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Nutrient availability, nutrient uptake and economics of bottle gourd (*Lagenaria siceraria*) under drip fertigation

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Abstract
During the 2020-2021 period, a field experiment titled "Standardization of fertigation schedule for bottle gourd in the summer season" was conducted. Employing a Randomized Block Design, the experiment comprised ten treatments replicated three times. Bottle gourd crops were manually planted on January 2nd, 2021, with a spacing of 2 x 1 meters. Results indicated that the treatment involving drip irrigation with 100% recommended fertilizer dosage through fertigation according to growth stages (T_1) demonstrated significantly superior growth and yield characteristics for bottle gourd. Notably, this treatment recorded the highest yield at 39.19 tons per hectare. Similarly, it was comparable to treatments T_4 (38.20 t/ha) and T_2 (37.38 t/ha), which involved 100% RDF through fertigation in 18 equal splits and drip irrigation with 80% recommended fertilizer dosage through fertigation according to growth stages, respectively. Soil NPK availability increased with the crop's age, peaking at 60 days after planting (DAP). Treatment T_1 exhibited the highest availability of NPK at 60 DAP (219.3 kg/ha of nitrogen, 28.33 kg/ha of phosphorus, and 358.51 kg/ha of potassium), on par with T_4 and T_2, while T_9 showed the lowest availability. Additionally, the highest total NPK uptake occurred in T_1 at harvest (78.27 kg/ha of nitrogen, 22.04 kg/ha of phosphorus, and 91.80 kg/ha of potassium), with similar results observed in T_4 and T_2, and the lowest nitrogen uptake in T_9. Based on these findings, it can be concluded that drip irrigation with 80% recommended fertilizer dosage through fertigation according to growth stages yields higher production, nutrient availability, and uptake for bottle gourd (var. Samrat) cultivated in medium-deep soils of Maharashtra, offering 20% fertilizer savings.

Keywords: Drip fertigation, Bottle gourd productivity, water soluble fertilizers, water use and economics

Introduction

Bottle gourd (*Lagenaria siceraria*) is a venerable cucurbitaceous crop widely cultivated in India and other tropical regions. In India, it spans 111 thousand hectares, with an annual production of 1836 thousand metric tons. Primary cultivating states include Rajasthan, Gujarat, Punjab, Uttar Pradesh, Bihar, West Bengal, Madhya Pradesh, Maharashtra, Andhra Pradesh, and Tamil Nadu (Anonymous, 2015) [2]. In arid conditions, optimal agricultural production relies heavily on irrigation. Traditional surface irrigation methods consume more water compared to pressurized systems like sprinkler and drip irrigation. The escalating demand for food coupled with diminishing water resources necessitates innovative technologies for efficient water and fertilizer use in agriculture.

Drip irrigation, a pressurized method, delivers water in portions to the plant root zone, significantly reducing water usage. Studies indicate water savings of 30% to 70% and yield increases of 20% to 90%, contingent on factors like soil, climate, crop characteristics, and proper system management (Postel *et al*., 2001; Çetin and Bilgel, 2002) [5, 14]. Additionally, water use efficiency rises by at least 50% (Chartzoulakis and Bertaki, 2015) [6]. Drip irrigation advantages include water conservation (30–50%), increased crop yield, optimal water utilization, and prevention of water availability for weeds.

Fertigation, the application of fertilizers through irrigation water, is integral to modern irrigated agriculture. Localized systems like drip irrigation enhance water and fertilizer efficiency.

Combining irrigation and fertilization is a widely adopted global practice (Yan *et al*, 2018) [18]. Drip irrigation proves ideal for fertigation, enabling precise application of water-soluble fertilizers to the plant's root zone (Chartzoulakis and Bertaki, 2015) [6].

Fertigation offers benefits such as healthier plants, rapid nutrient absorption, uniform nutrient distribution, reduced labor, lower water use, and enhanced fertilizer use efficiency. It saves 20-40% of fertilizer, maintains crop growth and yield, and reduces labor and energy in fertilizer application (Papadopoulos, 1995) [12]. Drip irrigation with fertigation is gaining momentum in contemporary crop production, addressing the crucial factors of water and nutrient scarcity in Indian agriculture. Despite India's extensive irrigation network and fertilizer usage, low efficiency emphasizes the need to maximize production per unit of water and nutrient. Consequently, considering fertilizer quantity, timing, crop stage, and nutrient demand during fertigation becomes imperative for achieving higher efficiency, yield, and economic returns. The present study aims to explore the response of bottle gourd under fertigation.

Materials and Methods

A field experiment conducted at the Research Farm of Interfaculty Department of Irrigation water Management, Post Graduate Institute, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar, Maharashtra, India, during summer season of 2020-2021 with objectives, to standardize the fertigation schedule for bottle gourd crop of Samrat variety to study the effect of fertigation on growth and yield of bottle gourd crop along with economics of bottle gourd crop using water soluble fertilizers. Geographically, the central campus of Mahatma Phule Krishi Vidyapeeth, Rahuri situated between 19^0 47' and 19^0 57' N latitude and between 74^0 19' and 74^0 32' E longitude. The altitude is 495 to 555 m above the mean sea level. Climatologically, the area falls under semi-arid and subtropical zone. The topography of experimental field was uniform and leveled. The soil of experimental field was well drained with 45 cm soil depth. Representative and composite soil sample was collected from experimental site for assessing the initial soil fertility status of the soil. The infiltration rate of the soil was 3.15 cm hr^{-1}.The soil was slightly alkaline in reaction (pH 7.9). The soil was low in available nitrogen (168 kg ha^{-1}), medium in available phosphorus (18 kg ha^{-1}) and high in available potassium (334.00 kg ha^{-1}). The mean values of moisture constants viz., field capacity and permanent wilting point were 38.4% and 19%, respectively. The bulk density of soil was 1.2 Mg m^{-3}.

The experiment comprised of ten treatments, T_1- Drip irrigation with 100% recommended dose of fertilizer through fertigation as per growth stages, T_2- Drip irrigation with 80% recommended dose of fertilizer through fertigation as per growth stages, T_3- Drip irrigation with 60% recommended dose of fertilizer through fertigation as per growth stages, T_4- Drip irrigation with 100% recommended dose of fertilizer through fertigation in 18 equal weekly splits, T_5- Drip irrigation with 80% recommended dose of fertilizer through fertigation in 18 equal splits, T_6- Drip irrigation with 60% recommended dose of fertilizer through fertigation in18 equal splits, T_7- Drip irrigation with 100% recommended dose of conventional fertilizer (N and K – drip and P- soil), T_8- Drip irrigation with 100% recommended dose of conventional fertilizer (soil), T_9 – Drip irrigation with no fertigation, T_{10} - Surface irrigation with 100% recommended dose of conventional fertilizer.

The water soluble fertilizers of different grades were used for fertigation. The fertigation was scheduled at every week commencing from first days after planting as per the treatments. Urea, urea phosphate (17:44:00) and white MOP grade WSF were used for fertigation. The quantity of WSF was calculated as per fertigation schedules (18 splits) and dissolve separately in ten liters of water. The dissolved solution of WSF was poured in fertilizer tank and mixed gently. Then with the help of automatic fertigation unit the fertigation was applied weekly. In fertigation treatment T_1 to T_3 the fertilizer were applied in 18 splits as per the growth stages of the crop (Table 1) and in treatment T_4 to T_6 the fertilizer were applied in 18 equal weekly splits. In treatment T_7 the entire N and K is applied through urea and muriate of potash in 18 equal splits through drip fertigation and the P is applied through single supper phosphate as a basal dose in soil. In conventional practice of fertilizer application (T_8 and T_{10}), 50% N and full dose of P and K was applied as a basal dose and remaining 50% dose is applied 30 DAP and 45 DAP in equal quantity.

Table 1: Application of fertilizer as per growth stages in 18 weekly splits

Days After Planting	Nutrients (%)		
	Nitrogen	Phosphorus	Potassium
01-35 (5 weeks)	25	30	15
36-70 (5 weeks)	35	35	35
71-105 (5 weeks)	30	25	30
106-126 (3 weeks)	10	10	20
Total	100	100	100

The crop was planted on January 2nd, 2021, with a spacing of 1 meter between plants and 2 meters between rows. Plant protection measures were implemented according to recommended practices. Drip irrigation was administered every other day. Soil samples were collected from the experimental field at 30, 60, and 90 days after planting, as well as at harvest, from a depth of 0-20 cm. These samples were thoroughly mixed, air-dried, ground in a mortar and pestle, and passed through a 2 mm sieve. Periodic assessments of available nitrogen, phosphorus, and potassium were conducted using standard methods. At harvest, bottle gourd plants and fruits were collected for chemical analysis. The plant samples were air-dried, then dried in an oven at 65 °C until a constant weight was achieved. Subsequently, the samples were finely ground into powder and analyzed for total nitrogen, phosphorus, and potassium content using standard methods.

The total cultivation expenses comprised the cost of cultivation and fixed expenses on irrigation systems, which were higher in drip irrigated treatments. This was attributed to the increased cost of water-soluble fertilizers and drip system installation. Seasonal income netted out expenses and reflected returns from fruit yield. Total net income included seasonal returns and additional earnings from irrigating extra land, made possible by water savings from drip irrigation.

The net additional income per hectare resulting from various treatments was determined by subtracting the net seasonal income of the control treatment from the net seasonal income of each respective treatment. The statistical analysis was performed by using analysis of variance (ANOVA) for randomized block design as per Panse and Sukhatme (1985) [11].

Results and Discussion

Yield and yield contributing characters

The data regarding yield of bottle gourd in tonnes per hectare was found maximum in treatment T_1 (39.19 t ha^{-1}). However it was at par with the treatment T_4 (38.20 t ha^{-1}) and T_2 (37.38 t ha^{-1}). The minimum yield is found in the treatment T_9 (22.5 t ha^{-1}). The treatment T_1 produced 22.70 percent higher yield than that of the control treatment *i.e.* T_8. The treatment T_4 produced 19.60 percent higher yield than that of control and T_2 produced 17.03 percent higher yield than that of control treatment. The number of fruits increased with increase in level of fertilizers. These results are in agreement with Hegade and Srinivas (1989) [8] in tomato. Mahajan and Singh (2006) reported increase in tomato yield due to fertigation as compared to conventional method of irrigation and fertilizer application. The significantly minimum weight of fruits plant^{-1} was observed in drip irrigation with no fertilizer (1.19 kg) followed by surface irrigation with 100% recommended dose of conventional fertilizer (1.66 kg). (Chartzoulakis and Bertaki, 2015) [6].

Soil Nutrient Availability

Availability of Nitrogen in Soil

The nitrogen availability in the root zone soil of bottle gourd was found to be influenced by period and levels of fertilizers and increased with increase in age of the crop and was maximum at 60 DAP.

The average nitrogen availability in soil was 186.57, 206.42, 188.51 and 174.83 kg ha^{-1} at 30, 60, 90 DAP and at harvest, respectively. The nitrogen availability increased with period from planting to 60 DAP and there after decreased up to harvesting stage in all the treatments. The decreased nitrogen availability in soil after 60 DAP may be due to higher uptake of nitrogen by plants at flower initiation and fruit development stage. The levels of fertilizer had influenced the nitrogen availability in soil up to some extent.

At 30 DAP the significantly higher availability of nitrogen (205.00 kg ha^{-1}) was observed in T_8 i.e. drip irrigation with 100% RD of CF. However it was at par with treatment of surface irrigation with 100% RD of CF (T_{10}). It might be due to application of half recommended dose of nitrogen as a basal dose at the time of planting in T_8 and T_{10}. At 60 and 90 DAP, the significantly highest nitrogen (219.33 and 198.63 kg ha^{-1}) availability is recorded in drip irrigation with 100% RDF through fertigation as per growth stages over other treatments, however it is at par with treatment of drip irrigation with 100% RDF through fertigation in 18 equal weekly splits (T_4). The lowest nitrogen availability was recorded in T_9 treatment.

At harvest the significantly higher nitrogen (180.00 kg ha^{-1}) availability is recorded in drip irrigation with 100% RD of CF (T_8), however it is at par with the treatment of drip irrigation with 100% RD of CF (N and K – drip and P – soil) T_7. The higher availability of nitrogen under drip irrigation with 100% RD of CF (T_8) is might be due to its low uptake of nitrogen as compare to fertigation treatments. These results are in close conformity with those reported by Ananda *et al*., (2020) [1] in ridge gourd and Varughese *et al*., (2014) [16] in okra crop.

Available phosphorus in soil

The phosphorus availability in the root zone soil was found to be influenced by period and levels of fertilizers and increased with increase in age of the crop and was maximum at 60 DAP.

The average phosphorus availability in soil was 22.30, 25.60, 21.36 and 18.70 kg ha^{-1} at 30, 60, 90 DAP and at harvest, respectively. The phosphorus availability was increased with period from planting to 60 DAP and there after decreased up to harvesting stage in all the treatments. Decreased availability of phosphorus after 60 DAP due to higher uptake of phosphorus at fruit formation and fruit maturation stage.

At 30 DAP, the significantly higher availability of phosphorus (25.33 kg ha^{-1}) was observed in T_8 i.e. drip irrigation with 100% RD of CF. However, it was at par with treatment of surface irrigation with 100% RD of CF (T_{10}) and drip irrigation with 100% RD of CF (N and K – drip and P – soil) T_7. It might be due to application of full recommended dose of phosphorus as a basal dose at the time of planting.

At 60 and 90 DAP the significantly highest phosphorus (28.33 and 24.71 kg ha^{-1}) availability is recorded in drip irrigation with 100% RDF through fertigation as per growth stages over other treatments, however it is at par with treatment of drip irrigation with 100% RDF through fertigation in 18 equal weekly splits (T_4). The lowest phosphorus availability was recorded in T_9 treatment.

At harvest, the significantly higher phosphorus (19.90 kg ha^{-1}) availability is recorded in drip irrigation with 100% RD of CF (T_8), however, it is at par with the treatment of drip irrigation with 100% RD of CF (N and K – drip and P – soil) T_7. The higher availability of phosphorus under drip irrigation with 100% RD of CF is might be due to its low uptake of nutrient as compare to fertigation treatments. These results are in close conformity with those reported by Ananda *et al*., (2020) [1] in ridge gourd, Madhusoodana (2016) [10] and Balsubramanian *et al*., (2000) [3] in cotton crop.

Available Potassium in Soil

The potassium availability in the root zone soil was found to be influenced by period and levels of fertilizers and increased with increase in age of the crop and was maximum at 60 DAP.

The average potassium availability in soil was 349.57, 358.10, 350.35 and 338.09 kg ha-1 at 30, 60, 90 DAP and at harvest, respectively.

The K availability was increased with period from planting to 60 DAP and there after decreased up to harvesting stage in all the treatments. The decreased potassium availability in soil after 60 DAP may be due to higher uptake of potassium by plants at fruit initiation and fruit maturation stage. The level of fertilizer had influenced the potassium availability in soil up to some extent.

At 30 DAP, the significantly higher availability of potassium (358.33 kg ha^{-1}) was observed in T_8 i.e. drip irrigation with 100% RD of CF. However, it was at par with treatment of surface irrigation with 100% RD of CF (T_{10}). It might be due to application of full recommended dose of potassium as a basal dose at the time of planting.

At 60 and 90 DAP the significantly highest potassium (368.51 and 352.16 kg ha^{-1}) availability is recorded in drip irrigation with 100% RDF through fertigation as per growth stages over other treatments, however it is at par with treatment of drip irrigation with 100% RDF through fertigation in 18 equal weekly splits (T_4). The lowest potassium availability was recorded in T_9 treatment.

At harvest the significantly higher potassium (343.20 kg ha^{-1}) availability is recorded in drip irrigation with 100% RD of CF (T_8), however it is at par with the treatment of drip irrigation with 100% RD of CF (N and K – drip and P – soil) T_7. The higher availability of potassium under drip irrigation with 100% RD of CF is might be due to its low uptake of potassium as compare to fertigation treatments. These results are in close conformity with those reported by Ananda *et al*., (2020) [1] in ridge gourd and Varughese *et al*., (2014) [16] in okra crop.

Table 2: Available NPK in soil influenced by different treatment

Tr. No.	Treatment	Available nitrogen (kg ha^{-1})				Available phosphorous (kg ha^{-1})				Available potassium (kg ha^{-1})			
		30 DAP	60 DAP	90 DAP	At harvest	30 DAP	60 DAP	90 DAP	At harvest	30 DAP	60 DAP	90 DAP	At harvest
T_1	DI with 100% RDF as per growth stages	188.33	219.33	198.63	175.00	22.67	28.33	24.71	17.25	351.67	368.51	352.16	340.10
T_2	DI with 80% RDF as per growth stages	187.67	215.00	193.40	172.44	22.33	25.67	20.80	16.74	346.67	362.44	352.30	338.67
T_3	DI with 60% RDF as per growth stages	174.67	201.33	180.33	168.00	21.67	23.33	19.68	15.40	343.33	351.00	343.58	335.00
T_4	DI with 100% RDF in 18 equal weekly splits	187.33	218.00	196.76	174.00	22.33	27.70	23.21	17.15	350.33	367.74	356.72	339.00
T_5	DI with 80% RDF in 18 equal weekly splits	183.33	210.33	192.75	171.67	20.67	24.77	20.58	16.17	345.67	361.02	351.33	337.54
T_6	DI with 60% RDF in 18 equal weekly splits	174.67	200.39	178.33	167.67	21.00	22.33	18.98	15.00	342.67	350.33	342.20	334.43
T_7	DI with 100% RD of CF (N & K – drip and P – soil)	190.4	213.67	194.27	176.88	23.70	26.33	22.05	19.00	350.00	355.33	354.33	342.20
T_8	DI with 100% RD of CF (soil)	205.00	211.67	191.73	180.00	25.33	26.00	21.23	19.90	358.33	364.67	353.11	343.20
T_9	DI with no fertigation	168.00	166.67	164.00	158.89	18.00	16.33	14.55	13.33	334.33	330.00	325.67	323.58
T_{10}	Surface irrigation with 100% RD of CF	203.40	208.56	191.42	178.80	24.00	25.00	20.58	19.33	357.67	363.33	350.33	340.69
	SE (±)	1.00	1.07	0.86	0.91	0.71	0.55	0.52	0.66	1.01	0.80	0.81	0.97
	CD at 5%	3.00	3.18	2.63	2.73	2.12	1.66	1.56	1.98	3.01	2.39	2.42	2.90
	General mean	186.57	206.42	188.51	174.83	22.30	25.60	21.36	18.70	349.57	358.10	350.35	338.09

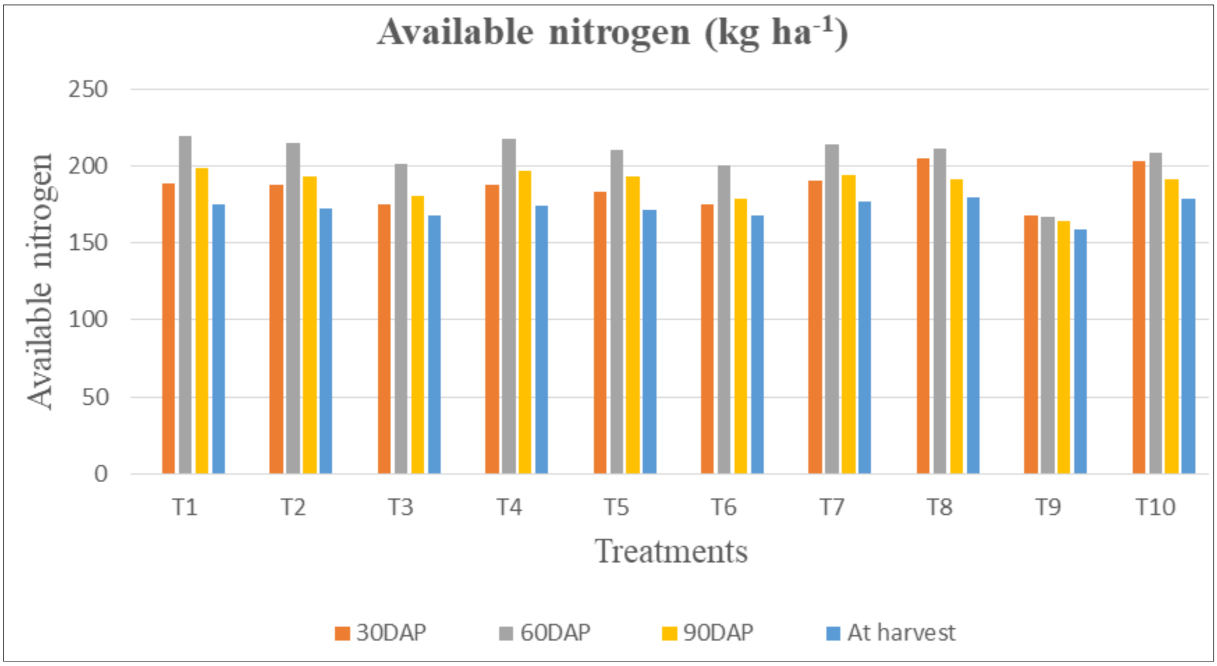

Fig 1: Available nitrogen in soil influenced by different treatments

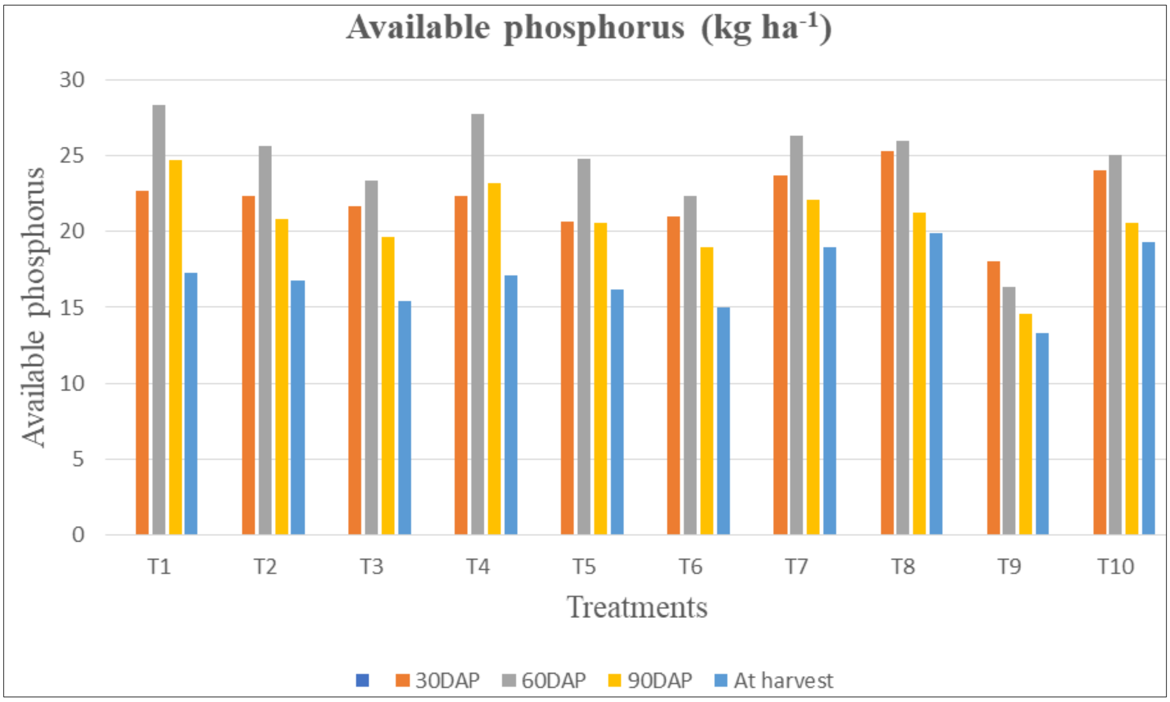

Fig 2: Available phosphorus in soil influenced by different treatments

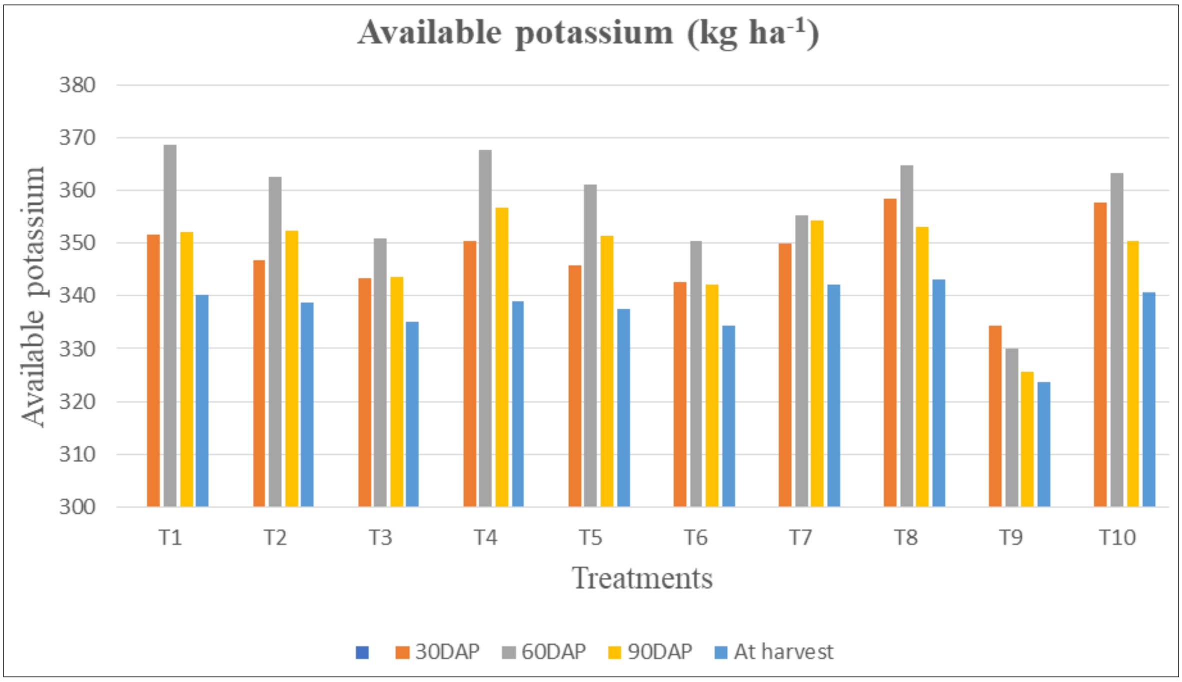

Fig 3: Available potassium in soil influenced by different treatments

Table 3: Nutrient use efficiency influenced by different treatments

Tr. No.	Treatment	Nutrient applied (kg)	Yield (t/ha)	Nutrient use efficiency (kg Yield / kg nutrient)
T_1	DI with 100% RDF as per growth stages	200	39.19	83.45
T_2	DI with 80% RDF as per growth stages	160	37.38	93.00
T_3	DI with 60% RDF as per growth stages	120	27.38S	40.66
T_4	DI with 100% RDF in 18 equal weekly splits	200	38.20	78.25
T_5	DI with 80% RDF in 18 equal weekly splits	160	36.25	85.93
T_6	DI with 60% RDF in 18 equal weekly splits	120	26.33	31.91
T_7	DI with RD of CF (N &K –Drip and P- soil)	200	34.38	59.40
T_8	DI with 100% RD of CF (soil)	200	31.94	47.20
T_9	DI with no fertigation	0	22.50	0
T_{10}	Surface irrigation with 100% RD of CF	200	29.69	35.95

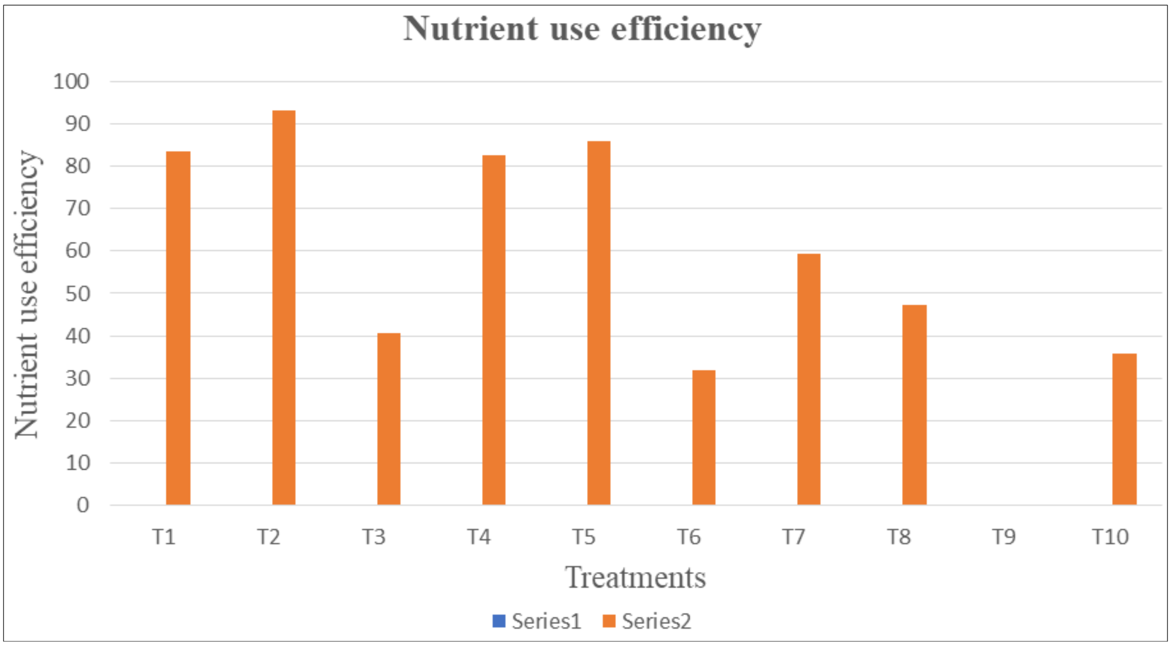

Fig 4: Nutrient use efficiency is influenced by different treatments

Table 4: Total nitrogen uptake in bottle gourd influenced by different treatments

Tr. No.	Treatment	Nitrogen (kg ha^{-1})					
		30 DAP	60 DAP	90 DAP	At harvest		
					Vine	Fruit	Total
T_1	DI with 100% RDF as per growth stages	9.28	22.92	53.51	67.94	10.33	78.27
T_2	DI with 80% RDF as per growth stages	8.24	21.51	51.31	65.75	9.33	75.08
T_3	DI with 60% RDF as per growth stages	8.68	19.78	44.87	55.18	7.67	62.82
T_4	DI with 100% RDF in 18 equal weekly splits	9.23	21.93	52.50	66.56	9.50	76.06
T_5	DI with 80% RDF in 18 equal weekly splits	8.09	20.28	50.12	65.00	9.00	74.5
T_6	DI with 60% RDF in 18 equal weekly splits	8.50	19.40	43.13	56.74	6.67	63.41
T_7	DI with RD of CF (N &K-Drip and P- soil)	9.40	21.19	49.23	64.30	9.27	73.57
T_8	DI with 100% RD of CF (soil)	9.75	21.01	49.05	64.46	8.97	73.43
T_9	DI with no fertigation	8.20	18.15	39.67	54.21	6.33	60.54
T_{10}	Surface irrigation with 100% RD of CF	9.58	20.16	48.86	64.11	7.33	71.44
	SE (±)	0.12	0.27	0.41	0.38	0.36	0.33
	CD at 5%	0.36	0.81	1.24	1.13	1.07	0.97
	General mean	9.01	20.68	48.22	62.38	8.41	70.81

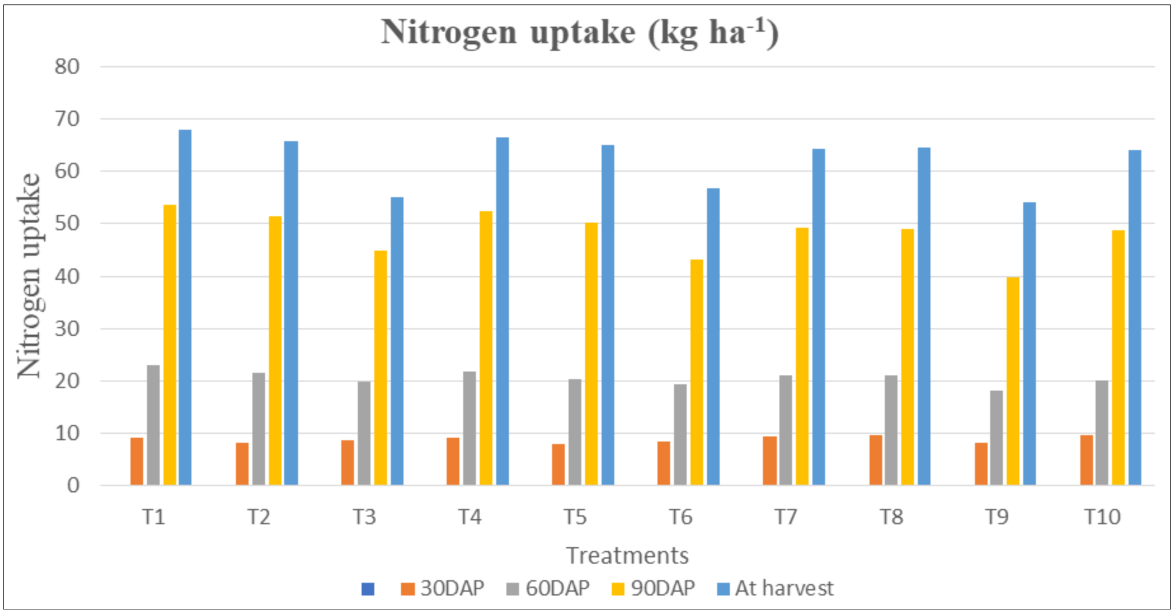

Fig 5: Total nitrogen uptake in bottle gourd influenced by different treatments

Table 5: Total phosphorus uptake by bottle gourd

Tr. No.	Treatment	Phosphorus (kg ha^{-1})					
		30 DAP	60 DAP	90 DAP	At harvest		
					Vine	Fruit	Total
T_1	DI with 100% RDF as per growth stages	2.35	4.56	10.15	12.84	9.20	22.04
T_2	DI with 80% RDF as per growth stages	2.22	4.14	8.84	11.50	8.98	20.48
T_3	DI with 60% RDF as per growth stages	1.79	3.34	6.46	9.73	7.38	17.11
T_4	DI with 100% RDF in 18 equal weekly splits	2.32	4.31	9.05	11.80	9.20	21.00
T_5	DI with 80% RDF in 18 equal weekly splits	2.02	4.01	8.27	11.81	5.80	17.61
T_6	DI with 60% RDF in 18 equal weekly splits	1.70	3.11	5.87	9.44	7.21	16.65
T_7	DI with RD of CF (N &K-Drip and P- soil)	2.43	3.79	8.03	10.76	8.50	19.26
T_8	DI with 100% RD of CF (soil)	2.58	3.70	7.86	10.57	8.11	18.68
T_9	DI with no fertigation	1.69	2.84	4.94	8.28	6.60	14.88
T_{10}	Surface irrigation with 100% RD of CF	2.46	3.42	7.13	10.49	7.75	18.24
	SE (±)	0.06	0.14	0.43	0.42	0.07	0.52
	CD at 5%	0.18	0.42	1.31	1.26	0.22	1.56
	General mean	2.15	3.69	7.55	10.92	7.87	18.80

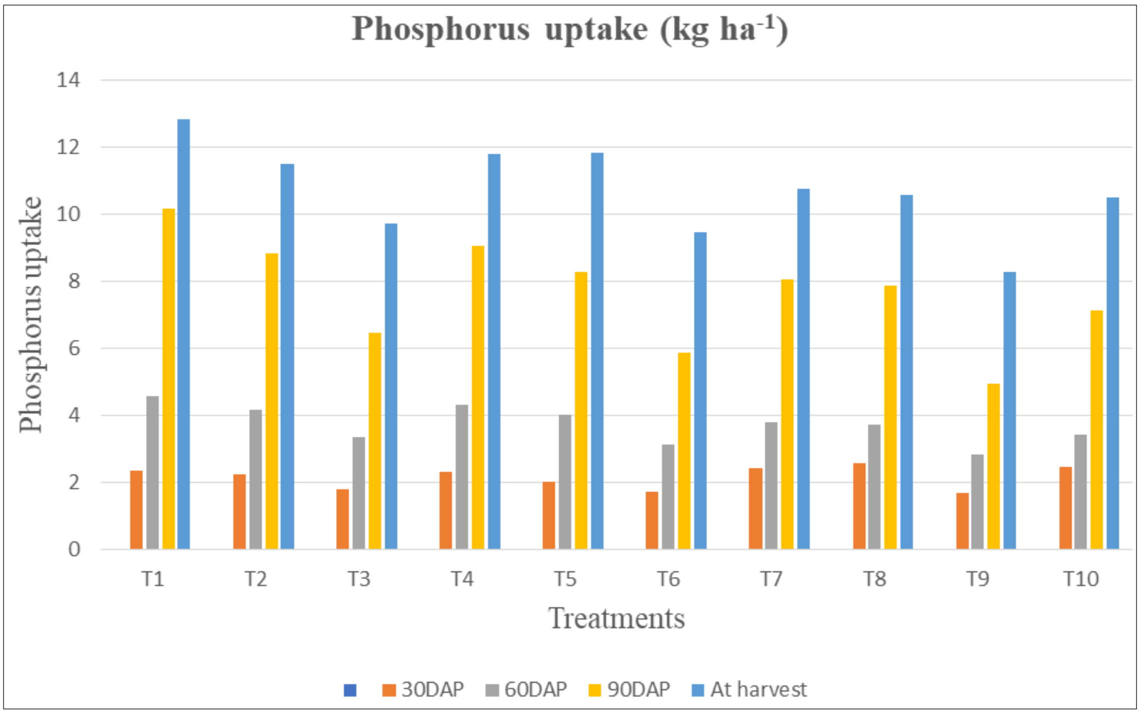

Fig 6: Total phosphorus uptake in bottle gourd influenced by different treatments

Table 6: Total potassium uptake by bottle gourd

Tr. No.	Treatment	Potassium (kg ha^{-1})					
		30 DAP	60 DAP	90 DAP	At harvest		
					Vine	Fruit	Total
T_1	DI with 100% RDF as per growth stages	9.18	25.30	57.03	71.21	19.67	91.88
T_2	DI with 80% RDF as per growth stages	8.31	23.78	55.74	70.37	18.33	88.70
T_3	DI with 60% RDF as per growth stages	7.98	21.64	44.46	57.76	14.67	72.43
T_4	DI with 100% RDF in 18 equal weekly splits	8.98	24.27	56.03	70.94	18.67	89.61
T_5	DI with 80% RDF in 18 equal weekly splits	8.20	23.46	53.03	69.11	17.33	86.44
T_6	DI with 60% RDF in 18 equal weekly splits	8.00	20.44	42.13	55.54	14.3	69.84
T_7	DI with RD of CF (N &K-Drip and P- soil)	10.35	23.02	51.82	65.34	17.3	82.64
T_8	DI with 100% RD of CF (soil)	10.61	22.76	51.39	65.44	17.33	82.77
T_9	DI with no fertigation	8.44	18.04	37.62	51.54	13.33	64.87
T_{10}	Surface irrigation with 100% RD of CF	10.35	22.08	50.43	64.17	16.00	80.17
	SE (±)	0.30	0.47	1.04	0.45	0.46	0.03
	CD at 5%	0.91	1.40	3.11	1.34	1.37	3.10
	General mean	9.64	22.38	49.91	64.14	16.70	80.93

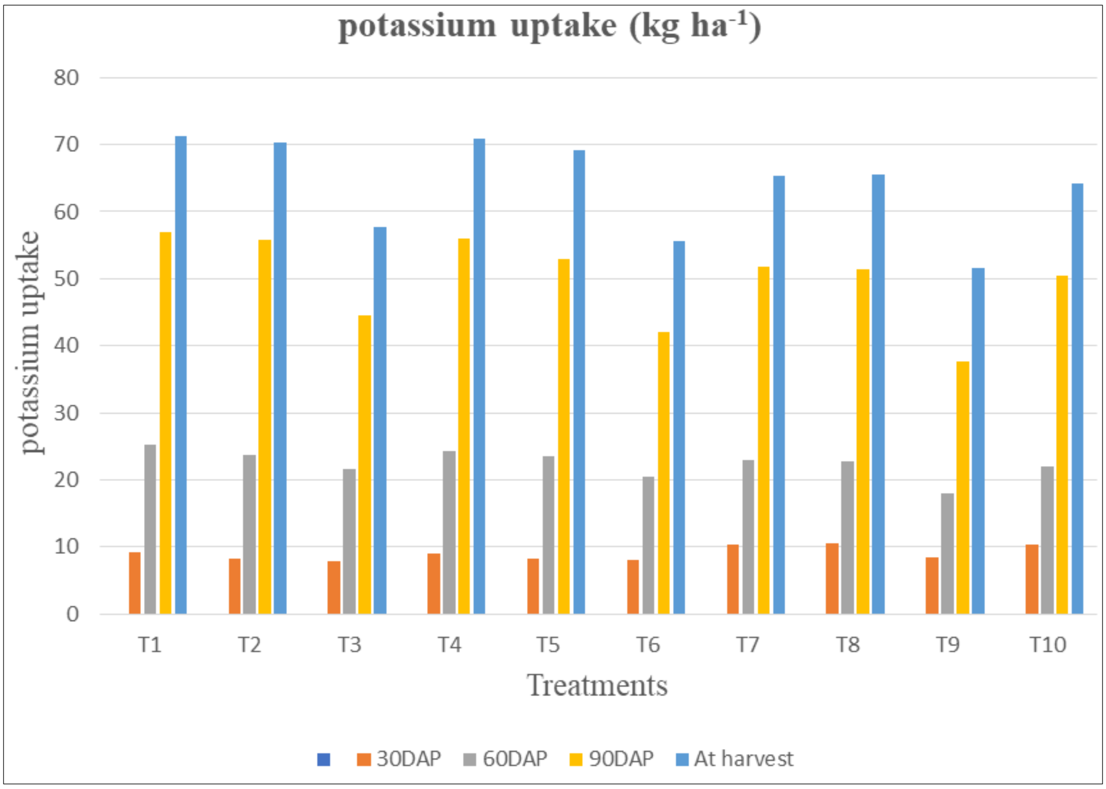

Fig 7: Total potassium uptake in bottle gourd influenced by different treatments

Table 7: Average weight of fruits vine^{-1} and yield of bottle gourd ha^{-1} influenced by different treatments

Tr. No.	Treatment	Weight of fruits per vine	Fruit yield (t ha^{-1})	% Increased over T_8
T_1	DI with 100% RDF as per growth stages	8.00	39.19	22.70
T_2	DI with 80% RDF as per growth stages	7.50	37.38	17.03
T_3	DI with 60% RDF as per growth stages	5.50	27.38	-14.28
T_4	DI with 100% RDF in 18 equal weekly splits	7.90	38.20	19.60
T_5	DI with 80% RDF in 18 equal weekly splits	7.33	36.25	13.49
T_6	DI with 60% RDF in 18 equal weekly splits	5.31	26.33	-17.56
T_7	DI with 100% RD of CF (N & K-drip and P-soil)	7.00	34.38	7.56
T_8	DI with 100% RD of CF (soil)	6.50	31.94	0
T_9	DI with no fertigation	4.50	22.5	-29.56
T_{10}	Surface irrigation with 100% RD of CF	6.00	29.69	-7.04
	SE (±)	0.30	1.29	
	CD at 5%	0.90	3.85	
	General mean	6.55	31.4	

Table 8: Economics of bottle gourd

Tr. No.	Cost of cultivation	Gross monetary return (Rs ha-1)	Net monetary return (Rs ha-1)	Net extra income over T_8 (Rs ha^{-1})	B:C ratio	Water productivity ((Rs/mm of water used)
T1	92022	391900	284434	67313	3.65	575
T2	89814	373800	268543	51420	3.55	542
T3	87607	273800	170750	-46373	2.66	345
T4	92022	382000	274535	57413	3.55	571
T5	89814	362500	257243	40120	3.44	520
T6	87607	263300	160250	-56873	2.56	324
T7	86835	343800	241522	24400	3.36	488
T8	86835	319400	217122	00	3.12	439
T9	79587	225000	129970	-87153	2.37	263
T10	88232	296900	200668	-16454	3.09	229

Nutrient use efficiency

The highest nutrient use efficiency is observed in the treatment of drip irrigation with 80% RDF through fertigation as per growth stages (T_2) i.e. 93 kg yield kg^{-1}. The minimum fertilize use efficiency is observed in the treatment of surface irrigation with 100% RD of CF (T_{10}) i.e. 35.95 kg yield kg^{-1}. These result are in confirmation with research finding of Bharambe *et al*., (1997) [4] in hybrid cotton.

Nutrient use efficiency determine the efficient use of the fertilizer in a crop. It gently impact on the management of the fertilizer. As the treatment T_2 having a maximum nutrient use efficiency as compared to the recommended dose of fertilizer of bottle gourd, it implies that there is 20% saving of the fertilizers in the treatment T_2. Similar results were reported by Veeranna *et al*., (2002) [17] that decreasing fertilizer level by 20% than the recommended level especially under fertigation may not affect the yield level in chilli because of improved fertilizer use efficiency.

Total nitrogen uptake

At 30 DAP, the highest uptake of nitrogen of 9.75 kg ha^{-1} is observed in the treatment of drip irrigation with 100% RD of CF (T_8). However, it is at par with surface irrigation with 100% RD of CF (T_{10}) and drip irrigation with 100% RD of CF (N & K – drip and P – soil) T_7. The highest uptake of N was observed in drip irrigation with 100% RD of CF might be due to application of half recommended dose of N as a basal at the time of planting.

At 60, 90 DAP and at harvest the highest uptake of nitrogen (22.92, 53.51 and 78.27 kg ha^{-1}) is recorded in the treatment of drip irrigation with 100% RDF through fertigation as per growth stages (T_1). However, it is at par with the treatment of drip irrigation with 100% RDF through fertigation in 18 equal weekly splits (T_4) and drip irrigation with 80% RDF through fertigation as per growth stages (T_2). It is also remained at par with T_5, drip irrigation with 80% RDF through fertigation in 18 equal weekly splits at 60 and 90 DAP.

The increase in nitrogen uptake in T_1 may due to the better availability of nutrients in the root zone as a result of frequent application of nutrients through fertigation. Similar observations of increased nutrient uptake as a result of water soluble fertilizers have resulted in lesser leaching of N and K is reported by Singhandhupe *et al*., (2003) and Patil *et al*., (2009) [13].

Total Phosphorus Uptake

The mean uptake of phosphorus at 30, 60, 90 DAP and at harvest is 2.15, 3.69, 7.75 and 10.92 kg ha^{-1} respectively.

At 30 DAP, the highest uptake of phosphorus (2.58 kg ha^{-1}) is observed in treatment of drip irrigation with 100% RD of CF (T_8). However, it is at par with treatment of surface irrigation with 100% RD of CF (T_{10}) and drip irrigation with 100% RD of CF (N & K – drip and P – soil) T_7. The highest uptake of P was observed in T_8 might be due to the application of full recommended dose of P as a basal at the time of planting.

At 60, 90 DAP and at harvest the maximum uptake of phosphorus (4.56, 10.15 and 22.04 kg ha^{-1}) is observed in treatment T_1 and it is at par with the treatment of drip irrigation with 100% RDF through fertigation in 18 equal weekly splits (T_4) and drip irrigation with 100% RDF through fertigation as per growth stages (T_2).

The significantly maximum nutrient uptake in the fertigation treatments might be due to availability of sufficient moisture in root zone of the crop of the crop as per growth stages. Similar result were reported by Patil *et al*., (2009) [13] and Imamsaheb *et al*., (2011) [9].

Total Potassium Uptake

The flow of water, nutrients, and carbohydrates within plants is correlated with potassium. its connection to the activation of plant enzymes that impact the synthesis of carbohydrates, protein, and adenosine triphosphate. K has a significant influence on the bottle gourd's yield because ATP synthesis can control the rate of photosynthesis. (Grozdova 1970) [7].

The mean uptake of potassium at 30, 60, 90 DAP and at harvest is 9.64, 22.38, 49.91 and 80.93 kg ha^{-1} respectively.

At 30 DAP, the highest uptake of potassium (10.61 kg ha^{-1}) is observed in treatment of drip irrigation with 100% recommended dose of conventional fertilizer (T_8), however it is at par with treatment of surface irrigation with 100% recommended dose of convetional fertilizer (T_{10}) and T_7 i.e. drip irrigation with 100% recommended dose of conventional fertilizer (N & K – drip and P – soil). The highest uptake of K was observed in T_8 i.e. drip irrigation with 100% recommended dose of conventional fertilizer might be due to application of full recommended dose of K as a basal dose at the time of planting.

At 60, 90 DAP and at harvest the maximum uptake of potassium (25.30, 57.03 and 91.80 kg ha^{-1}) is in treatment of drip irrigation with 100% recommanded dose of fertilizer through fertigation as per growth stages (T_1) and it is at par with the treatment of drip irrigation with 100% recommanded dose of fertilizer through fertigation in 18 equal weekly splits (T_4) and drip irrigation with 80% recommanded dose of fertilizer through fertigation as per growth stages (T_2). These results are in confirmation with the research findings of Patil *et al*., (2009) [13] in cotton crop.

Conclusions

Based on the results, drip irrigation combined with fertigation according to development stages and the 80% recommended fertilizer dose is the best way to maximize production, minimize water usage, and maximize financial returns from bottle gourd crops. (var. Samrat) grown in Maharashtra's medium-deep soil while using 20% less fertilizer.

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Study area/Sample Collection: PGI Farm, Rahuri, 413 722

Cultivar / Variety / Breed name: Bottle Gourd, Samrat

Conflict of Interest: None declared

Ethical approval: There are no studies by any of the writers of this article that involve human subjects or animals.
Ethical Committee Approval Number:

Ethical Committee Approval Number: Institutional Animal Ethics Committee (IAEC) -if the project involves field trails/experiments/exchange of specimens, human & animal materials etc.

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