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Effect of Fertigation and Mulching on Root Studies and Crop Growth Indices for Seed Production in Okra [*Abelmoschus esculentus* (L.) Moench]

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ABSTRACT

Background: Okra is an important vegetable crop in India, Method of fertilization also plays an important role in supplying the nutrient to the plants because, the efficacy of fertilizers applied in soil being low due to various losses and fixation, mainly in area of problematic soil. Water and fertilizers are the two important inputs which are used scientifically and judiciously through precision farming technologies to increase productivity, profitability and nutrient use efficiency in okra seed yield and quality.

Methods: The experiments were conducted during kharif 2016 and kharif 2017 to study the effect of precision farming technologies including fertigation and black polythene mulching to know the crop growth, yield, quality of seeds and root studies in okra seeds var. Arka Anamika and at ICAR-IIHR Hesaraghatta, Bengaluru. The experiment was laid out in RBD with three replication and four treatments each with mulch and on mulch *viz*., 100:50:75 N:P_2O_5:K_2O kg ha^{-1} 100:50:100 N:P_2O_5:K_2O kg ha^{-1} T_3-150:75:112.5 N:P_2O_5:K_2O kg ha^{-1} T_4-150:75:150 N:P_2O_5:K_2O kg ha^{-1} compared with soil application treatments.

Result: Application of water soluble fertilizer @ T_4-150:75:150 NPK kg/ha through fertigation either mulch (14.05q/ha) or non mulch (11.83q/ha) recorded significantly higher seed yield than fertilizer through soil application (9.92 q/ha).Similarly significantly higher value of Absolute Growth Rate (AGR) Crop Growth Rate (CGR) and root character were observed in the NPK fertigation treatment with or without mulch than the soil application of fertilizers (NPK soil application @ 100:50:100kg per ha (T_9) and NPK soil application @ 150:75:150kg per ha (T_{10}). Significantly higher root parameter tap root length (21.03cm), average length of primary roots (64.63cm), number of primary roots (10.83 nos), fibrous roots arising from main stem (26 nos) and root dry weight (23.07 g/plant) were recorded in the T_4-150:75:150 NPK kg ha^{-1} through fertigation (WSF) with mulch than the fertigation without mulch and fertilizer applied through soil.

Key words: Absolute growth rate and root studies, Crop growth rate, Fertigation, Mulching, Okra, Seed yield.

INTRODUCTION

Fertigation is the technique of supplying dissolved fertilizers solution to crops through an irrigation system. Small application of soluble nutrients save labours, reduces compaction in the field, thereby enhances productivity. Fertigation permits application of a nutrient directly at the site of active roots as required by the crop. Scheduling fertilizer applications on the basis of need, offers possibility of reducing nutrient element losses associated with conventional application methods which depend on the soil as a reservoir of nutrients there by increasing the nutrient use efficiency (Solaimalai *et al*., 2005). Fertigation is the most effective and suitable means of maintaining optimum fertility level and water supply according to the specific requirement and the savings in the use of fertilizers can be to the extent of 25-50 per cent (Haynes,1985). Intensification of agriculture with irrigation and enhanced use of fertilizers may generate pollution by increased level of nutrients in the underground and surface water. Therefore judicious management of plant nutrients available through different fertilizers needs to be catered. A higher efficiency is possible when a pressurised irrigation system is placed around the roots uniformly which allows rapid uptake of nutrients by the plant.

Water and nutrients must be managed efficiently not only to increase the yield but also to sustain environmental safety and quality. Nutrient management is the most basic factor and found to exert a great influence not only on growth and yield attributes of vegetables but also for obtaining sustained productivity. Among all nutrients; N, P and K are three most important major nutrients which contribute to proper growth and yield of plants and they also have direct effect on metabolism of plants (Abusaleha and Shanmugavelu, 1988). Method of fertilization also plays an

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important role in supplying the nutrient to the plants because, the efficacy of fertilizers applied in soil being low due to various losses and fixation, mainly in area of problematic soil. Drip fertigation has been well recognized as an efficient and precise method of applying fertilizers directly to the root zone for maximizing productivity and net returns in horticultural crops (Meenakshi, 2002).

The technique of covering the soil with crop residues or plastic films for soil and water conservation is practiced for production of vegetable under rainfed as well as irrigated agro ecosystems. In India, mulching has been practiced for many years using crop residues including dry straw, trash, stalks and leaves and nowadays plastic mulches have come into use due to the intrinsic advantages of efficient soil moisture conservation, weed suppression and maintenance of soil structure. Although a many varieties of vegetables can be successfully grown by means of mulches, the vegetables *viz*., cucumbers, capsicums, melons, tomatoes, cole crops and okra have shown significant increase in earliness, yield and quality. In addition to soil and water conservation, enhanced yield and quality, control of weed growth, mulches be able to improve the use efficiency of applied fertilizer nutrients and also use of reflective mulches are likely to reduce the incidence of virus diseases and deter the approach of some species of pests. Mulches also facilitate in regulation of soil temperature to a certain degree which can be made use of for growing thermo sensitive vegetables. Photodegradable plastic mulches are substitute to conventional plastic mulches considering of their retrieval and disposal problems. Even though photodegradable plastic looks much like other plastic mulch when it is installed, it can be broken down by ultraviolet sunlight. The actual rate of break-down depends on several factors including temperature, the proportion of the plastic shaded by the crop and the amount of sunlight received during the growing season. Now efforts are on the way of using bio degradable plastic mulches of varying densities to economize and make this an eco-friendly technology.

Burgeoning population and ever increasing urbanization has boosted the cultivation of vegetables in peri-urban areas in an intensive way. This creates a greater demand for quality seeds and it is very much necessary to ensure supply of good quality vegetable seeds. Combination fertigation and mulching have greater influence on quality and quantity of okra seed production.

MATERIALS AND METHODS

The experiments were conducted during *kharif* 2016 and *kharif* 2017 to study the effect of precision farming technologies including fertigation and black polythene mulching to know the growth, yield and quality of okra [*Abelmoschus esculentus* (L.) Moench] seeds var. Arka Anamika at ICAR-IIHR Hesaraghatta, Bengaluru. The experiment was laid out in RBD with three replication. The treatment details are as given below:

Treatment details

T_1-100:50:75 N:P_2O_5:K_2O kg ha^{-1} through fertigation (WSF) with mulch

T_2-100:50:100 N:P_2O_5:K_2O kg ha^{-1} through fertigation (WSF) with mulch

T_3-150:75:112.5 N:P_2O_5:K_2O kg ha^{-1} through fertigation (WSF) with mulch

T_4-150:75:150 N:P_2O_5:K_2O kg ha^{-1} through fertigation (WSF) with mulch

T_5-100:50:75 N:P_2O_5:K_2O kg ha^{-1} through fertigation (WSF) without mulch

T_6-100:50:100 N:P_2O_5:K_2O kg ha^{-1} through fertigation (WSF) without mulch

T_7-150:75:112.5 N:P_2O_5:K_2O kg ha^{-1} through fertigation (WSF) without mulch

T_8-150:75:150 N:P_2O_5:K_2O kg ha^{-1} through fertigation (WSF) without mulch

T_9-100:50:100 N:P_2O_5:K_2O kg ha^{-1}soil application of fertilizers without mulch

T_{10}-150:75:150 N:P_2O_5:K_2O kg ha^{-1}soil application of fertilizers without mulch

(WSF-water soluble fertilizer)

The experimental plots of 10.2 m (L) x 3.6 m (W) were prepared for sowing the okra seeds. The row to row and plant to plant spacing were 0.60 m and 0.30 m respectively. Black polythene mulch of 30 micron thickness was used. Water soluble fertilizers *viz*., 19:19:19, urea and potassium nitrate were used for fertigation treatments whereas regular NPK fertilizers were applied through soil for the treatments T_9 and T_{10} in the form of urea, Di ammonium phosphate (DAP) and muriate of potash (MOP) were used in two splits at 28 and 56 days after sowing in equal proportions. The water soluble fertilizers were injected in 16 equal splits at weekly interval and all other recommended cultural practices were followed in raising the crop.

Growth indices

Formulae used for calculating growth indices is given below

Growth indices	Formula	Unit	Author and year
Absolute Growth Rate (AGR)	W_2-W_1/T_2-T_1	g/day	Watson (1952)
Crop Growth Rate (CGR)	(W_2-W_1/T_2-T_1) x1/P	g/dm^2/day	Watson (1952)

Root studies

Two plants were selected in each treatment from the net plot after final harvest. After wetting the soil around the plant thoroughly, a trench was dug around the distance of 90cm from the base of the plant using jet of water, the soil around the plant stem was washed off till the complete net work of roots were visible. After recording the maximum depth of root penetration of roots, the roots were collected from soil, washed and length of individual roots was recorded. Root dry weight was recorded by drying the roots at 65°C and expressed in g/plant.

RESULTS AND DISCUSSION

In the present study, the influences of fertigation on root parameters were assessed in two year mean data analysis. Significantly higher root parameter tap root length (21.03 cm), average length of primary roots (64.63cm), number of primary roots (10.83 nos), fibrous roots arising from main stem (26 nos) and root dry weight (23.07 g/plant) were recorded in the T_4-150:75:150 NPK kg ha^{-1} through fertigation (WSF) with mulch than the fertigation without mulch and fertilizer applied through soil. The fertigation treatments generally resulted in higher number of roots per plant, indicating the efficiency of fertigation treatments in producing more number of roots than applied nutrients through soil. Similar results were observed in *Citrus paradisi* cv. White Marsh (grape fruit trees) by Zhang *et al.* (1996). Higher moisture and nutrient availability in the vicinity of the roots might be the probable reason for higher number of roots produced in the fertigation treatments combined with mulching. Besides the inoculation process stimulates the root growth and development (Baset Mia *et al.*, 2010), which occurred almost in all dimensions namely production of primary and secondary roots, longer roots and greater volume and mass. This was further confirmed in the present study with the treatment combinations of WSF through fertigation with or without mulch and fertilizer through soil without mulch recorded the maximum and minimum number of roots respectively. Besides, the number of roots per plant, the pattern and its distribution is also an important factor. The pattern of distribution assessed by the horizontal and vertical growth of roots clearly showed that, fertigation treatments produced shorter and shallow roots as compared to fertilizers applied through soil. This is expected under fertigation system as the nutrients and water are made available continuously right at the root zone area which does not necessitate extension of roots, either horizontally or vertically as against a deeper spread of roots under fertilizer through soil application. This study is in-line with works of Hari and Ramesh (2017) who reported that maximum penetration of root depth and lateral root length was observed in fertigation treatments than manual application in okra. A comparison between the fertigation treatments and the soil application of fertilizers indicated that the number of roots were higher in the fertigated treatments as compared to the soil application. This is in agreement with the findings of Mahalakshmi (2000). Thus, plants under fertigation might have efficiently utilized the water and nutrients made available in its vicinity which might have resulted in higher nutrient uptake and yield under fertigation. Sandal *et al.,* (2007) also reported that root mass density and root volume significantly improved in mulching as compared to no mulching in okra.

Plant growth analysis is considered to be a standard approach to study of any plant growth and productivity (Wilson, 1981). Growth and yield are functions of a large number of metabolic processes, which are affected by environmental and genetic factors. Studies of growth pattern and its understanding not only tell us how plant accumulates dry matter, but also reveals the events which can make a plant more or less productive singly or in population (Ahad, 1986). In the present investigation, the growth parameters *viz*., AGR and CGR were assessed for the first and second year of field experiment. The various levels of fertigation and soil application treatments influence AGR and CGR of okra. Among the treatments, significantly higher value of AGR (2.45 g/day) and CGR (0.14 g/dm^2/day) observed in the NPK fertigation @150:75:150 kg per ha with mulch (T_4) during initial 30 to 60 days interval, whereas at 60 to 90 days the maximum value of AGR (7.70 g/day) and CGR (0.43 g/dm^2/day) recorded in T_3-150:75:112.5 NPK kg ha^{-1} through fertigation (WSF) with mulch than the soil application of fertilizers (NPK soil application @ 100:50:100kg per ha (T_9) and NPK soil application @ 150:75:150kg per ha (T_{10}). Srivastava and Singh (1980) reported that growth process *i.e.*, CGR, RGR and NAR directly influenced the economic yield of lentil. Similarly, Thakur and Patel (1998) reported that dry matter production, LAI, LAD, CGR, NAR and RGR

Table 1: Effect of fertigation and mulching on seed yield (q/ha), AGR (g/day) and CGR (g/dm^2/day) of okra for seed production.

Treatment	Seed yield (q/ha)	AGR (g/day) 30-60 DAS	AGR (g/day) 60-90 DAS	CGR (g/dm^2/day) 30-60 DAS	CGR (g/dm^2/day) 60-90 DAS
T_1	11.96	1.71	6.89	0.10	0.38
T_2	11.76	1.41	7.01	0.08	0.39
T_3	14.02	1.01	7.70	0.06	0.43
T_4	14.05	2.45	7.25	0.14	0.40
T_5	10.21	0.95	6.11	0.05	0.34
T_6	10.42	1.41	6.15	0.08	0.34
T_7	11.83	1.67	6.33	0.09	0.35
T_8	11.73	1.28	7.46	0.07	0.41
T_9	8.70	1.27	4.20	0.07	0.23
T_{10}	9.92	1.60	4.23	0.09	0.24
SEm±	0.43	0.06	0.36	0.003	0.02
C.D. at 5%	1.27	0.17	1.08	0.01	0.06

Table 2: Effect of fertigation and mulching on root characters of okra for seed production at final harvest.

Treatment	Tap root length (cm)	Average length of primaryroots (cm)	Number of primary roots	Number of fibrous rootsarising from stem	Root dry weight (g/plant)
T_1	17.47	42.75	9.50	20.17	20.30
T_2	17.18	47.50	9.83	19.33	20.78
T_3	19.92	55.17	10.17	22.67	22.37
T_4	21.03	64.63	10.83	26.00	23.07
T_5	13.97	30.37	8.83	14.17	17.47
T_6	13.77	28.33	9.17	15.17	15.73
T_7	15.75	31.71	9.00	17.50	19.17
T_8	16.55	35.50	9.67	16.83	20.30
T_9	12.67	21.50	5.83	10.50	11.53
T_{10}	13.30	24.42	7.17	12.83	11.90
SEm±	0.40	1.29	0.31	0.50	0.61
C.D. at 5%	1.19	3.84	0.92	1.47	1.82

*DAS-Days after sowing.

Fig 1: Root growth in okra due to fertigation and mulching treatment .

are ultimately reflected in higher grain yield. Tesfaye *et al*., (2006) reported that attainment of high LAI that reduces soil water evaporation intercepts and converts radiation into dry matter efficiently and partitioning of the dry matter efficiently and partitioning of the dry matter to the seed is the major requirement of a high seed yield in grain legumes in semi-arid environments. In a crop growth parameters like optimum LAI and CGR at flowering have been identified as the major determinants of yield (Sun *et al*., 1999). A combination of these growth parameters explain different yields better than any individual growth variable (Ghosh and Singh, 1998). It is understood from the present study that the benefit cost ratio only cannot be kept as the yardstick to arrive at the best treatment to go with, it has to be equally given importance to the net returns from a unit area. In the present investigation the NPK fertigation @ 100:75:112.5kg per ha without mulch (T_7) and NPK fertigation @ 150:75:150kg per ha without mulch (T_8) resulted more or less benefit cost ratio 2.21 and 2.48, respectively. The expenditure towards the cost of production revealed that at fertilizers applied through soil in NPK soil application @ 100:50:100kg per ha (T_9), a sum of Rs. 107.19 was spent to produce one kg of okra seed and the next higher expenditure (Rs. 98.78 per kg) was arrived at NPK soil application @ 150:75:150kg per ha (T_{10}). It is worth to note that, the treatment of application of WSF through fertigation with mulching incurred the lowest expenditure (Rs. 86.11) on an average, to produce one kg of okra seed and for production of one kg okra seed with fertigation and non-mulch was Rs. 90.66.

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