Journal of Pharmacognosy and Phytochemistry
Available online at www.phytojournal.com

**E-ISSN:** 2278-4136
**P-ISSN:** 2349-8234
JPP 2018; SP1: 3172-3176

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# Study of water and nutrients requirement through drip irrigation in Okra

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**Abstract**
Precise estimation of water and nutrients requirement on a daily basis is important to apply water and fertilizers through drip irrigation system. A experiment was conducted to determine the optimum crop water and fertilizer requirement of okra at different stages of crop growth using drip irrigation in comparison to conventional method of irrigation at experimental field of Precision Farming Development Center, Department of Agricultural Engineering, Birsa Agricultural University, Ranchi, Jharkhand. The effect of fertigation was also studied on Okra yield and quality compared to conventional method of irrigation. The highest yield of Okra was found to be at drip irrigation at 0.8 ET + 80% of Recommended Doses of Fertilizers for Okra in comparison to other treatments including conventional method of irrigation (Furrow) and fertilizer application (Basal). The yield was found to be average 13 t/ha which is higher than 10.6 t/ha, which was found for conventional method. The cultivation of suitable variety of Okra (Saarika) through drip irrigation with fertigation through water soluble fertilizer. This system increases the productivity and quality of produce with added benefit of water saving and higher fertilizer use efficiency.

**Keywords:** Okra, Drip irrigation, Fertigation, Water and nutrients requirements

## Introduction
Okra, or Lady's finger, commonly known as 'Bhindi' in India is one of the most important vegetable grown throughout the tropics and sub-tropics zone. The nutritional value of 100 g of edible portion of okra contains 1.9 g of protein, 0.2 g fat, 6.4 g carbohydrate, 0.7 g minerals and 1.2 g fibre (Gopalan *et al*., 1989). Okra has a vast potential as one of the foreign exchange earner crops and accounts for about 60% of the export of fresh vegetables excluding potato, onion and garlic.
Okra is a crop of tropical and subtropical climate. The crop growth is vigorous during rainy season compared to spring summer. Seeds of okra fail to germinate below 20$^o$Ctemperature and optimum temperature for seed germination is 29 $^o$C. Okra can be grown in all types of soils, but the soil should be friable. However, it grows best in light soils ranging from sandy loam to loam (Anonymous, 2015).
In India, production of okra during year 2013-14 was 6346.4 Thousand MTonnes. Average area under okra cultivation in Jharkhand during 2013-14 was 32.52 thousand hectare, whereas total production and productivity of okra in Jharkhand was reported to be 447.4 thousand MT and13.76tonnes/ha, respectively (Anonymous, 2012).
Water is an essential requirement in agricultural production. In arid and semi-arid regions of India, water availability is becoming a major challenge of farm production. Water resources in India at present face many challenges, including increasing demands in many sectors. Maximum stress created directly orindirectly is due to agriculture sector (Anonymous, 2013). So it is important to judiciously use the already existing water resources by using suitable irrigation technology that not only increases vegetable production per unit area but also per unit of water used. Thus, a scientific and efficient management of water is needed especially in hot dry months of premonsoon period, to enhance water use efficiency and yield of crop. Drip irrigation is the technique in which roots of plants are supplied with water at specific rate.
Drip irrigation has been proved as an effective mode of water and nutrient application in greenhouse cultivation system. Drip irrigation research studies carried out at Precision Farming Development Centre, IIT Kharagpur, India on several vegetables and fruit crops showed increasein yield, saving in water and nutrients, higher fertilizer and water use efficiency and increase in net profit (Tiwari et. al. 1998, 2003 and 2014). Drip fertigation is the only option to replace the conventional fertilization method to achieve higher fertilizer use efficiency (Pandey *et al*. 2013). Fertigation is the method of applying fertilizers, soil amendments and other water soluble products required by the plants during its growth stages

through drip/sprinkler irrigation system.

Optimum moisture supplied by trickle method compared to surface method in mulched condition enhancing yield attributes and yield provides advantage of drip system over furrow method in (Sunilkumar and Jaikumaran, 2002). Results indicated that by drip irrigation system along with mulching, the yield of okra may increase upto 61%higher than surface irrigation method with same quantity of irrigation water applied (Mishra *et al*. 2009). During the year 2009 and 2010, 13.6 and 14.8 percent higher okra yield was observed under drip irrigation in comparison to flood irrigation method as reported by (Birbal *et al*. 2013). Singh and Rajput (2007) conducted a study to know the response of lateral placement depths of subsurface drip irrigation on okra and reported that drip irrigation may help in producing more water applied and allow crop cultivation in water scarce area. Sivanappan and Padmakumari (1980) compared drip and furrow irrigation systems and found that about $1/3^{rd}$to $1/5^{th}$of the normal quantity of water was enough for the drip irrigated plots compared to the normal quantity of water applied to plots under surface irrigation in vegetable crops. At Coimbatore, India, Sivanappan *et al*. (1987) recommended drip system of irrigation in place of conventional furrow irrigation due to economy in water utilization to the extent of 84.7%without any loss of yield. Based on the study conducted at Rahuri, India, Khade (1987) reported 60.1% higher yield of okra with water saving of 39.5% under drip irrigation as compared to conventional furrow irrigation.

The present study was conducted to determine the optimum crop water and fertilizer requirement for okra at different stages of crop growth using drip irrigation with the following objectives:

1. To determine the optimum crop water requirement and scheduling in okra at different stages of crop growth using drip irrigation compared to conventional method of irrigation.
2. To determine the optimum fertilizer requirement and scheduling in okra through fertigation with different fertilizer levels.
3. To estimate the cost economics for Okra cultivation with drip fertigation and conventional method of farming.

## Materials and Methods

To study growth and yield attributes of Okraunder effect of different irrigation and fertilizer levels with drip irrigation, a field experiment was conducted at the experimental field of Precision Farming Development Center, Department of Agricultural Engineering, Birsa Agricultural University, Ranchi, Jharkhand, during 2010 to 2013. The study consisted of three levels of irrigation (0.6 ET, 0.8 ET and 1.0 ET) and three levels of fertigation (60%, 80% and 100% of RDF) applied through drip irrigation system. The RDF (Recommended Doses of Fertilizers) for Okra was considered as 120:60:50 kg NPK/ha. For comparison, there was control treatment of conventional methods of fertilization as practiced by farmers of Jharkhand for Okra cultivation was also considered in the design of treatments with three replications. The experiment was laid out following Randomized Block Design (RBD) with three replications. The treatment details are follows:

$T_1$ ($I_1F_1$) - Drip at 0.6 ET + 60% fertigation

$T_2$ ($I_1CF_1$) - Drip at 0.6 ET + 60%with conventional fertilizers

$T_3$ ($I_2F_2$) - Drip at 0.8 ET + 80% fertigation

$T_4$ ($I_2CF_2$) - Drip at 0.8 ET + 80% with conventional fertilizers

$T_5$ ($I_3F_3$) - Drip at 1.0 ET + 100% fertigation

$T_6$ ($I_3CF_3$) - Drip at 1.0 ET + 100% with conventional fertilizers

$T_7$ (Control) - Conventional method of irrigation (Furrow) and fertilizer application (Basal)

### Experimental layout

After the completion of tillage operations of land80 cm wide beds were prepared with a spacing of 40 cm in between each bed. For control, ridges were prepared with 45 cm ridge spacing. Drip laterals were laid in between two rows of okra plants with inline drippers at a spacing of 30 cm. The drip irrigation system components were laid according to experimental design. Each emitter served the irrigation water requirement of four plants. Seeds of okra variety 'Saarika' were sown, as per the recommended seed rate of 25 kg/ha (Anonymous, 2013).For drip fertigation treatments sowing was done at spacing of 40 cm ×30 cm within each row. For the control treatment, the seeds were sown on 45 cm ×20 cm ridges spacing. For the experimental treatments, three fertilizerdoses were based on recommended dose of fertilizer was used in drip fertigation. Standard agronomic practices such as fertilization and plant protection measures were applied during the entire crop period. For control, urea was applied as per requirement of okra grown by conventional method i.e. 50% dose applied at sowing and remaining as top dressing after first picking (Anonymous, 2013). Irrigation was given on at the gap of one day and fertigation was given at seven days interval. In drip fertigation treatment fertilizers was applied in equal splits

Reference evapotranspiration ($ET_O$) was estimated using the method suggested by FAO-56 (Allen *et al*., 1998). The crop coefficient ($K_C$) for different growth stages of Okra were considered based on the unpublished report and local studies carried out in India. The actual evapotranspiration was estimated by multiplying reference evapotranspiration and crop coefficients for different months based on crop growth stages. The equation used to estimate $ET_O$ is described below:

$$ET_o = \frac{0.408\Delta(R_n - G) + \gamma \frac{900}{T+273} u_2(e_s - e_a)}{\Delta + \gamma(1 + 0.34u_2)} \quad \ldots\ldots\ldots(1)$$

Where,

$ET_O$ - Reference evapotranspiration [mm day$^{-1}$],$R_n$ - Net radiation at the crop surface [MJ m$^{-2}$day$^{-1}$],G- Soil heat flux density [MJ m$^{-2}$ day$^{-1}$],T- Mean daily air temperature at 2 m height [°C],$u_2$ - Wind speed at 2 m height [m s$^{-1}$],$e_s$- Saturation vapour pressure [kPa],$e_a$ - Actual vapour pressure [kPa],$e_s$-$e_a$- Saturation vapour pressure deficit [kPa],Δ - Slope vapour pressure curve [kPa °C$^{-1}$],γ- Psychrometric constant [kPa °C$^{-1}$].

The daily irrigation water requirement for the okra crop was estimated using thefollowing relationship:

$$IR = ET_O \times K_C - Re \quad \ldots\ldots\ldots (2)$$

Where,

IR = Net depth of irrigation (mm day$^{-1}$), $ET_O$= Reference evapotranspiration (mm day$^{-1}$), $K_C$ = Crop coefficient, Re = Effective rainfall (mm day$^{-1}$).

The net volume of water required by the plant can be calculated by the relationship

$$V = IR \times A \quad \ldots\ldots\ldots (3)$$

Where,

V = Net volume of water required by a plant (L day-1 plant$^{-1}$),

A = Area under each plant (m$^2$).

Selection and tagging of randomly selected five plants was done in each treatment for observing various crop parameters like plant height (m), No of nodes/plant, fruit length (cm), fruit circumference(cm), No of fruits/plant and total yield (q/ha).

In each treatment, fruits harvested in each picking were noted down from five already selected plants. Counting of fruits harvested from each of the selected plants in every experimental treatment was done till the final harvest. The average number of fruits per plant in every plot was computed. Three fruits were randomly selected during each picking from the selected plants and length was measured by using measuring ruler in centimeters. The average length and circumference of fruit was computed and noted in centimeters. Total weight of harvested fruits from each experimental treatment during each picking was noted till the final harvest and the total yield of fruits per hectare under different treatments were computed.

## Results and Discussion

### Effect of Different Levels of Irrigation

Application of irrigation water through drip irrigation system in okra crop during entire cropping season and irrigation scheduling at different growth stages is presented in the Table 1. Total number of irrigation provided during entire growing season of Okra crop is 37 and total amount of irrigation is 113.1 Liter/m$^2$.

The effect of different levels of irrigation on biometric parameters such as plant height (m), No of nodes /plant, fruit length (cm), fruit circumference(cm), No of fruits /plant and total yield (q/ha)were analyzed statistically and compared with that of furrow irrigation treatments. The experimental results of these biometric observations for all the four years are presented in Table 3. The results of analysis of variance showed that variation among three replications for all the treatments and all the 4 years was found to be statistically insignificant at 5% level of significance. The analysis of observations showed that different levels of irrigation with drip and conventional methods of fertilization responded differently to biometric parameters and yield of crop. The plant height responded significantly with different irrigation levels of drip irrigation, however, plant height was statistically at par with 100% irrigation supply with drip irrigation. The plant height was found to be highest in the treatment$T_4$ ($I_2CF_2$) as compared to other two irrigation treatments and control. Irrigation levels had no significant influence on number of nodes perplant (Sharma *et al*. 2016).There was a significant increase in the fruit length in response to drip irrigation treatment at all the levels of irrigation in comparison to control treatment of furrow irrigation (Tiwari *et al*. 1998). There was asignificant influence of 80% irrigation supply through drip [$T_4$ ($I_2CF_2$)] over 60% irrigation requirements through drip [$T_2$ ($I_1CF_1$)] on fruit length and 100% irrigation water supply through drip [$T_6$ ($I_3CF_3$)]. However, fruit size response at 100%irrigation supply [$T_6$ ($I_3CF_3$)] and 80% of water requirement supply [$T_4$ ($I_2CF_2$)] through drip was statistically at par. It can be seen that the 60%irrigation supply through drip [$T_2$ ($I_1CF_1$)] has significant influence on No of fruits /plant over two other irrigation levels under drip, that is, [$T_6$ ($I_3CF_3$)] and [$T_4$ ($I_2CF_2$)] and 100% irrigation supply under furrow irrigation [$T_7$ (Control)] (Sharma *et al*. 2016).

**Table 1:** Water applied in okra crop during entire cropping season

| Month | No. of irrigations | Crop Stage | Frequency | Water/ irrigation (lt/sq.m) | Lt/ plant | Time/ irrigation (minutes) | Monthly water application (lt/sq.m) |
|---|---|---|---|---|---|---|---|
| March | 6 | Germination | Daily | 1.16 | 0.17 | 10.53 | 6.96 |
| | 3 | Vegetative | Alternate Day | 1.80 | 0.27 | 16.20 | 5.40 |
| April | 13 | Vegetative | Alternate day | 2.66 | 0.40 | 24 | 34.58 |
| May | 10 | Flowering | Alternate day | 4.70 | 0.70 | 42.30 | 47.00 |
| | 2 | Harvesting | Alternate day | 4.48 | 0.67 | 40.32 | 8.96 |
| June | 3 | Harvesting | Alternate day | 3.40 | 0.51 | 30.60 | 10.20 |
| Total | 37 | | | | | | 113.1 |

### Effect of Different Levels of fertigation

Nutritional requirement through drip irrigation system with fertigation and fertigation scheduling for Okra crop at different growth stages (Germination, Vegetative, Flowering, Harvesting) are presented in Table 2.

It can be seen that the plant growth and yield were greater in drip with fertigation as compared to drip alone. Among the different treatments tried, drip with 100% fertigation [$T_5$ ($I_3F_3$)] responded the highest plant height (1.78 m). There was significant influence of drip with fertigation over drip alone and control treatment of conventional method of irrigation and fertilization on plant height. The influence of irrigation with fertigation or irrigation with conventional method of fertilization had no significant influence on No of nodes /plant. On the other hand, fruit length and fruit circumference were found to be highest in case of100% irrigation water supplied through drip irrigation with 100% fertigation [$T_5$ ($I_3F_3$)] and statistically significant at 5% level overconventional treatment $T_7$ (Control). However, response of treatment of drip irrigation with fertigation at all the levels of irrigation on fruit length and fruit circumference was at par at 5% level of significance. It can be seen that the treatment$T_5$ ($I_3F_3$) i.e. 100% irrigation water supplied with 100% has significant influence on No of fruits /plant over two other fertigation levels under drip, that is, [$T_3$ ($I_2F_2$)] and [$T_1$ ($I_1F_1$)] and 100% irrigation supply under furrow irrigation [$T_7$ (Control)].

**Table 2:** Nutrition requirement & fertigation scheduling

| Crop Stage | Basal Dose (kg/ha) | | | Nutrients through Fertigation (Kg/ ha) | | | | Fertilizers for Fertigation | |
|---|---|---|---|---|---|---|---|---|---|
| | FYM | DAP | MOP | N | $P_2O_5$ | $K_2O$ | others | Urea | Potassium Nitrate |
| Germination | 8000 | 130 | 41.6 | 23.4 | 60 | 25 | - | - | - |
| Vegetative | - | - | - | 13.3 | - | 6.24 | - | - | 13.88 |
| Vegetative | - | - | - | 13.3 | - | 6.24 | - | - | 13.88 |
| Flowering | - | - | - | 13.3 | - | 6.24 | - | - | 13.88 |
| Flowering | - | - | - | 13.3 | - | 6.24 | - | - | 13.88 |
| Flowering | - | - | - | 11.5 | - | - | - | - | - |
| Harvesting | - | - | - | 11.5 | - | - | - | - | - |

**Table 3:** Biometric data of Okra plant under different treatments

| Treatments | Plant Height (m) | No of nodes /plant | Fruit Length (cm) | Fruit Circumference (cm) | No of fruits /plant |
|---|---|---|---|---|---|
| $T_1$ ($I_1F_1$) | 1.74 | 16.10 | 17.53 | 6.70 | 15.63 |
| $T_2$ ($I_1CF_1$) | 1.43 | 14.05 | 15.40 | 5.90 | 13.58 |
| $T_3$ ($I_2F_2$) | 1.53 | 13.18 | 12.77 | 4.81 | 11.65 |
| $T_4$ ($I_2CF_2$) | 1.52 | 13.48 | 15.39 | 5.86 | 12.73 |
| $T_5$ ($I_3F_3$) | 1.78 | 16.30 | 17.94 | 6.97 | 15.83 |
| $T_6$ ($I_3CF_3$) | 1.48 | 11.63 | 11.33 | 4.36 | 11.34 |
| $T_7$ (Control) | 1.24 | 11.24 | 9.34 | 4.11 | 9.18 |
| S.Em(±) | *0.06* | *0.64* | *0.27* | *0.11* | *0.653* |
| CD 5% | *0.18* | *1.92* | *0.82* | *0.33* | *1.96* |
| CV% | *7.85* | *9.02* | *3.64* | *3.88* | *9.95* |

**Effect of Different Levels of irrigation and fertigationon Okra yield**

Okra yield results obtained in the experiment arepresented in Table. 4 along with statistical analysis results. Considering only the effect of fertilizerlevels, $T_5$ ($I_3F_3$)treatment was the best followedby $T_3$ ($I_2F_2$)and $T_1$ ($I_1F_1$). Treatment $T_5$ ($I_3F_3$) isstatistically at par with treatment$T_3$ ($I_2F_2$), but both aresignificantly better than $T_1$ ($I_1F_1$) treatment.Also,considering irrigation levels only, treatment $T_4$ ($I_2CF_2$) wasthe best followed by treatment $T_6$ ($I_3CF_3$) and treatment $T_2$($I_1CF_1$). Treatment $T_6$ ($I_3CF_3$) is statistically at par with treatment$T_4$ ($I_2CF_2$), but significantly better than treatment$T_2$ ($I_1CF_1$).

The maximum yield of Okra was recorded for the year 2012-13 in comparison to other three years (2010-11, 2011-12, and 2013-14). The maximum average yield of Okra was observed under the treatment $T_5$ ($I_3F_3$) i.e. 139.6 q/ha and the minimum yield was observed under the control treatment $T_7$ (111.0 q/ha) (Tiwari *et al*. 1998) (Table 4). The beneficial effect of irrigation on growth and yield of different vegetables was alsoreported by earlier investigators (Shrivastava *et al*., 1994). Split application ofnutrients by drip fertigation as compared totraditional furrow method may have resulted inreduced nutrient wastage and hence, leading to betteryield in drip fertigation method. Regular and oftenuse of drip irrigation results in maintaining moistureconditions in the crop root zone leading to higherwater as well as nutrient availability to the plant (Kaushal *et al*. 2011).It is clear from the results of the statistical analysisthat the effect of different levels offertigation and their combination has significant effect on okra yield.

**Table 4:** Treatment wise yield data of Okra

| Treatments | Yield (q/ha) | | | | |
|---|---|---|---|---|---|
| | **2010-11** | **2011-12** | **2012-13** | **2013-14** | **Average** |
| $T_1$ ($I_1F_1$) | 98.54 | 111.34 | 133.5 | 128.6 | 118.0 |
| $T_2$ ($I_1CF_1$) | 96.91 | 110.02 | 128.8 | 125.1 | 115.2 |
| $T_3$ ($I_2F_2$) | 102.57 | 126.51 | 154.4 | 148.4 | 133.0 |
| $T_4$ ($I_2CF_2$) | 85.88 | 112.48 | 152.2 | 135.9 | 121.6 |
| $T_5$ ($I_3F_3$) | 112.88 | 127.17 | 159.6 | 158.8 | 139.6 |
| $T_6$ ($I_3CF_3$) | 82.28 | 113.48 | 149.5 | 134.6 | 120.0 |
| $T_7$ (Control) | 75.14 | 111.77 | 132.4 | 124.7 | 111.0 |
| S.Em | *4.75* | *3.74* | *6.18* | *13.01* | *8.2* |
| CD | *1.52* | *1.20* | *1.98* | *4.17* | *2.9* |
| CV | *10.39* | *5.12* | *7.94* | *5.39* | *6.81* |

**Cost-Economics**

Table 5 presents the economic analysis of cultivation of okra with drip fertigation and conventional method of cultivation for0.0735ha. The total variable costs for Okra cultivation with drip fertigation and conventional method is 4051 and 814, respectively. The fixed cost for Okra cultivation with drip fertigation is 945. The total cost of production for Okra cultivation with drip fertigation and conventional method is 4996 and 814, respectively. The gross income and BC ratio for drip fertigation is 14024 and 3.81, respectively however for conventional method it is 1648 and 2.02, respectively.

**Table 5:** Cost economics of Okra cultivation with drip fertigation and conventional method

| Sl. No. | Particulars | Drip fertigation | | | Conventional method | | |
|---|---|---|---|---|---|---|---|
| | | **Quantity** | **Rate/ unit** | **Total amount (Rs)** | **Quantity** | **Rate/ unit** | **Total amount (Rs)** |
| A | Crop Name -Okra | | | | | | |
| | Crop Variety-Saarika | | | | | | |
| | Area (ha)-0.0735 | | | | | | |
| | Crop period/year-3 month | | | | | | |
| | Spacing (cm X cm)-40*30 | | | | | | |
| | No. of Plants/sqm-8 | | | | | | |
| | Total Yield (Ton /ha)- | 14.84 | | | 10.47 | | |
| | Sale Price ( Rs/Kg)-15 | | | | | | |
| B | Variable Costs (Rs / Sqm) | | | | | | |
| | Land Preparation | 630 | 1/$m^2$ | 630 | 105 | 1/$m^2$ | 105 |
| | Fertilizer | 630 | 1.73/ $m^2$ | 1090 | 105 | 1.73/ $m^2$ | 182 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Irrigation Costs | 630 | .7/m² | 441 | 105 | .7/m² | 105 |
| | Seed Costs | 630 | .5/m² | 315 | 105 | .5/m² | 53 |
| | Chemical Costs | 630 | 1.3/m² | 819 | 105 | 1.3/m² | 137 |
| | Soil solarization | | - | - | | | - |
| | Nursery management | | - | - | | | - |
| | Low tunnel | | - | - | | | - |
| | Mulching | | - | - | | | - |
| | Labour | 630 | .7/m² | 441 | | | |
| | Interest @ 10% | | - | - | | | |
| | System maintainance cost | 630 | .5/m² | 315 | | | |
| | Other Variable Costs | | - | | | | |
| | Total Variable Costs (Rs) | | | 4051 | | | 814 |
| C | Fixed Costs @ Sqm | | | | | | |
| | a. Shade net house | | | | | | |
| | b. Greenhouse | | | | | | |
| | c. Drip Irrigation System @ 10% | 630 | 1.5/m² | 945 | - | - | - |
| | d. Sprinkler Irrigation System | - | - | - | - | - | - |
| | Total Fixed Costs (a+b+c+d) Rs | | | 945 | | | - |
| B+C | Total Cost of Production (Variable + Fixed) Rs | 630 | 7.85/m² | 4996 | 105 | 7.75/m² | 814 |
| | Gross Income(Rs) | | 22.26/m² | 14024 | | 15.70/m² | 1648 |
| | BC Ratio | | | 3.81 | | | 2.02 |

## Conclusions

The drip irrigation is economical and cost effective when compared with conventional methods of irrigation and fertilization. The use of drip either alone or in combination with fertigation can increase the okra crop yield significantly over furrow irrigation and basal method of fertilization. To irrigate 1 ha of okra crop with drip irrigation 1131 $m^3$ (1131000liter) of water will be needed for the agro-climatic conditions of Ranchi, Jharkhand. The duration of operation of drip irrigation is 63.18 min, 798 min, 423 min and 172.4 min, respectively during germination, vegetative, flowering and harvesting stages. The gross income could be increased by about 88.2% by adopting drip with fertigation technology. The BC ratio was found highest (3.81) for drip irrigation without fertigation as compared to conventional methods of farming.

## Acknowledgements

Authors are thankful to the National Committee on Plasticulture Applications in Horticulture(NCPAH), Department of Agriculture and Cooperation, Ministry of Agriculture, Government of India for providing funds and Department of Agricultural Engineering, BAU, Ranchi, Jharkhand for making available necessary facilities to conduct this research studies.

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