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Effects of chemical fertilizer scheduling on performance of okra (*Abelmoschus esculentus* L.) crop under soil moisture sensor based automated drip and conventional drip irrigation system

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Abstract
A field experiment was conducted at Plasticulture Farm, CTAE, MPUAT Udaipur in year 2019, to investigate the effect of chemical fertilizer scheduling on growth and yield performance of okra (*Abelmoschus esculentus* L.) under Sensor Based Automated Drip and Conventional Drip System. In this study four fertigation scheduling treatments of chemical fertilizer were taken. Recommended dose of chemical fertilizer $N:P_2O_5:K_2O$, 60:30:30 kg/ha were supplied through different chemical fertilizers like Urea, Urea Ammonium Phosphate (UAP) and Sulphate of potash (SOP) during the crop period In this study the 40% and 60% of total recommended doses of fertilizer were applied during initial plus development stage and mid stage of crop growth respectively. The result revealed that the higher plant height and number of branch per plant in fertigation treatments T_2 may be attributed to continuous supply and consequent availability of plant nutrients in the root zone during development and mid stage of crop growth. This is in conformity with the findings of Venkadeswaran *et al.*, (2014). The highest pod yield of okra found under treatment T2 with a value of 11 t/hac, in which fertigation of NPK at recommended dose (60:30:30 kg NPK/ha) in equal splits through water soluble chemical fertilizers at 4 day interval under sensor based automated drip system. It may found because of that, under T2 treatment (fertigation in equal splits through water soluble chemical fertilizers at 4 day interval) nutrient supplied through continuous fertigation till late stage of crop growth. Fertilizer use efficiency was also found higher in sensor based drip irrigation treatments, it was probably due to less leaching of irrigation water with chemical fertizer because of frequent irrigation as per plant need. In this study phosphorus and potassium were supplied to okra crop through chemical fertilizers UAP and SOP respectively, because of that there was no precipitate of fertilizers was observed during mixing.

Keywords: Chemical fertilizers, chloride concentration, fertigation scheduling,

Introduction
Okra [*Abelmoschus esculentus* (L.) Moench] is a popular vegetable in India for its mature, tender and green fruits for the culinary purpose. Other than its nutritional values, it has high acceptability in Indian market and fetches good price (Haris *et al.*, 2014) [1]. In present era of acute water shortage caused by huge exploitation of both surface and sub terrain water resources, micro irrigation lend a helping hand to sustain vegetable production. The annual consumption of N: P: K in year 2015-16 was 173.7: 69.7: 24 Lakh Tonne in India. The major amount of chemical fertilizer import from other countries. In present scenario of varying water shortage caused by over utilization of ground water as well as depletion of both surface and sub terrain water resources, micro irrigation with appropriate fertigation scheduling to sustain vegetable production. Therefore, adoption of modern irrigation technique with advanced fertigation scheduling is needed to be emphasized to increase water use efficiency and bring more vegetable area under cultivation. Drip irrigation is the most effective way to supply water and nutrients to the plant which not only saves water but also increases yield of fruits and vegetable (Spehia *et al.*, 2010) [7]. Studies carried on elsewhere have indicated that the fertilizer should be applied regularly in small amount for better yield in onion (Neeraja *et al.*, 1999) [4]. Okra has responded with increased production with nitrogen, phosphorus and potash injected into the irrigation water as compared to soil application of recommended dose of fertilizers (Venkadeswaran *et al.*, 2014) [9]. Soil moisture content is an important component in the water cycle, both on a small agricultural scale and in large-scale modelling of land/atmosphere interaction process. Vegetation and crops always depend more on the moisture available at root level than on precipitation occurrence. Water budgeting for irrigation planning and management, as well as the actual scheduling of irrigation action, requires local soil moisture information.

Materials and Methods
Location of Study Area
The field experiment was conducted at Plasticulture Farm, CTAE campus, MPUAT Udaipur, which is situated at 24° 35’31.5” North latitude and 73o44’18.2” East longitude at an altitude of 582.17 meters above mean sea level (Fig. 1). The soil type was sandy loam. Maximum temperature goes as high as 46 °C during summer and minimum as low as 5 °C during winter months. The soil analysis was done in laboratory of soil science, RCA, Udaipur.

Fig 1: Location map of the study area

Conventional and automated drip irrigation setup details
The experimental systems consists of irrigation pump, Sand and Screen filters, Control valves, Ventury, Bypass valve, Gate valve, End cap, Jointer, Pressure gauges for conventional drip. In order to convert it as a soil moisture sensor based automated drip system a soil moisture sensor, controller and solenoid valve were also attached additionally with conventional drip system. In this system resistance based sensor was used to detect status of soil moisture. The micro controller was consist of different component such as 240 VAC to 24 VAC transformer , Bread Board, 50 k POT, Jumper wire, 5V battery, 10K Resistor, Soil moisture probes, LED, integrated circuit, transformer, capacitor, resistor, transistor, diode, electromagnetic relay. If the moisture content of the soil increases, the resistivity of the soil decreases. The value of resistivity changes in to volumetric water content of soil by module, which was fitted between microcontroller and moisture sensor proble. The soil moisture sensor sends command to irrigation controller at 1 hour interval. If soil moisture level in the soil goes below to the threshold value of moisture content then controller starts the pump. While, soil moisture content in soil reaches at threshold value or predefined value then system off automatically by micro controller and timer cum relay.

Chemical Fertilizer and fertigation
In this study okra seeds of variety Mahq 28 were shown in 27 February, 2019 and basic dose of FYM @250 q/ha was applied during land preparation. Recommended dose of chemical fertilizer $N:P_2O_5:K_2O$, 60:30:30 kg/ha were supplied as per during the crop period In this study the 40% and 60% of total recommended doses of fertilizer were applied during initial plus development stage and mid stage of crop growth (Fig 2). Respectively, through fertigation. In control treatment 50% recommended dose of Nitrogen and potassium and 100% recommended dose of phosphorus was applied as basal dose and remaining 50% dose of nitrogen and potassium (NPK @ 30:0:15 kg/ha) were applied through urea and MOP(50:0:0) in two splits i.e. after first intercultural/weeding of okra crop and at the time of flowering respectively.

Details of Irrigation Treatments
T1: 100% RDF through fertigation in equal splits at 2 day interval under soil moisture sensor automated drip irrigation

T2: 100% RDF through fertigation in equal splits at 4 day interval under soil moisture sensor automated drip irrigation

T3: 100% RDF through farmer’s practice under soil moisture sensor automated drip irrigation

T4: 100% RDF through fertigation in equal splits at 6 day interval under conventional drip irrigation (Control)

The drip application time in conventional drip system treatment was determined based on daily evaporative values collected from meteorological observatory and an Epan coefficient of 0.7. Various yield were recorded from five plants selected randomly replication wise in all the treatments. All the agronomic and plant protection measures were adopted as per the recommended package of practices. The experimental data were statistically analysed and compared using critical difference at five per cent probability level

Results and Discussion
The chemical properties of soil found under automated and conventional drip system was given in Table. 1. The data of plant height at different days after sowing (DAS) are presented in Table 2. The results shows that at the plant height at 30 DAS was found to be highest in Treatment T_1 with a value of 16.2 cm, while at 90 DAS and At harvest plant highest was found to be highest in treatment T_2 with values of 92.7 and 104.8 cm respectively. It is probably due to fact that at the time of 30 DAS, number of fertigation applied to crop was recorded maximum under treatment T_1 but later on at the time of 90 DAS and at harvest fertigation was not applied to treatment T_1 as per fertigation scheduling. Whereas, under treatment T_2 fertigation was continuously done as per scheduling that result higher plant height. In case of number of branch per plant similar trend was recorded (Table 3). Number of branch per plant at 30 DAS was found to be highest in Treatment T_1 with a value of 2 branches, while at 90 DAS and at harvest plant highest was found to be highest in treatment T_2 with values of 6 and 8 branches respectively. All the fertigation treatments resulted in better okra growth (Table 2) as seen by higher plant height at harvest and number of branch per plant compared to conventional soil application of chemical fertilizers. The higher plant height and number of branch per plant in fertigation treatments T_2 may be attributed to continuous supply and consequent availability of plant nutrients in the root zone during development and mid stage of crop growth (Fig 2). This is in conformity with the findings of Venkadeswaran *et al.*, (2014) [9]. It was also observed that the treatments T_1 that received the fertigation at 2 day interval have taken less number of days for flowering (39 days) over the conventional soil application of chemical fertilizers (T3) as per farmer’s practices, it is probably due to early supply of more number of chemical fertigation till mid stage of crop. From this study it was concluded that highest pod yield of okra found under treatment T2 with a value of 11 t/hac, in which fertigation of nitrogen and potash at recommended dose (60:30:30 kg NPK/ha) in equal splits through water soluble chemical fertilizers at 4 day interval under sensor based automated drip system. It may found because of that, under treatment having fertigation in equal splits through water soluble chemical fertilizers at 4 day interval, nutrient supplied through continuous fertigation till late stage of crop growth resulting availability of nutrient during late stage for higher crop yield.

Table 1: Chemical properties of soil under automated and conventional drip system

S. No	Chemical properties	Values
1	pH	7.6
2	Electrical conductivity (ms)	1.16
3	Calcium Carbonate CaCO3	3.2
4	Organic carbon	0.38
5	Total Nitrogen (Kg/hac)	96
6	Total Phosphorus (Kg/hac)	6.7
7	Total Potassium (Kg/hac)	96

Plate 1: Experimental view of crop yield in different treatments.

Table 2: Pant height at different days after sowing

Treatment	Plant Height (cm)			
	30 DAS	**60 DAS**	**90 DAS**	**AT HARVEST**
T_1	16.2	46.3	79.6	90.3
T_2	12.9	39.3	92.7	104.8
T_3	12.6	36.1	69.2	80.8
T_4 (control)	11.3	28.7	68.5	76.8
CD 5%	4.490316			

Table 3: Number of branch per plant at different days after sowing

Treatment	Number of branch per plant			
	30 DAS	**60 DAS**	**90 DAS**	**AT HARVEST**
T_1	2	3	5	5
T_2	1	3	6	8
T_3	1	2	4	4
T_4 (control)	1	2	2	3
CD 5%	1.12			

Table 2: Performance parameters of okra crop as affected by scheduling of chemical fertilizer

Treatments	Plant height at harvest (cm)	Days of first flowering	Number of branch/plant	Crop yield (t/hac)
T_1	90.3	39	5	8.7
T_2	104	42	8	11
T_3	80.8	48	4	7
T_4 (control)	76.8	45	3	6.1
CD 5%			1.12	

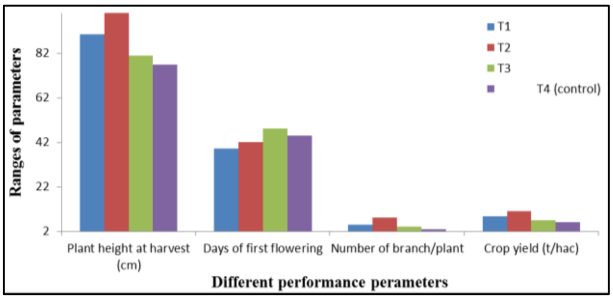

Fig 2: Performance parameter varies under different treatments.

In this study phosphorus and potassium were supplied to okra crop through chemical fertilizers UAP and SOP respectively, because of that there was no precipitate of fertilizers was observed during mixing. The red color MOP was quite difficult in mixing during fertigation which results chocking of drippers and enhance chloride concentration in plant root zone (responsible for poor plant growth).

Conclusion

In this study all performance parameters of okra crop significantly affected by scheduling of chemical fertilizer, similar results were reported by Nair *et al*, (2017) [3]. The result shows that at the time of 30 DAS, number of fertigation applied to crop was recorded maximum under treatment T_1 but later on at the time of 90 DAS and at harvest fertigation was not applied to treatment T_1 as per fertigation scheduling. Whereas, under treatment T_2 fertigation was continuously done as per scheduling that result higher plant height. In case of number of branch per plant similar trend was recorded. The values of performance parameters was found highest in treatment T_2 (100% RDF through fertigation in equal splits at 4 day interval under soil moisture sensor automated drip irrigation) may be due to continuous supply and consequent availability of plant nutrients in the plant root zone of okra crop during development, mid and late stages of crop growth. There was no nutrient stress was observed in treatment T_2 throughout whole growing period of crop. Fertilizer use efficiency was also found higher in sensor based drip irrigation treatments, it was probably due to less leaching of irrigation water with chemical fertizer because of frequent irrigation as per plant need.

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