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Original Research Paper

Effect of fertigation on growth and yield on Chilli hybrid Arka Meghana

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ABSTRACT

A field experiment was conducted to study the effect of fertigation on chilli F_1 Hybrid Arka Meghana during *kharif* of 2017 and 2018, with ten treatments, including different doses, sources of fertilizers and its frequency of application, in randomized block design with three replications. The pooled analysis revealed that application of fertilizer dose (125:100:125 kg N: P_2O_5: K_2O ha^{-1}) through fertigation on bi-weekly basis resulted in higher plant height (76.3 cm) at 80 days after transplanting, which was on par with the same dose and source applied at weekly interval (74.0 cm). These two treatments recorded higher fruit length (12.63 and 12.27 cm), number of fruits per plant (153.33 and 169.67) and dry weight of 10 fruits (9.00 and 8.63 g), respectively. All the fertigation treatments recorded higher yields over the conventional soil application of fertilizers to the tune of 14.84 to 61.55%. Among the fertigation treatments, application of 100% of fertilizer dose using water soluble fertilizers at bi-weekly interval resulted in significantly higher yield (32.44 t ha^{-1}) compared to all treatments except the treatment where the weekly application of same dose of fertilizer through the same sources (31.81 t ha^{-1}) and 75% of 125:100:125 kg N: P_2O_5: K_2O ha^{-1} was applied weekly or bi-weekly intervals (29.23 and 30.01 t ha^{-1}). Biweekly and weekly application of 100% fertilizer dose of 125:100:125 kg N: P_2O_5: K_2O ha^{-1} through fertigation could yield maximum net income (Rs. 400151 and Rs. 387551 ha^{-1}) with B: C (1.61 and 1.56). However, fertilizer applied to soil resulted in minimum net income of Rs.183054 ha^{-1} and B: C (0.84).

Keywords: Chilli, economics, fertigation, growth, yield

INTRODUCTION

Chilli (*Capsicum annuum* L.), a member of Solanaceae family, is an important spice crop in India. The states such as Andhra Pradesh, Karnataka, Bihar, Tamil Nadu, Uttar Pradesh and Maharashtra, account for 3/4 of the total area. The green chilli is grown in 4.05 lakh hectares with the production of 42.72 lakh tonnes. The productivity of green chilli is approximately 10.54 t ha^{-1} in India, which is low (Anonymous, 2022). The fruits of chilli are rich in vitamin A, C and minerals. Fresh green and ripe chilli are used to make pickles, sauces and paste. The essential oil, oleoresin is used in the food and beverage industries.

Although, it is one of the major crops grown, its yield is quite low. Increase in chilli production can be achieved either bringing more area under its cultivation or by adopting improved varieties and better cultural practices. The second approach is more often preferred and among various cultural practices, proper fertilizer application is one of the quickest and easiest ways of increasing the yield per unit area (Natsheh and Mousa, 2014). Balanced nutrition is one of the most important factor affecting the growth and productivity of the crops. The optimum levels at which the nutrients are to be applied and source from which they have derived are equally important. Nutrients applied to the crop contribute to crop production through yield increase and quality of the produce. Fertigation is an effective means of controlling timing and placement of fertilizers and improving fertilizer use efficiency by reducing losses through leaching, volatilization and fixation in the soil to less available forms (Papadopoulous, 1994). Source of nutrient is also a major contributing factor in yield increase and in the economics of production. Hence, the present experiment was conducted to study the influence of fertigation, its frequency and the source of nutrients on yield of green chilli.

MATERIALS AND METHODS

The experiment was conducted at ICAR-Indian Institute of Horticultural Research, Hesaraghatta, Bengaluru, Karnataka, India during *kharif* of 2017 and 2018. The institute is situated at 13° 7^2 N latitude,

72° 29² E longitude and an elevation of 890 meters above mean sea level. The experimental soil was well drained sandy loam (pH 6.60 and electrical conductivity 0.25 dSm^{-1}) characterized by medium organic carbon (0.63%), low available N (169 kg ha^{-1}), high available P (68 kg ha^{-1}) and medium available K (260 kg ha^{-1}). The soil has available water holding capacity of 130 mm in one-meter soil depth. The experiment was laid out in randomized block design with ten treatments and three replications. Prior to planting, a uniform amount of farmyard manure @ 25.0 t ha^{-1} was applied as basal application to all the treatments as common practice. The treatment details and quantity of different fertilizers applied have been presented in Table 1 and Table 2. The entire dose of P and half of N and K were applied as basal and remaining half of N and K was side dressed to soil in equal splits at 30 and 60 days after transplanting in T_1. Urea, 19:19:19 and sulphate of potash were used as water soluble fertilizers for treatments T_3 to T_{10}, while, urea, single super phosphate and muriate of potash were used as common fertilizers for treatments T_1 and T_2.

Thirty-five days old seedlings of chilli hybrid Arka Meghana were transplanted at 80-40 x 50 cm, under paired row system during first week of July in both the years. Drip irrigation was provided depending on the rate of evaporation and amount of effective rainfall received. The fertigation treatments started after two weeks of planting and fertilizers were applied through drip system at weekly and bi-weekly interval. The treatments were imposed dissolving desired amounts of fertilizers and applied via venturi system through drip irrigation. A total of 16 and 32 number of fertigation were given for weekly and bi-weekly interval, which was continued up to 15 days before completion of crop growth period. Five plants per replication in each of the treatments were selected randomly for recording yield parameters. Recommended package of practices including agronomic and plant protection measures were adopted to raise the crop (Prabhakar et al., 2010). Fertilizer use efficiency of chilli was calculated by using the following formula.

FUE (kg yield kg-NPK^{-1}) = Economic yield (kg ha^{-1}) / total NPK applied (kg ha^{-1})

The experimental data were statistically analysed (Gomez and Gomez, 1983) and compared using critical difference at 5% probability level.

Table 1 : Fertigation treatment details in chilli

Note	Treatment	Fertilizer	Application dose	Basal dose (kg ha^{-1})	Top dressing (kg ha^{-1})	Fertigaton (kg ha^{-1})	Frequency
T_1	100 % fertilizer dose	Common	100% soil application	62.5:100: 62.5	62.5: 0: 62.5	-	-
T_2	(125: 100: 125 kg N:	Common	50% NK fertigation	62.5: 100: 62.5	-	62.5: 0: 62.5	-
T_3	P_2O_5: K_2O ha^{-1})	WSF	100% NPK fertigation	-	-	125: 100: 125	Weekly
T_4		WSF	50% NK fertigation	62.5: 100: 62.5	-	62.5: 0: 62.5	Weekly
T_5	75 % fertilizer dose	WSF	100 % NPK fertigation	-	-	93.75: 100: 93.75	Weekly
T_6	(93.75: 75: 93.75 kg	WSF	50% NK fertigation	46.8: 75: 46.8	-	46.8: 0: 46.8	Weekly
	N: P_2O_5: K_2O ha^{-1})						
T_7	100 % fertilizer dose	WSF	100% NPK fertigation	-	-	125: 100: 125	Bi-weekly
T_8	(125:100:125 kg N:	WSF	50% NK fertigation	62.5: 100: 62.5	-	62.5: 0: 62.5	Bi-weekly
	P_2O_5: K_2O ha^{-1})						
T_9	75 % fertilizer dose	WSF	100% NPK fertigation	-	-	93.75: 100: 93.75	Bi-weekly
T_{10}	(93.75:75:93.75 kg	WSF	50% NK fertigation	46.8: 75: 46.8	-	46.8: 0: 46.8	Bi-weekly
	N: P_2O_5: K_2O ha^{-1})						

WSF: Water soluble fertilizers

Table 2 : Treatment wise fertilizers applied (kg ha^{-1}) under fertigation in chilli

Treatment	Basal dose			Top dressing		Fertigation			
	Urea	Single super phosphate	Muriate of potash	Urea	Muriate of potash	Urea	Muriate of potash	Sulphate of potash	19:19:19
T_1	135.5	625.0	104.5	135.5	104.5	0.00	0.00	0.00	0.00
T_2	135.5	625.0	104.5	-	-	135.5	104.5	-	-
T_3	0.0	0.0	0.0	-	-	54.0	-	50.0	526.0
T_4	135.5	625.0	104.0	-	-	135.5	-	125.0	-
T_5	0.0	0.0	0.0	-	-	40.50	-	37.5	394.0
T_6	102.0	469.0	78.0	-	-	102.0	-	94.0	-
T_7	0.0	0.0	0.0	-	-	54.00	-	50.0	526.0
T_8	135.5	625.0	104.0	-	-	135.5	-	125.0	-
T_9	0.0	0.0	0.0	-	-	40.50	-	37.5	394.0
T_{10}	102.0	469.0	78.0	-	-	102.0	-	94.0	-

RESULTS AND DISCUSSION

Growth parameters

The data pertaining to plant growth at 35, 80 days of transplanting (DAT) and harvest are presented in Fig. 1. Significant differences among the treatments were observed at 80 days after transplanting and harvest. However, 50% of N & K fertigation of the recommended dose through fertigation using water soluble fertilizers (T_4) has recorded the taller plants (55.4 cm) at initial stage of the growth (35 DAT) than other treatments, however, shortest plants (48.1 cm) were observed with T_2, where the common fertilizers were used for soil and fertigations. The treatments shown significant differences for the plant height at 80 DAT and harvest. Application of 100% fertilizer

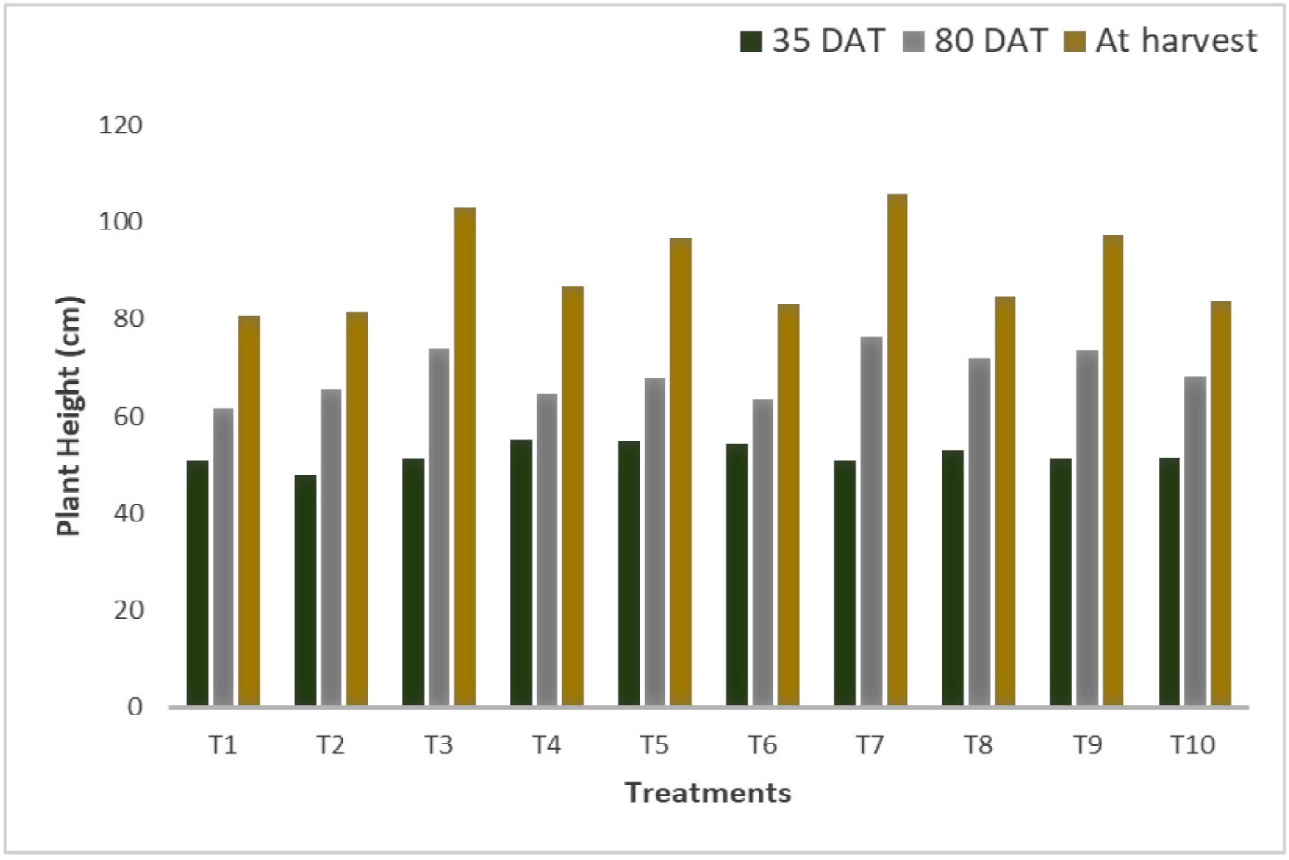

Fig. 1 : Effect of fertigation treatments on plant height (cm)

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dose through fertigation using water soluble fertilizers at bi-weekly interval (T_7) recorded significantly taller plants at 80 DAT (76.3 cm) and harvest (105.7 cm), which remained on par with T_8 (72.0 cm), T_9 (73.6 cm) and T_3 (74.0 cm) at 80 DAT and with only T_3 (103.0 cm) at harvest. The minimum values (61.7 and 80.6 cm) for the plant height was recorded with soil application of nutrients through common fertilizers at 80 days after transplanting and at harvest, respectively.

Different treatments produced significant differences for the number of branches per plant at harvest only (Fig. 2). However, application of 100% fertilizer dose through fertigation using water soluble fertilizers at bi-weekly interval (T_7) recorded higher number of branches per plant (7.8 and 9.2) at 35 and 80 DAT, respectively. The same treatment recorded significantly higher number of branches per plant (13.2) than other treatments except T_3, T_9 and T_{10} (11.8). However, minimum number of branches (9.7) was recorded with soil application of nutrients.

Application of higher dosage of water soluble fertilizers through fertigation produced best results in growth parameters like plant height and number of branches per plant, which might be due to better nutritional environment in the root zone for growth and development of plants, as nitrogen and phosphorus are considered as major nutrients required for proper growth and development of plant. Beside this, nitrogen is the main constituent of protoplasm, cell nucleus, amino acids, chlorophyll and many other metabolic processes like transpiration (Godara et al., 2013). The similar results were also reported by Vinayak et al. (2019) and Chandramohan Reddy et al. (2016).

Yield attributes

The data related to yield attributes has been presented in Table 3. Significantly higher number of fruits per plant was observed in T_3 (169.67), which was on par with T_7 (153.33), T_4 (150.0), T_8 (138.67) and T_9 (132.67), whereas, minimum number of fruits per plant was recorded with T_1 (72.67). The higher availability of soil moisture, optimum NPK nutrients and uptake when supplied through fertigation might have increased the number of fruits per plant. Fertigation might have increased the number of primary branches, shoot growth and potential sites

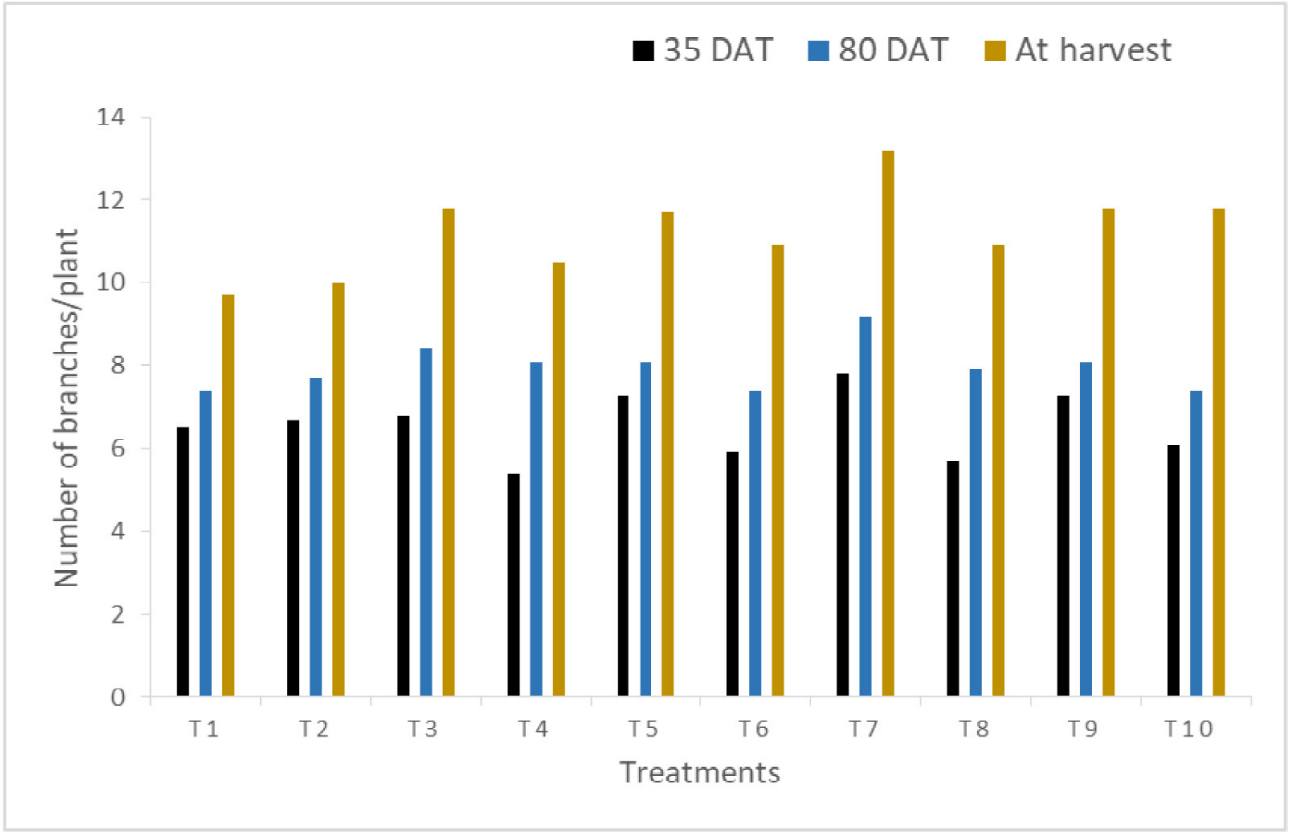

Fig. 2 : Effect of fertigation treatments on number of branches plant^{-1}

Table 3 : Effect of fertigation treatments on yield attributing characters, yield and FUE in chilli

Treatment	Fruits/plant (Nos.)	Fruit length (cm)	Fruit girth (cm)	Ten fruit weight (g)	Dry weight of ten fruits (g)	Yield (t ha^{-1})	Fertiliser use efficiency (kg kg^{-1})
T_1	72.67	10.77	4.05	77.27	6.90	20.08	57.37
T_2	112.33	10.99	4.22	79.33	7.16	23.06	65.89
T_3	169.67	12.27	4.01	86.67	8.63	31.81	90.89
T_4	150.00	11.92	3.89	81.77	8.06	23.67	67.63
T_5	109.67	11.98	4.33	84.53	8.10	29.23	111.35
T_6	112.67	11.03	3.84	79.57	7.43	23.30	88.76
T_7	153.33	12.63	3.81	91.90	9.00	32.44	92.69
T_8	138.67	11.96	4.01	82.27	7.83	27.64	78.97
T_9	132.67	12.19	3.93	85.23	8.40	30.01	114.32
T_{10}	114.67	11.37	3.80	80.60	7.43	24.40	92.95
SEm±	13.69	0.455	0.227	1.63	0.11	1.478	
CD (P=0.05)	40.99	1.36	NS	4.87	0.34	4.424	

where flower could develop. Similar results were also reported by Krishnamoorthy & Noorjehan (2014) and Chandramohan Reddy et al. (2016).

Significantly higher fruit length (12.63 cm) was observed in T_7, which was on par with most of the treatments except T_1 (10.77 cm), T_2 (10.99 cm) and T_6 (11.03 cm). There were no significant differences among the treatments for the fruit girth. However, T_5 recorded the maximum (4.33), while T_{10} recorded the minimum fruit girth (3.80 cm). Similarly, there were significant differences for ten fruit weight and T_7 resulted in significantly higher ten fruit weight (91.90 g), than all other treatments, while minimum ten fruit weight was recorded with T_1 (77.27 g). Bi-weekly application of 100% fertilizer dose through fertigation using water soluble fertilizers (T_7) resulted in significantly higher (9.00 g) dry weight of ten fruits than all other treatments. Weekly application of same amount of fertilizers through fertigation (T_3) recorded the second highest value (8.63 g) followed by T_9 (8.40 g), whereas minimum value (6.90 g) recorded with soil application of nutrients. This may be due to continues nutrient supplied through fertigation in the required and optimum form, which must have helped in healthy growth of plants and increased the fruit length and girth. The present findings are in accordance with the results of Krishnamoorthy and Noorjehan (2014) and Vinayak et al. (2019).

Yield

Irrespective of dosage and source of fertilizer, fertigation treatments were superior to conventional soil application treatment with respect to yield. All the fertigation treatments recorded higher yields over the conventional soil application of fertilizers to the tune of 14.84 to 61.55% (Table 3). Among the fertigation treatments, bi-weekly application of 100 % fertilizer dose through fertigation using water soluble fertilizers (T_7) resulted in significantly higher yield (32.44 t ha^{-1}) than all the other treatments except the treatment T_3, where the weekly application of same amount of fertilizer was given through the same sources (31.81 t ha^{-1}), T_9 (30.01 t ha^{-1}) and T_5 (29.23 t ha^{-1}), where 50% N and K of 75% fertilizer dose was applied through water soluble fertilizers at bi-weekly and weekly interval. Reducing the dosage of NK or NPK fertigation by 25% reduced the yield substantially.

This can be explained on the basis that fertigation saves fertilizer nutrients as it permits applying for fertilizer in small quantity at a time matching with the plants nutrient need. This contributes to an improved availability of moisture, nutrients, and uniform distribution of fertigated nutrients in the crop root zone throughout the growth stages leading to better uptake of nutrients. The enhancing effects

Table 4 : Economics of green chilli crop in relation to fertigation treatments

Treatment	Average yield (t ha^{-1})	Gross investment (Rs. ha^{-1})	Gross income (Rs. ha^{-1})	Net income (Rs. ha^{-1})	B:C ratio
T_1	20.08	218546	401600	183054	0.84
T_2	23.06	218546	461200	242654	1.11
T_3	31.81	248649	636200	387551	1.56
T_4	23.67	224199	473400	249201	1.11
T_5	29.23	238419	584600	346281	1.45
T_6	23.30	220150	466000	245950	1.12
T_7	32.44	248649	648800	400151	1.61
T_8	27.64	224199	552800	328601	1.46
T_9	30.01	238419	600200	361881	1.52
T_{10}	24.40	220150	488000	267850	1.21

Sale price = Rs.20/kg

of NPK on vegetative growth might be attributed to their vital contribution in several metabolic process in plants related to growth (Marschner, 1986). It stimulates the plant vegetative growth to generate leaves, which are able to produce photosynthetic products accumulation required for fruits formation and development and subsequently fruit yield and its attributes. Gireesh et al. (2020) and Vinayak et al. (2019) reported the similar results in chilli crop.

Fertilizer use efficiency

The fertilizer use efficiency was ranged between 65.89 to 114.32 kg kg^{-1} for the fertigation treatments (Table 3). Though, application of 100% fertilizer dose using water soluble fertilizers at bi-weekly interval (T_7) recorded the highest yield (32.44 t ha^{-1}), but the fertilizer use efficiency was higher (114.32 and 111.35 kg kg^{-1}) with the treatments where the 75% of fertilizer dose was applied through fertigation using water soluble fertilizers at bi-weekly and weekly intervals, which was followed by T_{10} (92.95 kg/kg), T_7 (92.69 kg/kg) and T_3 (90.89 kg kg^{-1}), however, minimum fertilizer use efficiency was recorded in soil application of common fertilizers (57.37 kg/kg). Ramachandrappa et al. (2010) also recorded higher fertilizer use efficiency at 75% recommended dose of NPK through fertigation than 100% recommended NPK fertigation in green chilli.

Economics

The averaged data pertaining to economic returns and benefit: cost ratio is presented in Table 4. All the fertigation treatments with water soluble fertilizers resulted in higher gross income than soil application (T_1) and fertigation with common fertilizers (T_2). Among the fertigation treatments, application of 100% fertilizer dose through fertigation on bi-weekly basis (T_7) has resulted in highest gross income (Rs. 648800 ha^{-1}) followed by T_3 *i.e.* same amount of fertilizer given on weekly basis (Rs. 636200 ha^{-1}). As far as net income is concerned, higher values were recorded with T_7 (Rs. 400151 ha^{-1}) and T_3 (Rs. 387551 ha^{-1}). Irrespective of dosage and frequency, fertigation with water soluble fertilizers resulted in higher B: C ratio (1.11 to 1.61) compared to soil application (0.84). Gireesh et al. (2020) and Suman Kumari et al. (2020) also reported maximum net returns and cost : benefit ratio with the application of 100% recommended dose of NPK through fertigation.

CONCLUSION

It can be concluded that application of water soluble fertilizers @ 125:100:125 kg N: P_2O_5: K_2O ha^{-1} during the cropping period through fertigation at bi-weekly intervals resulted in higher yield (32.44 t ha^{-1}), net income of (Rs. 400151 ha^{-1}) and B: C ratio (1.61) in *kharif* grown chilli, which remained on par with application of same amount of water soluble fertilizers through fertigation on weekly basis.

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