MICRO-SPRINKLER IRRIGATION AND FUSTIGATION AND LAND CONFIGURATION AS A BEST MANAGEMENT TECHNOLOGY PACKAGE FOR GROUNDNUT

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ABSTRACT

Field experiments were undertaken to study the effect of micro-sprinkler irrigation with fertigation under different land configurations on groundnut pod yield and water use efficiency at Agricultural College and Research Institute, Madurai, Tamil Nadu during June-September, 2002 and January-April, 2003. Soil application of fertilizers in surface irrigation was scheduled at 0.80 IW/CPE ratio with 6 cm depth under two types of land configuration. Micro-sprinkler irrigation was scheduled once in three days with two levels of irrigation (100 % ETc and 75 % ETc) and two methods of fertilizer application (soil application and fertigation) under two types of land configuration (check basin and broad bed and furrow). It was found that micro-sprinkler irrigation scheduled at 100 % ET_c recorded total water saving of 28 - 31per cent while micro-sprinkler irrigation scheduled at 75 % ET_c registered total water saving of 32 - 38 per cent over surface irrigation. Micro-sprinkler irrigation at 100 % ET_c with fertigation under broad bed and furrow registered the highest pod yield (3776 - 3844 kg/ha) and water use efficiency (8.57 - 9.47 kg/ha-mm) in both the crops.

Key words: Micro-sprinkler, Fertigation, Land Configuration, Groundnut, Water Use Efficiency

INTRODUCTION

Water management is an important element of irrigated crop production. Efficient irrigation management helps not only maintain farm profitability in a scenario of limited, higher cost water supplies but also result in water saving to meet future water requirements. Micro-sprinkler irrigation, which is the pressurized and low volume irrigation system, is recognized as an efficient irrigation technology to get more crop yield per drop (Krishnamurthi *et al*. 2003). It has an added advantage of applying fertilizers through irrigation water. Fertigation is an appropriate method of fertilizer application from the fertilizer use efficiency angle (Shinde *et al*. 2002). Similarly, broad bed furrow is the best land configuration to improve soil physical conditions suited for pod development (Nikam and Firake 2002). The purpose of the study is to

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consolidate the existing knowledge on input management potential in groundnut and examine the cumulative effects of efficient irrigation technology (micro-sprinkler irrigation), apt method of fertilizer application (fertigation) and appropriate land configuration (broad bed and furrow) on yield and water use efficiency in groundnut.

MATERIALS AND METHODS

Field experiments were conducted at Agricultural College and Research Institute, Madurai, Tamil Nadu during June-September, 2002 and January-April, 2003. The soils of the experimental fields were sandy clay loam in texture with field capacity of 21.89 per cent, permanent wilting point of 14.20 per cent, bulk density of 1.45 g cm^{-3}, pH of 7.5, and EC of 0.5 dSm^{-1}. The soil was low in available nitrogen and medium in both available phosphorus and available potassium. The gross size of treatment plots was 6 x 6m. Check basins and broad beds and furrows (beds of 120 cm top width with furrow of 30 cm top width and 15 cm depth) were formed as per the treatment. The seeds of VRI 2 groundnut were treated with *Trichoderma viridi* @ 4g kg^{-1} and the appropriate *Rhizobium* culture @ 600 g ha^{-1} and then dried in shade before sowing. Seed rate of 125 kg kernel ha^{-1} was adopted. A uniform spacing of 30 cm between rows and 10 cm between plants were adopted for check basin system and in the case of broad bed and furrow the seeds were sown with a spacing of 24 cm between rows and 10 cm between plants to maintain the uniform plant population of 33 plants m^{-2} area in both the land configurations.

To carry out micro-sprinkler irrigation treatments, 63 mm PVC main pipes and 50 mm PVC sub main pipes were used to convey the water from the source to the field. The laterals with 12 mm LDPE pipes were placed at a distance of 3 m to a length of 6 m on either side of the sub main. The micro-sprinklers were placed along the laterals at an interval of 2 m in order to have 100 per cent wetting area. The 2 kg cm^{-2} operating pressure of micro-sprinklers was maintained at the time of each irrigation operation. The discharge rate of micro-sprinklers was 60 lph. The experiments were conducted with ten treatments and laid out in a randomized block design with three replications. The treatments consisted of soil application of 100 % recommended dose of fertilizer (17 : 34 : 54 kg NPK ha^{-1}) in surface irrigation at 0.80 IW/CPE ratio with 6 cm depth under two types of land configurations and micro-sprinkler irrigation scheduled once in three days with two levels of irrigation (100 % ETc and 75 % ETc) and two methods of fertilizer application with 100 % recommended dose of fertilizer namely 17 : 34 : 54 kg NPK ha^{-1} (soil application and fertigation) under two types of land configurations (check basin and broad bed and furrow).

Phosphorous in the form of single super phosphate was applied before sowing as basal dose through soil application for all the treatments under study. Nitrogen in the form of urea and potash in the form of muriate of potash were given at sowing as basal dose through soil application for treatments. For the remaining treatments, they were given through fertigation in 9 splits at 7 days interval starting from 14 days after sowing to 70 days after sowing. During each fertigation, the required quantity of N and K fertilizers were dissolved separately in ten litres of water and supplied through ventury unit. The dates of sowing and harvest are given below.

Details	Date of sowing	Date of harvest		Field duration (days)	
		MSI	SI	MSI	SI
First crop	26.06.2002	30.09.2002	14.10.2002	97	111
Second crop	08.01.2003	17.04.2003	30.04.2003	100	113

MSI – Micro-Sprinkler Irrigation SI – Surface Irrigation

The sowing and life irrigation were given uniformly to all the plots irrespective of the treatment schedule and subsequent irrigations were given as per the treatments based on the evaporation values. Irrigation was given through field channels for the surface plots by using a parshall flume. The micro-sprinkler irrigation was scheduled based on Evapo-transpiration of crop (ET_c).

$$ET_c = E_p \times K_p \times K_c$$

Where,

ET_c = Evapo-transpiration of crop (mm)

E_p = Pan evaporation (mm)

K_p = Pan factor (0.80)

K_c = Crop Coefficient

Crop Coefficient (K_c) Values for Different Stages of Growth in Groundnut Source: FAO (1998)

Crop Characteristics	Stages of Development				
	Initial	Crop Development	Mid-Season	Late	Total
Stage Length (days)	25	25	30	25	105
Crop Coefficient	0.4	0.4 – 1.15	1.15	0.6	-

RESULTS AND DISCUSSION

Consumptive Use

Consumptive use of water was assessed to find out the quantum of water used by the crop. It was computed using quantity of irrigation water applied and effective rainfall. The results are presented in Table 1.

It was observed that crop II during the year 2003 consumed more irrigation water than crop I during the year 2002 irrespective of the irrigation treatments. Regarding irrigation methods, in both the crops, surface irrigation required higher quantity of irrigation water as compared to micro-sprinkler irrigation. Among the micro-sprinkler irrigation treatments, irrigation scheduled at 100 % ET_c registered higher irrigation water use than irrigation scheduling at 75 % ET_c. Consequently, it was found that the micro-sprinkler irrigation at 100 % ET_c saved irrigation water up to 31 per cent in Crop I and 28 per cent in Crop II as compared to surface irrigation at 0.80 IW/CPE ratio with 6 cm depth. Micro-sprinkler irrigation at 75 % ET_c saved more irrigation water up to 42 per cent and 39 percent in Crop I and Crop II respectively. It was obvious that micro-sprinkler irrigation at 75 % ET_c saved 11 per cent more irrigation water than micro-sprinkler irrigation at 100 % ET_c.

Table 1. Effects of Irrigation Method and Irrigation Scheduling on Consumptive Use

Treatments	Irrigation Water (mm)		Water Saving (per cent)		Effective Rainfall (mm)		Consumptive Use (mm)		Total Water Saving (per cent)	
	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003
Surface Irrigation at 0.8 IW/CPE	480.00	600.00			112.00	8.50	592.20	608.50		
Microsprinkler Irrigation at 100 % ET_c	332.65	433.13	31	28	73.17	7.60	405.82	440.73	31	28
Microsprinkler Irrigation at 75 % ET_c	279.49	368.46	42	39	121.62	7.60	401.11	376.06	32	38

* Statistically not analyzed

The data on effective rainfall revealed that Crop I recorded higher effective rainfall as compared to Crop II. Surface irrigation plots received higher effective rainfall than micro-sprinkler irrigation. However, micro-sprinkler irrigation at 75 % ET_c experienced higher effective rainfall than micro-sprinkler irrigation at 100 % ET_c during Crop I. In Crop II, the difference between micro-sprinkler irrigation at 75 % ET_c and micro-sprinkler irrigation at 100 % ET_c was almost negligible.

Consumptive use was observed to be higher for surface irrigation (592.20 mm – 608.50 mm) than micro-sprinkler irrigation. Within the micro-sprinkler irrigation treatments, it was observed that micro-sprinkler irrigation at 100 % ET_c registered higher consumptive use (405.82 mm – 440.73 mm) than 75 % ET_c (376.06 mm – 401.11 mm) in both crops. Micro-sprinkler irrigation at 100 ET_c recorded total water saving of 31 per cent in Crop I and 28 per cent in Crop II while micro-sprinkler irrigation at 75 ET_c registered total water saving of 32 per cent in Crop I and 38 per cent in Crop II as compared to surface irrigation at 0.8 IW/CPE ratio with 6 cm depth. These results corroborate the findings of Rama Praba Nalini (1999).

Pod Yield

The pod yield data (Table 2) reveled that in both the crops, micro-sprinkler irrigation recorded higher pod yield as compared to surface irrigation. The increase in pod yield in micro-sprinkler irrigation was mainly due to high frequency irrigation which in turn maintained the soil moisture content in the active root zone at adequate level throughout the crop period. The results confirm the findings of Krishnamurthi *et al.* (2003). Within the micro-sprinkler irrigation treatments, there was an increase in pod yield with micro-sprinkler irrigation scheduling at 100 % ET_c (52 – 400 kg/ha) over micro-sprinkler irrigation scheduling at 75 % ETc, depending on the method of fertilizer application and land configuration. Fertigation through micro-sprinkler irrigation registered significantly higher pod yield than soil application under micro-sprinkler irrigation or surface irrigation irrespective of the effects of land configuration. Further, fertigation through micro-sprinkler irrigation indicated that high frequency of fertigation leads to efficient utilization of applied fertilizer by the crop. This resulted in higher growth and yield attributes leading to a considerable yield increase in groundnut. The result confirms the findings of Prabhakaran (2000). It was further noted that broad bed and furrow recorded higher pod yield than check basin regardless of the irrigation and fertilizer application methods. The analysis of the combined effects of irrigation method with scheduling, fertilizer application method and land configuration revealed that micro-sprinkler irrigation at 100 % ET_c with fertigation under broad bed and furrow (T_8) resulted in significantly higher pod yield of 3844 kg/ha in Crop I and 3776 kg/ha in Crop II.

Table 2. Effects of Land Configuration, Micro-sprinkler Irrigation and Fertigation on Pod Yield and Water Use Efficiency of Groundnut

Treatments	**Pod Yield ($kg\ ha^{-1}$)**		**Water Use Efficiency ($kg\ ha\text{-}mm^{-1}$)**	
	2002	2003	2002	2003
T_1 – CB + SI + SA	1563	1511	2.64	2.48
T_2 – BBF + SI + SA	1909	1867	3.22	3.07
T_3 – CB + MSI at 100 % ET_c + SA	2171	2051	5.35	4.65
T_4 – CB +MSI at 100 % ET_c + F	3430	3387	8.45	7.69
T_5 – CB + MSI at 75 % ET_c + SA	2067	2009	5.15	5.34
T_6 – CB +MSI at 75 % ET_c + F	3053	2899	7.61	7.71
T_7 – BBF + MSI at 100 % ET_c + SA	2367	2255	5.83	5.12
T_8 – BBF +MSI at 100 % ET_c + F	3844	3776	9.47	8.57
T_9 – BBF + MSI at 75 % ET_c + SA	2113	2047	5.27	5.44
T_{10} – BBF +MSI at 75 % ET_c + F	3202	3128	7.98	8.32
SEd	107	111	0.25	0.26
CD (P = 0.05)	225	234	0.53	0.55

Note: CB – Check Basin, BBF – Broad Bed and Furrow, SI – Surface Irrigation
SA – Soil Application of Fertilizer, MSI – Micro-sprinkler Irrigation,
F - Fertigation

Water Use Efficiency

Water use efficiency explains effective utilization of water by crop in terms of water saving as well as yield augmentation. Data on water use efficiency are given in Table 2. While comparing the irrigation methods, it was found that in both the crops, micro-sprinkler irrigation recorded higher water use efficiency as compared to surface irrigation. It was mainly due to higher pod yield and maximum saving in irrigation water. The low water use efficiency in surface irrigation might be the result of higher irrigation water use with comparatively less yield. Within the micro-sprinkler irrigation treatments, micro-sprinkler irrigation at 100 % ET_c registered higher water use efficiency than 75 % ET_c in Crop I and vice versa in Crop II, regardless of the effects of fertilizer application method and land configuration.

Fertigation through micro-sprinkler irrigation recorded higher water use efficiency than soil application under micro-sprinkler irrigation or surface irrigation irrespective of the effects of land configuration. The beneficial effects of combining fertigation with micro-sprinkler irrigation on pod yield, and hence on water use efficiency, might perhaps largely stem from the constant soil moisture content at field capacity leading to proper proportion of water and air in the active root zone and also reduction of nutrient leaching losses due to the restriction of wetting area to active root zone. Deolankar and Firake (1999) and Tumbare and Bhoite (2002) reported similar findings in chilli while Shinde et al. (2002) inferred the same observation in brinjal. With regard to land configuration, it was observed that broad bed and furrow registered higher water use efficiency than check basin irrespective of the irrigation and fertilizer application methods due to improve soil physical conditions suited for pod development (Nikam and Firake 2002).

The analysis of the combined effects of irrigation method with scheduling, fertilizer application method and land configuration revealed that micro-sprinkler irrigation at 100 % ET_c with fertigation under broad bed and furrow (T_8) registered significantly higher water use efficiency of 9.47 kg/ha-mm in Crop I and 8.57 kg/ha-mm in Crop II. Surface irrigation with soil application of fertilizers under check basin (T_1) recorded the least water use efficiency of 2.64 kg/ha-mm in Crop I and 2.48 kg/ha-mm in Crop II.

It could be concluded that NK fertigation with 100 % recommended dose of fertilizer in 9 splits at 7 days interval through micro-sprinkler irrigation at 100 % ETc under broad bed furrow recorded higher water use efficiency than soil application of 100 % recommended dose of fertilizers with either broad bed furrow or check basin under surface irrigation at 0.8 IW/CPE ratio (6 cm depth). The study therefore infers that micro-sprinkler irrigation system is suited for improving water use efficiency in field crops through water saving and yield augmentation.

BEST MANAGEMENT TECHNOLOGY PACKAGE FOR GROUNDNUT

The experiment aimed at identifying the best micro-sprinkler irrigation regime, optimum fertigation level, appropriate fertigation frequency and suitable land configuration for groundnut. Results obtained on all these dimensions enabled the formulation of a package of the best management practices for realising maximum yield and income from groundnut. Individually, each of the following treatments proved to be the most effective practice

- Micro-sprinkler irrigation at 100 % ET_c
- Fertigation of 100 % RDF
- Fertigation in 9 equal splits at 7days interval from 14 DAS to 70 DAS
- Land configuration of broad bed and furrow formation

The combination of the above four technologies proved to be the best management technology package for groundnut. This is evident from the comparison of the best management technology package (BMTP) with the traditional practice of surface irrigation with soil application of fertilisers on many counts as described below:

Particulars	Unit	Traditional Technology	Best Management Technology Package
Pod Yield	kg ha^{-1}	1537	3810
Increase in Pod Yield	Percent		148
Costs of Cultivation	Rs. ha^{-1}	15722	19634
Gross Income	Rs. ha^{-1}	23061	57151
Net Income	Rs. ha^{-1}	7339	37517
B:C Ratio		1.47	2.91
Water Use	mm	600	423
Water Saving	Per cent		30
Water Use Efficiency	kg ha-mm^{-1}	2.56	9.02
Oil Content	Per cent	37.27	49.59
Protein Content	Per cent	23.79	29.77

The payback period for micro-sprinkler irrigation system can be considerably reduced by adoption of the best management technology package which includes fertigation scheduling and land shaping. The evidence from this study indicates that payback period for a micro-sprinkler irrigation system in groundnut cultivation can be reduced to 2 seasons of cropping by adoption of the best management technology package comprising micro-sprinkler irrigation at 100 % ET_c, fertigation with 100 % RDF (17:34:54 kg NPK ha^{-1}) in 9 equal splits at 7 days interval from 14 DAS to 70 DAS and land shaping into broad bed and furrow.

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