Tropical Agricultural Research Vol. 3 1991

Water Use Efficiency and Yield of Chillies Grown in Sandy Regosol Treated with Soil Amendments and Polyethylene Lined Furrows

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ABSTRACT. A field experiment was conducted on sandy regosols with a local variety of chillies (MI – 1). The main objective of the study was to improve the physical properties of sandy regosols and to establish a suitable irrigation method for the same. Irrigation in furrows with polyethylene lining having plants either on ridges or in furrows were compared with basin irrigation under two different soil conditions. Sandy soil and sandy soil treated with non calcic brown soil and tank silt are the two soil conditions. The results indicate that addition of non calcic brown soil and tank silt could affect physical and chemical properties of sandy regosols. Yield of plants as indicated by the pod weight was higher in treated soil. Furrow irrigation with furrow planting method showed better performances among the irrigation treatments. Water use efficiency of chillies was highest for furrow planting with treated soil and lowest for ridge planting in control treatment. The beneficial aspect with respect to the yield and thereby total income and saving of water indicates, that addition of non calcic brown soil and tank silt to regosols and adopting polyethylene lined furrow irrigation with plants in furrows is a feasible solution for cultivation of sandy regosols.

INTRODUCTION

The wide spread occurrence of sandy soils along the coastal regions as well as in some other parts of Sri Lanka draws great attention for agricultural development and expansion. Sandy soils deserve special considerations, since they have a large percentage of sand fractions. The

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physical properties of sandy soils particularly their low water holding capacity affect the irrigation practices in these soils. Surface irrigation presently practised or in any other forms, is not the most suitable method for sandy soils. Irrigation of sandy soils by surface irrigation methods without good management practices may lead to water wastage by deep percolation, thus leading to low irrigation efficiency which is less than 50%. Moreover, the yield of crop may also be affected by non uniformity in application and leaching of nutrients. Therefore, there is a need for developing proper soil and water management practices in these soils. In this context, an experiment was conducted to study the effects of irrigation by polyethylene lined furrows and textural changes brought about by the addition of soil amendments on water use, growth and yield of chillies.

MATERIALS AND METHODS

The study was conducted on regosols with a total area of 0.23 ha planted with a local variety (MI – 1) of chillies at a spacing of 75 cm x 60 cm. Three different irrigation treatments were used in both amended (T)* and control soils (C)* using a split – plot design. Size of each plot was 15 m x 7.25 m and the number of replicates was three. Non calcic brown soil and tank silt at the rate of 72 and 24 mt/ha were used as amendments and mixed with the top soil up to a depth of 30 cm. Basin irrigation (B)* was practised with a basin size of 1.5 m x 1.25 m made for the purpose. Furrow irrigation was practised in 15 m long, 20 – 25 cm deep furrows, 75 cm apart, and lined with 300 gauge polyethylene. In the furrow irrigation treatment two methods were tested, one in which holes were made at the bottom of the furrow lining for planting (FF)* chillies and the other on the side walls of the furrow lining for lateral movement of water towards the plants planted on the ridges (FR)*. Plants were irrigated with predetermined amounts of water based on soil moisture constants. Matured green pods were plucked from 90 days after planting at 15 day intervals to determine yield. Water use efficiency of chillies was calculated based on the total yield of pods per unit volume of water applied.

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* Abbreviations used for different soil and irrigation treatments.

RESULTS AND DISCUSSION

The physical and chemical properties of sandy soil (control) and the same after treatment are given in Table 1. The results indicate the response to soil amendments to be considerable in increasing available water holding capacity, reducing infiltration rate and increasing availability of nutrients *etc.*, of sandy regosols.

However, a small scale textural change seems to consume a large quantity of amending material which require additional considerations with regard to its cost and availability.

The improvement of physical and chemical properties of sandy soil was reflected directly or indirectly on the yield of chillies and on the amount of water used.

Yield analysis

The mean yield of control and treated soil are 3280 kg/ha and 6325 kg/ha respectively. The yield from the treated soil consisting about 65% of the total yield is highly significant ($P > 0.001$) compared to that of control. A marked response to soil amendments was shown by the treated soil. The yield of chillies was almost double that of the control (Table 2). Poor growth conditions characterized by high water losses, low availability of water and nutrients would have been the causes for the yield reduction in the control soils.

Results further indicated that the yield differences among irrigation treatments were highly significant. Among the three irrigation methods, yield from the FF method of irrigation was significantly higher than the other methods at all stages. The FF method showed best performance, yielding 7987 kg/ha and 4713 kg/ha treatment and control respectively. The plants under basin irrigation gave the next highest yield. The FR method of irrigation gave unsatisfactory yield, particularly in sandy soils, where the yield was 1680 kg/ha, the lowest among all treatments.

The furrows that were covered by polyethylene provide less access for moisture to escape by evaporation. As a consequence, the plants in the furrows were able to use more available moisture than the plants in the basin plots, thus accounting for high yields in the FF plots. The

Table 1. The physical and chemical properties of control and treated soil.

Soil	Physical properties							
	Texture		App.sp.gravity		Infiltration		Soil moisture	
							FC	PWP
Control	Sandy		1.58g/cm		150cm/hr		7.82%	4.41%
Treated	Loamy sand		1.52g/cm		110cm/hr		10.43%	5.16%
	Chemical properties							
	pH	Total N(%)	O.M (%)	Exch.K		Avai. P	CEC	
Control	6.2	0.052	1.11	0.12m.eq/100g		12.8ppm	7.1m.eq/100g	
Treated	6.4	0.083	1.70	0.24m.eq/100g		23.5ppm	9.3m.eq/100g	

Table 2. Yield, total amount of water applied, irrigation interval, number of irrigations and water use efficiency of chillies.

	Control			Treated		
	Basin	FR	FF	Basin	FR	FF
Yield (Kg/ha)	3445	1680	4703	6764	4224	7967
Total amount of water applied(ha – cm).	155.4	162.5	113.8	156.3	212.9	126.4
Irrigation interval(hr)	24	24	36	36	24	48
No.of irrigations(days)	148	134**	101	101	148	76
Water use efficiency * (kg/ha – cm)	22.2	10.3	41.4	43.3	19.8	63.2

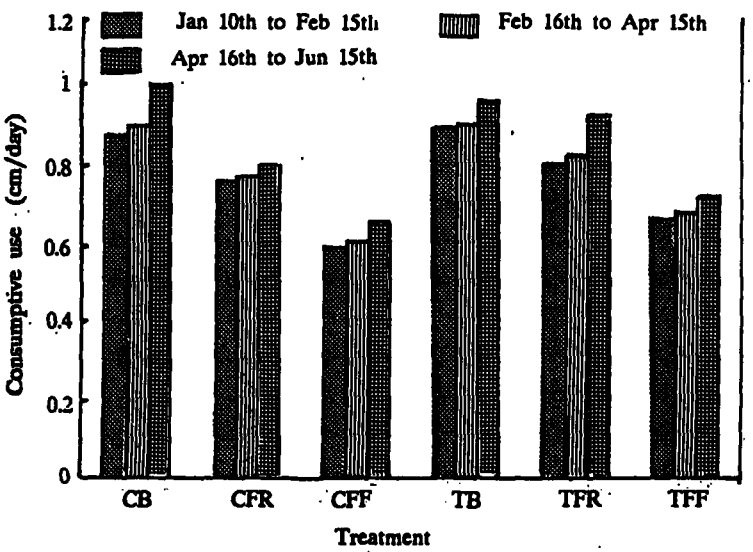
* Water use efficiency was estimated dividing the yield per hectare by total water applied per hectare during growth period of chillies.

** Though the irrigation interval is same as the CB and TFR, the reason for the reduced number of irrigations in this method was the shortened growth duration of plants in this method.

polyethylene cover which acts as a mulch controlled the growth of weeds effectively thereby reducing competition for water and nutrients available to the plants in the FF plots. Better utilization of fertilizer may be an added reason for the increased yield reported from the FF method. As fertilizer was mixed with water and given exactly to the plant base easy absorption would have been possible for the plants in the furrows. Comparatively lower yield obtained from FR treatment (Table 2), indicates that the method has no justification for its suitability under the sandy soil conditions. The main reason for lower yield from sandy soils may be the inadequate supply of water to the plants. Though the yield of plants in the FF method was superior to other methods, the potential yield would have been affected by high temperature that was developed under the polyethylene cover. This high temperature that was generated under the polyethylene furrows can be considered as a set back for the future development of this method.

Water requirement

The textural change from sandy to loamy sand which was brought about by adding amendments resulted in a considerable increase (48.7%) in the available water which in turn would have had an effect on the amount and the frequency of irrigation. The soil moisture at the time of irrigation was monitored thrice during the season and the depth of water to be applied during different periods was determined independently for different treatments (Table 2). It was noted that the rate of moisture depletion from the soil was high in treatments such as basin and FR where high evaporation losses were inevitable. Therefore, the frequency of irrigation of these treatments were shortened (Table 2) but were not less than one day. Soil moisture depletion rate was comparatively low in the TFF treatment where the frequency of irrigation was two days. Figure 1, shows the treatments and respective consumptive use in cm/day and the average consumptive use from treated soil is higher than control. Though the evaporative demand is higher in the control, the rate of moisture loss is restricted due to the limited amount of water stored in the root zone. In addition, the plants that grew well under treated soil conditions used more moisture for transpiration, which accounts for increased consumptive use. Among the irrigation treatments, consumptive use rate was lowest in FF. The reason could be the mulching effect of polyethylene which reduced the moisture loss by evaporation to a considerable extent. Consumptive use was



CB - Control soil Basin irrgation
CFR - Control soil Furrow irrgation with ridgeplanting
CFF - Control Soil Furrow planting
TB - Treated Soil Basin irrgation
TFR - Treated soil Furrow irrgation ridge planting
TFF - Treated Soil Furrow irrgation Furrow planting

Figure 1. Consumptive use under different soil and irrigated conditions.

Note: The consumptive use was estimated based on soil water depletion.

higher in basin irrigation which has comparatively higher evaporation losses from the soil.

The number of irrigations and the total amount of water applied in each treatment during the whole season is given in Table 2. The treated soil received 7.6% more water than the control. The increased consumptive use from plants in the treated soil required more water to replenish the soil when compared with the control. It was observed that the amount of water required for the FF method of irrigation was comparatively lower than other methods. This obviously indicates that the loss of water, particularly by direct evaporation, from the soil was effectively controlled by polyethylene lining.

Water use efficiency

Water use efficiency (WUE) is generally defined as the mass ratio of crop yield to water used (Viets, 1960). The yield can be characterised by the end product of a plant and the water used can be characterised as the total evaporation needed to produce that yield. The results indicated that the WUE of the treatments with amended soil was highly significant compared to the control. There are two ways to increase WUE; (1) by increasing yield and maintaining constant water use, and, (2) by maintaining equal yield with decreasing water use (Hillel, 1982). Even though more water was used by treated soil the WUE has increased because of the increased yield from this soil.

Among the irrigation treatments, the FF method showed the highest WUE (Table 2). It is important to note that this increased WUE in FF treatment could be attributed not only to the increased yield but also to the reduced amount of water used. Generally, it is more promising to attempt to increase WUE by increasing crop yield than by decreasing crop evapotranspiration, since the plants are subjected to a certain evaporative demand in the field. It was found in this study that the losses of evaporation has been appreciably reduced in the FF method compared to the other methods of irrigation. Hence the FF method has the provision to increase the WUE either by increasing yield or by reducing water use.

Lowest WUE was shown by the FR method with poor yield response in spite of the highest amount of water consumed. The lateral

movement of water is limited in coarse textured soil. Therefore, the plants in the ridges were not able to get adequate water despite the application of sufficient quantities of water. Consequently, the frequency of irrigation was shortened in order to meet the water requirement of the plots in the FR method. This has increased the total amount of water applied and thus reduced the WUE of the FR method. The results further indicate that the yield from the TFR is 10.4% less than that of the CFF. However, an appreciable reduction in WUE, accounting for nearly 50%, was observed in the TFR when compared to the CFF. It is important to note that the increase in WUE in the CFF method is prominently brought about by the decrease in water use by this method. Therefore this observation could undoubtedly support the fact that the performance of polyethylene lined furrows was superior to other methods in view of reducing the water use in the field and thereby increasing WUE in coarse textured soils in particular. Comparing the TB and CFF, the yield from the former was more than the latter while both produced almost similar WUE. This puts forward a question whether to adopt a method with optimum WUE or with maximum yield. It would be desirable to have a compromise between optimum WUE and maximum yield depending on the local constraints with regard to the water availability and cost benefit ratio.

CONCLUSION

A textural improvement made by incorporating non calcic brown soil and tank silt responded well by overcoming the general problems in irrigating sandy soils. The performance of three irrigation methods were clearly identified. Polyethylene lined furrow irrigation with furrow planting was the highest yielding method. The growth and yield of plants were unsatisfactory in polyethylene lined furrow irrigation with ridge planting method, particularly, under sandy soil conditions. It was observed that furrow irrigation with furrow planting method had the lowest consumptive use which had an influence on high irrigation interval and low seasonal water requirement of the method. The response of yield to the amount of water used has ranked the furrow irrigation with furrow planting method as the best method. The performance of all the irrigation methods were highly significant over the controls when they were tested in treated soil. This shows that it is essential to amend sandy soil to increase its agricultural potential and to achieve reasonable results from it.

REFERENCES

Arar, A. and Kadry, L.T. (1978). Regional applied research on sandy soils. FAO Soils bulletin (sandy soils). Vol. 25: 147 – 150.

Baudelaire, J.P. (1973). Irrigation of sandy soils. FAO/UNDP Seminar on reclamation and management of sandy soils in the Near East and North Africa. FAO, Rome.

Hillel, D. and Guron, Y. (1973). Relation between evapotranspiration rate and Maize yield. Water Resources Research 9(3): 743 – 748.

Holmen, H. (1965). "Polyethylene for Irrigation Ditches". Final project report on project S – 4 – 4. (Prefabricated linings for irrigation ditches. Department of Agricultural Engineering, North Dakota, State University, Fargo, U.S.A.

Viets, F.G. (1962). Fertilizers and efficient use of water. Advances in Agronomy. 14: 223 – 264.