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Standardization of fertigation schedule for tomato (*Solanum lycopersicum* L) under open precision farming

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ABSTRACT

An investigation was carried out in College of Agriculture, Vellayani, Thiruvananthapuram, to standardize the fetigation schedule for tomato and to assess the impact of precision farming practices on growth, yield and economics of tomato under open precision farming during summer season of 2015. Experiment was laid out in split plot design with four replication. Four fertigation levels (75, 100, 125 and 150 per cent recommended dose of nitrogen and potassium) and two fertigation intervals (four days, eight days) along with two controls were tested in the present investigation. Maximum drymatter production (219.42 g plant^{-1}), fruit set per cent (62.77), fruits plant^{-1} (33.67) and fruit yield (42.36 t ha^{-1}) were registered for 125 per cent recommended dose of N and K. Higher leaf area index (1.87), dry matter production(224.21g plant^{-1}), fruit set per cent (60.74), fruits plant^{-1} (35.53), and fruit yield (44.25 t ha^{-1}) were recorded for fertigation at four days interval. Economic analysis revealed that 125 % RD of N and K registered the highest net income (4,55,466 ha^{-1}) and B: C ratio (2.16) compared to other fertigation levels and fertigation at four days interval registered significantly higher net income (4,93,051ha^{-1}) and B: C (2.26) ratio compared to fertigation at eight days interval.

***Keywords**: Fertigation, fertigation interval, tomato, yield*

Tomato is an important and widely grown solanaceous vegetable crop around the world, both for fresh market and processing. It is an important source of vitamins and minerals. In India, tomato covers an area of about 8.8 lakh ha with a production of 182.27 lakh tons and productivity of 20.7 t ha^{-1} (NHB, 2013). As far as Kerala is concerned, the extent of cultivated land is limited and hence it is essential to exploit the full potential of vegetable production through proper agronomic practices. For realising maximum yield potential, management of water, nutrients and weeds is very important. Precision farming is considered as one such approach to enhance productivity. Drip irrigation has gained wide spread popularity as an efficient method for fertigation because both time of application and rate of nutrients can be controlled to meet the requirements of a crop at each physiological growth stage (Bar-Yosef, 1997). Fertigation is an important practice in precision farming that permits the farmer to apply optimum fertilizers through drip irrigation, which enhance production and productivity per unit area**.** Fertilizers should be applied in a form that becomes available in synchrony with crop demand for maximum utilization of nutrients from fertilizers (Boyhan *et al*., 2001). Hebbar *et al*. (2004) observed higher tomato yield through fertigation than banded and furrow irrigation or banded and then trickle irrigated.Tomato responds well to additional fertilizer applied and it is reported to be a heavy feeder of NPK.Fertigation in tomato and brinjal gave encouraging results in terms of yield and economic return (Akanda *et al.*, 2004). Standardisation of fertigation schedule *i.e.*, quantity of fertilizers to be applied through fertigation and fertigation interval, in open field precision farming in tomato will be useful for vegetable farmers to enhance the productivity of the crop.

MATERIALS AND METHODS

The field experiment was conducted during summer 2015 in Thiruvananthapuram, Kerala, India. Soil of the experimental site was red sandy loam, slightly acidic in nature, low in available nitrogen and medium in available potassium and phosphorus. The experiment was laid out in split plot design with four replication. Four fertigation levels (l_1- 75 per cent recommended dose (RD) of N and K, l_2- 100 per cent RD of N and K, l_3- 125 per cent RD of N and K, l_4- 150 per cent RD of N and K) constituted the main plot treatments and two fertigation intervals (i_1- four days, i_2- eight days) constituted the sub plot treatments. The two control treatments were, control 1 (Kerala Agricultural University (KAU) *ad hoc* Package of practices (POP) recommendations for precision farming) and control 2 (KAU POP for conventional farming- 75 : 40 : 25 kg NPK ha^{-1}). Raised beds of 20 cm height were taken and mulched with black polythene. Drip installation was carried out .Two sub main lines were laid out in the field to supply water and nutrients to the plant. Five

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laterals were laid out in each plots and inline drippers with a discharge rate of 4 litres hour^{-1}at 60 cm spacing was provided to supply water and nutrients to the root zone of the crop. Hybrid tomato variety Lakshmi (grafted on wild brinjal) was planted at 60 x 60 cm spacing in plots incorporated with 25 t ha^{-1} FYM and 200 kg ha^{-1} rock phosphate during third week of February. For fertigation except control 1(KAU *Ad hoc* POP for precision farming), N and K were supplied as urea and muriate of potash. In control 1, 19:19:19, 12:61:0, 13:0:45, urea and rock phosphate were given as N, P and K source, wherein, 264 kg nitrogen, 130 kg phosphorus and 281 kg potassium were applied through fertigation at three days interval. Observations on biometric characters, *viz.*, plant height (30,60 and 90 DAP), leaf area index (LAI) at flowering and dry matter production were recorded. Yield attributes, *viz*., fruit set per cent, number of fruits plant^{-1}, and yield were recorded. Economic analysis and statistical analysis of data were carried out by applying the technique of analysis of variance (ANOVA) for split plot design (Panse and Sukhatme, 1985)

RESULTS AND DISCUSSION

Growth attributes

A perusal of the data revealed that the fertigation levels and fertigation intervals tested did not have any significant influence on plant height and primary branches plant^{-1}(Table 1).Fertigation levels did not exhibit significant influence on LAI. However, dry matter production varied significantly with fertigation levels.Application of 125 per cent RD of N and K (l_3) recorded the highest dry matter production (219.42 g plant $^{-1}$) which was *on par* with l_4, *i.e.*, 150 per cent RD of N and K with a dry matter production of 208.00 g plant^{-1}.LAI and dry matter production were significantly influenced by fertigation intervals. The fertigation interval i_1 (four days) was significantly superior and registered the highest LAI (1.87) and dry matter production (224.21 g plant^{-1}) compared to i_2 (fertigation at eight days interval). Higher LAI in i_1 might be due to the increased photosynthetic capacity of plants in this treatment as evidenced by higher LAI, due to the continuous availability of nitrogen and potassium through drip system. These results are in agreement with Prabhakara *et al*. (2010). Higher LAI contributes to greater carbohyd rate synthesis and better dry matter yield (Le Bot *et al*., 1998). Control 1 (264 kg N, 130 kg P and 281 kg K were applied through fertigation at three days interval in 40 splits) registered significantly higher growth attributes (plant height, primary branches plant^{-1}, LAI and dry matter production) compared to control 2 (Soil application of 75:40:25 kg NPK ha^{-1}). Increased growth attributes in fertigation treatments in tomato compared to conventional soil application were reported by Singandhupe *et al.* (2003) and Gupta *et al.* (2010).

Yield attributes and yield

Among different fertigation levels, l_3 (125 per cent RD of N and K)recorded the highest number of fruits plant^{-1}(33.67), fruit set percentage (62.77), fruit yield (42.36 t ha^{-1}) and was significantly superior to other fertigation levels tested. This might be due to the enhanced supply of nitrogen and potassium in the root rhizosphere resulting in increased uptake of these nutrients contributing to better expression of growth and yield attributes. Increase in fruit yield could be related to significantly higher number of fruits plant^{-1} and per cent fruit set in 125 per cent RD of N and K. Better expression of growth parameters, *viz.*, dry matter production (DMP) and comparatively higher photosynthetic surface area as indicated by higher LAI coupled with better yield parameters like per cent fruit set and number of fruits plant^{-1} might be the reason for realising significantly higher fruit yield at l_3. Brahma *et al*. (2010) obtained the highest productivity of tomato at higher fertigation level (100 per cent N and K fertilizers) and they reported that the marketable yield of tomato showed an increasing trend with each corresponding increase in the level of N and K fertigation.

Fertigation at four days interval (i_1) recorded higher number of fruits plant^{-1} (35.53), fruit set percentage (60.74) and fruit yield (44.25 t ha^{-1}) and was significantly superior to i_2 (fertigation at eight days interval). Per cent increase in fruit yield in i_1 compared to i_2 was 32. This might be due to the frequent supply of nutrients directly in the vicinity of the root zone throughout the crop growth period resulting in better nutrient uptake and use efficiency leading to enhanced yield attributes. These results are in general agreement with the results reported by Cook and Sanders, 1991; Al-Ghawas and Al-Mazidi, 2004.

Control 1 (KAU *ad hoc* POP for precision farming) registered significantly higher number of fruits plant^{-1} compared to control 2 (KAU POP for conventional farming). With respect to number of fruits plant^{-1}, treatment mean was significantly superior to control 2. In the case of fruit yield, control 1 (KAU *ad hoc* POP for precision farming) and treatment mean were significantly superior to control 2 (KAU POP for conventional farming). Normal soil application of fertilizers generally tends to cause uneven distribution of fertilizers in the root zone. Alternatively, all of the soluble NPK fertilizers can be applied *via* fertigation through drip system to obtain proper distribution in soil. This is the reason for better response in fertigation where nutrients were applied through split doses to match the nutrients uptake by the crop. Increased number of fruits plant^{-1} and fruit weight due to fertigation over soil application have been reported by Lara *et al*. (1996), Locascio *et al.* (1997) and Pan *et al*. (1999).

Economics

Among different fertigation levels tested, 125 per cent RD of N and K (l_3) registered the highest net income (¹ 4,55,466ha^{-1}) and B: C ratio (2.16) and it was significantly superior to other fertigation levels, lowest B: C ratio being registered for 75 per cent RD of N and K (l_1) (Table 2). According to Brahma *et al*. (2010) the highest B: C ratio in tomato was recorded in the cent per cent fertigation of recommended dose of nutrients and lowest B : C ratio was recorded by 50 per cent fertigation level.

Fertigation interval of four days showed significantly higher net income (¹ 4,93,051ha^{-1}) and B : C ratio (2.26) and it was superior to i_2(fertigaton at eight days interval). The substantial yield increase due to frequent fertigation (four days interval) resulted in significantly higher net income and B: C ratio in this treatment, even though the expenditure on fertigation was comparatively more than that in i_2 (fertigation at eight days interval).

Control 1 (KAU *ad hoc* POP for precision farming) and treatment mean registered significantly higher B: C ratio compared to control 2 (KAU POP for conventional farming). This is because of the higher yield obtained in fertigation treatments (both control 1 and treatment mean) compared to conventional soil application of fertilizers (control 2).

Based on the results of the present field investigation, it can be concluded that application of 125 per cent RD of N and K (93.75 kg N and 31.25 kg K ha^{-1}) as urea and muriate of potash respectively, in 30 splits throughfertigationat 4 days interval along with the basal application of farm yard manure @ 25 t ha^{-1}and soil application of 40 kg $P_2O_5$is the best schedule for hybrid tomato under precision farming.

Table 1: Effect of fertigation levels and fertigation intervals on growth attributes

Treatments	Plant height (cm)			No. of primary branches plant^{-1}			LAI	Dry matter production (g plant^{-1})
	30 DAP	60 DAP	90 DAP	30 DAP	60 DAP	90 DAP		
Fertigation levels (l)								
l_1	55.98	80.92	132.04	7.83	11.89	13.13	1.57	190.44
l_2	54.84	82.51	133.10	8.23	12.32	13.09	1.67	200.49
l_3	55.49	81.64	132.99	8.40	12.96	13.56	1.83	219.42
l_4	55.78	83.49	133.21	8.40	12.94	13.40	1.83	208.00
SEm (±)	**1.618**	**1.222**	**2.395**	**0.306**	**0.531**	**0.223**	**0.089**	**4.328**
LSD (0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**13.848**
Fertigation intervals (i)								
i_1	56.54	83.06	133.85	8.41	12.89	13.30	1.87	224.21
i_2	54.50	81.22	131.82	8.02	12.17	13.29	1.58	184.97
SEm (±)	**1.023**	**1.204**	**1.826**	**0.239**	**0.254**	**0.184**	**0.073**	**2.458**
LSD (0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**0.228**	**7.575**
Treatment mean	55.51	82.14	132.84	8.21	12.52	17.52	1.72	204.59
Control 1	62.24	88.17	142.92	10.85	15.41	18.12	2.10	241.24
Control 2	51.47	78.09	126.09	7.83	10.77	16.25	1.29	171.27
Control 1 vs. Control 2	S	S	S	S	S	S	S	S
Control 1 vs. Treatment	S	S	S	S	S	NS	S	S
Control 2 vs. Treatment	NS	NS	NS	NS	NS	S	NS	S

Note: S- Significant and NS- non significant at 5% level of significance

Table 2: Effect of fertigation levels and fertigation intervals on yield attributes, yield and economics

Treatments	Fruit set (%)	Fruits plant^{-1}	Fruit yield (t ha^{-1})	Net income (^{1} ha^{-1})	B: C ratio
Fertigation levels (l)					
l_1	54.74	30.33	34.60	3,01,871	1.77
l_2	58.87	29.86	35.29	3,15,334	1.81
l_3	62.77	33.67	42.36	4,55,466	2.16
l_4	58.14	29.03	36.46	3,36,256	1.86
SEm (±)	**1.217**	**0.999**	**0.952**	**19029.6**	**0.049**
CD (0.05)	**3.896**	**3.198**	**3.047**	**60875. 3**	**0.158**
Fertigation intervals (i)					
i_1	60.74	35.53	44.25	4,93,051	2.26
i_2	56.52	25.91	30.11	2,11,411	1.54
SEm (±)	**0.959**	**0.617**	**0.605**	**12095.4**	**0.029**
LSD (0.05)	**2.957**	**1.904**	**1.865**	**37273.2**	**0.090**
Treatment mean	58.63	30.72	37.17	3,52,232	1.90
Control 1	60.84	38.22	50.12	4,67,272	1.87
Control 2	56.48	25.83	28.26	2,21,634	1.65
Control 1 vs. Control 2	NS	S	S	S	S
Control 1 vs. Treatment	NS	S	S	S	NS
Control 2 vs. Treatment	NS	S	S	S	S

Note: S- Significant and NS- non significant at 5% level of significance

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