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COMPARATIVE STUDY OF SCIENTIFIC AND TRADITIONAL WATER APPLICATION PRACTICES FOR WHEAT CROP

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ABSTRACT

Farmers apply injudicious amount of water to crops, without considering the crop water requirement, which results in colossal wastage of water. However, the best way to apply water without undue excess is the application of water in a scientific manner. A study was carried out to compare the scientific and traditional water application practices for wheat crop. Scientific water application practice was provided at 50% depletion of soil moisture content and traditional water application practice was opted on the basis of farmers' interviews. The scientific water application practice saved 20.85% of water (P< 0.01), obtained 36% more yield (P< 0.01) and 50.56% more water use efficiency (P< 0.01) compared to traditional water application practice. It is concluded that water should be applied according to scientific water application practice; it not only saves water, but also increases yield.

Keywords: scientific water application, traditional water application, water saving, water use efficiency, yield

INTRODUCTION

The rapid growth in population approximately 2.05% per year (Ministry of Finance, 2011) has increased the demands for food and fiber, which have exerted great pressures on the agriculture sector to produce more food in order to feed the ever increasing population of the country (Kahlown and Majeed, 2004). Moreover, Pakistan is extremely short of freshwater resources. The per capita availability of water, which was 5650 m^3 per year in 1951 and 1200 m^3 per year in 2003, is expected to decline further to 1000 m^3 per year in 2010 and to 800 m^3 per year in 2026 (GoP-PC, 2007). Hence, it becomes imperative to enhance the agriculture production with appropriate use of available water resources.

The country is situated in arid to semi-arid climatic regions. The average annual rainfall distribution has broad regional variations and ranges between 125 mm in Balochistan to 750 mm in northern west (Ishfaque, 2002). Additionally, major portion of the rainfall occurs in the monsoon seasons of July and August and this cannot be fully utilized by the agriculture (Kahlown and Majeed, 2004).

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The groundwater potential of the country is estimated at 66 MAF per year (Amin, 2004), while the safe yield is around 55 MAF (Tariq, 2010). However, about 42 MAF is being exploited annually through > 700,000 farmers tubewells and > 5000 public sector tubewells (Rajput, 2005). This continuous exploitation of fresh groundwater has deteriorated the groundwater quality by up conning of saline groundwater into the fresh groundwater zone. Thus, farmers rely on surface water as the main source of freshwater in the country. No doubt Pakistan has one of the largest integrated irrigation systems in the world. Despite having this well-established irrigation system enormous amount of water is lost in conveyance system creating waterlogging and salinity problems. This is consistent with Khan (1997), who reported that out of 146 MAF of annual river flows; about 106 MAF is diverted to the canal system, whereas about 31 MAF is lost in conveyance system.

In contrast farmers prefer to adopt traditional flood irrigation methods such as border, basin and furrow. In which they apply water equal to the top edges of banks/ bunds considering the traditional plant based indicators; which create ponds rather than irrigating the crops. Hamdy *et al.* (2003) concluded that imprudent application of irrigation water through traditional irrigation methods has reduced the cropping intensities and yields. This is consistent with Ishfaque (2002), who concluded that traditional water application practices have created the twin problem of waterlogging and salinity with substantial reduction in the overall irrigation efficiency. Therefore government organizations including National Agricultural Research Council (NARC), Pakistan Agricultural Research Council (PARC), Pakistan Council of Research in Water Resources (PCRWR) as well as agriculture based universities have taken lots of efforts to propagate and familiarize micro irrigation methods (sprinkler and drip). However, a few farmers with the assistance of government have installed drip and sprinkler irrigation methods, because they require high installation and maintenance cost and are also difficult to operate without skilled labor. The best solution to halt the further wastage of water is the application of water in scientific manner.

Wheat (*Triticum aestivum* L.), the king of cereals has been playing pivotal role in the country's economy as well as plays most important role during the prevailing conditions of shortage of food items (Malik *et al.*, 2010). According to the Hobbs and Morris (1996) to meet the supply demands across the Asian Subcontinent, growth rate of wheat at 2.5% per annum will have to be maintained over the next 30 years.

The shortage of freshwater resources and colossal wastage of water by farming community through faulty/ non-technical water application practices would further result in the shortage of water. Additionally, it would leach most of nutrients down to the groundwater. Therefore, a study was designed to compare the scientific and traditional water application practices for wheat crop.

MATERIALS AND METHODS

Experimental site

A study was conducted at the experimental site of Department of Land and Water Management, Faculty of Agricultural Engineering, Sindh Agriculture University, Tandojam. It is located at 25°25' (N), 68°26' (E), in the southern climatic zones of Sindh province. The climate of Tandojam is very dry with average annual rainfall less than 50 mm.

Preparation of land

The experimental site was deeply ploughed using moldboard plough, followed by rotavator and then leveled. The area (26m × 40m) was then divided into six equal plots (13.0m x 13.0m). Three randomly selected plots were occupied by scientific water application practice and three randomly selected plots were employed by traditional water application practice using Completely Randomized Design (CRD) (Figure 1). A polyethylene sheet was provided between traditional to scientific water application practice plots up to depth of 0.8 m to avoid the seepage of water.

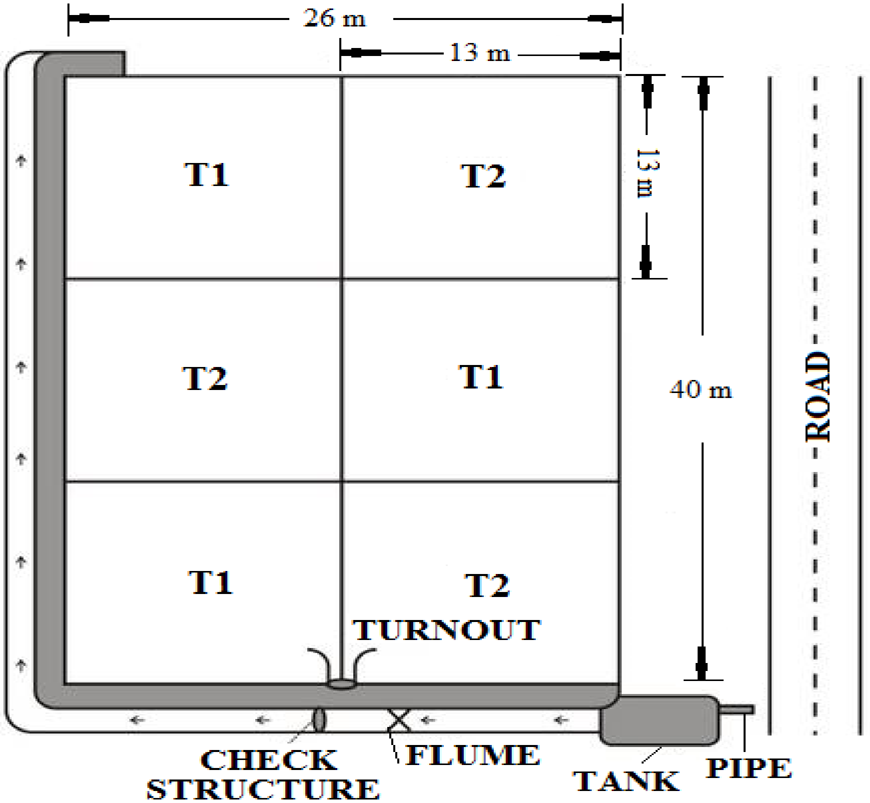

Figure 1. Layout of experimental site

Soil physical properties

The composite soil samples were procured from each plot at the depths of 0-15, 15-30, 30-45 and 45-60cm with the help of tube sampler. The dry bulk density of the soil was then calculated using following formula:

$$\rho d = \frac{W_d}{V} \quad (1)$$

where; ρd is dry bulk density (g cm^{-3}), Wd is weight of dry soil sample (g) and V is total volume of the soil (cm^3).

Soil texture was determined by Bouycous Hydrometer Method (Bouyoucos, 1927). Infiltration rate of the soil was measured by a simple instrument known as double ring infiltrometer (USDA Salinity Lab. 1969).

Chemical analysis
To determine the quality of irrigation water (EC, pH and SAR), nine (09) water samples, three at each plot, were collected at an interval of one hour.

Sowing of crop
A soaking dose of 100 mm was applied to the plots to bring the soil at workable condition. Subsequently wheat seed (TJ-83) was broadcasted and incorporated into the soil with light tillage using cultivator. The fertilizers and chemicals were applied as per recommendations of OFWM Manual-VI (2005).

Water application practices
(a) Traditional water application practice
In traditional water application practice, a 100 mm depth of water was applied to the plots. This depth was opted on the basis of interviews of the farmers of Hyderabad region. Irrigation water is allocated to the farmers' fields on rotation (warabandi) system. Therefore interval of 15 days was fixed per each irrigation.

(b) Scientific water application practice
In scientific practice, water was applied at 50% depletion of the moisture content (Michael, 2008). The depth of water required for irrigation was calculated using following relation (Isrealson *et al.,* 1980):

$$D = \frac{SMD}{100} \times \rho_b \times d_r \quad (2)$$

where,
D = Depth of water required (m)
SMD = Soil moisture deficit level (50%)
ρ_b = Bulk density (g cm^{-3})
d_r = Crop root depth (m)

The following relation was employed to determine soil moisture deficit (SMD): soil moisture content at 50% depletion and field capacity (θ):

$$SMD = \theta_f - \theta_{\circ} \quad (3)$$

The following relation was used to determine soil moisture content at 50% depletion (θ):

$$\theta = \frac{W_w - W_d}{W_d} \times 100 \qquad (4)$$

where;
SMD = Soil moisture deficit level
θ_f = Moisture content at field capacity (%)
$\theta_\circ$ = Moisture content at 50 % SMD
θ = Moisture content on dry weight basis (%)
W_w = Wet weight of soil (g)
W_d = Oven dried weight of soil (g)

To apply the required depth of water to plots in each irrigation; a cutthroat flume (0.1016 m X 0.46 m) was installed at the center of field channel. Hence, the measured quantity of water (eq. 5) was applied for a given time period (eq. 6).

$$Q_s = \frac{C_S \left(H_U - H_d\right)^{nf}}{\left(-\log S\right)^{ns}} \qquad (5)$$

where;
Q_s = submerged flow discharge rate, $m^3\ sec^{-1}$;
C_s = submerged flow coefficient,
h_d = downstream flow depth,
nf = free flow exponent, dimensionless
ns = submerged flow exponent, dimensionless; and
S = submergence; dimensionless

$$t = \frac{28AD}{Q} \qquad (6)$$

where;
Q = discharge in ($m^3\ hr^{-1}$)
t = time (sec)
A = area (m^2)
D = depth (m)

Fertilizers
The following fertilizer doses were applied (OFWM Manual VI, 2005):

123.55-160.62 kg N ha^{-1}
61.78-98.84 kg P_2O_5 ha^{-1}
29.65 Kg K_2O ha^{-1}
Full of P and K and half of the N were applied at sowing and remaining half of N was applied at 1st irrigation.

Water saving
The water saving under scientific and traditional irrigation methods was calculated using following relation:

$$WS = \frac{W_a - W_b}{W_a} \times 100 \qquad (7)$$

Where,
WS = Water Saving (%),
W_a = Total water used under traditional water application practice (m^3 ha^{-1}),
W_b = Total water used under scientific water application practice (m^3 ha^{-1}).

Harvesting and threshing
Harvesting of crop from all plots was done manually using sickle. The harvested crop was bundled and tagged with their specific plot. The bundles were then threshed, dried and stored in separate polyethylene bags. The bags were measured and grain weight of each bag was recorded.

Yield of crop
The increase in yield (%) of crop was computed using following relation:

$$Y_{Increase} = \frac{Y_1 - Y_2}{Y_1} \times 100 \qquad (8)$$

where;
$Y_{Increase}$ = Increase in yield (%)
Y_1 = Total yield obtained under scientific water application practice (Kg ha^{-1}),
Y_2 = Total yield obtained under traditional water application practice (Kg ha^{-1}).

Water use efficiency
The water use efficiency (WUE) under scientific and traditional water application practices was calculated by following formula:

$$WUE = \frac{Y}{WR} \qquad (9)$$

Where;
WUE = Water Use Efficiency (Kg m^{-3})
Y = Yield of Crop (Kg ha^{-1})

WR = Total water consumed for crop production (m^3 ha^{-1})

Statistical analysis
One way ANOVA was performed using SPSS-16.0 (SPSS, 2007) at p = 0.05.

RESULTS AND DISCUSSION

Soil physical properties
Soil texture of the experimental site was clay loam, average dry bulk density was 1.24 g cm^{-3} and the average infiltration rate was 22 mm hr^{-1} (Table 1).

Table 1. Soil physical properties

S. No.	Parameter	Value/ Description
1	Sand (%)	26
2	Silt (%)	36
3	Clay (%)	38
4	Textural class	Clay loam
5	Dry bulk density (g cm^{-3})	1.24
6	Infiltration rate (mm hr^{-1})	22

Irrigation water quality
Quality of irrigation water plays a vital role in the growth of plants and development of salinity. The results showed that irrigation water used in the experiment was good (ECw< 1500 micro-S/cm and SAR< 10) for irrigation (Table 2).

Table 2. Average chemical properties of irrigation water samples

S. No.	ECw (µS m^{-1})	pH	SAR
1	750	7.6	6.71
2	753	7.6	6.81
3	755	7.6	6.83

Irrigation water used
Total volume of water applied to crop under traditional water application practice was 6037 m^3 ha^{-1}, while the total volume of water applied to the crop under scientific water application practice was 4778 m^3 ha^{-1} as shown in Figure 2. The results revealed that total volume of water used under scientific water application was less than that of traditional water application practice.

Crop yield
The total yield of crop under scientific water application practice was 2958 kg ha^{-1}; while the total yield of crop under traditional water application was 1893 Kg ha^{-1} as shown in Figure 3. The result showed that total yield of crop under scientific water application was more than that of traditional water application practice.

Water saving, increase in yield and water use efficiency

Table 3 shows that scientific water application practice saved 20.85% of water (p< 0.01), obtained 36% (p< 0.01) more yield and 50.56% (p< 0.01) more water use efficiency compared to traditional water application practice. These results indicated that scientific water application practice used less water and gave higher yield as well as water use efficiency than that of traditional water application practice. It may be because farmers apply water more than the water requirements of crop, which results in the wastage of water due to which water and nutrients cannot move towards the roots of crops. Moreover, it also leaches most of the nutrients down to the groundwater.

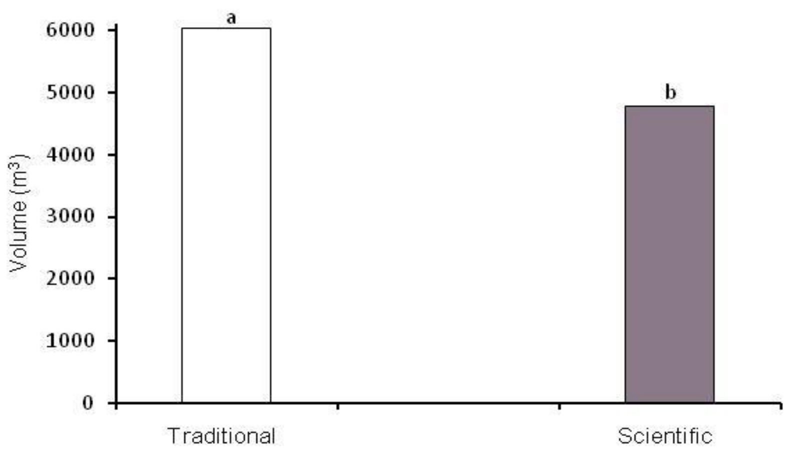

Figure 2. Total water used under traditional and scientific water application practices (different letters (a, b) denote that the data is significantly different)

Figure 3. Yield of crop in traditional and scientific water application practices (different letters (a, b) denote that the data is significantly different)

Table 3. Water saving, increase in yield of crop and water use efficiency under scientific and traditional water application practices

Water saving (%)	Increase in yield (%)	Water use efficiency (kg m^{-3})	
		Scientific water application practice	Traditional water application practice
20.85***	36***	0.619***	0.313*

* Non-significant *** Highly significant

Similar results were also obtained by Ashraf *et al.* (2001), who concluded that the farmers apply water almost double than water applied under the scheduled fields that has reduced water use efficiency (WUE), who concluded that the estimated efficiency of irrigation system in Pakistan was 35.5% which showed that the agriculture water that reached the fields was not precisely used by the crops. Mahar *et al.* (1990) reported that under field conditions, consumptive use of water of 0.375 m for wheat gave higher yields and higher water use efficiency. Shaikh *et al.* (1988) achieved a higher yield and water use efficiency of wheat through proper scheduling of crop.

CONCLUSION

The study has shown that the scientific water application practice used less water and gave higher yield as well as water used efficiency than that of traditional water application practice. Following conclusions were drawn from the study. Total volume of water applied to crop under traditional practice was 6037 m^3 ha^{-1}, while under scientific water application practice was 4778 m^3 ha^{-1}. The total yield of crop under scientific water application practice was 2958 kg ha^{-1}; while under traditional water application practice was 1893 kg ha^{-1}. Scientific water application practice saved 20.85% of water, obtained 36% more yield and 50.56% more water use efficiency as compared to traditional water application practice.

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