MICRO IRRIGATION TECHNOLOGY: A REMEDY FOR GROUNDWATER MANAGEMENT IN JAFFNA PENINSULA

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Abstract

The study was conducted with the objective of estimating groundwater saving, irrigation intervals and duration for cabbage, a field trial was carried out with sprinkler irrigation to see the performance of yield. The field posses the main soil type of Calcic red yellow latosol and located under DL_3 region. The ten treatments were carried out including farmers' practices, morning sprinkler irrigation for 15 and 25 minutes and morning and evening sprinkler irrigation for15 and 25 minutes with two varieties analyzed by two factorial randomized block complete design. Irrigation duration of 15 minutes sprinkler irrigation with Green coronet variety field was record highest yield of 4.53 kg/m^2 and 15 minutes sprinkler irrigation with K – Y cross variety field was record lowest yield of 3.94 kg/m^2. Morning sprinkler irrigation was statistically not significant different from morning & evening sprinkler irrigation and these two treatments were statistically significant different from ridge and furrow irrigation for two varieties. Finally 15 minutes sprinkler irrigation was selected as best treatment and followed by 25 minutes sprinkler irrigation. Green coronet variety more response to sprinkler irrigation than K – Y cross variety. The depth of water application was higher in ridge and furrow irrigation than sprinkler irrigation. The saving of 69.31% of groundwater was accounted under sprinkler irrigation system with 15 min duration compared to ridge and furrow irrigation method. Adaptation of sprinkler irrigation is more economical and water saving than the ridge and furrow irrigation.

Key words: *Groundwater, Sprinkler irrigation, yield response, cabbage*

1.0 INTRODUCTION

Increasing water scarcity in Sri Lanka, together with evidence of its inefficient use and increasing competitive demand has given momentum to the call to treat water as an economic good. One of the technical mechanisms available to improve the efficiency of irrigation water use is adoption of micro irrigation technologies to reduce losses at distribution and at on-farm water management. It was found that on farm irrigation efficiency was about 90% under properly designed and managed drip irrigation system, 80% for sprinkler irrigation and only about 45% for surface irrigation methods (Sivanappan, 1994). The annual water resource of the island has been estimated as 4.32 million ha m and present withdrawal is about 20 percent mainly for agricultural purposes. However, the increased demand for industrial and domestic water will result in a reduction in water diversions to agriculture.

Water application uniformity is essential for an efficient agriculture especially in regions where water resources are limited and precipitation is not main source to respond water demand. Hassanli *et al*., 2010 indicated that irrigation methods has key role in efficient use of water but still there is limited information on their application on crop performance. One of the best methods to increase the efficiency and the uniformity of irrigation is the use of micro-scale irrigation techniques for irrigating the agricultural lands. In micro-irrigation, water will be supplied on demand to the effective root zone of plants with high efficiency (Sanchez *et al.*, 1994). Micro Irrigation plays an important role in the management of crops to obtain the maximum yield from lesser quantity of water, chemicals and fertilizers compared to other forms of irrigation (Aheeyar *et al.*, 2004). Dharmasena and Karunainathan, 2004 stated that agro-well water is utilized for growing chilli, onion, fruits vegetables by smallholder farmers and the current trend is to cultivate fruits and vegetables by using micro irrigation systems at commercial level.

Groundwater can provide supplementary irrigation in many areas of the dry zone except the Northern district, Jaffna district in which groundwater is the major irrigation source (Srimanne, 1967 and De

Silva, 1996). The average annual rainfall of Jaffna is about 1200 mm. Normally, rainfall period restricted to 3-4 months of this area. Groundwater use has exceeded safe limits in most areas of Jaffna where sustainable irrigation depends on maintaining a delicate balance between recharge and extraction (Rajasooriyar *et al.*, 2002). The Jaffna farmers face difficulties in irrigation interval and duration when use micro irrigation (Jayapiratha *et al.*, 2010). They do not have recommended intervals and durations.

1.1 Objectives of the study

Adaptation of micro irrigation is important in Jaffna Peninsula to conserve the quality and quantity of groundwater. Hence the objectives of the study was selected as to determine the irrigation duration and irrigation interval of sprinkler irrigation in cabbage crop and its influence on yield component of two different varieties of cabbage with determination of groundwater saving under sprinkler irrigation in comparison with surface irrigation

2.0 MATERIALS AND METHODS

2.1 Measurement of system parameters

Research study was conducted in a field located at District Agricultural Training Center at Thirunelvely in Jaffna district where cabbage are cultivated under sprinkler and surface method irrigated conditions. Randomly selected rotary head type sprinklers were fitted on laterals with equal spacing with riser height of 42 cm in the sprinkler system. The system parameters, such as discharge rate of the nozzle, the average wetted area and the depth of water applications were measured. The commonly used measurement tool to determine the uniformity of sprinkler systems is catch can test (Li *et al*., 2005). Once the data are collected by catch cans, a number of different calculations can be performed. For the measurement of uniformity of water distribution, twenty five catch cans were placed around sprinkler. Sprinklers were allowed to operate for 30 minutes and total collected water in the cups was measured by using a measuring cylinder. For the calculation of uniformity of water distribution from rotating head sprinklers, a formula developed by Christiansen (Sivanappan, 1987) was used.

$$Cu = 100\left(1.0 - \frac{\sum X}{mn}\right)$$

In which,

C_u- Co-efficient of uniformity
m - Average value of all observations (average application rate), mm
n - Total number of observation points
X – Numerical deviation of individual observation from the average application rate, mm.

Calculated uniformity coefficient values were plotted and compared with internationally accepted value of 85%.

2.2 Collection of weather parameters

The weather records such as rainfall, relative humidity, wind velocity, sunshine hours and Temperature were collected from Thirunelvely, Meteorological station in Jaffna, for the January, February, March and April 2008 to of study period 2009 to see the suitability of the sprinkler system .

2.3 Treatments

The cabbage was selected and grown as the test crop for this experiment. In this crop, K-Y cross and Green coronet varieties were selected. Two irrigation methods were selected as treatment. The ridge and furrow method was selected as control because most of the farmers planting the cabbage in ridges and furrows irrigation. The research was done with the following ten treatment combinations (Table 1) and three replicates. The experimental data was analyzed statistically following factorial randomized complete block design. Control was designed as every fourth day to Ridge and furrow.

Table 1: *Combination of treatment*

Treatment	Irrigation interval (every day)	Irrigation duration(minutes)	variety	Irrigation type
T_1	Morning & evening	15	K - Y cross	Sprinkler
T_2	Morning & evening	15	Green coronet	Sprinkler
T_3	Morning & evening	25	Green coronet	Sprinkler
T_4	Morning & evening	25	K - Y cross	Sprinkler
T_5	Morning	15	K - Y cross	Sprinkler
T_6	Morning	15	Green coronet	Sprinkler
T_7	Morning	25	Green coronet	Sprinkler
T_8	Morning	25	K - Y cross	Sprinkler
T_9	-	-	Green coronet	Ridge & furrow
T_{10}	-	-	K - Y cross	Ridge & furrow

Except irrigation duration and irrigation interval all other cultural activities such as nursery management, planting, weed control, fertilizer application and chemical application were maintained the same for all treatment plots. The ridge and furrow was irrigated at three days irrigation intervals to represent farmer's practices. The discharge rate of the pump and duration of irrigation were measured during each furrow irrigation time to get the total depth of water irrigated.

3.4 Measurement of yield parameters

Out of two hundred and forty, forty eight samples of each treatment were selected randomly. The following yield parameters; mean head weight, plant height, head diameter, head height, yield, root length were measured.

3.5 Statistical analysis

The experimental data was analyzed statistically following randomized complete block design and factorial randomized complete block design by the use of SAS computer software package at 5%level.

3.0 RESULTS AND DISCUSSION

3.1 Measurement of system parameter

Mean diameter of the wetted area was 6.4 m at 42 cm riser height. The mean discharge rate of sprinkler nozzle was 0.1467 lit/sec and the depth of water applied 33 mm/hour. The christiansen uniformity coefficient value was 92.42% and it was acceptable since the value was greater than the best internationally accepted uniformity coefficient value of greater than 85% (Gupta *et al*., 2001).

3.2 Variation of weather parameters

The study area belongs to dry zone low country (DL_3) agro climatic region where the soil is calcic red latosols. The average temperature, rainfall and wind velocity were 27 ^oC, 356.9 mm and 4.56 km/h respectively. The average maximum temperature was 31.65 ^oC with standard deviation of ± 1.65 ^oC. The highest maximum temperature was 34.7 ^oC and lowest maximum temperature was 26.4 ^oC. This climatic condition is preferable for growth of the cabbage crop. Out of 91 days, in total 356.9 mm rainfall was received with twelve rainy days. The relative humidity was varied from 48% to 98% and average RH was 67.16% with standard deviation of ± 9.32%. The average wind speed was 4.56 km/h and standard deviation ± 2.89 km/h. Most of the days, the speed of the wind was less than10 km/h. Hence there was no any influence of wind speed in uniformity coefficient of sprinkler irrigation.

3.3 Response of irrigation treatment on yield performance

Analysis was done in two ways. First, six treatments were considered as morning sprinkler irrigation, morning & evening sprinkler irrigation and ridge and furrow irrigation for two varieties. Another analysis was done within the sprinkler irrigation treatment. Four treatments were considered (Morning sprinkler irrigation – 15 min & 25 min and morning & evening sprinkler irrigation – 15 min & 25 min). The mean head weights ranged from 4.81 to 8.43 kg/m^2. The highest mean head weight at 1.69 kg and 1.66 kg were obtained in morning and morning and evening sprinkler irrigation for Green

coronet varieties respectively (Figure 1). Morning sprinkler irrigation was statistically not significant different from morning & evening sprinkler irrigation and these two treatments were statistically significant different from ridge and furrow irrigation for two varieties. The lowest head weights were obtained from ridge and furrow irrigation with K – Y cross variety and Green coronet variety which had 1.13 kg, 0.96 kg respectively. Mean time, the higher yield was received in green cornet variety than K-Y cross verity. According to the other analysis the highest mean head weight of 1.69 kg was obtained in morning 15 minutes sprinkler irrigation. The lowest mean head weight at 1.65 kg was obtained in morning & evening 25 minutes sprinkler irrigation (Figure 2).

Mean head weight and mean plant height were significantly differed in sprinkler irrigation and ridge and furrow irrigation but mean head width, mean head height and mean root length were not significantly different within these treatments for K – Y cross (Table 2). Mean head weight, mean plant height, mean head width, mean head height and mean root length were significantly differed for in sprinkler irrigation and ridge and furrow irrigation for green coronet (Table 3). But all the measured characters were significantly differed between two varieties because of its varietal characters.

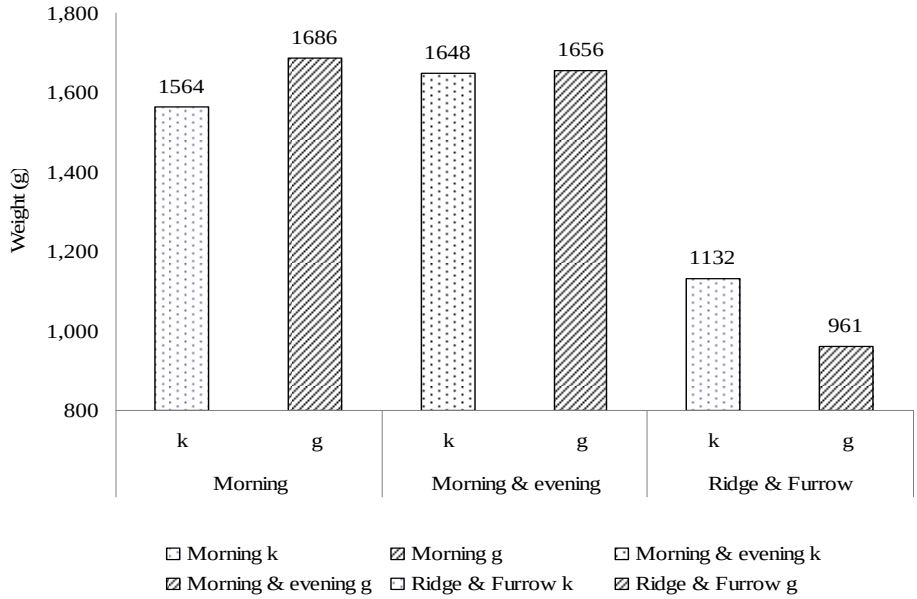

Figure 1: *Mean head weight in different irrigation systems*

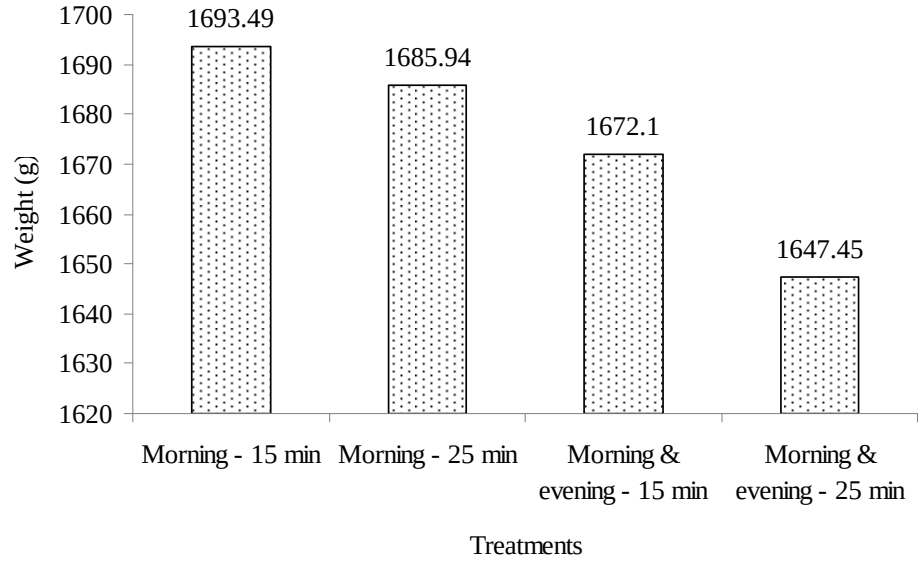

Figure 2: *Mean head weight in different irrigation durations and intervals under sprinkler irrigation systems.*

Table 2: *Mean head weight, mean plant height, mean head width, mean head height and mean root length of K – Y cross variety.*

Irrigation type	Mean head weight (g)	Mean plant height (cm)	Mean head width (cm)	Mean head height (cm)	Mean root length (cm)
Morning sprinkler	1564[a]	28.922[a]	20.651[a]	13.693[a]	19.783[a]
Morning & evening sprinkler	1648[a]	28.801[a]	20.371[a]	13.291[a]	19.526[a]
Ridge & furrow	1132[b]	22.125[b]	18.812[a]	12.271[a]	17.833[a]

(Mean followed by the same letters is not significantly different at 5%level).

Table 3: *Mean head weight, mean plant height, mean head width, mean head height and mean root length of green coronet.*

Irrigation type	Mean head weight (g)	Mean plant height (cm)	Mean head width (cm)	Mean head height (cm)	Mean root length (cm)
Morning sprinkler	1686[a]	34.718[a]	16.906[a]	15.651[a]	21.687[a]
Morning & evening sprinkler	1656[a]	34.125[a]	16.704[a]	15.407[a]	21.250[a]
Ridge & furrow	961[b]	30.687[b]	14.406[b]	13.042[b]	18.958[b]

(Mean followed by the same letters is not significantly different at 5%level).

3.4 Groundwater saving

Table 4 shows the depth of water applied in single irrigation and total water used during entire crop growing season with mean head weight. The depth of water application in each 15 min irrigation was 3.17 mm, 5.29 mm of water in 25 min irrigation and 30.95 mm of water in ridge and furrow irrigation. While comparing the depth of irrigation applied and mean head weight, 15 min sprinkler irrigation was more economic than other irrigations. The saving of 69.31% of groundwater was accounted under sprinkler irrigation system with 15 min duration compared to ridge and furrow irrigation method. Adaptation of sprinkler irrigation is more economical and groundwater saving than the ridge and furrow irrigation.

Table 4: *Depth of water used during growing season*

Treatment	Depth of water used (mm)	Total depth of water used (mm)	Mean head (g)
Morning – 15 min	3.17	380.85	1693.49
Morning – 25 min	5.29	634.75	1685.94
Morning & evening – 15 min	6.34	761.70	1672.1
Morning & evening – 25 min	10.58	1269.51	1647.45
Ridge & furrow	30.95	1238	1046.5

4.0 CONCLUSION

In yield parameters, mean head width, mean head height, mean root length, mean head weight and mean plant height were significantly varies among sprinkler and ridge and furrow irrigation of Green coronet variety. Mean head weight and mean plant height were significantly varies among sprinkler and ridge and furrow irrigation of K – Y cross variety. Every day morning 15 minutes sprinkler irrigation was suitable to cabbage crop under calcic red yellow latosol considering the head weight. The saving of 69.31% of groundwater was accounted under sprinkler irrigation system with 15 min duration compared to ridge and furrow irrigation method. Adaptation of sprinkler irrigation is more economical and groundwater saving than the ridge and furrow irrigation.

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