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Growing Okra with Drip Fertigation- A Review

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ABSTRACT: *Okra commonly called lady finger or bhindi is one of the most popular and extensively grown vegetable crop all over India. Water and fertilizers plays a major role in okra production. Drip fertigation is the technique which applies fertilizers with water by drip irrigation system. In the present paper, as reported by different research workers throughout world drip fertigation in okra saves 20% to 61% of water, increases yield by 13% to 76%, fertilizer saving from 15% to 30% and results in higher water use efficiency from 35.5% to 50.8 % as compared with traditional method. It is also economically viable with benefit to cost ratio varying from 1.41 to 2.99.*

KEYWORDS: *Drip fertigation, drip irrigation, water use efficiency, okra, yield*

I. INTRODUCTION

Okra (*Abelmoschus esculentus* L. *Moench)* is extensively grown vegetable crop all over India. Okra plant requires warm temperatures under optimal range of 21^{o}C to 30^{o}C and unable to tolerate frost conditions i.e. the temperature below 18^{o}C [1]. It is an enormous challenge to fulfil the vegetable requirement for the world's second largest and ever increasing Indian population, putting immense stress on utilization of natural resources. Proper use of existing water resources by using suitable irrigation technologies to increase okra production per unit area, keeping in consideration per unit of water used is need of the hour. Application of fertilizers with drip irrigation system which is called drip fertigation may be an ultimate solution to save and make optimum use of water and land, and also to increase yield and water productivity.

II. REVIEW OF LITERATURE

The work done by the research workers/scientists throughout the world on drip fertigation in Okra has been collected and critically analyzed and is being presented under following sub-heads.

2.1 Yield response
2.2 Water productivity
2.3 Emitter clogging in drip fertigation
2.4 Economics

2.1 Yield response

Yield and yield attributes of bhindi as influenced by mulching and methods of irrigation in tropical monsoon climate and sandy clay loam soil was studied by [2]. Randomized block design consisted ten treatments which included three treatments at 0.04, 0.06 and 0.08 MPa soil moisture tension under drip irrigation without mulch; three treatments at 0.04, 0.06 and 0.08 MPa soil moisture tension under drip irrigation with mulch and three treatments at 0.04, 0.06 and 0.08 MPa soil moisture tension under furrow irrigation with mulch. The experiment also included a control treatment i.e. furrow irrigation without mulch. It was reported that drip irrigated crop along with mulch condition produced yield of 22.70 tha^{-1}, whereas mulched and furrow irrigated crop produced 20.95 tha^{-1} and the control produced 12.86 tha^{-1}; indicating better yield by sustainable water supply under drip irrigation along with mulching than furrow irrigation.

Response of okra to drip irrigation and mulching in coastal Orissa was studied by conducting an experiment in which drip irrigation system was scheduled on alternate days [3]. The experiment involved treatments which included irrigation requirements 100%, 80%, 60% under drip irrigation and with 100% irrigation requirement under surface irrigation with and without application of black coloured plastic mulch. The design of experiment was randomized block design with three times replications of each treatment. The drip irrigation system was observed to be economical and cost effective as compared with conventional surface irrigation. Maximum yield was reported to be achieved under the treatment with 100% irrigation requirement in combination with black coloured plastic mulch. Drip irrigation system either alone or in combination with mulching increase the okra yield up to an extent of 61 per cent over surface irrigation method.

Performance of Okra crop under drip irrigation was experimentally studied by [4] in 2009 from January to April. The experiment consisted of six replications of three irrigation treatments applied i.e. T1 as 15 min duration and T2 as 30 min duration through drip irrigation whereas third treatment T3 was applied under basin irrigation with three days irrigation interval as control with randomized block design. Yield for 1000 m^2 area was reported to be 1516, 1514 and 1084 kg corresponding to 15 minute irrigation, 30 minute irrigation and basin irrigation treatment, respectively. The percentage of yield increase was indicated to be 28.12% and 26% under 15 minute irrigation and 30 minute irrigation, respectively as compared to control.

Effect of irrigation methods and different mulches on yield of okra in Ber based vegetable production system during the year 2009 and 2010 was studied by [5]. It was reported that highest yield of 83.92 qha^{-1} were obtained under the combination of drip irrigation and plastic mulch as compared to 45.3 qha^{-1} obtained by surface irrigation method, whereas it was also indicated that drip irrigation had 13.6 and 14.8 per cent higher yield in comparison to flood irrigation method.

Experiment on yield and water use of Okra grown under micro-sprinkler irrigation system during off-seasons was conducted by [6]. Nine micro-Irrigation plots (2×2 m^2) were established following a 3×3 completely randomized block design. Yield and water use of okra under three different irrigation water managements i.e. irrigation water treatments at 20% - Low irrigation, 50% - medium irrigation and 75% - high irrigation ; were measured. Yield response of okra to irrigation reported to show high positive correlation range of 0.9584 to 0.997 while yield increased from 1.08tha^{-1} at 183.89mm to 2.78tha^{-1} at 222.30mm for the three treatments. Hence, it was suggested that yield of okra especially in dry areas and during off-seasons can be obtained through high water irrigation application, but where water is moderately scarce, medium irrigation treatment is recommended to serve as supplement.

Effect of different irrigation practices on growth parameters of okra was reported by [7]. Experiment included methods such as surface irrigation method, sprinkler irrigation, drip irrigation and sub-surface irrigation. It was concluded that average fruit yield under drip irrigation was 22.40tha^{-1} which is significantly higher than the surface irrigation.

2.2 Water productivity

A study of simple micro-irrigation methods done by [8] to improve irrigation efficiency on vegetable gardens by decreasing soil evaporation and drainage losses and by creating and maintaining suitable soil moisture conditions for crop growth. Evaluation of micro irrigation techniques on crops i.e. maize, tomato, rape, okra and cabbage was done under low-head drip irrigation, pitcher irrigation and subsurface irrigation using clay pipes. The study reported the mean best improvement in water use efficiency as 35.5% for subsurface drip irrigation treatments which was indicated to be significantly higher than other techniques.

Influence of drip fertigation on yield and resource use efficiency of bhendi (okra) was field studied by [9] for two years on a sandy loam soil. The experiment consisted of 12 treatments: three drip irrigation i.e. 0.5, 0.75 and 1.0 (on Epan basis) respectively, three fertigation rates i.e. 60, 90 and 120 (N kg ha^{-1}) respectively, furrow irrigation +120 kg N ha^{-1}, family drip system +120 kg N ha^{-1} and a control treatment (drip at 1.0 Epan basis + 0 kg N ha^{-1}) and was laid out in a randomized block design with three replications. Results indicated that yield and water use efficiency differed significantly among the treatments. Water use efficiency i.e. 8.23 and 8.10 kg ha^{-1} mm^{-1} were reported when the crop was drip irrigated at 1.0 Epan and fertigated with 120 kg N ha^{-1}.

A study on effect of drip irrigation on okra at Indian Agricultural Research Institute, New Delhi, India during 2003 and 2004 was conducted by [10]. Okra crop was cultivated in three sub-plots with four treatments of drip lateral depths *viz*. on the surface, and at depths of 0, 0.05, 0.10 and 0.15 m below the soil surface. Laterals used for three sub-plots were inline drip laterals having discharge rate of 2.03×10^{-6}, 1.53×10^{-6} and 1.22×10^{-6} m^3 s^{-1} per meter length. Crop was irrigated as per irrigation schedule to fulfil its water requirement and the observations were recorded on growth parameter, soil moisture content and yield of crop. The study indicated that water use efficiency of sub-surface drip irrigation is highest at 0.10m depth varying from 43.60 to 58.80$Mgha^{-1}m^{-1}$.

Effect of drip irrigation levels and emitters depth studied by [1] on Okra growth under experiment of four irrigation rates at 60 %(T1), 80 %(T2), 100% (T3) and 120% (T4) of the estimated evapotranspiration and four drip irrigation emitters depth at surface 0 m (D0), 0.15m (D1), 0.25m (D2) and 0.35m (D3) with split plot design. Crop water use efficiency was reported to range from 1.45 to 2.93 kg m^{-3} and 1.29 to 2.43 kg m^{-3} in 2005 and 2006 respectively.

Effect of irrigation levels and organic compost on okra plants, grown in sandy calcareous soil was seen by [11] by conducting field experiments in the crop growing seasons 2008 and 2009. The split-plot experimental design consisted of three irrigation levels 1198.8 (I1), 1798.2 (I2) and 2397.6 (I3) m^3 per acre with drip in conjunction with two organic fertilizers comprising of composted plant remains and chicken waste manure at the rate of 6 m^3 per acre. It was reported that irrigation water quantity 1798.2 (I2) m^3 per acre met through drip irrigation along with the two types organic fertilizers gave the highest yield (3.3 Mg per acre) with 104%

increase in yield as compared to I1 and I3. Highest mean water use efficiency through drip irrigation was reported to be 1.83 under I2 treatment with 1.38 and 0.58 under I1 and I3 treatment respectively.

A research study on the effects of marginal quality ground water in comparison to good quality water (tap water) on okra yield and water use efficiency was conducted by [12]. Okra was grown under drip system of irrigation during the year, 2011. For T1 marginal quality water (saline water and tap water mixture of equal proportions) and for T2 tap water was supplied through emitters. The study reported that higher crop yield and higher water use efficiency i.e. $18.93tha^{-1}$ and $2.7kgm^{-3}$ were reported under T1 whereas T2 obtained yield and water use efficiency as $17.0tha^{-1}$ and $2.4kgm^{-3}$ respectively. The increase of yield and water use efficiency in T1 over T2 was about 10 per cent in each case.

Effect of salinity of irrigation water on the yield of okra under drip irrigation was evaluated by [13]. The study was performed in randomized block design with four levels of saline irrigation water with (Electrical conductivity) EC_{iw}=0.2, 2.0, 4.0, 8.0 dSm^{-1} in three replications. Significant change in the yield of okra (Var: *Mahyco*-10 *Hy*) was reported at 1% level of significance. Highest water use efficiency was reported to be with available fresh water of 0.2 dSm^{-1} at 0.49; for the treatments of 2.0, 4.0, 8.0dSm^{-1} it was reported at 0.49, 0.46 and 0.38$tha^{-1}cm^{-1}$, respectively.

Effect of different fertilizers and irrigation methods on yield of okra grown in the Keta Sand Spit of Southeast Ghana was reported by [14]. Four treatments were compared i.e. sprinkler irrigation, manure spread fertilization; sprinkler irrigation, localized manure fertilization; drip irrigation, localized manure fertilization; drip irrigation, fertigation with N–K chemical fertilizers, respectively. Highest water productivity was reported to be 6.5 kg m^{-3} with the treatment involving drip fertigation with N-K fertilizers. Water productivity was indicated to be significantly higher in drip irrigation treatment than other treatments within 5% level of significance.

2.3 Emitter clogging in drip fertigation

Performance of subsurface drip irrigation system with line source of water application for irrigating okra crop during 2003 and 2004 was reported by [15]. The experiment consisted of treatments randomly placed laterals at 5, 10 and 15cm depths from surface, with three times replication of each treatment. The parameters evaluated were pressure-discharge relationship of emitters, and uniformity of water application including discharge variation, coefficient of variation, uniformity coefficient, statistical uniformity, and distribution uniformity. The highest level of performance was reported to be of Sub-surface drip system with the depth of lateral at 10cm and discharge at 7.3 litre h^{-1}; as the values of coefficient of variation, uniformity coefficient, statistical uniformity and distribution uniformity was reported to be 0.082, 98.11, 97.68 and 97.02, respectively.

A study on clogging behaviour of drippers of different discharge rates as influenced by different fertigation and irrigation water levels was conducted by [16]. Use of either lower discharge rate of dripper having 1.2 litre h^{-1} or higher salinity water i.e. 8 EC, clogged the dripper 15 to 30 days earlier as compared to use of higher discharge rate of dripper 4litre h^{-1} or lower salinity water i.e. 1.47 EC, respectively.

A study on emitter clogging using reclaimed water for evaluation of the effects of different irrigation frequencies was conducted by [17], including once per 2 days (IF1/2), once per 4 days (IF1/4), once per 8 days (IF1/8) and once per 16 days (IF1/16), on dynamic emitters' outflows and biofilms' growth. It was reported that emitter clogging degrees increased with shorter drip irrigation interval, mainly because that discharge ratio variation (Dra) and Christiansen uniformity coefficient (CU) both decreased. Combined these with previous studying results, irrigated between once/8 days and once/4 days was believed to be appropriate for planting maize in North China Plain using reclaimed water drip irrigation.

2.4 Economics

Economic viability of drip irrigation in combination with different types of mulches for an okra crop was evaluated by [18]. The effect of three irrigation levels that are VD, 0.8 VD and 0.6 VD with drip in conjunction with black plastic mulch were studied on biometric and yield response compared to furrow irrigation. The net seasonal income was reported to be highest as USD 1243 for drip irrigation with plastic mulch (VD+PM) treatment and benefit to cost ratio vary between 1.77 as highest for VD to 1.28 lowest for VF+PM.

Economics of producing Okra and Amaranth under four irrigation methods-basin, drip, furrow and sprinkler was evaluated in a research study conducted by [19]. Fixed and variable costs of all the methods were estimated using results from field experiments. The cost-benefit ratios were reported to be 1.24, 1.41, 1.01, and 1.52 (okra) and 1.50, 1.78, 1.22, and 1.55 (amaranth) for sprinkler, drip, basin, and furrow irrigation, respectively. Drip irrigation had the highest cost to benefit rate for amaranth, with a return of N1.78 and N1.41$\cdot ha^{-1}$ for amaranth and okra, respectively. It was reported that 2.5 and 3 year period would be needed to pay off fixed assets for drip irrigation for amaranth and okra, respectively.

Economics of low pressure drip irrigation and hand watering for vegetable production in the Sahel region was studied by [20]. The agronomic and economic performance of the African Market Garden system (AMG) based on low-pressure drip irrigation combined with an improved crop management package. AMG is compared to two gardens irrigated manually with watering cans. One of these gardens was managed according to the same improved crop management package as in the AMG. The other garden was managed according to common practices of vegetable producers in the area. Crop productivity, labour and water use were observed for two vegetable species (okra and eggplants). The experiment was performed on-station in Niger on three adjacent 500 m^2 plots in a sandy acid soil. The returns on water for the cultivation of eggplant are around USD 2 per m^3 in the AMG, against USD 0.1 in the Farmers Practice. It was reported that improved crop management practices substantially increase crop productivity over traditional methods at comparable production costs. The AMG gave higher crop yields and higher returns to investment than the treatments irrigated with watering cans.

An experiment to study the effect of crop geometry on okra was conducted by [21]. The seeds were sown under two plant geometries at 40 x 20 cm and 75 x 40 cm spacing between row to row and plant to plant, respectively with four irrigation volumes as surface irrigation (1.0 V), drip irrigation 1.0 V, drip irrigation 0.8 V and drip irrigation 0.6 V, in main plots, two cultivars as 'Arka Anamika' and 'Tulsi' assigned to sub plots and three types of mulching as no mulch, organic mulch (*Aerva persica*) and black polythene (25 micron) in sub-plots. Highest benefit to cost ratio was reported with 0.6 V of drip irrigation levels as 2.54.

An experiment to study the effect of spacing and fertilizer levels on the various crop parameters and economic feasibility of Okra Hybrid (*Abelmoschus esculentus* L. *Moench*) under drip fertigation system was conducted by [22]. The treatments consisted of two spacings (M_1- 60 × 45 cm and M_2- 60 × 30 cm) and eight drip fertigation levels and were replicated three times under split plot design. It was reported that drip fertigation at 100 per cent with recommended dose of water soluble fertilizer along with Azophosmet and humic acid under wider spacing was reported to have higher benefit to cost ratio of 2.99.

III. CONCLUSION

This paper reveals that the studies on raising okra by drip fertigation leads to saving of water, fertilizers, increased yield and water productivity. Although, a lot of work in drip fertigation on okra is carried out all over the world but the results may vary with local agro-climatic conditions. Hence, the research workers/ scientist may test the drip fertigation for growing okra in their local regions, so that the locally obtained results of research work may be passed as recommendation/farming practices to farmers.

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