

EFFECT OF FERTIGATION ON AVAILABILITY OF NUTRIENTS (N, P & K) IN SOIL- A REVIEW

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ABSTRACT

The right combination of water and nutrients is the key for increasing the yield and quality of produce. The availability of N, P and K nutrient was found to be higher in root zone area of drip fertigated plot. Nitrogen and potassium moved laterally from point source up to 15 cm and vertically up to 15-25 cm and P moved 5 cm both laterally and vertically and thereafter dwindled. Fertigation frequency enables to reduce the concentration of immobile elements such as P, K and trace elements in irrigation water. Fertigation of nutrients significantly increased saving of fertilizer nutrients up to 40 per cent without affecting the yield of crops compared to the conventional method of nutrient application.

India is the third fertilizer producing and consuming country in the world. The nutrient consumption per hectare and fertilizer use efficiency is very low in India. The main reasons for low efficiency are the type of fertilizer used and its method of application adopted by Indian farmers. Hence, there is a need to develop a suitable method of application of fertilizer, which will improve the quality and quantity of crop production. Fertigation is the process of application of water soluble solid fertilizers or liquid fertilizers through drip irrigation system. Through fertigation, nutrients are applied directly into the wetted volume of soil immediately below the emitter, where root activity is concentrated. Fertigation is possible only in drip irrigation.

Nutrient distribution

Debashis *et al.* (1999) conducted experiment in a sandy loam soil of IARI farm with broccoli to investigate the movement and distribution of nitrogen in soil. At the points 15 and 30 cm from the emitter the variation in concentration of $\text{NH}_4\text{-N}$ from the top to bottom layer of the profile was less than that at the point immediately closer to the source. The increase in $\text{NH}_4\text{-N}$ concentration immediately in the vicinity of the emitter is a consequence of the hydrolysis of urea (Haynes, 1990). $\text{NH}_4\text{-N}$ is adsorbed

by the soil matrix and therefore the maximum concentration changes are confined to the top layer and around the emitter. There was no appreciable change 30 cm away from the emitter up to the third split dose of fertilizer application.

The wet condition around the emitter also ensures that the conversion of $\text{NH}_4\text{-N}$ to $\text{NO}_3\text{-N}$ occurs at some distance away from the emitter in a relatively drier zone, where more oxygen is available. This results in peak concentration of $\text{NO}_3\text{-N}$ occurring below the soil surface (20 – 40 cm layer) and far away from the emitter. $\text{NO}_3\text{-N}$ being mobile, has a tendency to move away from the emitter to the periphery of the water front (Haynes, 1990) and does not become available to the plant. It neither accumulated at the periphery of the wetting front nor is leached from the root zone under drip system.

The N use efficiency was considerably increased with the application of N through drip over soil application and it was highest under 75 kg N ha⁻¹ applied through drip application in a parbhani clayey soil at Maharashtra. This can be ascribed to the improved distribution of fertilizer with minimum leaching beyond the root zone or runoff (Bharambe *et al.*, 1997).

The number of microorganisms in the saturated zone around the source is lower than their number farther away. Nitrification seems to occur mostly outside the saturated zone, as reflected through high nitrate levels and occurrence of nitrifying bacteria at this part of the soil (Laher and Avnimelech, 1980). The increase in nitrate concentration with distance from the source is due to the radial geometry. Moreover, at the end of fertilization cycle, about 50 per cent of the added nitrogen is found as nitrate, practically all of which is in the soil volume outside the saturated core (**Table 1**).

Higher amounts of available P were confined at the top 0- 15 cm layer just immediately below the emitter. The concentration P decreased with increasing depth of soil profile irrespective of planting methods in banana (Normal, square and rectangular planting methods and depth of irrigation water (0.6 ET_c, 0.8 ET_c and 1.0 ET_c – Irrigation depth) (Bharambe *et al.*, 2001).

Higher accumulation of residual soil P occurred with time in plots fertigated with 60 mg P l⁻¹. Greater P accumulation occurred in the surface (0-15 cm) layer in trickle irrigated potato in agreement with the expected slow movement of P in the soil (Papadopoulos, 1992).

Topdressing of 80 lbs per acre of P₂O₅ annually to a fine sandy loam resulted in measurable downward movement to above two feet after 17 years. Horizontal movement of P was lesser compared to vertical movement of P (Ludwick, 1998).

Bangar and Chaudhari (2004) conducted an experiment with different sources of fertilizers such as Richfield water soluble fertilizer and straight fertilizer with different levels i.e., 50, 75, 100 and 125 per cent of recommended dose of fertilizer applied through drip irrigation. The available

N content was confined to maximum at immediately below the emitter and moved laterally up to 15 cm and vertically up to 15- 25 cm and thereafter dwindled. The N mobility in soil was due to the concentration gradient created on account of mass flow which rendered nutrients to move from higher concentration to a lower one. The mobility of P was observed to be the highest immediately below the emitter zone, moved laterally and vertically up to 5 cm and thereafter dwindled. As regards available K, it moved both laterally and vertically up to 15 cm and thereafter reduced. Comparatively higher available nutrients were observed in Richfield water soluble fertilizer than straight fertilizer because Richfield water soluble fertilizer contains high soluble nutrients. Among the different levels of fertilizer, the treatment that received 125 per cent of recommended dose of fertilizer, registered high available nutrients followed by 100 per cent recommended dose of fertilizer with respect to two sources of nutrients.

Fertigation resulted in lesser leaching of NO₃-N and K to deeper layers of soil. Subsurface drip fertigation caused higher assimilable nutrients in deeper layers.

Response of crops to fertigation

Patel and Rajput (2005) reported that fertigation of nutrients significantly increased saving of fertilizer nutrients up to 40 per cent without affecting the yield of crops compared to the conventional method of nutrient application. They also reported that fertilizer application at 100 per cent of recommended dose through fertigation recorded an increase in yield of 25.21 per cent from 23.0 t/ha to 28.8 t/ha, in the year 2000 and 16.5 per cent from 23.56 t/ha to 27.47 t/ha, in the year 2001 as compared to broadcasting method of fertilizer application.

Table 1. Quantity of NO₃-N (mg) in concentric tubes around the source

Depth (cm)	Before fertilizer application			Four weeks after fertilizer application		
	r (cm)			r (cm)		
	0-15	15-30	30-45	0-15	15-30	30-45
0-20	39	214	500	24	367	729
20-40	10	275	310	25	270	568
40-60	14	260	296	29	291	458
60-80	7	132	296	25	133	271
Total for the tube	70	881	1422	103	1061	2126
Total		2373			3290	

(Laher and Avnimelech, 1980)

Frequent application of nutrients through drip system improved the uptake of nutrients through two main mechanisms: i) continuous replenishment of nutrients in the depletion zone at the vicinity of root interface and ii) enhanced transport of dissolved nutrients by mass flow, due to the higher averaged water content in the medium. Fertigation frequency enables to reduce the concentration of immobile elements such as P, K and trace elements in irrigation water. It significantly increased the yield at low concentration level. This might be primarily related to enhancement of nutrient uptake especially P (Silber *et al.*, 2003).

The influence of fertigation on growth attributes and physiological characteristics reflected on higher yield and related characters in papaya. Number of fruits and fruit weight were observed to be high in fertigated plants (**Table 2**). Fruit length, circumference and fruit volume also followed the same trend by recording higher values in fertigated plants. The production of more photosynthates due to more number of leaves and leaf area besides enhanced physiological traits might have resulted in better transfer to the sink, the developing fruit with thicker flesh and sweetness. The quality improvement is due to the involvement of K in carbohydrate synthesis, breakdown and translocation of starch, protein synthesis and

neutralization of physiologically important organic acids (Jeyakumar *et al.*, 2001).

The plant height and seed cotton yield of TCHB cotton was significantly improved by drip irrigation over furrow irrigation. The plant height and seed cotton yield was 9.3 and 13.6 per cent during winter and summer seasons, respectively. Nitrogen application by drip fertigation and drip band methods respectively increased the seed cotton yield by 10.8 and 9.8 per cent in winter and 15 and 10.9 per cent in summer season over furrow band application. This might be attributed to increased frequency of irrigation and fertigation with 100 per cent water plus 125 kg N ha⁻¹ which would have led to effective absorption and utilization of nutrients. Increased proliferation of roots resulting in quick canopy growth would have enhanced higher production and translocation of photosynthates from source to sink (Veeraputhiran *et al.*, 2002).

Alon and Lynn (2003) studied the response of sweet corn to continuous application of P fertilizer. Continuous application ensures higher biomass production as compared to pulse treatment (intermittent application of P given for 4 h once in every 2 days interval). This might be due to the three dimensional distribution of solutes and water which caused the mass flow action which ultimately led to

Table 2. Yield and its attributes influenced by fertigation in papaya

Characters	Control	Fertigated	% increase over control
Number of fruits	76.40	94.73	23.90
Fruit weight (kg)	1.86	2.43	30.60
Fruit length (cm)	26.30	29.60	12.50
Dry seed weight (g fruit ⁻¹)	16.45	18.56	12.82
TSS (Übrix)	11.20	12.40	10.70

(Jeyakumar *et al.*, 2001)

breakdown the region of immobile P. Hence, the concentration of P in plant tissues was found to be high which resulted in higher biomass yield.

Banu Rekha *et al.* (2005) conducted an experiment to investigate the effect of various levels of irrigation (0.5, 0.75 and 1.0 Epan) and nitrogen (60, 90 and 120 kg ha⁻¹) on pod yield of Bhendi. The results indicated that crop irrigated through drip at 1.0 Epan and fertigated with 120 kg N ha⁻¹ produced significantly higher yield as compared to other levels.

The influence of fertigation and broadcast mineral fertilization on yield and quality of 4 cabbage cultivars (*Brassica oleracea* var. *capitata* L.) was studied in a field trial in Ljubljana (Nina and Joze (2004). Five treatments were formed: K – classical fertilization with 150 kg N ha⁻¹ (broadcast incorporated); FNPK – all nutrients (NPK) were applied via fertigation; FN – P, K were added by classical methods and total N by fertigation; FNPK/30% - 30% of total N was incorporated before transplanting, total P and K and remaining N were applied via fertigation; FN/30% - total P and K and 30% of total N were incorporated before transplanting, the remaining N was applied via fertigation. The largest average marketable yield was achieved by fertigation with soluble nutrients, combined with pre-plant broadcast nitrogen incorporation, with each individual cultivar as follows: Hermes F1 (38.7 t ha⁻¹), Parel F1 (71.1 t ha⁻¹) and

Tropicana F1 (70.7 t ha⁻¹) and the lowest yield was observed in fertigation with N, where the total amount of P and K were pre-plant broadcast incorporated, with cultivars as follows: Hermes F1 (20.9 t ha⁻¹) and Parel F1 (50.4 ha⁻¹) and Tropicana F1 (63.0 t ha⁻¹) and Fieldwinner F1 (66.1 t ha⁻¹). The firmness of cabbage heads was also influenced by the method of nutrient application.

The pointed gourd (*Trichosanthes dioica*) fertilized through drip system with 100 % recommended dose at monthly interval gave higher yield of 4.27 t ha⁻¹ and it was statistically on par with 75 % recommended dose. Thus there was 25 % savings of fertilizer, which was applied through drip system. Application of 50 % recommended dose of fertilizer improved fertilizer use efficiency of nitrogen, phosphorus and potassium. Reverse was the trend, when the fertilizer dose was increased to 100 % recommended dose of fertilizer (Singandhupe *et al.*, 2007).

Ravi *et al.*, (2007) was conducted experiment during December 1996 to May 2006 to evaluate the effect of four fertigation levels (25, 50, 75 and 100% of recommended fertilizer dose, 100:18:117 g N: P: K palm⁻¹ year⁻¹), three frequencies of fertigation (10, 20 and 30 days) and two controls (control 1, i.e., drip irrigation without fertilizer application and control 2, i.e., drip with 100% NPK soil application) on productivity of arecanut.

Pooled analysis of experimental data indicated the significant influence of both fertilizer dose and frequency of fertigation on kernel yield of arecanut. Among fertigation levels, the kernel yield was significantly higher in 75% NPK fertigation, i.e., 75:13.5:87.7 g N, P, K application per year (3721 kg ha⁻¹) compared to other levels. The yield observed in 10 (3431 kg ha⁻¹) and 20 days frequencies (3382 kg ha⁻¹) were on par and significantly superior to monthly fertigation frequency (2952 kg ha⁻¹). Fertigation of 75% NPK at 10 days frequency registered the highest yield (4017 kg ha⁻¹), which was closely followed by fertigation of 75% NPK at 20 days frequency (3924 kg ha⁻¹) and fertigation of 100% NPK at 20 days frequency (3579 kg ha⁻¹). The yield increase with 75% NPK fertigated at 10 days interval was 100% over control (2008 kg ha⁻¹).

Manish *et al.* (2007) conducted an experiment to evaluate the agro techniques viz., growing media, irrigation regime, fertigation and mulching on productivity of tomato. They reported that growing media of soil: compost: sand (2:1:1), irrigation regime of 20 kPa, 50 kg ha⁻¹ as basal dose with straight fertilizers and fertigation @ 250 kg ha⁻¹ with polyfeed (water soluble fertilizer)

with black polythene mulched recorded significantly higher plant height (3.11 m), flower cluster/plant (12.16), fruits/plant (48.33) and fruit yield (2.85 kg/plant and 9.48 kg/m²).

Anant *et al.* (2006) reported that the highest fruit yield of tomato was noticed when N (urea) was supplied in 8 or 10 split doses with 100 % ET_o through drip irrigation.

Fertigation with 100 % recommended dose of macro and micro nutrients in water soluble form recorded the highest crop growth rate, total chlorophyll content, soluble protein content, nitrate reductase activity and minimum indole acetic acid oxidase activity in bitter melon (Meenakshi and Vadivel, 2005).

Neelam and Rajput (2005) reported that the highest yield was recorded in daily fertigation (29.2 t ha⁻¹) followed by alternate day fertigation (28 t ha⁻¹) and weekly fertigation (27.4 t ha⁻¹) while the lowest was recorded in monthly fertigation (22.4 t ha⁻¹). They also reported that application of 57.7 cm irrigation water with 3.4 kg N ha⁻¹ as urea in daily fertigation resulted highest yield of onion (29.2 t ha⁻¹) with least amount of leaching of nitrate nitrogen as compared to other treatments.

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