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RESEARCH PAPER

Response of maize (*Zea mays* L.) to varying fertigation levels under drip irrigation in Ghataprabha command area

SIDDANAGOUDA PATIL[1*], B. N. ARAVINDA KUMAR[1], SHIVANAND HONNALI[1], P. S. KANANNAVAR[2] AND B. C. PUNITHA[3]

[1]Department of Agronomy, [2]Department of Agril. Engineering, [3]Department of Soil Science and Agril. Chemistry
College of Agriculture, Dharwad - 580 005
University of Agricultural Sciences, Dharwad - 580 005, India
*E mail: siddarthpatil48@gmail.com

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Abstract: A field experiment was conducted during *rabi* 2023-24 at the Irrigation Water Management Research Centre, Arabhavi, to evaluate the effect of different fertigation strategies on the growth, yield, nutrient uptake and economics of maize (*Zea mays* L.) under the Ghataprabha Command Area. The experiment was laid out in a randomized complete block design with ten treatments replicated thrice, including varying proportions of recommended NPK applied through drip fertigation and basal methods, along with conventional application and an absolute control. Results revealed that fertigation with 75% of the recommended NPK using water-soluble fertilizers, combined with 25% as basal application (T4), significantly improved growth attributes such as plant height (268.7 cm), leaf area (995 dm^2), and dry matter accumulation (20,098 kg ha^{-1}). This treatment also recorded the highest grain yield (9212 kg ha^{-1}), stover yield (12,847 kg ha^{-1}), cob weight (184.3 g), test weight (38.83 g), and kernel weight per cob (162 g). Furthermore, it achieved the highest nutrient uptake (227.55 kg N, 68.18 kg P, and 266.65 kg K ha^{-1}), gross returns (₹ 2,02,808 ha^{-1}), net returns (₹ 1,14,142 ha^{-1}) and benefit-cost ratio (2.28). These values were statistically on par with 100% NPK applied entirely through fertigation (T3). The findings indicate that adopting a drip fertigation strategy involving a 75:25 ratio of fertigation to basal application is not only agronomically effective but also economically viable, offering a potential reduction in fertilizer usage without compromising yields.

Key words: Drip irrigation, Fertigation, Maize, Nutrient uptake, Water-soluble fertilizers

Introduction

Maize (*Zea mays* L.) is one of the most important cereal crops globally, serving as a staple food, animal feed and a raw material for various industrial products. In India, maize ranks fifth in total production and fourteenth in global exports (Anon., 2024a). During 2023-24, the crop was cultivated on 9.89 million hectares with a total production of 38.1 million tonnes (Anon., 2024b). Karnataka is among the leading maize-producing states, contributing approximately 1.39 million hectares of cultivation and 4.14 million tonnes of production, with an average productivity of 2.98 t ha^{-1} (Anon., 2024c).

The Ghataprabha command area in Karnataka is a prominent maize-growing region due to its favourable agro-climatic conditions. However, sustaining high yields in this region is challenging, primarily due to sub-optimal fertilizer use efficiency and water scarcity (Nargal and Patil, 2020). Efficient resource management strategies are therefore essential to enhance productivity and sustainability. Drip fertigation, a modern technique that combines irrigation and nutrient application, has emerged as a promising solution to these challenges. It allows precise and frequent application of water-soluble fertilizers directly to the root zone, enhancing nutrient uptake, reducing losses through leaching and volatilization and ultimately improving crop performance (Li *et al.*, 2021). Compared to conventional methods, drip fertigation enables better synchronization of nutrient supply with crop demand throughout different growth stages, particularly for mobile nutrients like nitrogen.

Nutrient use efficiency in maize is particularly sensitive to the method and timing of nitrogen application. Studies have shown that maize plants absorb nearly 70% of their total nitrogen before the silking stage, while the remaining 30% is taken up during reproductive growth (Mueller and Vyn, 2017). Hence, frequent and well-timed fertigation can play a crucial role in meeting the crop's nutrient demands at critical stages, supporting better kernel development and higher yields. Despite its advantages, the adoption of fertigation in maize cultivation remains limited in many regions. There is a need to establish region-specific fertigation schedules and nutrient combinations to optimize input use and maximize returns. In this context, the present study was undertaken to assess the impact of different NPK fertigation levels using water-soluble fertilizers on the growth, yield, nutrient uptake and economics of maize in the Ghataprabha Command Area. The study also aims to compare these fertigation treatments with conventional fertilizer application to determine the most efficient and cost-effective approach.

Material and methods

A field experiment was conducted during the *rabi* season of 2023–24 at the Irrigation Water Management Research Centre (IWMRC), Arabhavi, located in the Ghataprabha Command Area of Karnataka. The experimental site is characterized by a semi-arid climate with erratic rainfall distribution. During the cropping period, the total rainfall recorded was 65.9 mm less than the 10-year average, with uneven distribution and increased temperatures, particularly from April to June, which enhanced evaporative demand. The soil of the experimental site was classified as sandy clay loam in texture. It was alkaline in reaction (pH 7.69), had normal electrical conductivity (0.23 dS m^{-1}) and was medium in organic carbon content (0.48%). Available nitrogen was low (234 kg ha^{-1}), while phosphorus (24.72 kg ha^{-1}) and potassium (215 kg ha^{-1}) were in the medium range. The experiment was laid out in a Randomized Complete Block Design (RCBD) with ten treatments replicated three times. A total of 30 experimental plots were established. The gross plot size was 7.2 × 6.0 m (43.2 m²) and the net plot size was 6.0 m × 5.2 m (31.2 m²). The treatments involved varied levels and combinations of nitrogen (N), phosphorus (P_2O_5) and potassium (K_2O) applied through fertigation and/or as basal applications. The recommended fertilizer dose (RDF) for irrigated maize was 150:65:65 kg N:P_2O_5: K_2O ha^{-1}.

The fertigation application schedule was planned according to different treatments in maize over ten weeks, starting November 8 (Table 1). Treatments varied by the proportion and timing of nitrogen (N), phosphorus (P) and potassium (K) applications, either as basal doses or via fertigation. For example, T1 received 100% N through fertigation and 100% P and K as basal, whereas T3 received 100% NPK entirely through fertigation. Treatment T4 combined 75% NPK through fertigation with 25% as basal. Urea was used as the nitrogen source, monoammonium phosphate (MAP) as a source of nitrogen, phosphorus and wettable potash as the potassium source. Basal applications were made at sowing as per treatment design and fertigation was applied weekly through a drip irrigation system.The maize hybrid DKC-9133 was used for the experiment. Standard agronomic practices, including timely weeding, irrigation and pest control, were followed uniformly across all treatments to maintain optimal crop growth conditions.Observations were recorded on growth parameters (plant height, leaf area, dry matter accumulation), yield attributes (cob weight, test weight, cob length, kernel weight per cob), kernel and stover yields, total nutrient uptake (N, P, K) and economic returns (gross returns, net returns and benefit-cost ratio).The data were analyzed using Fisher's method of analysis of variance (ANOVA) as outlined by Gomez and Gomez (1984). Treatment means were compared using Duncan's Multiple Range Test (DMRT) at a 5% level of significance. Critical differences (CD) were calculated where the 'F' test showed significant differences.

Results and discussion

Effect on growth parameters

The application of NPK through drip fertigation significantly influenced the growth parameters of maize (Table 2). The tallest plants (268.7 cm) were recorded in the treatment receiving 75% of the recommended NPK via fertigation combined with 25% as basal application (T4), followed closely by 100% NPK through fertigation without basal application (265.0 cm; T3). Enhanced plant height in these treatments can be attributed to the continuous and readily available supply of nutrients, particularly nitrogen, in the root zone facilitated better

Table 1. Fertilizer application schedule according to the treatments

Dates		Basal	Nov 8	Nov 15	Nov 22	Nov 29	Dec 6	Dec 13	Dec 20	Dec 27	Jan 3	Jan 10
Treatments	Fertilizers (kgha^{-1})											
T1(100% N fert.	Nitrogen	-	7.5	11.25	15	18.75	22.5	22.5	18.75	15	11.25	7.5
100% P&K basal)	Phosphorous	65	-	-	-	-	-	-	-	-	-	-
	Potassium	65	-	-	-	-	-	-	-	-	-	-
T2(100% N& K fert.	Nitrogen	-	7.5	11.25	15	18.75	22.5	22.5	18.75	15	11.25	7.5
100% P basal)	Phosphorous	65	-	-	-	-	-	-	-	-	-	-
	Potassium	-	3.25	4.875	6.5	8.125	9.75	9.75	8.125	6.5	4.875	3.25
T3(100% N,P,K fert.)	Nitrogen	-	7.5	11.25	15	18.75	22.5	22.5	18.75	15	11.25	7.5
	Phosphorous	-	19.5	16.25	13	6.5	4.875	4.875				
	Potassium	-	3.25	4.875	6.5	8.125	9.75	9.75	8.125	6.5	4.875	3.25
T4(75% N,P,K fert.	Nitrogen	37.5	5.625	8.438	11.25	14.063	16.88	16.88	14.06	11.25	8.438	5.625
25% NPK as basal)	Phosphorous	16.25	14.625	12.19	9.75	4.875	3.66	3.66				
	Potassium	16.25	2.44	3.66	4.88	6.1	7.31	7.31	6.1	4.88	3.66	2.44
T5(75% N fert.	Nitrogen	-	5.625	8.438	11.25	14.063	16.88	16.88	14.06	11.25	8.438	5.625
75% P & K basal)	Phosphorous	48.75	-	-	-	-	-	-	-	-	-	-
	Potassium	48.75	-	-	—	-	-	-	-	-	-	-
T6(75% N,Kfert.	Nitrogen	-	5.625	8.438	11.25	14.063	16.88	16.88	14.06	11.25	8.438	5.625
75 % P basal)	Phosphorous	48.75	-	-	-	-	-	-	-	-	-	-
	Potassium	-	2.44	3.66	4.88	6.1	7.31	7.31	6.1	4.88	3.66	2.44
T7(75% N,P,K fert.)	Nitrogen	-	5.625	8.438	11.25	14.063	16.88	16.88	14.06	11.25	8.438	5.625
	Phosphorous	-	14.625	12.19	9.75	4.875	3.66	3.66				
	Potassium	-	2.44	3.66	4.88	6.1	7.31	7.31	6.1	4.88	3.66	2.44
T8(56% N,P,K fert.	Nitrogen	28.5	4.2	6.3	8.4	10.5	12.6	12.6	10.5	8.4	6.3	4.2
19 % NPK as basal)	Phosphorous	12.35	10.92	9.1	7.28	3.64	2.73	2.73				
	Potassium	12.35	1.82	2.73	3.64	4.55	5.46	5.46	4.55	3.64	2.73	1.82
T_9- RDF -	full dose of phosphorous, potassiumand 1/3rd of nitrogen and was applied as basal dose and remaining nitrogen applied at 2 splits at knee-high and tasselling stages.											
T_{10}-	No fertilizer application											

Table 2. Effect of different levels of fertigation on growth attributes of maize

Treatments	Plant height (cm)at harvest	Leaf area (dm^2) at 60 DAS	Dry matter accumulation (kg/ha) at harvest	Tasseling to silking interval (in days)
T_1- 100% N fertigation with 100% P & K basal	252.4^{bc}	979^{bc}	18892^{bc}	7.33^{a}
T_2- 100% N & K fertigation with 100% P basal	257.8^{b}	979^{bc}	19008^{bc}	7.00^{ab}
T_3- 100% N, P & K fertigation with no basal	265.0^{a}	983^{ab}	19696^{ab}	7.00^{ab}
T_4- 75% NPK fertigation with 25% NPK as basal	268.7^{a}	995^{ab}	20098^{a}	7.00^{ab}
T_5- 75% N fertigation with 75% P & K basal	238.6^{d}	942^{e}	16989^{e}	7.00^{ab}
T_6- 75% N & K fertigation with 75% P basal	241.3^{d}	960^{d}	17675^{de}	7.00^{ab}
T_7- 75% N, P & K fertigation with no basal	246.9^{c}	967^{cd}	17958^{cde}	7.00^{ab}
T_8- 56% NPK fertigation with 19% NPK as basal	252.2^{bc}	973^{bcd}	18389^{cd}	6.34^{b}
T_9- 100% NPK through Conventional fertilizers & method (Control)	229.4^{e}	706^{f}	16900^{e}	7.00^{ab}
T_{10}-Absolute control (No Fertilizer)	174.2^{f}	415^{g}	8000^{f}	7.00^{ab}
S.Em ±	1.88	4.444	346.98	

vegetative growth. These findings are consistent with earlier research works by Sandhya (2014) and Basava *et al.* (2012).

Leaf area and total dry matter accumulation were also significantly higher under T4 (995 dm^2 and 20,098 kg ha^{-1}, respectively), indicating enhanced photosynthetic efficiency and biomass production due to improved nutrient availability and uptake. The consistent supply of nutrients through fertigation likely promoted vigorous vegetative growth and canopy development, thereby increasing the leaf area index and facilitating greater light interception. This, in turn, enhanced the photosynthetic rate and assimilates production throughout the growth period. Similar results were reported by Bibe *et al.* (2017), who observed a substantial increase in leaf area and dry matter in maize under fertigation due to better synchrony between nutrient supply and plant demand. Additionally, Li *et al.* (2021) demonstrated that drip fertigation significantly improves nutrient uptake efficiency, especially for nitrogen and potassium, which are critical for cell expansion and dry matter accumulation in cereals. Further, Qadeer *et al.* (2024) confirmed that water-soluble fertilizer application through fertigation leads to greater vegetative growth and biomass due to the continuous nutrient supply aligned with crop developmental stages.

The tasseling to silking interval (TSI) is a critical reproductive parameter in maize, as it influences pollination success, kernel set and ultimately grain yield. In the present study, the TSI varied slightly among treatments, ranging from 6.34 to 7.33 days, but no statistically significant differences were observed among most treatments (Table 2).The shortest interval (6.34 days) was recorded in T8 (56% NPK through fertigation + 19% NPK as basal), while the longest interval (7.33 days) was observed in T1 (100% N fertigation with 100% P and K as basal). Although the variation was marginal, treatments with balanced nutrient availability, especially under fertigation (*e.g.*, T4 and T3), maintained an optimal and synchronized tasseling-silking phase (7.00 days), which is crucial for enhancing pollination efficiency and kernel development.

Efficient nutrient management through fertigation may have helped maintain hormonal balance and improved plant vigor during reproductive stages, thereby reducing the stress-induced delay between tasseling and silking. This observation is consistent with the findings of Mueller and Vyn (2017), who noted that nitrogen availability during the pre- and post-silking phases is critical for synchronized reproductive development in maize. Similarly, Uhart and Andrade (1995) reported that a prolonged TSI is often associated with stress conditions, especially nitrogen deficiency, which leads to reduced ovule fertilization and lower grain yield. Further, Otegui and Andrade (2000) emphasized that minimizing the TSI enhances kernel set and yield potential, particularly when nutrient supply and environmental conditions are favorable. In the current study, although all fertigation treatments showed similar TSI values, the consistently lower intervals compared to the control and unfertilized plots suggest that drip fertigation supports better reproductive synchrony, thereby contributing to improved yield attributes.

Table 3. Effect of different levels of fertigation on cob weight, test weight, cob length and Kernel weight cob^{-1} of maize

Treatments	Cob weight (g)	Test weight (g)	Cob length (cm)	Kernel weight cob^{-1} (g)
T_1- 100% N fertigation with 100% P&K basal	164.0^{ab}	37.00^{a-c}	17.2^{a-c}	142^{bc}
T_2- 100% N &K fertigation with 100% P basal	165.0^{ab}	37.33^{a-c}	17.4^{ab}	148^{a-c}
T_3- 100% N, P &K fertigation with no basal	173.3^{ab}	38.13^{ab}	17.5^{ab}	156^{ab}
T_4- 75% NPK fertigation with 25% NPK as basal	184.3^{a}	38.83^{a}	17.7^{a}	162^{a}
T_5- 75% N fertigation with 75 % P & K basal	145.7^{bc}	35.00^{b-d}	16.8^{cd}	134^{c}
T_6- 75% N & K fertigation with 75% P basal	153.3^{a-c}	35.43^{b-d}	16.8^{cd}	134^{c}
T_7- 75% N, P & K fertigation with no basal	158.3^{a-c}	36.33^{a-c}	17.1^{bc}	139^{c}
T_8- 56% NPK fertigation with 19% NPK as basal	160.0^{ab}	36.90^{a-c}	17.1^{bc}	141^{bc}
T_9- 100% NPK through Conventional fertilizers & method (Control)	139.3^{bc}	34.47^{cd}	16.5^{d}	132^{c}
T_{10}-Absolute control (No Fertilizer)	125.0^{c}	32.33^{d}	14.9^{e}	110^{d}
S.Em±	10.21	0.97	0.15	4.83

Table 4. Effect of different levels of fertigation on kernel yield and stover yield of maize.

Treatments	Kernel yield (kg ha^{-1})	Stover yield (kg ha^{-1})
T_1- 100% N fertigation with 100% P & K basal	7828^{c}	11766^{ab}
T_2- 100% N & K fertigation with 100% P basal	8304^{b}	12034^{ab}
T_3- 100% N, P & K fertigation with no basal	9098^{a}	12598^{a}
T_4- 75% NPK fertigation with 25% NPK as basal	9212^{a}	12847^{a}
T_5- 75% N fertigation with 75% P & K basal	7226^{e}	9996^{b-d}
T_6- 75% N & K fertigation with 75% P basal	7511^{d}	10173^{b-d}
T_7- 75% N, P & K fertigation with no basal	7599^{cd}	10983^{a-c}
T_8- 56% NPK fertigation with 19% NPK as basal	7800^{c}	11166^{a-c}
T_9- 100% NPK through Conventional fertilizers & method (Control)	7403de	9016^{cd}
T_{10}-Absolute control (No Fertilizer)	5801^{f}	8424^{d}
S.Em±	78.18	719.92

Effect on yield attributes

Cob weight was highest in T4 (184.3 g), followed by T3 (173.3 g), with both treatments significantly out performing the conventional fertilizer application (T9) and the absolute control (T10) (Table 3). Enhanced cob weight under fertigation was likely due to better translocation of assimilates during the grain-filling period, supported by adequate nutrient supply. Similar trends were observed in kernel weight per cob, with T4 recording 162 g.The 100-kernel weight (test weight) ranged from 32.33 g in T10 to 38.83 g in T4, reflecting the impact of nutrient availability on grain development. Drip fertigation ensured nutrient supply during critical stages, improving kernel size and weight, in line with the results reported by Roja *et al.* (2017). Cob length was significantly greater in T4 (17.7 cm), followed by T3 (17.5 cm) and T2 (17.4 cm). These results highlight the effectiveness of fertigation in supporting reproductive development and minimizing nutrient stress during flowering, as supported by Saha *et al.* (2023).

The highest kernel yield (9212 kg ha^{-1}) was recorded under T4, which was statistically on par with T3 (9098 kg ha^{-1}) (Table 4). These yields were substantially higher than those obtained from conventional fertilizer application (7403 kg ha^{-1}; T9) and the absolute control (5801 kg ha^{-1}; T10). The superior yields in fertigated treatments can be linked to improved nutrient synchrony, especially nitrogen availability during post-flowering stages, enhancing grain filling. This observation corroborates findings by Bibe *et al.* (2017) and Mueller and Vyn (2017). Stover yield followed a similar trend, with T4 registering the highest value (12,847 kg ha^{-1}), significantly outperforming conventional and control treatments.

Nutrient uptake

Total uptake of nitrogen, phosphorus and potassium by maize was significantly enhanced under fertigation treatments (Table 5), particularly in T4 (227.55 kg N, 68.18 kg P and 266.65 kg K ha^{-1}) and T3 (222.39 kg N, 59.84 kg P and 253.56 kg K ha^{-1}). This marked improvement in nutrient uptake can be attributed to the precise and continuous delivery of nutrients in soluble form through drip fertigation, which maintains consistent nutrient availability in the root zone during the crop's peak demand periods. Fertigation promotes synchrony between nutrient supply and crop growth stages, reducing the chances of nutrient losses through leaching or volatilization and enhancing uptake efficiency (Li *et al*., 2021). In particular, nitrogen applied in multiple splits through fertigation improves its availability during critical phases such as tasseling and grain filling, contributing to better translocation of nutrients and higher kernel weight. Potassium and phosphorus, which are relatively immobile in the soil, also benefit from localized placement and improved root-soil contact in fertigation systems. These findings are in agreement with Qadeer *et al.* (2024), who reported increased nitrogen and potassium uptake in maize under drip fertigation due to better root proliferation and nutrient mobility. Additionally, Solaimalai *et al.* (2005) emphasized that fertigation enhances nutrient absorption by maintaining optimal soil moisture conditions and reducing nutrient fixation in the rhizosphere. The significantly higher nutrient uptake observed in this study under T4 and T3 treatments ultimately translated into superior growth, yield and

Table 5. Effect of different levels of fertigation on total nutrient uptake of maize

Treatments	Total nutrient uptake		
	Total nitrogen uptake (kg ha^{-1})	Total phosphorous uptake (kg ha^{-1})	Total potassium uptake (kg ha^{-1})
T_1- 100% N fertigation with 100% P & K basal	187.40^{bc}	45.88^{c}	228.58^{b}
T_2- 100% N & K fertigation with 100% P basal	195.89^{b}	48.34^{c}	237.36^{b}
T_3- 100% N, P& K fertigation with no basal	222.39^{a}	59.84^{b}	253.56^{ab}
T_4- 75% NPK fertigation with 25% NPK as basal	227.55^{a}	68.18^{a}	266.65^{a}
T_5- 75% N fertigation with 25% NPK as basal	151.19^{e}	30.54^{ef}	168.20^{d}
T_6- 75% N & K fertigation with 75% P basal	157.93^{de}	33.62^{de}	181.29^{c}
T_7- 75% N,P& K fertigation with no basal	169.84^{c-e}	37.40^{d}	198.97^{c}
T_8- 56% NPK fertigation with 19% NPK as basal	176.10^{b-d}	39.05^{d}	203.46^{c}
T_9- 100% NPK through Conventional fertilizers & method (Control)	147.63^{e}	26.69^{f}	148.58^{e}
T_{10}-Absolute control (No Fertilizer)	101.72^{f}	16.37^{g}	95.77^{f}
S.Em±	7.27	1.78	8.26

Table 6. Economics of maize as influenced by different fertigation levels

Treatments	Cost of cultivation (₹ ha^{-1})	Gross returns (ha^{-1})	Net returns (ha^{-1})	B:C ratio
T_1- 100% N fertigation with 100% P &K basal	84199	173017^{bc}	88818^{b-d}	2.05^{bc}
T_2- 100% N &K fertigation with 100% P basal	84875	183180^{ab}	98305^{bc}	2.16^{b}
T_3- 100% N, P &K fertigation with no basal	96351	200226^{a}	103875^{ab}	2.07^{bc}
T_4- 75% NPK fertigation with 25% NPK as basal	88666	202808^{a}	114142^{a}	2.28^{a}
T_5- 75% N fertigation with 75% P & K basal	81967	159019^{c}	77052^{cd}	1.94^{bc}
T_6- 75% N & K fertigation with 75% P basal	82465	165118^{bc}	82653^{b-d}	2.00^{bc}
T_7- 75% N, P & K fertigation with no basal	90368	167605^{bc}	77237^{cd}	1.85^{c}
T_8- 56% NPK fertigation with 19% NPK as basal	88368	171952^{bc}	83584^{b-d}	1.94^{bc}
T_9- 100% NPK through Conventional fertilizers & method (Control)	83886	161935^{bc}	78049^{cd}	1.93^{bc}
T_{10}-Absolute control (No Fertilizer)	74523	127979^{d}	53456^{d}	1.71^{bc}
S.Em±		6996	6996	0.115

economic returns, reaffirming the role of fertigation in integrated nutrient management for maize cultivation.

Economic analysis

Among all the treatments evaluated, T4 (75% recommended NPK through fertigation + 25% as basal application) recorded the highest gross returns (₹ 2,02,808 ha^{-1}), net returns (₹ 1,14,142 ha^{-1}) and a benefit-cost (B:C) ratio of 2.28 followed closely by T3 (100% NPK through fertigation), which reported gross returns of ₹ 2,00,226 ha^{-1}, net returns of ₹ 1,03,875 ha^{-1}, and a B:C ratio of 2.07 (Table 6). These superior economic returns were attributed to significantly higher grain and stover yields obtained through efficient nutrient and water management under fertigation.

Drip fertigation enables precise and timely application of nutrients directly to the root zone, minimizing nutrient losses due to leaching or volatilization and enhancing nutrient use efficiency (Li *et al.*, 2021). This not only improves crop performance but also reduces the cost of fertilizer application, contributing to better net returns. Moreover, the partial basal application in T4 ensured early nutrient availability during crop establishment, which, when followed by fertigation, supported sustained growth and higher productivity throughout the growing period.

In contrast, the conventional method (T9), which involved 100% NPK applied through soil without fertigation, resulted in lower gross returns (₹ 161,935 ha^{-1}), net returns (₹ 78,049 ha^{-1}), and a B:C ratio of 1.93. The absolute control (T10) recorded the lowest economic performance (net returns ₹ 53,456 ha^{-1}), clearly indicating the importance of proper nutrient management. These findings are consistent with studies by Bibe *et al.* (2017) and Yadav *et al.* (2020), who reported that drip fertigation significantly enhances economic returns in maize and other field crops due to improved yield response and input use efficiency. Therefore, integrating fertigation with a partial basal dose proves not only agronomically superior but also economically sustainable in maize cultivation under command area conditions.

Conclusion

Drip fertigation with 75% NPK and 25% basal application significantly enhanced maize yield, nutrient uptake, and profitability compared to conventional methods. The approach improved input efficiency, with the highest grain yield (9212 kg ha^{-1}) and B:C ratio (2.28), highlighting its potential as a sustainable nutrient management practice in irrigated maize cultivation. Compared to conventional fertilizer application, fertigation not only reduced fertilizer input but also enhanced profitability, making it a viable and sustainable nutrient management strategy for maize cultivation in irrigated command areas. These findings advocate for the wider adoption of drip fertigation using water-soluble fertilizers as a best management practice, particularly in water-scarce and nutrient-deficient regions, to achieve higher productivity and resource-use efficiency in maize.

References

Anon, 2024a, Area, production and productivity of maize in the world, https://cb.apps.fao.org/country. jsp? code=IND & utm_sou

Anon, 2024b, Area, production and productivity of maize, Ministry of Agriculture and Farmers Welfares, 3rd Advance estimates, 2023-24, https://apeda.gov.in/Maize

Anon, 2024c, Area, production and productivity of maize in Karnataka, https://raitamitra.Karnataka.gov.in

Basava P, Shankar A G and Ramesh R, 2012, Effect of fertigation on growth and yield of maize. *Karnataka Journal of Agricultural Sciences*, 25(4): 509-512.

Bibe S M, Jadhav K T and Chavan A S, 2017, Response of irrigation and fertigation management on growth and yield of maize. *International Journal of Current Microbiology and Applied Sciences*, 6(11): 4054-4060.

Gomez K A and Gomez A A, 1984, *Statistical Procedures for Agricultural Research*, 2nd Edn. John Wiley and Sons, New York, USA, p 680.

Li H, Mei X, Wang J, Huang F, Hao W and Li B, 2021, Drip fertigation significantly increased crop yield, water productivity and nitrogen use efficiency with respect to traditional irrigation and fertilization practices: A meta-analysis in China, *Agricultural Water Management*, 244, 106534, https://doi.org/10.1016/j.agwat.2020.106534.

Mueller S M and Vyn T J, 2017, Maize plant resilience to N stress and post-silking N capacity changes over time: A Review. *Frontiers in Plant Science*, 7(53): 1-14.

Nargal B V and Patil R H, 2020, Potential and rainfed yield gap for maize hybrid NK-6240 under current climate of north interior Karnataka: DSSAT Model based Assessment. *International Journal of Current Microbiology Applied Sciences*, 9(12): 2245-2251.

Otegui M E and Andrade F H, 2000, New insights into the relationship between kernel set and crop growth in maize. In: Westgate, M. E., & Boote, K. J. (Eds.), *Physiology and Modeling Kernel Set in Maize* (pp. 1-13). CSSA Special Publication.

Qadeer A, Yaseen M, Naveed M and Shahbaz M, 2024, Effect of urea-phosphate and its application methods on maize (*Zea mays* L.) growth, yield and nutrient use efficiency. *Applied Ecology and Environmental Research*, 22(1): 215-234.

Roja M, Kumar K S, Ramulu V and Kumar G M, 2017, Yield and yield attributes of maize (*Zea mays* L.) as influenced by different surface and drip irrigation levels. *Environment and Ecology*, 35(3C): 2257-2260.

Saha R, Choudhary G L, Kumari R, Shree S, Nath P, Sah S B and Singh K, 2023, Effect of slow releasing soil conditioner Zypmite on the yield and yield attributes of Maize in Kosi Region. *International Journal of Statistics and Applied Mathematics*, 8(7): 21-24

Sandya N, 2014, Effect of plant densities and nitrogen rates on productivity of sweet corn during *rabi*. Ph. D *Thesis*, Acharya N.G Ranga Agricultural University, Hyderabad, India.

Solaimalai A, Baskar M, Sadasakthi A, and Subburamu K, 2005, Fertigation in high value crops. *Agricultural Reviews*, 26(1): 1-13.

Uhart S A and Andrade F H, 1995, Nitrogen deficiency in maize: I. Effects on crop growth, development, dry matter partitioning, and kernel set. *Crop Science*, 35(5): 1376-1383. https://doi.org/10.2135/cropsci1995.0011183X003500050032x

Yadav R K, Satyendra S, Tomar A S and Singh A K, 2020, Economic analysis of drip fertigation in maize (*Zea mays* L.) under semi-arid conditions. *International Journal of Chemical Studies*, 8(1): 1477-1481.