

IRRIGATION WATER REQUIREMENT OF HYBRID MAIZE GROWN ON RHODUSTALFS IN SRI LANKA

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ABSTRACT

Maize (*Zea mays* L.) is the second important cereal crop, which can be grown successfully in many parts of Sri Lanka under rainfed and irrigated conditions. Among the farmers, hybrid maize varieties are most popular than open pollinated varieties (OPV). However, at present irrigation recommendation is available only for OPV maize in Sri Lanka. Field experiments were conducted to study the effect of different irrigation water levels applied at different growth stages on maize seed yield in Rhodustalfs soil. The five different irrigation water (IW)/cumulative pan evaporation (CPE) ratios, 0.7, 0.85, 1, 1.15 and 1.3 were selected. These irrigation ratios were applied at different stages (1st, 2nd and 3rd month growth stages) of hybrid maize and in year 2010 variety Sampath and 2011 in 2013 variety Pacific 999 super was used. Altogether thirteen treatment combinations were tested with three replications in Randomized Complete Block Design. The result revealed that the highest seed yield (9.3 t/ha -var. Pacific 999 super) was recorded by the treatment combination of 0.85, 1.15, 1.15 ratios supplied at three different stages, respectively and this was not significantly different to ratios of IW/ CPE 0.7, 1.15 and 1.15 supplied at the same stage. This combination consumed average of 430 mm of water giving water productivity of 2.1 kg/m³. There was a significant yield reduction when the IW/ CPE ratio was below 1.15 at 2nd month (flowering stage). Hence, the IW/ CPE ratio of 0.7, 1.15, 1.15 in 1st, 2nd and 3rd months could be recommended to achieve high yield in hybrid maize grown on Rhodustalfs soil.

Key words: Hybrid maize, Irrigation water requirement, IW/ CPE ratio

INTRODUCTION

Maize (*Zea mays* L.) is one of the most important cereals for both human and animal consumption. Due to the high energy value and low cultivation cost, it has become popular among Sri Lankan farmers and consumers (Ranaweera *et al.*, 2011). Around 425,000 Mt. of maize is needed annually for the local consumption requirement of Sri Lanka and only locally produces 250,000-275,000 Mt. Accordingly, 175,000 Mt. of maize is imported annually, and a large amount of foreign exchange is expended for the same. In this situation, it is a national necessity to promote maize cultivation and increase production capacity (Performance Report, 2017). Maize production in Sri Lanka is increasing since 2000 due to cultivation of hybrid varieties and increasing cultivation land area. In Sri Lanka, average maize yield of local hybrid varieties (MI Maize Hybrid 01) is 4.5 and 5.5 t/ha in *Yala* and *Maha* seasons, respectively. The potential yield of the same variety was recorded 7 t/ha (Bentota, 2013).

Among farmers, hybrid maize varieties are more popular than OPV as the hybrid maize produce higher yield compared to present OPVs. It is being grown under irrigation. However, there is no irrigation water requirement recommendation for the cultivation of hybrid maize in Sri Lanka. For maximum production, a medium maturity grain crop requires between 500 and 800 mm of water (Allen *et al.*, 1998).

Maize is an efficient user of water in terms of total dry matter production among cereals. A crop requires a certain amount of water at some fixed time interval throughout its period of growth. The basic objective of irrigation is supplement of water to the crop so as to obtain an optimum crop yield. The crop yield from an agricultural land depends upon a number of factors. Perhaps the most important factor is that the crops should get adequate water at the various stages of the growth (Arora, 2002). The maize is a sensitive crop for water and this leads low productivity when the irrigation water supply is in deficit or excess levels. Therefore, it is required to supply required amount of water to obtain the optimum production. The total water requirement of a 115 day OPV maize crop during the dry season at Mahalluppallama was found to be 615 mm (Ranaweera *et al.*, 1982). Maize yields decreased significantly when irrigated below the 50% depletion level of available soil moisture. Grain yield of maize, when irrigated at 50% depletion level of available moisture, was 4.1 t/ha, whereas at 75% depletion level, the yield dropped to 2.2 t/ha (Ranaweera *et al.*, 1982).

With the background information of irrigation requirement in different growth stages of hybrid maize crop, the experiment was planned with the objectives to find out the optimum irrigation water requirement for hybrid maize and irrigation water requirement in different growth stages of maize grown in Rhodustalfs Soil.

MATERIALS AND METHODS

Field experiments were conducted during *Yala* 2010, 2011 and 2013 seasons at Field Crops Research and Development Institute (FCRDI), Mahailuppallama. The site belongs to Agro-ecological zone Low Country Dry Zone (DL_{1b}) of Sri Lanka and located at 8.07 °N, 80.28 °E and 117 m above mean sea level. The average maximum and minimum temperatures were 32.8 °C and 23.9 °C, respectively. The location receives a mean ten year (1999-2008) *Yala* rainfall of 384 mm where predominant soil type is Reddish Brown Earth Soil (Rhodustalfs) under well drain condition (Annual Performance Report 2010).

Five different irrigation water (IW)/cumulative pan evaporation (CPE) ratios, 0.7, 0.85, 1, 1.15 and 1.3 were selected based on the previous study (Annual report, 2009). These irrigation ratios were applied at different stages *i.e.* 1st, 2nd and 3rd month growth stages for hybrid maize variety *Sampath* in year 2010 and 2011 and variety Pacific 999 super in 2013. Altogether thirteen treatment combinations of 5 IW/CPE ratios and 3 stages as 1st, 2nd and 3rd month were tested during the cropping period with three replications. Treatments were arranged in a Randomized Complete Block Design (RCBD). Plot size of 3.6 m x 3.6 m was allocated for the each IW/CPE ratio combinations. From the previous study on irrigation water requirement by using IW/CPE ratio, the same IW/CPE ratio was used throughout cropping period with different ratios as the treatments including ratio of 1.15. It was found that the ratio 1.15 showed the best for optimum yield throughout the growing period regardless of the stages (Annual report, 2009). In present study, the ratio of 1.15 considered as control and set of treatments were used in three stages to study response in different growing stages.

Seeds were soaked and uniformly germinated seeds were planted at 30 cm x 60 cm spacing and 3 cm depth. Irrigation water need was estimated using evaporation data by using Class A pan evaporimeter and pan coefficient was taken as 0.7. The amount of irrigation water was based on ratios of IW/CPE. The irrigation water was applied twice

a week through the surface (farrowed basin) irrigation methods. The space of 1.8 m distance was maintained between plots to avoid the cross contamination of water. Rainfall received during the experimentation was considered and cumulative pan evaporation was calculated using the equation given.

$$\text{Cumulative Pan Evaporation (CPE)} = K_p \times E_p;$$

$$K_p = \text{Pan Evaporation (mm/day)}, E_p = \text{Pan Coefficient (0.7)}$$

$$\text{Ratio} = \frac{IW}{CPE}$$

IW= Irrigation Water requirement

Application efficiency of irrigation was considered as 70% (with field observation)

The crop water requirement (in mm) computed with yield (kg/ha) divided by water productivity (kg/m³) divided by 10.

Fertilizer was applied according to the recommendation of Department of Agriculture. Harvesting was done at the fully matured stage of the crop when the cobs become brownish yellow in color. Disease problem was not experienced and for the pest attack recommended chemical was applied.

Data analysis

The statistical analysis of the data of each parameter was done by the statistical method known as “Analysis of variance” appropriate for randomized block design. The Coefficient of variance (C.V.) was worked out. Wherever the results were significant, the least significant difference (LSD) at 5 per cent level of significance was worked out.

RESULTS AND DISCUSSION

Rainfall distribution

Total rainfall of 137.7 mm was received during the growing period from mid April to End July 2013. Many long dry spells were experienced during this period. However, prevailed rainfall was not affected the irrigation treatments (Figure 1). Only few considerable rains occurred and included in the estimation of water requirement of maize.

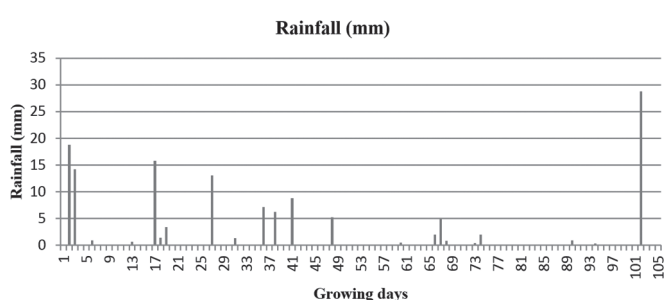


Figure 1. Rainfall distribution throughout the study period in 2013

Grain yield of maize crop

Yield performance of maize with respect to the irrigation treatments is given in Table 1. According to the dry grains yield, amount of irrigation significantly affected on yield. In year 2013, the highest seed yield of 9.3 t/ha (var. Pacific 999 super) was recorded by the treatment combination of 0.85, 1.15, 1.15 ratios of IW/ CPE (T_2) in 1st, 2nd and 3rd month, respectively which is not significantly different from treatments of T_1 , T_3 , T_4 , T_5 , T_9 , T_{11} , T_{13} . Similar trend was recorded in 2010. The highest seed yield in year 2011 was found to be 6.72 t/ha with the treatment combination of 0.85, 1.15, 1.15 ratios (T_2) which is not significantly different to the all other. This result revealed that the application of the lowest ratio (0.7) during the 1st month of growing period for the maize crop is sufficient to achieve an optimum yield by keeping control level of ratio (1.15) during the remaining growing period as it is an initial and vegetative stage. In 1st month period, the IW/ CPE ratio of 0.7 (T_1) was the lowest water requirement 430 mm for the variety Pacific 999 super and the highest water requirement of 500 mm was with the treatment T_5 (ratio of 1.3).

With considering different ratios (0.70- T_6 , 0.85- T_7 , 1.00- T_4 , 1.15- T_8 and 1.30- T_9) applied during 2nd month of growing period in 2013 with the var. Pacific 999 super, the highest yield (8.6 t/ha) was observed with T_9 which is at par with T_4 (8.4 t/ha) and significantly higher than T_8 . The lowest yields of 7.1 and 7.5 t/ha was obtain with the ratio of 0.85- T_7 and 0.70- T_6 , respectively. This result indicated that the application of irrigation water with the ratio below 1.15 (control) reduce the yield significantly at it covers the reproductive stage of the crop. Hence, the crop should not experience the moisture deficit during the 2nd month of growing period. In year 2011 and 2010, almost similar result was found with hybrid maize variety of Sampath (Table 1). Treatment combination of 1.15, 0.85, 1.15 ratios (T_6) was showed the lowest grains yield of 5.75 and 4.33 t/ha in year

2010 and 2011, respectively. It is due to the crop get water stress during the 2nd month similar to the year 2013. Both the maize varieties showed almost similar trend to the irrigation treatments in all the years. Sahu, (1967) reported the maize crop is sensitive to low as well to excess soil water conditions at tasselling and silking stages. The knee-high stage has been observed to be sensitive to excess water condition. The tasselling stage is considered as the most critical stage of water need.

Application of different treatment with the IW/ CPE ratio (0.70-T₁₀, 0.85-T₁₁, 1.00-T₁₂, 1.15-T₄ and 1.30-T₁₃) during 3rd month of growing period (pre matured and matured stage) in 2013 with the var. Pacific 999 super, almost all the treatment combinations were not significantly different from the highest yield of the treatment of T₂ except T₁₀. Similar trend was observed in year 2010 and 2011 with the var. Sampath. With the overall observation among the tested treatment combination, the best IW/ CPE ratio was found to be 0.7, 1.15 and 1.15 (T₁) to achieve a yield of 9.0 t/ha, highest water productivity of 2.1 kg/m³ and lowest crop water requirement of 430 mm for var. Pacific 999 super and similar trend to the other variety of Sampath.

Table 1. Yield performances of maize crop with respect to the irrigation quantity treatments

Treatment number	Months - IWR/ CPE ratio			Grain yield (t/ ha)		
	First	Second	Third	2010 Var. Sampath	2011 Var. Sampath	2013 Var. Pacific
T ₁	0.70	1.15	1.15	6.09 ^a	6.34 ^a	9.0 ^{ab}
T ₂	0.85	1.15	1.15	5.62 ^{ab}	6.72 ^a	9.3 ^a
T ₃	1.00	1.15	1.15	6.18 ^a	6.39 ^a	8.5 ^{ab}
T ₄	1.15	1.15	1.15	5.77 ^a	5.95 ^a	8.4 ^{abc}
T ₅	1.30	1.15	1.15	5.91 ^a	6.71 ^a	9.0 ^{ab}
T ₆	1.15	0.70	1.15	4.33 ^c	5.75 ^a	7.5 ^{cd}
T ₇	1.15	0.85	1.15	4.91 ^{bc}	6.55 ^a	7.1 ^d
T ₈	1.15	1.00	1.15	4.89 ^{bc}	5.94 ^a	8.2 ^{bc}
T ₉	1.15	1.30	1.15	5.98 ^a	6.52 ^a	8.6 ^{ab}
T ₁₀	1.15	1.15	0.70	5.74 ^a	6.69 ^a	8.2 ^{bc}
T ₁₁	1.15	1.15	0.85	5.68 ^a	6.57 ^a	8.7 ^{ab}
T ₁₂	1.15	1.15	1.00	5.98 ^a	6.43 ^a	8.6 ^{ab}
T ₁₃	1.15	1.15	1.30	5.93 ^a	6.52 ^a	8.7 ^{ab}
Least Significant Difference				0.75	1.22	1.02
CV %				7.93	11.29	7.10

Comparisons are significant at the 0.05 level

Means denoted by same letter is not significantly different from each other, at p = 0.05

Water productivity of maize

According to the water productivity in Table 2, water productivity was ranged between 1.6 - 2.1 kg/m³ in 2013. Treatment T₁ and T₂ were recorded higher water productivity and these treatments were consumed low amount of irrigation water in 1st month of growing. The lowest amount of water productivity was observed in treatment combination of 1.15, 0.85, 1.15 ratios (T₇) this treatment revealed that the lower level of irrigation water applied in 2nd month. Similar trend was observed in year 2010 and 2011. It was found to be same as yield performance. The best irrigation combination (T₁) consumed 430 mm of water by the var. Pacific 999 super which is more popular among farmers. The total water requirement of a 115 day maize crop during the dry season at Mahalluppallama was found to be 615 mm for maize OPV (Ranaweera *et al.*, 1982).

Table 2. Water productivity of maize crop with respect to the irrigation quantity treatments

Treatment number	Water Use Efficiency (kg/M ³)		
	2010 Var. Sampath	2011 Var. Sampath	2013Var. Pacific
T ₁	1.31	1.22	2.1
T ₂	1.18	1.26	2.1
T ₃	1.27	1.16	1.8
T ₄	1.16	1.05	1.7
T ₅	1.16	1.11	1.8
T ₆	1.03	1.18	1.8
T ₇	1.10	1.27	1.6
T ₈	1.03	1.10	1.8
T ₉	1.36	1.10	1.7
T ₁₀	1.18	1.41	2.0
T ₁₁	1.19	1.30	2.0
T ₁₂	1.20	1.20	1.9
T ₁₃	1.14	1.09	1.7
Least Significant Difference	0.23	0.22	0.30
CV %	8.01	11.23	12.2

Comparisons are significant at the 0.05 level

T₄ = Control

CONCLUSION

With the overall observation among the tested treatment combinations, the best IW/ CPE ratio was found to be 0.7, 1.15 and 1.15 (T_1) to achieve a yield of 9.0 t/ha, highest water productivity of 2.1 kg/m³ and lowest crop water requirement of 430 mm for var. Pacific 999 super and similar trend to the other tested variety Sampath. Therefore, the IW/ CPE ratio of 0.7, 1.15, 1.15 in 1st, 2nd and 3rd month of growing stages, respectively could be recommended for hybrid maize in Rhodustalfts soil. Water restriction during the second month is more critical on the maize yield compared to that of the first and the third months of the growth stage. Hence, It is important to maintain the irrigation water level that should not below the IW/CPE = 1.15 during 2nd month of cropping period.

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