kothakunta* sub watershed (having 206 working bore wells with cultivated area of 203.5 ha) in Siddipet district of Telangana, India during *kharif* and *rabi* season of 2008 to 2012, data were collected from 147 farmers on rice, maize, cotton, potato, flora beans and tomato crops grown under irrigation. The water applied to crops was measured by fixing water meters at the end of water delivery pipe and recorded the quantity of water applied each time. For rice crop four plots were taken and for other crops two plots were taken for measuring the water. The water use and productivity were assessed by using standard procedure.

Result: The water productivity was found to be higher to vegetables, which ranged between 2.43 kg of potato, 1.57 kg of beans and 1.26 kg of tomato than cereals (0.79 kg for maize and 0.39 kg for *rabi* rice) per cubic meter of irrigation water consumed. Water productivity in terms of monetary return (₹) per cubic meter of water consumed was higher with beans (₹ 17.20) in contrast to potato (₹ 16.12). Rice equivalent yield (REY) calculated per cubic meter of irrigation water consumption was very similar to economic return (₹ per cubic meter of water).

Key words: Crop yield, *Kothakunta* sub watershed, Water consumed, Water productivity.

INTRODUCTION

Agricultural sector is facing two major challenges: the ever-increasing population growth that places continuous increase in the demand (Hedayat, 2005) and the need to improve utilization methods of the limited water resources (Falkenmark and Rockstrom, 2004). Estimates suggest that in the next three decades, the global food systems will need 40-50 per cent more freshwater than today. Municipal and industrial demand for water will increase by 50-70 per cent during this period, while demand for energy sector will increase by 85 per cent. In India, 78 per cent of water resources are devoted for irrigation and it is most vulnerable country in the world which faces high water stress. To face this challenge there is need to improve the water productivity in agriculture (Global Water Partnership 2000) and this is the only avenue for meeting the water demand in agriculture (FAO, 2016).

In developing countries like India, the Water Productivity (WP) concept became prominent only during first decade of this century (Barker *et al.*, 2003). The water productivity estimates will help in identifying wastage in water use or yield gaps limiting due to scarcity of water and that supports improvement in agricultural water productivity. The term physical water productivity expressed in kilogram of crop produce per unit of irrigation water used (kg m^{-3}) and combined physical and economic water productivity of water

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expressed as net or gross economic value of crop produce (₹ m^{-3}) (Kumar *et al.*, 2008). The Telangana state has a combination of problems and potentials for water resources and hence recommendations for achieving proper utilization of water resources needs more precise scientific data on crop water requirements in different seasons and quantity of water needed for producing targeted yields specific to crops.

The low water use efficiency can lead to poor crop yield and quality (Cooper *et al.*, 1987) which is bound to affect

accessibility to food and fiber of the masses and may lead to various socio-economic problems in the rural communities (Hedayat, 2005). Low water productivity not only results in dissipation of water resources, but also leads to poor crop yield (Fapohunda, 1992). It is vital for the crop production system in the region to determine actual irrigation efficiency and WP necessary for sustainable crop production system. Hence, this study was undertaken to estimate the yield, crop water requirement and water productivity of different crops grown in *Kothakunta* sub watershed in Siddipet district of Telangana of peninsular India.

MATERIALS AND METHODS

The Wargal village of Wargal mandal (administrative unit containing 18 villages) is located at latitude 17° 41'19.4" N and longitude 78° 29'24.0" E and is 55 km from Hyderabad at an elevation of 576-590 m above sea level in Siddipet district of Telangana. The area of Wargal village is having 2618 ha that includes 2522 ha cultivable land (1460 ha rainfed, 167 ha tank and 235 ha bore wells irrigation) predominantly red *chalka* (Red sandy/sandy clay loams – Alfisols, 2336 ha) and to a lesser extent black cotton soils (Vertisols, 280 ha). The physiography of the watershed area (15 km²) is undulating with 1-5% slope and having slight erosion and moderately drained. The depth of the soil is shallow to medium having coarse to medium texture with a pH range of 6.5 to 7.5. The soils are low in available N, low to high in available phosphorus and medium to high in available K. The normal rainfall is 773 mm and most of it is received during South West monsoon period.

The watershed programmes of the government were not taken up for long time before the assessment of water productivity in the village. The village is a cluster of 7 hamlets with one big village; there are 23 small to big tanks (*kuntas*) with a command area of 0.4 ha to 18.0 ha. Further, there are three big tanks (*kuntas*) with an area of 21.42 - 27.32 ha. There are two tanks irrigating 47.2 and 119.04 ha. These tanks are interconnected one and another through drains forming water conservation structures and land area drains into *kunta* or a tank.

From the 2618 ha, the study area consists of 482 ha sub-watershed under *Kothakunta* of Wargal village. In the study area, there are 206 bore wells, the only source irrigating 192.91 ha. The major crops cultivated under bore wells include rice, maize, cotton and vegetables (tomato, bhendi, brinjal, beans, potato, ridge guard, onion, bitter guard and vegetable cowpea).

In order to quantify the water use and assess water productivity in Wargal sub-watershed, different crops grown under irrigation during *kharif* and *rabi* season of 2008-12 were studied. The data were collected from 147 farmers on cultivated area and crops grown across Wargal sub watershed area. There were 206 working bore wells during 2008-09 in the watershed area with cultivated area of 203.5 ha. In the watershed area 50 ha of the area was under *kharif* fallow and 71.6 ha area was under *rabi* fallow. Rice, maize,

cotton, potato, flora beans and tomato were cultivated in the watershed area. The water applied to crops was measured by fixing water meters at the end of water delivery pipe and recorded the quantity of water applied each time. For rice crop four plots and for other crops two plots were taken for measuring the water.

The *kharif* crops maize and cotton were given supplemental irrigations and rice and *rabi* crops were raised completely with ground water application from bore wells. The yield data of all the farmers were collected and average yield arrived. The total water received for each crop was assessed from the irrigation water given through bore well and estimating the effective rainfall. The rice equivalent yield was calculated by estimating the total value of different crops and back converting to rice based on the prevailing price of the product during the crop season.

Rice equivalent yield (kg ha⁻¹) =

$$\frac{\text{Yield of the particular crop (kg ha}^{-1}\text{)} \times \text{price of the crop (Rs kg}^{-1}\text{)}}{\text{Price of rice (Rs kg}^{-1}\text{)}}$$

Water productivity

Water productivity (WP) (kg grain m⁻³ of water) was calculated for rice equivalent yield as shown below:

$$\text{Water productivity (for Rice Equivalent Yield)} = \frac{Y}{(IR + R)}$$

Where

Y = Rice Equivalent Yield (kg ha⁻¹).

IR = Irrigation water (mm or m³).

R = Effective rain fall (mm or m³).

(IR + R) = total water input.

RESULTS AND DISCUSSION

Yield of crops

In Wargal watershed, a total area of 287.9 ha was cultivated during *kharif* and *rabi* seasons by using irrigation water and supplemental irrigation (Table 1). Of this area, 153.5 ha was cultivated by 285 farmers mainly under three crops rice, maize and cotton and 134.35 ha during *rabi* by 333 farmers under rice, potato, beans and tomato. The cropping intensity of watershed area was 1.41. The mean rice yield was 4286 kg ha⁻¹ and 4843 kg ha⁻¹ during *kharif* and *rabi*, respectively. The mean yield recorded by maize was 3453 kg ha⁻¹ and cotton 3545 kg ha⁻¹ during *kharif*. The mean yield recorded by potato was 13066 kg ha⁻¹, beans 7579 kg ha⁻¹ and tomato 6498 kg ha⁻¹. The gross income generated from 203.5 ha of the watershed averaged of Rs. 49,323 ha⁻¹.

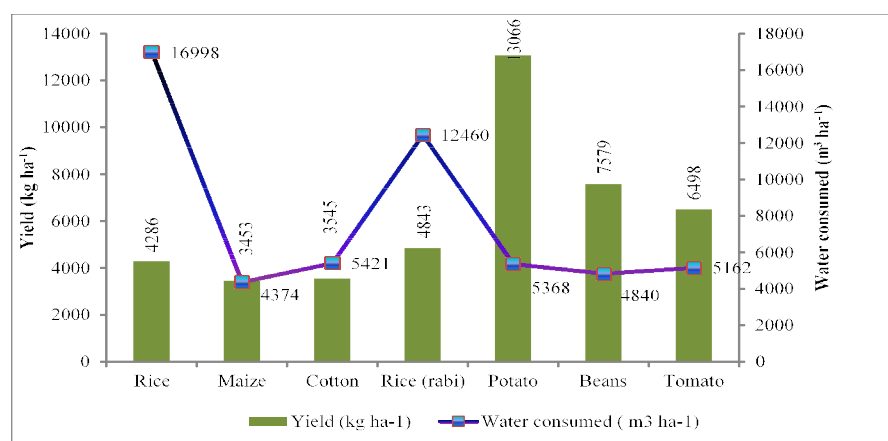
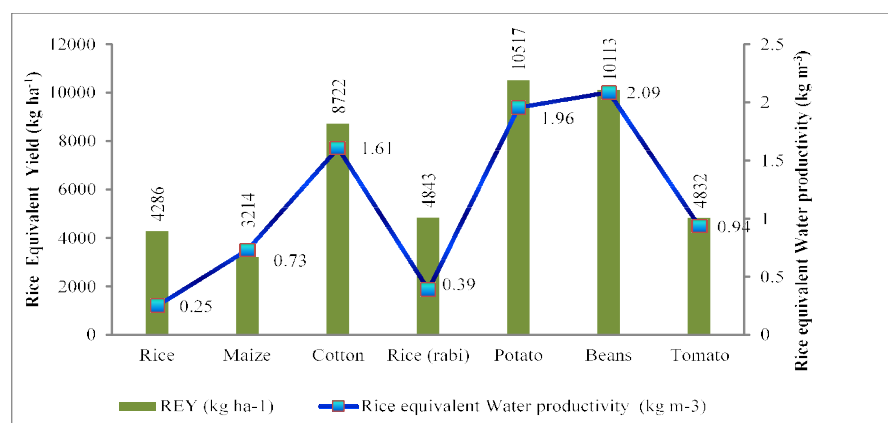
Water use and productivity

The *kharif* rice consumed 16998 m³ ha⁻¹ (1699.8 mm) water as compared to *rabi* rice (12460 m³ ha⁻¹) (1246 mm) (Table 1 and Fig 1). The maize and cotton crops received supplemental irrigation of 894 m³ (89.4 mm) and 1341 m³ ha⁻¹ (134.1 mm) besides effective rainfall of 3480 m³ (348 mm) and 4080 m³ ha⁻¹ (408 mm) during *kharif* and *rabi* seasons. During *rabi*, the rice crop consumed 12460 m³ ha⁻¹

Table 1: Crop production and water productivity of Wargal sub-watershed area.

Crop	Number of farmers	Area (ha)	Yield (kg ha ⁻¹)	Price (Rs kg ⁻¹)	Gross income (Rs ha ⁻¹)	REY (kg ha ⁻¹)	Effective rainfall (mm)	Irrigation water (mm)	Quantity of water (m ³ ha ⁻¹)	Water productivity (kg m ⁻³)	Water productivity (kg m ⁻³)	REY water productivity (kg m ⁻³)
Rice (K)	137	73.5	4286	8.35	35788	4286	465	1234	16998	2.11	0.25	0.25
Rice (R)	132	68.7	4843	8.23	39856	4843	4	1242	12460	3.20	0.39	0.39
Maize (K)	107	55.6	3453	7.77	26831	3214	348	89	4374	6.13	0.79	0.73
Cotton	41	24.4	3545	20.54	72819	8722	408	134	5421	13.44	0.65	1.61
Potato (R)	109	38.8	13066	6.62	86554	10517	0	536	5368	16.12	2.43	1.96
Beans (S)	88	26.1	7579	10.98	83233	10113	0	484	4840	17.20	1.57	2.09
Tomato	4	0.75	6498	6.12	39768	4832	0	516	5162	7.70	1.26	0.94

Note: K-Kharif, R- Rabi, S-Summer.

**Fig 1:** Yield and water consumed by different crops in Wargal watershed area.**Fig 2:** Rice equivalent yield and rice equivalent water productivity of different crops in Wargal watershed area.

(1246 mm) of water as compared to 5368 m³ ha⁻¹ (536.8 mm) by potato, 4840 m³ ha⁻¹ (484 mm) by beans and 5162 m³ ha⁻¹ (516.2 mm) by tomato crops. The increased consumption by rice crop was more than two times that of potato, beans and tomato.

Among different crops grown in Wargal watershed, potato cultivated during *rabi* recorded higher water productivity (2.43 kg m⁻³) followed by beans grown during summer (1.57 kg m⁻³). The water productivity of maize was 0.79 kg m⁻³, cotton 0.65 kg m⁻³, *rabi* rice 0.39 kg m⁻³ and

tomato 1.26 kg m⁻³. The *kharif* rice recorded the lowest water productivity of 0.25 kg m⁻³.

Water productivity was found to be higher in vegetables, which ranged between 2.43 kg of potato, 1.57 kg of beans and 1.26 kg of tomato than cereals (0.79 kg for maize and 0.39 kg for *rabi* rice) per cubic meter of irrigation water consumed. The higher water productivity by vegetables was obviously due to high water content in their economic produce (> 80%), whereas in rice the water content is only 12%.

Water productivity in terms of monetary return (₹) per cubic meter of water consumed was higher with beans (₹ 17.20) in contrast to potato (₹ 16.12) which had better physical produce (2.43 kg) than beans (1.26 kg) (Fig 2). In the same way cotton, which had only 0.65 kg (*kapas*) per cubic meter of irrigation water could give a monetary benefit of ₹ 13.44 than tomato (₹ 7.70). Rice and maize being food grains with low commercial value, their economic returns were the least (₹ 2.11 and 6.13) compared to other crops cultivated in this area. Rice equivalent yield (REY) calculated per cubic meter of irrigation water consumption was very similar to economic return (Fig 2 and Table 1) (₹ per cubic meter of water).

CONCLUSION

The rice equivalent water productivity was higher with cotton and maize over rice during *kharif* (rainy season) and potato and beans than rice in *rabi* (rain free period).

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