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INFLUENCE OF DRIP IRRIGATION SCHEDULING AND NITROGEN LEVELS ON YIELD ATTRIBUTES OF SUMMER OKRA (*ABELMOSCHUS ESCULENTUS* L.)

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ABSTRACT

A field experiment was conducted at Water Technology Centre, College of Agriculture, Rajendranagar during *summer* 2020-21 on "Influence of Drip Irrigation Scheduling and Nitrogen Levels on yield Attributes of Summer Okra (*Abelmoschus esculentus* L.)". The experiment was laid out in a split-plot design with 12 treatments. The treatments comprise of three irrigation treatments *viz*., surface drip irrigation at 0.75 Epan, 1.0 Epan and 1.25 Epan as main-plots and four fertigation treatments *viz*., 75% RDN (112.5 kg N ha^{-1}), 100% RDN (150 kg N ha^{-1}), 125% RDN (187.5 kg N ha^{-1}) and 150% RDN (225 kg N ha^{-1}) as sub-plots with recommended dose (RD) of nutrients of 150: 75: 75 kg N, P_2O_5 and K_2O ha^{-1}. Results indicated that, under 1.0 Epan (I_2) with increasing nitrogen doses from 75% RDN (112.5 kg N ha^{-1}) to 100% RDN (150 kg N ha^{-1}) the pod length, diameter, green pods weight $plant^{-1}$, total number of green pods $plant^{-1}$ and yield were increased and further increment in nitrogen dose from 100% RDN to 125% RDN and 125% RDN to 150 % RDN decreased the yield attributes. A similar trend was also reflected in 0.75 Epan (I_1) and 1.25 Epan (I_3) irrigation scheduling. Among the interaction effect, the crop irrigation scheduled at 1.0 Epan in conjunction with 100% RDN recorded maximum green pod yield in okra during summer.

Key words : Irrigation, Nitrogen, Drip, Yield attributes.

Introduction

Okra (*Abelmoschus esculentus* L.) is an important vegetable of India occupies 5.90 lakh hectare areas with total production of 69.49 lakh tonnes and productivity of 12.0 t ha^{-1} (Horticultural Statistics at a Glance, 2018). It is one of the popular vegetable crops grown in Telangana with total 13,006-hectare area, while in summer it occupies an area of 810 hectares (Horticulture Department, Telangana State, 2019) with overall production of 2.60 lakh tonnes and 20.49 t ha^{-1} productivity. Okra is a warm-season vegetable crop requires warm and humid conditions for good growth. Okra preferably suitable for grown in all types of soil, but well drained sandy loam soils is mostly preferred and the pH range of 6-7 should be consider good (Akanbi *et al*., 2010 and Akande *et al*., 2010). It is susceptible to low temperature. Seeds of okra fail to germinate below 20ÚC temperature. For optimal growth, flowering and fruit initiation, okra requires an average temperature ranging between 25–30^{o}C. The okra plants grow taller in the rainy season than in the warm summer (Akshay and Neeraj, 2016). For yield enhancement of okra, suitable water supply to maintain sufficient moisture condition in soil throughout the crop growth period is essential especially during summer season. The influence of water deficit on yield in this span is more under surroundings of high temperature and low humidity (Vadar *et al*., 2019), which is more common during summer season. To meet these optimal conditions, drip irrigation was proved to be most effective agronomic management option for enhancement of yield and quality of okra. It was reported that, the drip irrigation alone enhances the crop yield up 40% over conventional irrigation (Sivanappan *et al.*, 1987).

Materials and Methods

The field experiment was conducted during summer 2020-2021 at Water Technology Center, College Farm, College of Agriculture, Professor Jayashankar Telangana State Agricultural University (PJTSAU), Rajendranagar, Hyderabad. Soil texture is sandy loam soil, which was alkaline in reaction and non-saline, low in nitrogen, high in available phosphorus and available potassium, medium in organic carbon content. Irrigation water was neutral (7.20 pH) was classified as C3 class suggesting that it suitable for irrigation purpose by following good management practices. The experiment was laid out in a split plot design consisting of 12 treatments replicated thrice *viz*., drip irrigation scheduled at 0.75 (I_1), 1.0 (I_2) and 1.25 (I_3) Epan and four nitrogen levels of 75% RDN (N_1), 100% RDN (N_2), 125% RDN (N_3) and 150% RDN (N_4) and replicated thrice. The recommended dose of fertilizers (RDF) was 150: 75: 75 kg NPK ha^{-1} and entire dose of P_2O_5 and K_2O was applied was applied as basal, nitrogen was applied as fertigation in 18 splits in the form of urea with 4 days interval from 15 days after sowing to final picking. The data of Epan was collected from agrometeorological observatory away from 500 m at Agricultural Research Institute, Rajendranagar and accordingly application rate and drip system operation time were calculated. The crop was irrigated once in every alternate day. Need based plant protection measures were taken up and kept weeds low to avoid crop weed competition by weeding at 30 days after sowing.

Results and Discussion

Green pod length

Irrigation scheduling

The green pod length (cm) of okra was influenced by irrigation scheduling presented in Table 1. The maximum green pod length of 13.22 cm was recorded with 1.00 Epan treatments. However, it was on par with 1.25 Epan (13.15 cm) and significantly more over 0.75 Epan (11.93). While crop irrigation scheduled at 0.75 Epan (I_1) remained significantly inferior to 1.0 Epan (I_2) and 1.25 Epan (I_3) irrigation treatments. These results indicated that crop irrigation scheduled either at 1.0 Epan

Fig. 1 : Layout of *summer* okra experiment under drip irrigation.

Table 1 : Effect of drip irrigation scheduling and nitrogen levels on yield attributes of okra crop.

Treatments	Green pod length (cm)	Green pod diameter (cm)	Green pods weight (g)	Number of green pods per plant
Main plot – (Irrigation regimes):				
I_1: Surface drip irrigation at 0.75 Epan	11.9	1.44	336.0	37.0
I_2: Surface drip irrigation at 1.0 Epan	13.2	1.61	501.6	44.0
I_3: Surface drip irrigation at 1.25 Epan	13.1	1.55	424.6	40.7
SEm ±	0.24	0.02	7.5	1.2
C.D (P=0.05)	1.00	0.11	30.3	5.0
Sub plot – (Fertigation levels):				
N_1 – 75 % RD N (112.5 kg ha^{-1})	11.7	1.44	381.2	35.6
N_2 – 100 % RD N (150 kg N ha^{-1})	13.2	1.61	466.6	43.5
N_3 – 125 % RD N (187.5 kg N ha^{-1})	13.0	1.54	425.6	42.1
N_4 – 150 % RD N (225 kg N ha^{-1})	13.0	1.53	409.8	41.2
SEm ±	0.23	0.03	7.6	1.0
C.D (P=0.05)	0.7	0.09	23.0	3.1
Interaction:				
Fertigation levels at same level of irrigation regimes:				
SEm ±	0.49	0.05	15.0	2.5
C.D (P=0.05)	NS	NS	NS	NS
Irrigation regimes at same or different levels of fertigation:				
SEm ±	0.42	0.05	13.7	2.0
C.D (P=0.05)	NS	NS	NS	NS

provided optimum availability of soil moisture to plant and thus had has a positive effect on pod length. These results are partially in agreement with the findings of Kamble *et al.* (2020), who also opined that significantly higher green pod length was recorded with crop irrigation scheduled at 1.0 Epan which provided optimum moisture conditions compared to minimal 0.8 Epan and maximal 1.2 Epan irrigation treatments, respectively. Similar results were also reported by Naik (2017), Rani and Marippan (2019) and Farias *et al.* (2019).

Nitrogen levels

The green pod length (cm) of okra was influenced by nitrogen levels is presented in Table 1. The crop nurtured with 100 % RDN (N_2) recorded maximum green pod length of 13.23 cm which was on par with succeeding higher nitrogen doses of N_3 (125 % RDN) and N_4 (150% RDN) and significantly more over its preceding lower dose N_1 (75% RDN) levels. The crop nurtured with 75% RDN remained significantly inferior to N_2, N_3 and N_4 treatments. Similar trends were also reported by several researchers (Uddin *et al.*, 2014; Moniruzzaman and Quamruzzaman, 2009; Khanal *et al.*, 2020; Mahendran *et al.*, 2011 and Naik *et al.*, 2017).

Interaction effect

The interaction effect of different irrigation scheduling and nitrogen levels on green pod length (cm) was not significant. The values range from 10.6 cm to 13.7 cm.

Green pod diameter

Irrigation scheduling

The green pod diameter (cm) of okra differed significantly with irrigation scheduling is presented in Table 1. The maximum green pod diameter of 1.61 cm was recorded with 1.0 Epantreatment which was on par with 1.25 Epan (1.55 cm) and significantly more over 0.75 Epan (1.44 cm) treatment. While the crop irrigation scheduled at 0.75 Epan (I_1) remained significantly inferior to I_2 (1.0 Epan) and I_3 (1.25 Epan) treatments. This might be due to a stable moisture content and physical favourable condition of soil may have led to unrestricted expanded root growth and subsequent increase in nutrient absorption. The reduction in green pod diameter with increase in the irrigation levels might hamper the availability of sufficient oxygen in root zone of the crop. The reduction in green pod diameter at 0.75 Epan scheduling was due to deficit soil moisture condition prevailing in root zone of the crop (Kamble *et al*., 2020). These results were in accordance with the findings of Puneet and Arun (2016), Farias *et al*. (2017), Rani and Mariappan, (2019), Naik *et al*. (2017).

Nitrogen levels

The green pod diameter (cm) of okra differed significantly with nitrogen levelsis presented in Table 1. The crop nurtured with 100% RDN (N_2) recorded maximum green pod diameter of 1.61 cm, which was on par with succeeding higher nitrogen doses of 125% RDN (1.54 cm) and 150% RDN (1.53 cm) and significantly more over its preceding lower dose 75% RDN (1.44 cm). However, the pod diameter recorded with 75% RDN (N_1), 150% RDN (N_4) were found to be on par with each other. This might be due to fact that in addition of higher doses of nitrogen levels, rooting medium proved to be inhibitory to okra. Possibly, reduction in growth under high nitrogen supply results from its general adaptation to low nitrogen. These results indicated that more N availability to plant has a positive effect on pod length up to certain dose (100% RDN) and further increase in nitrogen doses did not influence significantly (Bhatti *et al*., 2011). Similar results were also reported by Uddin *et al*. (2014), Moniruzzaman and Quamruzzaman (2009), Khanal *et al*. (2020), Naik (2017), Mahendran *et al*. (2011).

Interaction effect

The interaction effect of different irrigation and nitrogen levels on green pod diameter (cm) was not significant. The values range from 1.40 cm to 1.73 cm.

Green pods weight (g plant^{-1})

Irrigation scheduling

The green pod weight (g) of okra differed significantly with irrigation scheduling is presented in Table 1. The maximum green pod weight of 501.6 g was recorded with crop irrigation scheduled at 1.0 Epan (I_2), which was significantly more over 0.75 Epan (336.0 g) and 1.25 Epan (424.6 g). While the crop irrigation scheduled at 0.75 Epan (I_1) remained significantly inferior to I_2 (0.75 Epan) and I_3 (1.0 Epan) treatments. This could be due to maintenance of optimum soil moisture coupled with effective utilization of nutrients throughout the crop growth which ultimately resulted in maximum pod weight. These findings are in conformity with the results reported by Kamble *et al.* (2020), who reported that the amount of irrigation more than 1.0 Epan could not increase the green pod weight. This trend probably might be due to excessive moisture availability under water application at 1.25 Epan. Similarly at 0.75 Epan irrigation scheduling there was reduction in green pod weight due to less soil moisture condition prevailing at root zone of the crop. Similar results were also obtained by Haris *et al*. (2014), Bahadur *et al.* (2020), Thokal *et al.* (2020), Naik *et al.* (2017), Rani and Marippan (2019) in okra crop.

Nitrogen levels

The green pod weight (g) of okra was influenced by nitrogen levelsis presented in Table 1. The maximum green pod weight of 466.2 g plant^{-1} was recorded with 100% RDN, which was significantly more over to its succeeding higher nitrogen doses of 125% RDN (425.6 g) and 150% RDN (409.8 g) and preceding lower dose of 75 % RDN (381.2 g) of nitrogen levels. While the crop nurtured with 75% RDN (N_1) remained significantly inferior to N_2, N_3, N_4 treatments. These results clearly indicated that the increment in fresh pod weight in response to nitrogen availability was up to 100% RDN only. Thereafter, further increment in nitrogen supply resulted in decrease in green pod weight. Similar results were also reported by Fatima *et al*. (2019), Nair *et al.* (2017), Khanal *et al.* (2020), Naik (2017), Mahendran *et al.* (2011), Raval *et al.* (2013).

Interaction effect

The interaction effect of irrigation scheduling and nitrogen levels on green pod weight (g) was found to be non-significant. The values range from 319.3 to 542.6.

Total number of green pods plant^{-1}

Irrigation scheduling

The total number of green pods plant^{-1} of okra differed significantly with irrigation scheduling is presented in Table 1 and depicted in Fig. 2. The number of green pods plant^{-1} (44.0) was recorded with crop irrigation scheduled at 1.0 Epan (I2), which was significantly moreover 0.75 Epan (37.0) and 1.25 Epan (40.7). However, the total number of green pods plant^{-1} recorded with 1.25 Epan (I_3) and 0.75 Epan (I_1) were found on par with each other. The above results indicated that, the amount of irrigation more than 1.0 Epan could not increase the pod number. This trend probably due to excess moisture conditions under 1.25 Epan. Similarly at 0.75 Epan irrigation scheduling there was reduction in total number of green pods due to less soil moisture condition prevailing at root zone of the crop (Kamble *et al*., 2020). Similar results were reported by Thokal *et al.* (2020), Bahadur *et al.* (2020) and Naik (2017).

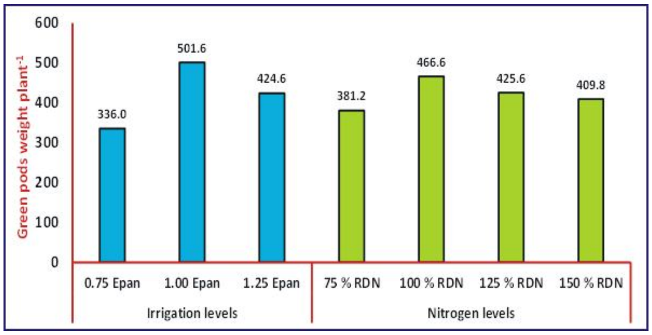

Fig. 2 : Effect of drip irrigation scheduling and nitrogen levels on green pods weight plant^{-1}.

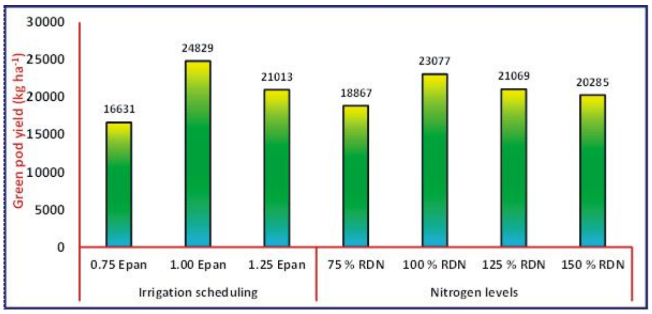

Fig. 3 : Effect of irrigation scheduling and nitrogen levels on green pod yield (kg ha^{-1}) of okra.

Nitrogen levels

The total number of green pods plant^{-1} of okra was differed significantly with nitrogen levels is presented in Table 1 and depicted in Fig. 2. The crop nurtured with 100% RDN (N_2) recorded maximum number of green pods plant^{-1} (43.5), which was comparable with 125% RDN (42.1) and 150% RDN (41.2) treatment. While the lowest number of green pods plant^{-1} (35.6) was recorded in 75 % RDN (N_1), which remained significantly inferior to N_2, N_3 and N_4 treatments, respectively.

The above results indicated that pods formation increased with increasing nitrogen dose from 75 % RDN to 100% RDN. Further addition of nitrogen dose from 125% to 150% RDN, the crop caused a gradual decline in pod formation was observed (Saba *et al.*, 2019). Further, Bhatti *et al.* (2011) stated that yield attributes significantly increased with increase in nitrogen supply. At higher nitrogen levels, the rooting medium proved to be inhibitory to okra. Possibly, reduction in growth under high nitrogen supply results from its general adaptation to low nitrogen. Similar results were reported by Uddin *et al*. (2014), Nagegowda *et al*. (2019), Padmanabha *et al*. (2018).

Interaction effect

The interaction effect of irrigation scheduling and nitrogen levels on total number of green pods per plant was significant. The values range from 31.3 to 47.8.

Total green pod yield (kg ha^{-1})

Irrigation scheduling

The green pod yield (kg ha^{-1}) of okra differed significantly with irrigation scheduling is depicted in Fig. 3. The maximum green pod yield (24829 kg ha^{-1}) was recorded with 1.0 Epan, which was significantly more over 1.25 Epan (21013 kg ha^{-1}) and 0.75 Epan (16631 kg ha^{-1}). While the crop irrigation scheduled at 0.75 Epan (I_1) remained significantly inferior to 1.0 Epan (I_2) and 1.25 Epan (I_3) treatments.

Green pod yield is a function of different growth parameters and their interaction with growing environment. The crop yield is mainly limited by factors such as low nutrient and water availability, because they compromise physiological processes related to plant growth (Puneet *at al*., 2016). The reason for higher grain yield in I_2 (1.0 Epan) might be attributed to favourable soil moisture conditions maintained throughout the crop growth. Krittika and Misal (2018) reported that irrigation practices were carried out at 0.8 Epan considerably higher pod yield was obtained under such irrigation conditions. Okra pod yield decreased when irrigation practices were performed with higher irrigation treatment at 1.25 Epan. Therefore, irrigation of okra should be performed at 1.0 Epan irrigation scheduling so that to provide optimal soil moisture to produce higher yield. Similar results were also reported by several researchers (Haris *et al*., 2014; Babu *et al*., 2015; Bahadur *et al*., 2020; Naik, 2017; Khedkar, 2018; Rani and Mariappan, 2019).

Nitrogen levels

The green pod yield of okra was influenced by nitrogen levelsis depicted in Fig. 3. The crop nurtured with 100% RDN (N_2) recorded maximum green pod yield (23077 kg ha^{-1}) as compared to its preceding lower 75% RDN (18867 kg ha^{-1}) as well as succeeding higher 125% RDN (21069 kg ha^{-1}) and 150% RDN (20285 kg ha^{-1}) treatments. With increasing the nitrogen dose from 100% RDN to 125% RDN and further to 150% RDN, the green pod yield was decreased significantly. While the lowest green pod yield (18867 kg ha^{-1}) was recorded with crop nurtured with 75 % RDN (N_1) significantly remained inferior to N_2, N_3 and N_4 treatments, respectively. Chovatia (2005) stated that application of 150 kg N ha^{-1} recorded maximum yield of okra, which was at par with 112.5 kg N ha^{-1}. This was due to favourable nutrition to the plants. Over and above, the yield attributing characters like number of fruits per plant seems favourably influenced the greater photosynthetic activity and thereby producing more photosynthate, which is responsible for increase in growth attributes. The higher number of metabolites might have helped in increasing these characters. Feroz (2009) reported that positive response of N availability on yield production could also be due to its role in delaying plant maturity and resultant more assimilate synthesis that played significant role in more pods production. Uddin *et al*. (2014) stated that growth attributes significantly increased with increasing nitrogen supply. In addition, higher optimal levels of nitrogen of the rooting medium proved to be inhibitory to okra. Possibly, reduction in growth under high nitrogen supply results from its general adaptation to low nitrogen. Symptoms of toxicity due to an excess of nitrogen or symptoms of nitrogen deficiency were not observed on plants. These results were in accordance with the findings of Puneet *et al*. (2016), Saba *et al.* (2019), Kanal *et al.* (2020), Nair *et al*. (2017), Padmanabha *et al.* (2018), Raval *et al.* (2013), Naik (2017).

Interaction effect

The interaction effect of irrigation scheduling and nitrogen levels on green pod yield (kg ha^{-1}) of okra was found significant is depicted in Fig. 4.

The crop irrigation scheduled at I_1 (0.75Epan) with increasing nitrogen dose from 75% RDN to 100 % RDN, the green pod yield was increased significantly from 15810 to 18629 kg ha^{-1} and further increasing nitrogen dose from 100 to 125% and 125% RDN to 150% RDN, the green pod yield was decreased significantly from 16188 to 15897 kg ha^{-1}, respectively. Similar trend was also reflected at 1.0 Epan (I_2).

At I_3 irrigation scheduling the significantly higher green pod yield (23745 kg ha^{-1}) was recorded with 100% RDN which was followed by 125% RDN (21160 kg ha^{-1}). The lowest green pod yield was recorded with N_1 which was comparable with N_4 and significantly inferior to N_2 and N_3 levels.

Among the combination of treatment, the crop irrigation scheduled at I_2 (1.0 Epan) in conjunction with 100% RDN (I_2N_2) recorded maximum green pod yield of 26857 kg ha^{-1}. However, it was comparable with 1.0 Epan (I_2) in conjunction with 125% RDN (I_2N_3) with green pod yield of 25859 kg ha^{-1}, which remained significantly more over rest of the treatment combinations. The interaction effects between irrigation scheduling and nitrogen levels clearly indicated that, for okra crop 100% RDN is optimum for maximum green pod yield irrespective of irrigation scheduling. Krittika and Misal (2018) stated that maximum green pod yield was recorded with application of 0.8 Epan in conjunction with 80% RDN, which was followed by 1.0 Epan in conjunction with 80% RDN. Bhatti *et al*. (2011) also stated that under high

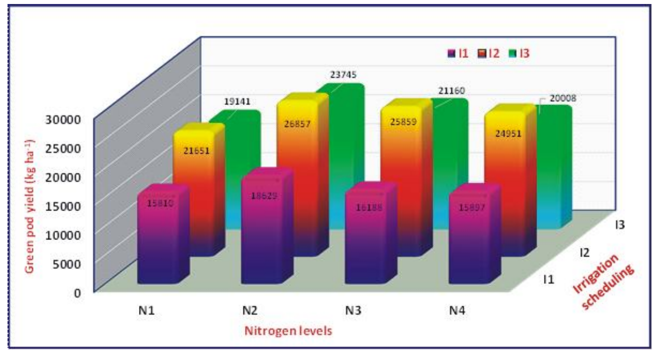

Fig. 4 : Interaction effect of irrigation scheduling and nitrogen levels on green pod yield (kg ha^{-1}) of okra.

nitrogen supply nitrogen is translocated to shoot in the form of nitrate where, it is reduced. Reduction and assimilation of nitrate have a high-energy requirement, *i.e.*, 15 mol ATP for reduction of 1 mol of NO_3. Possibly diversion of energy may cause the reduced growth. The results are in line with finding of several at researchers (Puneet and Arun, 2016; krittika and Misal, 2018; Thokal *et al*., 2020; Rekha *et al.*, 2006; Job *et al*., 2018; Sukruth, 2006).

Conclusion

The study concluded that by using drip irrigation scheduling and nitrogen levels in commercial vegetable crop like okra under semi-arid region of Telangana is need of hour to save water without compromising yield and quality of produce. The results concluded that drip irrigation scheduled at 1.00 Epan in conjunction with 100% RDN produced maximum green pod yield as compared to rest of the treatment, which facilitated in accumulation of more photosynthates and conversation of optimum soil moisture at root zone of the crop resulting in increased size and weight of fruits.

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