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Optimization of Fertigation Level and Depth of Lateral under Subsurface Drip Irrigation for Amaranthus

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ABSTRACT

The main concept of drip irrigation is to create a continuous wetted strip directly beneath the soil where the active roots are concentrated. The fertigation allows application of right amounts of plant nutrients uniformly to the wetted root zone. A field experiment was conducted to evaluate the effect of different fertigation levels and depth of laterals under plastic mulch on the performance of Amaranthus (*Amaranthus hypochondriacu,* variety: kannara local). The yield showed significant difference with different levels of fertigation and depth of laterals. Based on the statistical analysis the study suggested that treatment of 80% fertigation and 10 cm lateral depth is better due to the fact that it gives higher crop yields (7.2 t/ha) with substantial saving in fertilizer usage. Hence, subsurface drip irrigation of 10 cm lateral depth with 80% fertigation level under plastic mulching for amaranthus is a good option.

Key words *Fertigation, lateral depths, subsurface irrigation, plastic mulching.*

Micro irrigation is one of the most efficient methods of water application directly into soil at the root zone of plants. It permits a small uniform flow of water at a constant discharge (Hanson, 1994). It also permits the irrigation to limit the watering closely to the consumptive use of plants and it minimizes the conventional losses such as deep percolation, runoff and soil evaporation. Subsurface Drip Irrigation is a types of Micro irrigation in which water is applied directly to the root zone of plants by means of applicators (E.g. orifices, emitters, and porous tubing) placed below the ground surface. It is potentially more efficient than flood or sprinkler irrigation, due to large part to reduced evaporation (Hernandez *et al*., 1991 and Oron *et al*., 1991).

Fertigation provides flexibility of fertilizer application, which enables three specific nutritional requirements of the crop to be met at different stages of its crop yields with substantial saving in fertilizer usage. Micro irrigation coupled fertigation ensures the congruence of sustainability, productivity and profitability (Lamm *et al.,*1995). The productivity of crops is based on effective utilization of water and fertilizer, along with other agricultural inputs through emitters of pre-determined discharge placed along water delivery line i.e., lateral or emitting pipe. The frequency and application depth of irrigations depend heavily on the amount of soil water available to the crop's roots. Installation of laterals in the field also affects the yield (Hernandez *et al*., 1991). As amaranthus (*Amaranthus hypochondriacu,* variety: kannara local) is a leafy vegetable, fertilizer is mainly used for producing more leaves.

Mulching is a relevant practice for soil moisture conservation. Fertigation along with mulching helps to achieve both the objectives of efficient utilization of available water and the conservation of soil moisture. Plastic mulch can reduce the loss of soil moisture and controls the weed growth (Raina *et al*., 1999). Since micro irrigation greatly enhances water, fertilizer and energy use efficiency, the sustainability in agriculture could be achieved without the burden of environmental degradation. This study has undertaken to optimize the fertigation level and depth of laterals under subsurface drip irrigation for amaranthus.

MATERIALS AND METHODS

The study was conducted at the Instructional Farm, Kelappaji College of Agricultural Engineering and Technology (KCAET), Tavanur, Malappuram,

Table 1. Treatment details

Sl. No.	Treatments	Name	Description
1	T1	F1D1	120% of fertigation level, lateral of 4 l/h at 10 cm depth
2	T2	F2D1	100% of fertigation level, lateral of 4 l/h at 10 cm depth
3	T3	F3D1	80% of fertigation level, lateral of 4 l/h at 10 cm depth
4	T4	F1D2	120% of fertigation level, lateral of 4 l/h at 20 cm depth
5	T5	F2D2	100% of fertigation level, lateral of 4 l/h at 20 cm depth
6	T6	F3D2	80% of fertigation level, lateral of 4 l/h at 20 cm depth
7	T7	F1D3	120% of fertigation level, lateral of 4 l/h at 30 cm depth
8	T8	F2D3	100% of fertigation level, lateral of 4 l/h at 30 cm depth
9	T9	F3D3	80% of fertigation level, lateral of 4 l/h at 30 cm depth
10	C		Control

Kerala during the period of October 2012 to January2013. Major part of the rainfall in this region is obtained from South west monsoon. The total area selected for the study was 32x13 m^2. Low density polyethylene pipe of 16 mm diameter was used as the laterals which were provided with individual tap to control the flow rate and end caps are provided at the end of laterals. The inline drippers of 4 liters per hour discharge with a spacing of 40 cm were used for the study. Dosmatic fertigation unit was used for this study. The required quantity of fertilizers were taken in a container and mixed thoroughly with water proportionately.

Treatment details

The experiment was laid out with ten treatments, from which nine treatments are the combination consisting of three fertigation levels and three depths of laterals and one treatment as control were shown in Table 1 and the ten treatment was replicated thrice shown in Fig 1.

Installation of drip system

A pump of 4 hp was used for this study. Two pressure gauges with pressure range of 0-7 kg (f)/ cm^2 were located before and after the fertigation unit for indicating the pressure in the system. PVC pipes of 90 mm and 75 mm diameter with pressure rating of 6 kg (f)/cm^2 was used as the main and sub main respectively. Raised beds of size 12x0.9 m^2 of 30 numbers were taken and in between two beds a spacing of 15 cm was given. The laterals were placed at three different depths of 10, 20 and 30 cm below the soil surface. Black plastic mulch (12m length and width of 1.2 m) sheet of 30 micron was used for covering the soil and holes of 10 cm diameter were punched evenly at 40 cm × 40 cm grid points on the LDPE sheets.

Transplanting

Amaranth (*Amaranthus spp.*) variety kannara local was chosen this study. A spacing of 40×40 cm^2, recommended for amaranthus in the Package of practices recommendations: Crops (KAU, 2005) was adopted. Amaranth kannara local requires about 2 l/day/plant. Amaranthus is a transplanted crop. Seeds were sown in the prepared soil bed of 8x1 m^2 with a seed rate of 4.2 gm/m^2 and two week old seedlings were transplanted to the main field. In the mulched plots seedlings were then planted in the holes. The transplanting was done at a spacing of 40 cm × 40 cm with 60 plants in each plot.

Fertilizer application

The recommended dose of fertilizer requirement for the amaranth crop was 50:50:50 kg/ha (KAU, 2005) fertilizer was applied as per treatments in sixteen equal splits at four days interval. Nitrogen, phosphorus and potassium were the main nutrients required for the growth and these was applied *Rajphos* as a basal dose, urea, multi K and *polyfeed* (19:19:19) through dosmatic fertigation unit except control unit from five week to thirteenth week after planting. The recommended dose of fertizer for control treatment was applied to the base of the plant. Fertilizer

Table 2. Fertilizer requirement per bed (Recommended dose of N: P: K is 50:50:50 kg/ha)

Treatment (%)	Fertilizer required(g)				
	Urea (46 : 0 : 0)	Polyfeed (19 : 19 : 19)	Multi K (13 : 0 : 44)	Potash (0 : 0 : 50)	Rajphos
120	9.6	22	36	8.4	-
100	8.0	18	30	7	-
80	6.4	14.5	24	5.6	-
Control	8.0	-	-	7	9

requirement for different treatments were shown in Table 2

Collection of experimental data

For analyzing the growth pattern of the crop, three plants were selected randomly from the net plot area in each treatment and were tagged to record the variations. The average girth and numbers of leaves of the randomly selected plants grown under each treatment was taken in a weekly interval and the observation was first taken two weeks after planting. The first yield (kg/ha) was taken one month after transplanting. After the first harvest, other harvests were done at an interval of 7 days. The total of the seven harvests were taken.

Statistical analysis was done by analysis of variance (ANOVA). Analysis was compared between the treatments.

RESULTS AND DISCUSSION

The results obtained from the study were analyzed to provide basic information of different fertigation level and depth under subsurface drip irrigation and its performance on growth and yield of crop.

Stem girth

The readings were taken up to 7 week after transplanting shown in Table 3. The maximum value obtained (5.6 cm) in the case of stem girth was observed for the treatment 100% fertigation level and 10cm lateral depth. From the first observation onwards, it is clearly seen that maximum stem girth was observed in case of treatment is having 100% fertigation level and 10cm lateral depth. The minimum value (4.2 cm) is seen for the treatment 100% fertigation level and 30 cm lateral depth. The control treatment shows 4.4 cm stem girth. The statistical analysis shows that the stem girth at different days after planting did not differ significantly with respect to the different treatments (Reddy *et al.,* 2005). The analysis also shows that for the stem girth, there was no significant difference in between replications and treatments.

Number of leaves

The maximum number of leaves was observed for the treatment 100% fertigation with 10 cm lateral depth and minimum was seen in control. The readings are shown in Table 4. In case of fertigation, it was observed that maximum fertilizer utilization is at a depth of 10 cm. This clearly indicates that, for different fertigation levels, more extraction of fertilizer can be seen in 10 cm depth compared to 20 and 30 cm depths. But there were no significant variations in number of leaves in other treatments i.e., with 20 and 30 cm depths

Table 3. Stem girth (cm) at different days as influenced by 10 treatments

	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	C
3 Nov	1.5	2.4	1.6	1.8	1.6	1.5	1.4	1.5	1.5	1.4
10Nov	3.7	3.9	3.4	3.2	3.3	3.1	3.1	3.2	3.9	3.3
17Nov	4.3	4.5	4.1	3.6	3.8	3.5	3.9	3.7	4.2	3.7
24Nov	5.0	5.1	4.6	4.0	4.1	4.3	4.5	3.9	4.3	4.0
30Nov	5.3	5.6	4.8	4.3	4.3	4.8	4.7	4.2	4.5	4.4

Table 4. Number of leaves at different intervals of days as influenced by 10 treatments

	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	C
3Nov	16	25	13	15	17	17	12	15	19	14
10Nov	36	56	34	33	45	34	33	31	42	26
17Nov	82	99	53	51	57	61	59	63	84	47
24Nov	108	159	105	82	94	100	88	72	111	96
30Nov	169	181	139	107	115	120	129	110	121	108

Table 5. Yield (t/ha) of amaranthus as influenced by different treatments

	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	C
1st harvest	0.56	0.60	0.46	0.31	0.15	0.19	0.28	0.43	0.26	0.00
2nd harvest	1.39	1.65	1.30	1.24	1.30	0.77	1.11	1.12	1.14	0.65
3rd harvest	1.11	1.25	1.20	0.55	0.88	1.02	0.87	0.69	1.03	0.78
4th harvest	1.48	1.71	1.44	1.23	1.30	1.11	1.43	1.23	1.39	1.26
5th harvest	1.30	1.63	1.34	1.37	1.20	1.30	1.39	1.37	1.39	1.26
6th harvest	1.57	1.67	1.46	1.11	1.44	1.16	1.14	1.27	1.16	1.12

Kant and Naoi (1998) also reported the similar results.

Yield of amaranthus

In the first harvest at 30 days after planting, the high yield (0.6 t/ha) was observed for treatment 100% fertigation with10 cm lateral and the plants in the control plot were not matured enough to harvest. The readings are shown in Table 4. In the case of treatment 100% fertigation with 10cm lateral depth, the number of leaves was also more as compared with the other treatments. The yield of treatment 100% fertigation with 10 cm lateral depth is obtained increased due to higher moister extraction. (Kant and Naoi, 1998). In treatment control, conventional practices were followed and yield per beds were observed minimum when compared to other treatments, fertigation with plastic mulching.

In statistical analysis, it was found that the treatments 120% fertigation level with 10 cm lateral depth and treatment 100 % fertigation with 10 cm lateral depth were on par with treatment 80% fertigation with 10 cm lateral depth, but other treatments were significantly varies with these treatments. In treatment 80 % fertigation level with 10 cm lateral depth, it is possible to save 20% fertilizer. Hence, this study suggested that treatment is having 80 % fertigation level with 10 cm lateral depth, is better because it needs less amount of fertilizer.

Accurate management of water, fertilizers and lateral depth with subsurface drip irrigation systems is the next step in producing high yield. Maximum yield was observed for the treatment which is of 10 cm lateral depth with 100 % fertigation level. Statistically the treatment of 10 cm lateral depth with 100 % fertigation level is on par with the treatment of 80% fertigation and 10 cm lateral depth. The study suggested that treatment of 80% fertigation and 10 cm lateral depth is better due to the fact that it gives higher crop yields with substantial saving in fertilizer usage. Hence, subsurface drip irrigation of 10 cm lateral depth with 80 % fertigation level under plastic mulching for amaranthus is a good option as compared with conventional methods.

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