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Comparison of Crop Water Productivity of Traditional and Hybrid Maize Varieties

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ABSTRACT

A field study was conducted on clay loam soil at the research farm of The University of Agriculture Peshawar during Kharif 2012. Objective of the study was to compare the crop water productivity of maize using two traditional (V_1=Azam and V_2=Jalal) and two hybrid (V_3=3025W and V_4=30K08) varieties having four replicates. Soil moisture was determined by gravimetric method taking into account soil moisture, rainfall, and irrigation water applied. Crop water productivity (CWP) was calculated by dividing grain yield and total seasonal water applied to each variety. Results showed that CWP of maize variety V_1 ranged from 0.75-0.8 kg m^{-3} with a mean of 0.8 kg m^{-3}, CWP of V_2 ranged from 0.82-0.91 kg m^{-3} with a mean of 0.85 kg m^{-3}, CWP of V_3 ranged from 1.16-1.23 kg m^{-3} with a mean of 1.19 kg m^{-3} and CWP of V_4 ranged from 1.19-1.31 kg m^{-3} with a mean value of 1.24 kg m^{-3}. Crop water productivity in case of V_1 was low compared to FAO reported values. CWP was found statistically significant ($P \leq 0.05$) for the selected maize varieties. Results showed that among all the varieties V_4 performed better therefore, it is recommended for irrigated areas of Khyber Pakhtunkhwa.

Key Words: crop water productivity, hybrid maize, traditional varieties.

INTRODUCTION

Maize is the 2nd most important crop after wheat in Khyber Pakhtunkhwa and Pakistan. Maize being the highest yielding cereal crop in the world is of significant importance for countries like Pakistan. It is one of the major cereals both for human and animal use and is grown for grain and forage. Maize has its origin in a semi arid and is not a dependable crop for growing under dry land situation, with limited or variable rainfall (Arnon, 1972). In Pakistan, it is planted on about 43% cropped area with the production of 461,000 tons and average grain yield of 3671 kg ha^{-1} and 37% in Khyber Pakhtunkhwa, produce 101,515 tons and average grain yield of 2984 kg ha^{-1} (Govt. of Pakistan, 2010).

It is normally cultivated under smallholder continuation farming systems, both under rain fed and irrigated conditions in the major and minor seasons that keep up a correspondence to the Monsoons. For maximum production a medium matured maize crop requires between 500 to 800 mm of water depending on environment (FAO, 2012). The effect of limited water on maize grain yield is significant and cautious control of frequency and depth of irrigation is required to optimize yields under circumstances of water scarcity (FAO, 2000). However, crop growth and seed yields are generally lower in the drier seasons due to low water availability to crop need, as a result crop goes under moisture stress condition which is the significant cause for yield loss in maize after low soil fertility (Edmeades et al, 1992).

Maize crop is a C_4 plant, which is more capable to use CO_2, solar radiation, water and N in photosynthesis as compared to C_3 crops. Crop water productivity (CWP) of maize is about twice than C_3 crops grown at the similar places. Its transpiration ratio (molecules of water lost per molecule of CO_2 fixed) is 388, corresponding to 0.0026 in CWP (Jensen, 1973). Different maize cultivars have varying water requirement and crop water use efficiencies (Asare et al, 2011). The yields and crop water productivity are different for different maize hybrids. Also irrigation water requirement differ statistically among all the hybrids (Maria, 2009). To a careful estimate, only low water availability to crop demand results 50% or more declines in average yields internationally (Wang et al, 2003). Maize has a high water and nutrient demand with the flowering stage being the most sensitive to water stress during which grain yield may be decreased by declining grain number and kernel weight (Pandey et al, 2000). For normal growth and development of maize, its maximum and even yields and high class, it is essential to keep optimal soil moisture during the growing period. Only optimal situation allow the plants to use water as their needs.

Objectives

Specific objectives of the study were to:

Determine crop water productivity of selected maize varieties.

MATERIALS AND METHODS

The proposed study on “Comparison of crop water requirement of traditional vs hybrid maize varieties.” was conducted at the research farm of The University of Agriculture Peshawar, during Kharif 2012.

Experimental Design

The experiment was laid out in Randomized Complete Block Design having four replications. The detail of the varieties is as follow:

V_1 = Azam (Traditional)
V_2 = Jalal (Traditional)
V_3 = 3025W (Hybrid)
V_4 = 30K08 (Hybrid)

Field Preparation

The experimental field having size of 95 m × 19 m was ploughed and properly levelled before crop sowing to make sure the uniform application of water (Figure 3.1). A pre-irrigation was applied to the field for easy tillage operation and plots preparation. A field ditch of one meter width was constructed along with each sub-plot from the main irrigation channel for the easy entrance of water. The experimental field was divided into 16 subplots of 4 m x 20 m, where plant to plant and row to row distance was kept 0.2 and 0.70 m, respectively.

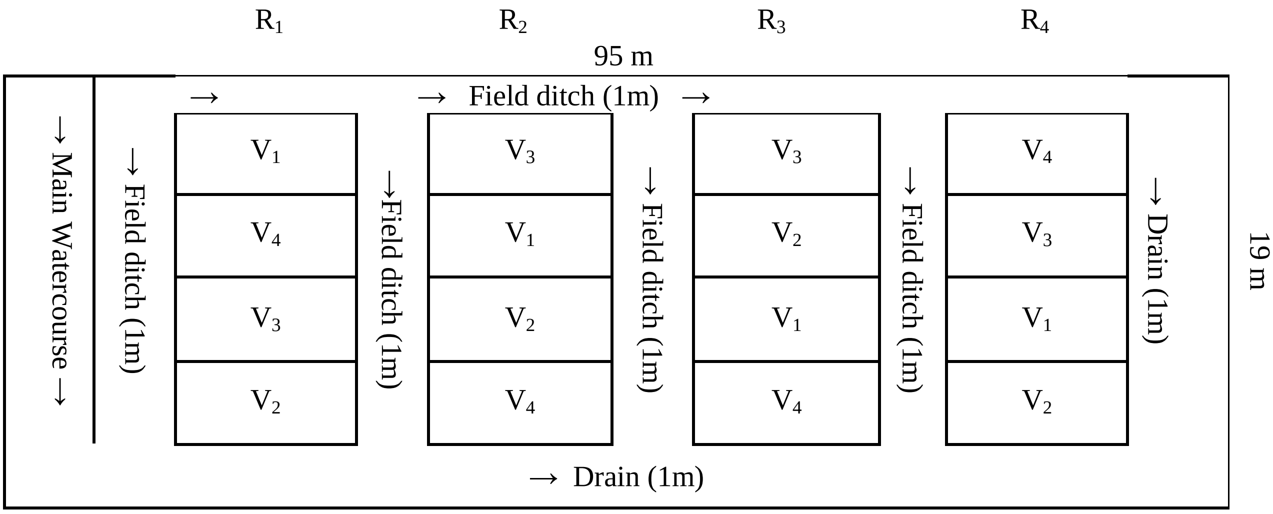

Figure 3.1 Layout of experimental plots for Maize

Crop Sowing

Maize crop was sown at recommended seed rate of 28 kg ha^{-1} in rows in the last week of June, 2012 by hand hoe. Weeds were removed manually when required to save losses of available soil moisture and nutrients from the soil. The textural class of the research plot soil was Clay Loam with the maximum infiltration rate of 8 mm hr^{-1}. Fertilizer (N:P:K) was applied at the rate of 160:80:0 kg ha^{-1}, respectively.

Determination of Soil Moisture Content

The moisture content of the soil was determined by gravimetric method. The first soil sampling for moisture estimation was done at the time of crop sowing. Subsequent soil moisture samplings were carried out at an interval of 7 to 10 days until harvest of the crop. Soil moisture samples were also collected in between irrigation periods to check depletion of moisture in the soil. Similarly, after each substantial rain, a moisture sample was taken. Final moisture sampling was taken at the time of crop harvest.

A soil sample was taken at 0-100 cm depth from each treatment of the block. Soil moisture samples were dried in oven at 105^0C for 24 hrs. Percent soil moisture content was calculated on a dry weight basis by using the following formula:

$$\theta m = \frac{Ww - Wd}{Wd} \times 100$$

Where,

θm = Soil moisture content (% by wt.)

Ww = Wet weight of soil (g); and

Wd = Oven dry weight of soil (g).

The percent soil moisture content on a volume basis was calculated by using the following relationships:

$$\theta v = \rho b \times \frac{\theta m}{\rho w}$$

Where,

θv = Soil moisture content (% by vol.)

ρw = Density of water (g cm^{-3}); and

ρb = Bulk density of the soil (g cm^{-3}).

Irrigation

Flow rate of the watercourse was measured with the help of cut-throat flume, which was installed at the inlet of the research field. Discharge readings and the time of irrigation was noted periodically until the flow cut off. Each plot was irrigated separately by applying the measured amount of irrigation water.

The irrigation was applied at 55% depletion of available water (FAO, 2012). Subsequent irrigations were applied to the respective plots, when soil moisture reached to critical moisture level. The critical moisture level on volume basis was computed as follows:

$$\theta c = \frac{FC-(MAD \times AW)}{Drz} \times 100$$

The depth of irrigation to be applied to each plot was calculated as follow:

$$Dw = \frac{Drz(FC-\theta i)}{100}$$

Where,

dw = Depth of water to be applied (cm)

Drz = Depth of root zone (cm)

FC = Field capacity (%); and

θi = Soil moisture content before irrigation (% by vol.).

Gross irrigation requirement (mm) for maize was calculated from the following equations:

$$GIR = \frac{dw}{Ea}$$

Where,

dw = Depth of water to be applied (mm)

GIR = Gross irrigation requirement (mm); and

Ea = Application efficiency (%).

The field application efficiency was taken 80%, to overcome the losses of water due to non uniform infiltrations of experimental field. The time of irrigation required to get the required depth of water for each plot was calculated as follow (Jensen, 1998).

$$t = \frac{A \times dw}{Q}$$

Where,

t = Time required to irrigate (s)

A = Area of subplot (m^2)

dw = Depth of water to be applied (mm); and

Q = Discharge from the watercourse ($l\ s^{-1}$).

Crop Water Productivity

Crop water productivity (CWP) means producing more food with the application of less water. CWP may be quantified in terms of yield, nutritional worth or economic return. It is an sign of link between the amount of water required for a particular reason and the amount of water delivered or used or (Kijne, 2003). CWP can be expressed in kg m^{-3} and is an efficiency term, showing the amount of viable product (e.g. kilograms of grain) in relation to the amount of input (cubic meters of water) required to produce that output. Crop water productivity may be defined as "the mass of physical production or value of economical production calculated beside gross inflows, depleted water or available water (Moulden, 1997). The crop water productivity was calculated by using the following formula:

$$CWP\ (kg/m3) = \frac{\text{Crop Yield (Kg)}}{\text{Water applied (m3)}}$$

Statistical Analysis

All the data collected for different parameters was subjected to the statistical analysis appropriate for randomized complete block design (RCBD). The analysis of the variance and LSD test was carried out to detect whether the actual evapotranspiration of different maize varieties was significantly different.

RESULTS AND DISCUSSIONS

A filed study was conducted to compare of crop water requirement of traditional vs hybrid maize varieties during the Kharif 2012, at research farm of The University of Agriculture, Peshawar. The data was collected on actual evapotranspiration (ETa), crop coefficient (Kc), crop yield and its components, crop water productivity (CWP) and harvest index (HI) of traditional and hybrid maize varieties. The results of the study are presented and discussed in the following sections.

Crop Water Productivity (CWP)

Statistical results revealed that there was significant difference in crop water productivity (CWP) of all the varieties (Table 4.3). There was not much difference in mean values of CWP of traditional and hybrid maize varieties. CWP was recorded minimum 0.8 kg m^{-3} for traditional varieties V_1 and V_2 and maximum for hybrid maize varieties V_3 and V_4 have 1.2 kg m^{-3}(Table 4.10). The difference between CWP was might be that hybrid requires more water than traditional and give higher grain yield. Lower CWP values of V_1 and V_2 could be due to rainfall during growing period, as CWP is the function of grain yield and water applied including rainfall throughout growing season.

Table 4.3 Analysis of variance of crop water productivity of selected maize varieties

Varieties	Crop water productivity (kg m^{-3})
V_1	0.77d
V_2	0.82c
V_3	1.20b
V_4	1.23a
Significance	*
LSD 5%	0.029

Mean value of same category followed by different letters are significantly different from each other at $P \leq 0.5$ using LSD test.
ns = Non significant, * = Significant, ** = Highly significant

Conclusions

Some of the conclusions of the study are as follows:

- Highest crop water productivity (1.24 kg m^{-3}) was observed for V_4 and lowest (0.78 kg m^{-3}) for V_1.

Recommendation/ Suggestions

- Among all the varieties hybrid variety V_4 (30K08) performed best with regard potential to grain yield, crop water productivity and harvest index.
- Similarly, V_2 (Jalal) is best traditional variety as compared to V_1 because of its grain yield and yield components.

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