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# Designing of drip irrigation and fertigation scheduling in bitter gourd (*Momordica charantia*) crop

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■ **ABSTRACT :** The study was conducted in an area of 7 ha at ACF Farm in the village- Achhoti, dist. - Durg (C.G.) during 2012. Drip irrigation provides the ultimate water use efficiency for open field agriculture, often resulting water savings of 25-50 per cent compared to flood irrigation. The Irrigation scheduling was done for calculating the water requirement of crop at different stage of the crop. It was calculated by calculating the crop factor, canopy factor at different stage of crop and weekly evaporation data collecting from evaporation pan of metrological department at I.G.K.V. Raipur. The water requirement of the bitter gourd varied from 42.833 – 127.48 cu.m/ha/day during the period of establishment of plant to flowering and harvesting. Fertigation is a most important part of drip irrigation system by which the most advanced and efficient practices of fertilization were done. Fertigation enables the farmers to apply optimum quantity and right combination of fertilizer nutrient mixed in water uniformly throughout the irrigated area according to the crop development phases. The availability of nutrients is influenced by the pH, moisture and quality and quantity of plants. The fertigation scheduling gives idea about proper supply of fertilizer at calculated quantity to plants. Drip irrigation is most advanced method of irrigation, applied the small amount of water to the crop through the drippers placed above the soil surface. A properly designed drip irrigation system has advantage over other method of irrigation to help growers of fruits, vegetable, flowers and other cash crops by saving water, increasing yield, improving quality of produce, reducing labour cost, reducing salt concentration in the root zone, permitting use in greenhouse, controlling and reducing diseases. It minimizes conventional losses such as deep percolation, runoff and soil water evaporation.

■ **KEY WORDS :** Drip irrigation, Irrigation scheduling, Design of drip irrigation

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Bitter gourd crop is a well known vegetable crop grown in *Kharif* and *Rabi*. It belongs to family Cucurbitaceae. Its botanical name is *Momordica charantia*. The bitter gourd is native to China or India. The total geographical area of Chhattisgarh (C.G.) is 13.5 m ha of which 5.9 mha area is under cultivation. In C.G. about 600-acre area is covered by bitter gourd under drip irrigation. The average production of bitter gourd in Chhattisgarh is about 1.3 t/ha. Bitter gourd requires a minimum temperature of 18$^{o}$C during early growth, but optimal temperature are in the range of 24-27$^{o}$C. It is more tolerant to low temperature compared to other gourds, but cool temperature will retard growth and frost will kill the plant. The plant is adapted to a wide variety of rainfall conditions. But regular irrigation is needed to ensure high yield.

Water is vital for life. It is a crucial input for agriculture and major resource constraint that limits economic development and food grain production in India. Its availability is becoming scarce and costly. Therefore, judicious application of water has great significance. The share of water for agriculture is likely to reduce from present level of 84 per cent to 69 per cent by 2025 with increasing demand from other sector but on the other hand, demand of water for agricultural purposes were estimated to increase to produce more food for increasing population of the country. Therefore, emphasis is needed to achieve more crops per unit volume of water applied so the irrigation scheduling is a concept used for proper management of water.

Irrigation scheduling is a concept by which we are able to obtain the proper management of water with respect to time and use. It is for providing a better environment for the crop production as per plant growth stage. By using drip irrigation the irrigation scheduling is properly done with respect to time.

Drip irrigation is a recent development in irrigation methods (Bralts and Gitlin, 1981 and Karmeli and Keller, 1975). Simca Blass, a hydraulic engineer in 1959, originally developed it in Israel. Drip irrigation was based on the fundamental concept of irrigating root zone rather than entire land surface, which results in higher water use efficiency or consumptive use and enhanced crop yield (Bresler, 1977 and Israel and Hansen, 1950). Thus, drip irrigation minimizes conventional losses like deep percolation, runoff and soil evaporation. It also permits the utilization of fertilizer, pesticides and other water-soluble chemicals along with irrigation water with better crop response. The quality, quantity and grade of bitter gourd crop were involved with drip irrigation system over other methods were recorded with the treatment of drip irrigation. Higher labour saving and more cost of returns as compared with other methods.

## ■ METHODOLOGY

The field experiment was conducted at the ACF Farm of Mr. Jai Prakash Chawda in the village- Achhoti, dist. - Durg (C.G.) during the period from June 2012 to September 2012.

### Physical and chemical properties of soil:

Bitter gourd is well suited to sandy loam soils with well drained clay subsoil however, bitter gourd crop can be grown on a variety of soil yet sandy loam soil is best suited to it. It grows satisfactorily at 6.0 to 6.7 PH. The soil of farm was having under sandy clay soil texture classification.

### Method of irrigation:

Irrigation method selected for the experiment was the low pressure drip irrigation method for irrigation purpose because it is a advance method by which we save the water, labour and weeding cost. By this method we are also able to maintain irrigation schedule.

In the field 5 HP submersible pump of 6 stages for getting water from bore well was used with discharge of pump set 4.680 cu.m/hr. The drip irrigation system consisted of component like pressure gauge, disc filter, booster pump, fertilizer injector, ball valve, flush valve, main line, sub main line, drip line and end plugs, etc. Calculated amount of fertilizer could be applied uniformly in the field.

### Component of drip irrigation:

Drip irrigation consists of following component such as follows:

### Pump:

Pump is most important part of drip irrigation system; pumps play an important role to supply the irrigation water from water sources to the field. In the field irrigation as mention above that 6 inch bore wells radial flow submersible pump set installed having 5 H.P. with 3.7 KW having 6 stages with head range 44-67 m having discharge of about 4.680 cu m/hr.

### Main line and sub main pipe line:

The main and sub main pipelines were used in drip irrigation system. By these pipelines the water was supplied from head unit to laterals.

In the field 110 mm diameter main line made up of P.V.C was used and sub main line is 63 mm diameter is also made up of P.V.C., the holes are made in sub main line for delivering water from sub main to lateral.

### Fertilizer injector:

Fertigation is important concept for improving quality and quantity of the crop yield. The basic concept of fertigation is that if we are getting large amount of yield from the soil then we get the nutrient from the soil in the form of crop. So we will have to maintain the ratio of NPK in the soil by doing fertigation. Fertigation system, the basic components include a fertilizer tank, ventuary injector, pressure gauge, check valves and a pressure regulator.

**Filtration unit:**

Filtration unit consist of different type of filter such as disc filter, gravel filter, screen filter, and hydro cyclone filter etc. Gravel filter is used to filter algae, solid particle and dirt from the water, hydro cyclone filter is used to separate sand from irrigation water and disc or screen filter is used for fine filtration. In the field twin disc filter was installed having capacity 20,000 litres filtering capacity.

**Drip line:**

There were two main types of drip line was occurring that in inline and online pattern. Inline means the emitters are inside of drip pipe, and online means the emitters outside of drip pipe. In the field there was inline drip line installed of diameter 16 mm, the spacing between emitter is 0.3048 m, and discharge of drip line 1.3 lph. The drip line placed at a distance of 1.8m.

**Valve:**

Valves were used in distribution of the water in equal proportion to the plant. They were also useful to increase or decrease the pressure in the pipeline. The valves are useful to convey water from one main line to many sub main lines.

**Glycerine pressure gauges:**

Glycerin pressure gauges were used for measuring the pressure in the head unit of system. It was also used in measurement of pressure in mainline, sub main line and lateral. In the field we have to maintain the pressure in mainline of about 1.5 kg/sq.cm.

**End plug:**

The end plugs were used to close the drip line at the point. By this proper pressure could be maintained in the system.

**Design of drip irrigation system:**

The following general information is required for designing a drip irrigation system.

**Water source:**

The sources of water were usually well, bore well or a tank storing rainfall runoff. Firstly water is pumped from well and bore well and stored it in tank or supplied it directly to the field.

**Type of crop:**

Different crop requires different plant spacing and irrigation. The general layout of system and especially spacing between emitters depend on type of crop. In the field experimental for bitter gourd crop the spacing was 0.30×1.8 sq. m.

**Topographical condition:**

It was necessary to know the general land slope to determine the size and location of main and sub main lines by which pressure was maintained in the fields.

**Soils:**

Keeping in view different physical properties of soil, emitter type, spacing, irrigation scheduling is done.

**Method for estimation of water requirement of crop:**

The pan evaporation method was used for estimation of water requirement. The estimation of crop water requirement were based on crop factor, canopy factor and pan evaporation (Chakravarti and Sastri, 1977 and Christiansen, 1966).

**Estimation of evapotranspiration:**

The relationship between evapotranspiration and pan evaporation were given by the crop factor.

$$ET = Eo \times Kc \quad \ldots (1)$$

where,

ET= Evapotranspiration or consumptive use

Eo= pan evaporation

Kc= crop co-efficient.

On the basis of above formula irrigation scheduling for bitter gourd crop was carried out, considering crop canopy as wetted area, so the following formula used for calculating the canopy factor of plant. Estimation of water requirements of crop were calculated by considering canopy factor as a wetted area (Jackson, 1982).

**Canopy factor= G.C. + 0.15(1-G.C)** … (2)

where,

G.C. = Ground cover (Shadow area /plant area).

G.C. = Evapotranspiration or irrigation required or water requirement of crop were given by,

**ET = Pan evaporation × Crop factor × Canopy factor** ….(3)

### Estimation of water requirement of crop :

After calculating the ET in mm converted into L/ha for this used following conversion.

**1mm=4047 L/ha**

**4047 L/acre=4.047cu.m/ha**

On the basis of above formulas calculated irrigation scheduling for bitter gourd crop from period of transplanting to harvest data on this were given in Table 2 from this determined the water requirement of crop in cu m ha/ week by using above formula.

Water requirement of crop is given by = **ET × day in week (7) × area of field in sq.m (cu.m/acre)** … (4)

Calculated value for water requirement of crop is given in Table 3.

### Estimation of irrigation rate:

It is the ratio of application of the water applied by the dripper per unit area, it was calculated by:

**Irrigation rate (mm/hr) I=Dripper discharge (lph) / [Lateral spacing (m) × Dripper spacing (m)]** ... (5)

From data given in Table 3 calculated rate of discharge of dripper is 2.377mm/hr.

### Rate of discharge:

Rate of discharge was given by rate of irrigation with area to be irrigated, calculated by following formula:

**Qt (lit/hr) = irrigation rate (mm/hr) × area to be irrigated ($m^2$)** … (6)

### Determination of irrigation time:

It is time required to complete the irrigation. It is dependent on irrigation water requirement mm/day and rate discharge mm/hr. It was calculated by,

**Irrigation time (hr.) = Water requirement per day (mm/ day) / Rate of discharge (mm/hr)** … (7)

## RESULTS AND DISCUSSION

The results obtained from ACF farm through the field experimentations and discussions for that are presented under the sub heads of irrigation scheduling, fertigation scheduling, irrigation water requirement, rate of discharge, design of drip system and irrigation time of bitter gourd cultivation under drip irrigation.

**Table 1 : Design for drip irrigation in bitter gourd crop**

| Sr. No. | Design parameter | Content |
|---|---|---|
| 1. | Crop | Bitter gourd |
| 2. | Crop command ($m^2$) | 380.0×95.5 |
| 3. | Spacing between plants (m) | 0.30 |
| 4. | Spacing between rows (m) | 1.8 |
| 5. | Total no of plant | 6590 |
| 6. | No. of lateral | 150 |
| 7. | No. of emitter per plant | 1 |
| 8. | No. of emitter per lateral | 250 |
| 9. | Emitter flow (lph) | 1.3 |
| 10. | Emitter operating pressure (kg/$cm^2$) | 1 |
| 11. | Type of emitter | Inline |
| 12. | Type of lateral | LDPE |
| 13. | Diameter of lateral (mm) | 16 |
| | Lateral length (m) | |
| 14. | In one line | 95.5 |
| | Overall | 20161 |
| 15. | Type of sub main | PVC |
| 16. | Diameter of sub main (mm) | 63 |
| 17. | Length of sub main (m) | 380 |
| 18. | No. of section | 4 |
| 19. | Area covered by sub main ($m^2$) | 380.0×95.5 |
| 20. | Slope along sub main (%) | 0.1 |
| 21. | Head loss in sub main line (m) | 0.2 |
| 22. | Diameter of main line (mm) | 110 |
| 23. | Head loss in main line (m) | 0.2 |
| 24. | Length of main line (m) | 380 |

### Calculation of irrigation scheduling:

For calculation of effect of irrigation scheduling considered the crop factor, canopy factor of plant and evaporation data. The weekly pan evaporation for particular month was used to weekly use of water by crop. At the germination or transplanting to bud initiation the crop factor of bitter gourd crop is 0.4-0.5. During the crop development phase the crop factor is about 0.7-0.8. In the mid season development stage the crop factor is 0.95-1.25. Thereafter, the crop factor gradually decreases. During the last 10 per cent stage crop is about 0.7 or less.

So calculation of water requirement of bitter gourd crop on the basis of pan evaporation, crop factor and canopy factor is expressed in Table 2.

### Determination of irrigation time:

Irrigation times were determined by calculation of rate of discharge and water requirement of crop in mm/

**Table 2 : Irrigation schedule for bitter gourd crop**

| Type of soil | | | | Sandy loam | |
|---|---|---|---|---|---|
| Planting date | | | | June 5 , 2012 | |
| Harvesting | | | | July 23, 2012 | |
| Harvesting period | | | | 59 days | |
| Days after planting | Crop growth sub periods | Crop factor | Epan (mm/d) | Crop Eta (mm/d) | Water (cu. m/ha/ week) |
| 00-07 | Establishment | 0.40 | 3.78 | 1.512 | 42.833 |
| 08-14 | Vegetative | 0.40 | 3.90 | 1.560 | 43.793 |
| 15-21 | Vegetative | 0.50 | 3.98 | 1.990 | 56.374 |
| 22-28 | Vegetative+ Flowering | 0.70 | 4.02 | 2.814 | 79.717 |
| 29-35 | Flowering+Fruiting | 0.95 | 4.15 | 3.942 | 111.687 |
| 36-42 | Fruiting+Harvesting | 1.20 | 3.75 | 4.500 | 127.480 |
| 43-49 | Fruiting+Harvesting | 1.25 | 3.45 | 4.312 | 122.169 |
| 50-56 | Fruiting+Harvesting | 1.05 | 3.40 | 3.570 | 101.137 |
| 57-63 | Fruiting+Harvesting | 1.05 | 3.15 | 3.307 | 93.690 |
| 64-70 | Fruiting+Harvesting | 1.05 | 3.10 | 3.255 | 92.210 |
| 71-77 | Fruiting+Harvesting | 0.95 | 3.05 | 2.897 | 82.083 |
| 78-84 | Fruiting+Harvesting | 0.95 | 3.25 | 3.082 | 87.465 |
| 85-91 | Fruiting+Harvesting | 0.85 | 2.97 | 2.524 | 71.516 |
| 92-98 | Fruiting+Harvesting | 0.75 | 2.95 | 2.212 | 62.677 |
| 99-105 | Fruiting+Harvesting | 0.70 | 2.90 | 2.030 | 57.507 |

**Table 3 : Irrigation time for bitter gourd crop/acre**

| Sr. No. | Week after transplanting | Water requirement by crop (mm/day) | Irrigation time (hrs) |
|---|---|---|---|
| 1. | 1 | 1.512 | 0.636 |
| 2. | 2 | 1.560 | 0.656 |
| 3. | 3 | 1.990 | 0.837 |
| 4. | 4 | 2.814 | 1.183 |
| 5. | 5 | 3.942 | 1.658 |
| 6. | 6 | 4.500 | 1.893 |
| 7. | 7 | 4.312 | 1.814 |
| 8. | 8 | 3.570 | 1.501 |
| 9. | 9 | 3.307 | 1.391 |
| 10. | 10 | 3.255 | 1.369 |
| 11. | 11 | 2.897 | 1.218 |
| 12. | 12 | 3.082 | 1.296 |
| 13. | 13 | 2.524 | 1.061 |
| 14. | 14 | 2.212 | 0.930 |
| 15. | 15 | 2.030 | 0.854 |

**Table 4 : Fertigation schedule for bitter gourd crop/acre**

| Sr. No. | Growth stage | Duration (days) | Fertigation | Application rate (kg/day) | Total Qty. (kg) |
|---|---|---|---|---|---|
| 1. | Germination- transplanting to flowering | 28 | Urea + M.O.P | 1 + 1.5 | 28 + 42 |
| 2. | Flowering to fruit set to first picking | 20 | Urea + M.O.P | 1 + 1.5 | 20 + 30 |
| 3. | During harvesting | 59 | $ASO_4$ + M.O.P. + $MgSO_4$ + Urea | 1 + 1 + 0.25 + 0.75 | 59 + 59 +15 + 44 |

day. The rate of discharge was dependent on the discharge of emitter which were 1.3 lph for drip line use in experimental field having diameter 16 mm and spacing between two dripper was 0.30 m, lateral spacing was 1.8 m. So rate of discharge occurred about 2.377 mm/ hr.

The Table 3 indicated the irrigation time calculated by considering the evapotranspiration data. The graph plotted for irrigation time is given in Fig 1.

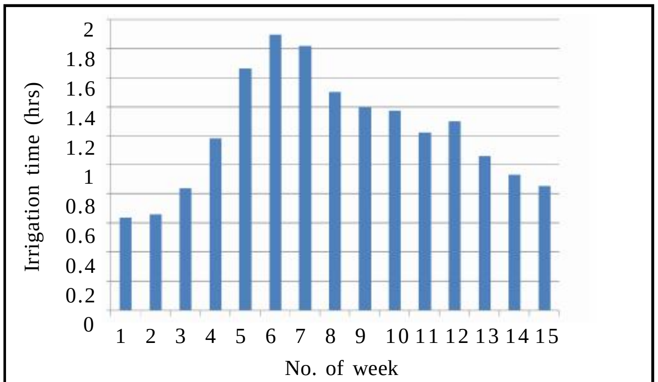


**Fig. 1 : Irrigation time for bitter gourd crop**

## Estimation of fertigation scheduling:

The fertigation scheduling gives idea about proper supply of fertilizer at calculated quantity to plants. It is also helpful in improving the quality. The fertilizers are provided through the fertilizer injector with the help of PPM calculation are mentioned in Table 4 show the overall fertigation schedule for bitter gourd crop. Table 5 indicated that total quantity of fertilizer in bitter gourd crop (Viets, 1962).

## Conclusion:

The effect of irrigation and fertigation scheduling by calculating, irrigation time, water requirement, crop growth stages, design of system for bitter gourd crop under drip irrigation etc. were studied. On the basis of results obtained through field observations following conclusions were drawn.

**Table 5 : Total quantity of fertilizer for bitter gourd crop/acre**

| Type of application | Basal | By drip irrigation |
|---|---|---|
| Organic manure (Cattle+ Poultry) | 8 ton +4 ton | - |
| D.A.P. | 75 kg | - |
| Mn | 2.0 kg | - |
| Zn | 2.5 kg | - |
| Boron | 1.5 kg | - |
| $FeSO_4$ | 1.0 kg | - |
| $ZnSO_4$ | 1.5 kg | - |
| Urea | - | 92 kg |
| M.O.P. | - | 131 kg |
| $(NH_4)_2 SO_4$ | - | 59 kg |
| $MgSO_4$ | - | 15 kg |

– The water requirement of the bitter gourd varied from 42.83-127.48 cu.m/ha/day during the period of establishment of plant to flowering and harvesting (June-September).

– The drip irrigation method was used for observing the irrigation schedule. By this method we were able to provide a calculated amount of water to the crop at particular time for calculated period.

– The calculated irrigation time varied from 0.636 – 1.893 hrs.

– The amount of water irrigated was nearly in ascending order but some fluctuation was seen during certain weeks.

– The fertigation schedules were calculated on the basis of the assumption that the amount of fertilizer required by the crop for one tonne production. By this calculation, the total amount of fertilizer applied to crop was calculated.

– Drip irrigation resulted in higher yield over flood irrigation of farmers practice.

– The total production of bitter gourd was obtained 200 q/ha.

– The total profit of bitter gourd was obtained 119362 Rs./ha.

On the basis of result obtained from through field observation conclusion drawn show the water used by the bitter gourd crop reduced to about 55 per cent than used in furrow irrigation and total yield increased to about 50 per cent more than furrow irrigation.

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