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EFFECT OF SPLIT APPLICATION OF MAJOR NUTRIENTS THROUGH FERTIGATION IN ONION (*ALLIUM CEPA* L.)

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ABSTRACT

Onion (*Allium cepa* L.) is highly responsive to external fertilization owing to its shallow root system and dense plant population. A field experiment was conducted to assess the impact of split application of major nutrients through fertigation on growth, nutrient uptake, and yield. The study employed a randomized complete block design with 12 treatment combinations and three replications, comparing 100 % and 75 % of the recommended dose of fertilizers (RDF) applied *via* fertigation using water-soluble fertilizers against conventional basal application. Results indicated that applying 25 % RDF as basal and 75 % RDF of N, P, and K through fertigation significantly enhanced growth, yield attributes, nutrient uptake (162.78 kg ha^{-1} N, 26.70 kg ha^{-1} P, 114.18 kg ha^{-1} K), quality parameters and storability of onion bulb. Conversely, 100 % RDF applied as conventional basal fertilizer resulted in higher residual soil nutrient availability after harvest (186.47 kg ha^{-1} N, 24 kg ha^{-1} P, 592.47 kg ha^{-1} K), but did not translate into improved crop performance. These findings highlight fertigation as an efficient nutrient management strategy for maximizing onion productivity and nutrient use efficiency compared with conventional fertilizer application.
Keywords **:** Fertigation, Split application, Drip irrigation, Soil fertility.

Introduction

Water has become a limited resource for agriculture because of competition from rapid industrialization, population growth, and urbanization. It's crucial to minimize irrigation water use by creating new, efficient technologies and methods to utilize this valuable resource effectively (Jeyabaskaran *et al.*, 2021). To ensure food, nutrition and financial stability, water needs to be used more effectively, equally and sustainably in agriculture. Enhancing water use efficiency and water productivity is essential at present era, because of declining in availability of usable water. To tackle the problem of water scarcity, it's essential to reduce water losses and boost water efficiency by increasing the crop yield for each volume of water applied, a goal that can be met through the use of technology like drip irrigation and fertigation.

Irrigation and fertilization are crucial strategies in agriculture to enhance productivity. The integration of drip irrigation with fertilization, known as fertigation, allows for better management of water and nutrient delivery to crops, ensuring optimal nutrient ion concentration and distribution in the soil. Fertigation results in application of water and nutrients directly to the root zone. This technique enables precise nutrient delivery when there is specific demand of crops during critical growth stages. By facilitating the direct application of nutrients in liquid form to the rhizosphere, fertigation effectively minimizes losses associated with volatilization, thereby improving nutrient use efficiency. Due to frequent application fertilizers in small doses, the amount of fertilizers present in the soil at any time is small, which prevents losses from leaching beyond effective crop root zone and run off during heavy rainfall. This method not only optimizes nutrient uptake but also enhances water utilization, contributing to the sustainability of agricultural practices.

The timing and dosage of fertilizer application are critical factors influencing crop growth, development, and soil nutrient balance. Inadequate or improper use of NPK fertilizers can lead to reduced productivity and inefficient nutrient utilization efficiency. Split application of nitrogen fertilizer is one of the methods to improve N use by the crop, while reducing the nutrient loss through leaching, denitrification, runoff and volatilization (Gehl *et al*., 2005). Application of phosphate fertilizer only at pre-planting reduces the availability of P throughout the crop cycle, due to precipitation and sorption reactions of phosphate. Thus, split applications of P tend to synchronize the plant's demand with P availability *via* fertilizer, which reduces the fraction of this nutrient in solution susceptible to sorption (Khokhar, 2019). In general required dose of potassium needed for the crop is applied at sowing, but it may not be accessible during crucial growth phases due to leaching losses, competition from microorganisms and plants, and K fixation in clay minerals, all of which limit its availability (Sharma and Sing, 2021). Taking into account soil and crop limitations, nutrients should be applied in alignment with crop needs in smaller amounts throughout the growing season.

Onion is one of the important commercial crop having high return and a significant export-earning. After China, India is the second-largest producer of onion in the world. In the nation, it is primarily grown during the *kharif*, late *kharif* and *rabi* seasons. It is grown in India in an area of 16.2 l ha with an 18.23 t ha^{-1} productivity (Anon., 2021). The poor level of productivity in the nation can be ascribed to a number of factors, including improper and ineffective nutrient management, increased disease incidence, a lack of vital inputs, particularly water, and a lack of adoption of recent improved production technology. Among these many elements that contribute to excellent crop output, using the right amount of fertilizer at the right time is essential for increasing onion productivity. For maximum yields, onions need a greater level of N, P and K fertilizer. Onions are receptive to externally applied fertilizers due to their shallow roots and dense population. When fertilizers and water are applied at the right times in a crops development, a regular supply of both ensures faster growth and greater yields. The objective of this study was to investigate "the effect of split application of major nutrients through fertigation on growth and yield of onion (*Allium cepa* L.)".

Material and Methods

Study site and experimental design

A field experiment was conducted during *Rabi* 2022-23 at Irrigation Water Management Research Centre (IWMRC), Belvatagi, Navalagund taluk of Dharwad district which is situated in the Northern dry zone (Zone-3) of Karnataka. It is located at a latitude of $15^{o}16^{1}$ North latitude, $75^{o}23^{1}$ East longitude with an altitude of 579 m above mean sea level. The soil of experimental site was clay in texture with bulk density of soil was 1.38 Mg m^{-3}, pH is 8.13, $EC_{2.5}$ is 0.48 dS m^{-1}, and organic carbon content is 3.3 g kg^{-1}. The initial nutritional status of soil was low in available nitrogen and phosphorous (161.0 and 16.23 kg ha^{-1}, respectively) and high in available potassium (525 kg ha^{-1}). The design of experiment was randomized complete block design with 12 treatments and three replications with two level of fertilization *viz.* 100 per cent and 75 per cent of RDF applied through fertigation in different split compared to conventional soil application as basal through use of conventional fertilizer. The raised nursery beds of 6m length x 1.2m breadth x 0.1m height were prepared for raising the onion seedling of *Bheema shakthi* variety. For each bed 20 kg of FYM and 0.5 kg of 15:15:15 fertilizer NPK mixture was applied as a basal dose. Seeds were sown in the lines of 10 cm apart and seeds were covered with thin layer of FYM and soil. The land was ploughed twice and brought to fine tilth by repeated harrowing's. Raised beds of size 1.2m x4m (4.8 m^2) were prepared and transplanting was done at 45 days after sowing with a spacing of 15cm x 10 cm.

Soil and plant analysis

Soil samples were collected from all treatments at a depth of 0−30 cm after harvesting. These soil samples were processed and sieved using a 2.0 mm sieve before being used for soil analysis. Soil samples were analysed for pH (Jackson, 1973), organic carbon (Walkley and Black, 1934), available soil N was estimated using the alkaline permanganate method (Sharawat and Buford, 1982), phosphorus (Olsen's method of extraction using spectrophotometer, Sparks, 1996) and potassium (Neutral N ammonium acetate method and estimated in flame photometer, Sparks, 1996). Five plant samples (whole plants) were collected from each treatment at the time of harvest. These samples were thoroughly washed and rinsed with distilled water. The bulbs and leaves were then separated, chopped into pieces, and air-dried. Once air-dried, the bulb and leaf samples were further over-dried in an oven at 60°C until a constant weight was reached. After reaching a constant weight, the dry weight of both the bulbs and leaves was recorded. Subsequently, the leaf and bulb samples were ground, passed through a 2.0 mm sieve, and used for plant nutrient analysis. Total N was analysed using the micro-Kjeldahl method. To estimate total phosphorus and potassium, 0.5 g of plant samples were digested using di-acid mixture. Following digestion, the digest was thoroughly washed with distilled water and filtered through Whatman Number 40 filter paper. Subsequently, the filtrate was used for total P and K analysis. Total P was determined using the ammonium vanado-molybdate method, total K using the flame photometer method. TSS was determined by digital hand refractometer, ascorbic acid content was determined using dicholrophenol indophenol titration procedure (Casanas *et al*., 2002), total phenol analysis was made by Folin – ciocalteau reagent (FCR) (Vinson *et al*., 1995), total pyruvic acid content was estimated by 2, 4 dinito phenyl hydrazine method (Schwimmer and Weston, 1961). For storage studies initially known weight of bulb was kept for storage and weight was recorded by subtracting with initial weight at 30 and 60 days after storage and expressed in percentage, percentage of sprouting and rotting were also noted and expressed in percentage.

Nutrient uptake

The uptake of N, P and K was worked out using formula equation.

$$\text{Nutrient uptake (kg ha}^{-1}) = \frac{\text{Nutrient content (\%)} \times \text{Dry matter production (kg ha}^{-1})}{100}$$

Note: Source of fertilizers used in fertigation are urea (46:0:0), urea phosphate (17:44:0) and muriate of potash (0:0:60) which are completely water soluble, where as in control treatment urea, DAP (18:46:0) and MOP are used, whereas for sulphur bentonite sulphur is used. Recommended dose of fertilizer for onion is 125:75:125:30 of N: P_2O_5: K_2O: S kg ha^{-1}.

Quantity of water required

The required quantity of water per plot based on 80 per cent cumulative pan evaporation was calculated by using USWB open pan evaporimeter and irrigation was given twice in a week. There were two lateral for each plot with spacing of 60cm apart which is running along the length of raised bund. Drippers of 4 lph capacity were fitted at 40 cm spacing along the lateral line. So by taking into consideration of 80 per cen PAN evaporation reading total volume of water required for one hactre is 6448 m^3. Ventury was installed in the sub-line for fertigation. Individual control valves were provided for each treatment for imposing different fertigation treatments. Fertilizer application is done in weekly interval. N & K_2O are given in 10 splits where as P_2O_5 was given in 6 splits.

Quality of irrigation water used for experiment

Properties	Value
pH	7.12
EC (dS m^{-1})	1.37
TDS (ppm)	750

Treatment Details

T_1: 100 % RDN fertigation with 100% RDP & K basal (100 % RDNPK)

T_2: 100 %RDN & K fertigation with 100% RDP basal (100 % RDNPK)

T_3: 100 % RDN, P & K fertigation with no basal (100 % RDNPK)

T_4: 75 % RDNPK fertigation and 25 % RDNPK as basal (100 % RDNPK)

T_5: 50 % RDNPK fertigation and 50% RDNPK as basal (100 % RDNPK)

T_6: 75 % RDN fertigation with 75 % RDP & K basal (75 %RDNPK)

T_7: 75 % RDN & K fertigation with 75 % RDP basal (75 % RDNPK)

T_8: 75 % RDN, P & K fertigation with no basal (75 % RDNPK)

T_9: 56 % RDNPK fertigation and 19 % RDNPK as basal (75 % RDNPK)

T_{10}: 37.5 % RDNPK fertigation and 37.5% RDNPK as basal (75 % RDNPK)

T_{11}: 100 % RDNPK through conventional fertilizers and method (Control)

T_{12}: Absolute control (No fertilizer)

RD: Recommended dose, N: Nitrogen, P: Phosphorus, K: Potassium

Nutrient Use Efficiency (NUE)

The efficiency of applied nutrients namely N, P and K at harvest was calculated as mentioned below. It is the ration of difference between uptake of nutrients by the crop in fertilized plot and uptake of nutrients by crop in control plot to the quantity of respective nutrient applied.

Water Use Efficiency (WUE)

Water Use Efficiency (WUE) is calculated as the crop yield in kilograms per hectare divided by the total amount of water applied in cubic metres per hectare.

Statistical analysis

Fisher's method of analysis of variances was adopted for statistical analysis and interpretation of the data (Gomez and Gomez, 1984).

Results

Growth parameter

In the current experiment, the split application of major nutrients through fertigation had a substantial impact on growth characteristics such as plant height, number of leaves and neck thickness. Application of 25 per cent of RDF as basal and 75 per cent of RDF through fertigation (T_4) results in significantly higher growth parameter (Table 2) which was followed by 100 per cent of RDF applied through fertigation (T_3) and 50 per cent of RDF applied as basal and 50 per cent of RDF applied through fertigation (T_5).

Yield parameter

Split application of major nutrients by use of completely water soluble fertilizers through fertigation recorded superior yield attributing character and yield compared to soil application of conventional fertilizer by conventional method (Table 2). Significantly higher polar diameter, equatorial diameter and yield was recorded in T_4 which was followed by T_3 and T_5.

Nutrient uptake

Major nutrients through fertigation by use of completely water soluble fertilizers resulted in significantly higher uptake of nutrients than soil based application of conventional fertilizer (Table 3). Noticeably higher nutrient uptake (162.78, 26.70 and114.18, kg ha^{-1} of N, P and K, respectively) was recorded with T_4. This is due to the fact that, increased biomass production as a result of the crop's constant access to water and nutrients in the vicinity of root zone led to an increase in nutrient uptake by split application of major nutrients through fertigation (Rajaraman *et al*., 2010 and Vasu and Reddy, 2013, Sanju *et al*., 2014 and Pooja *et al*. 2021).

Available major nutrient

There is significant difference between different fertigation dose and between fertigation and soil application of NPK through conventional fertilizers on soil nutrient availability after harvest of crop. Significantly higher availability of N, P and K after harvest of crop was recorded with soil application of conventional fertilizer (Table 4). Among different fertigation treatment 100 per cent RDF application (T_1 to T_5) recorded numerically higher nutrient availability compared to 75 per cent RDF (T_6 to T_{10})

Nutrient Use Efficiency

Split application of major nutrient through fertigation has significantly higher nutrient use efficiency than use of conventional fertilizer and method (Table 7). Higher nutrient use efficiency (470.61 kg kg^{-1}, 784.33 kg kg^{-1}, 470.61 kg kg^{-1} and 181.00 kg kg^{-1} for N, P, K and total nutrient use efficiency, respectively) was recorded with 56 per cent of RDF applied through fertigation and 19 per cent of RDF applied as basal.

Quality parameter

Fertigation markedly enhanced the biochemical quality attributes (Table 5) of the crop compared to conventional soil application of fertilizers. Among the treatments, the regime comprising 75% of the recommended dose of fertilizers (RDF) supplied through fertigation and 25% applied as basal (T4) recorded the highest values of total soluble solids (13.67 °Brix), ascorbic acid (12.58 mg 100 g^{-1}), pyruvic acid (3.54 μmol g^{-1}), and phenols (52.54 mg 100 g^{-1}) (Table 15; Fig. 7).

Storage studies

Split application of nutrients through fertigation markedly improved onion bulb storability by reducing physiological weight loss, sprouting, and rotting (Table 6) compared to other nutrient management practices, with the treatment involving 75% RDF applied *via* fertigation and 25% as basal (T_4) consistently recording the lowest physiological weight loss (4.41% and 9.15% at 30 and 60 days, respectively), sprouting (1.62% at 60 days), and rotting (1.23% and 2.78% at 30 and 60 days), closely followed by 56% RDF applied through fertigation and 19% as basal (T_9), which also showed significantly reduced losses; in contrast, 100% RDF applied through conventional fertilizers and methods (T_{11}) resulted in considerably higher physiological weight loss (7.32% and 14.54% at 30 and 60 days), sprouting (4.56% at 60 days), and rotting (3.16% and 6.53%), while the absolute control (T12) exhibited the most severe deterioration with maximum physiological weight loss (7.32% and 14.54%), sprouting (5.12%), and rotting (3.54% and 7.24%).

Discussion

Growth parameter

Application of major nutrients through fertigation results in significantly higher growth parameter (plant height, number of leaves, neck thickness) (Table 2). Because fertilizers applied through fertigation split by matching the crop growth and nutrient requirement helps in increasing availability of nutrients which may favored the cell division, cell elongation through carbohydrate metabolism and synthesis of protein, enzymes, co-enzymes, chlorophyll and other metabolites. Similar findings were reported by Kakade *et al*. (2015), Narendra (2017), Der *et al*. (2018) and Pooja *et al*. (2018).

Yield parameter

Fertigation treatment results in significantly higher yield parameters (Table 2) compared to application of fertilizers through conventional method. This might be due to the fact that 25 per cent of RDF applied through basal helped in providing adequate nutrient during early growth stage of crop and remaining 75 per cent of RDF applied through fertigation split by matching the crop growth and requirement help in increasing nutrient availability which favoured the better root establishment, cell division, synthesis of chlorophyll and other metabolites which results in higher photosynthetic rate and better translocation of photosynthetic assimilates from source to sink thus helps in increasing yield attributing character like equatorial and polar diameter and yield of onion. Similar results were reported by Neelam and Rajput (2005), Kakade *et al*. (2015), Geetha (2022), Rajesh *et al*. (2018), Pradhan *et al*. (2021) and Natarajan *et al.* (2022). Application of 75 per cent RDF through fertigation and 25 per cent as basal (T_4) recorded higher value than 100 per cent of RDF applied through fertigation (T_3). This might be due to fact that in soil with low concentration of nutrient content especially nitrogen and phosphorous, if basal fertilization quantity is reduced, the decreased growth of crop in early stage of growth is responsible for reduction in growth characteristic like plant height, leaf length, number of leaves and root length which results decreasing quantity of nutrients uptake and photosynthetic activity which lead to decreasing translocation of photosynthetic assimilates from source to sink there by reducing total yield of onion bulb. Basal application of optimum dose of fertilizers resulted in higher nutrient (nitrogen and phosphorous) concentration which will enhance the crop productivity (Yeijin *et al*., 2022). The superior performance of T_4 (25% basal + 75% fertigation) compared to T_3 (100% fertigation) highlights what may be termed the “Basal Paradox.” Although fertigation is generally considered more efficient due to localized nutrient placement, onion seedlings in their physiological “startup” phase possess underdeveloped root systems with limited spatial reach. At this stage, roots are unable to effectively intercept nutrients confined to fertigation zones. The basal application in T_4 likely provided a uniformly distributed nutrient supply in the bulk soil, ensuring immediate availability during early establishment. As the root system expanded, the subsequent fertigation (75%) sustained nutrient uptake more efficiently. This dual-phase nutrient strategy explains the observed advantage of T_4 over T_3, underscoring the importance of basal supplementation in crops with small, shallow root systems during establishment.

Nutrient Use Efficiency

Application of 75 per cent of RDF results in higher nutrient use efficiency because lesser quantity of NPK applied results in better utilization, soil available nutrient status after harvest of crop, indicate that applied nutrients are effectively utilized with application of 56 per cent of RDF applied through fertigation and 19 per cent of RDF applied as basal (T_9) Narendra (2017) and Sourab (2022).

Nutrient uptake

Application of fertilizers through fertigation results higher major nutrient uptake because increased biomass production as a result of the crop's constant access to water and nutrients in the vicinity of root zone led to an increase in nutrient uptake by split application of major nutrients through fertigation (Rajaraman *et al*., 2010 and Vasu and Reddy, 2013, Sanju *et al.*, 2014 and Pooja *et al*. 2021).

Available nutrient

Conventional method of fertilization by using conventional fertilizers results in significantly higher available nutrient. This might be due to the fact that application of 50 per cent of N and 100 per cent of P and K as basal and remaining 50 per after 30 days after transplanting through conventional fertilizer results in lower uptake of N, P and K by crop because of less nutrient use efficiency of conventional fertilizers which results in nutrients accumulation in soil after harvest of crop there by increasing available nutrient after harvest of crop. Similar findings were reported by Magare *et al*. (2018), Sourabh (2022) and Nikzad *et al*. (2020).

Quality parameter

Fertigation treatment gives higher value for quality parameters like TSS, ascorbic acid, pyruvic acid and phenol (Table 5). The increase in TSS can be attributed to improved nitrogen uptake, which promoted vigorous vegetative growth and enhanced chlorophyll content, thereby stimulating photosynthetic activity and carbohydrate accumulation in the bulb (Kakade *et al*., 2015). Elevated ascorbic acid levels may be explained by the role of nitrogen in protein and enzyme biosynthesis, which indirectly supports vitamin C formation, while phosphorus regulates carbohydrate metabolism, providing essential precursors for ascorbic acid synthesis (Smirnoff & Wheeler, 2010; Wang et al., 2013). Enhanced pyruvic acid content under fertigation is likely due to greater sulfur uptake, leading to increased production of volatile sulfur compounds that contribute to pyruvate accumulation (Souza *et al.*, 2015; Meher *et al*., 2016). Similarly, higher phenolic content under fertigation reflects the stimulatory effect of nitrogen on secondary metabolism, particularly the phenylpropanoid pathway (Kallapa, 2008). Furthermore, optimal phosphorus and potassium supply is critical for diverse biochemical processes, and their adequate availability under fertigation likely facilitated enhanced synthesis of phenolic compounds (Narendra, 2017; Geetha, 2020).

Storage studies

Fertigation helps to reduces losses during storage of onion(Table 6). This might be due to fact that additive effect of phosphorous and potassium has checked the adverse effect of higher dose of nitrogen in reducing rate of respiration and keeping onion bulb in hydration condition. Similar findings were reported with Muluneh *et al*. (2018), Singh and Dankhar, (1991) and Nandi *et al.* (2002) who reported that physiological weight loss, rotting and sprouting per cent were reduced considerably with application of 100 kg of potassium and favorable effect of phosphorous with respect to minimum loss of the bulb weight, decreasing sprouting and rotting of bulbs. Although thicker necks are generally associated with higher rotting incidence due to delayed drying, our results suggest that improved nutrient status, particularly phosphorus and potassium, may mitigate this effect. Adequate P and K enhance bulb maturity, skin integrity, and tissue strength, thereby reducing rotting percentage even in treatments with relatively thicker necks.

Conclusion

Application of major nutrients through fertigation by use of completely water soluble fertilizer, according to need based approach at different growth stages results in getting significantly higher value for growth parameter, yield attributing character and ultimately higher yield. In soil with low nutrient content some amount of basal application of fertilizer is required compared to complete fertilizer application through split fertigation to obtain maximum yield.

Tabel 1: Weekly application of different split of fertilizers through fertigation.

Critical crop growth stages	Weeks	N (%)	P (%)	K (%)
Vegetative stage	I	5.0	30.0	5.0
	II	7.5	25.0	7.5
	III	10.0	20.0	10.0
	IV	12.5	10.0	12.5
	V	15.0	7.5	15.0
Bulb initiation stage	VI	15.0	7.5	15.0
	VII	12.5	-	12.5
	VIII	10.0	-	10.0
Bulb development stage	IX	7.5	-	7.5
	X	5.0	-	5.0

Table 2: Effect of split application of major nutrients through fertigation on growth and yield of onion.

Treatments	Plant height (cm)	Number of leaves	Neck thick ness (cm)	Equatorial diameter (cm)	Polar diameter (cm)	Yield (t ha^{-1})
T_1: 100 % RDN fertigation with 100 % RDP & K basal	43.47	9.04	1.24	4.70	4.06	43.94
T_2: 100 % RDN & K fertigation with 100 % RDP basal	44.13	9.16	1.26	4.85	4.12	44.23
T_3: 100 % RDN, P & K fertigation with no basal	48.36	10.24	1.37	6.38	5.23	48.56
T_4: 25 % RDNPK as basal and 75 % RDNPK fertigation	53.54	11.55	1.62	7.04	5.67	54.40
T_5: 50 % RDNPK as basal and 50 % RDNPK fertigation	48.04	10.17	1.35	6.13	5.21	48.32
T_6: 75 % RDN fertigation with 75 % RDP & K basal	41.13	7.75	1.17	4.09	3.72	41.06
T_7: 75 % RDN & K fertigation with 75 % RDP basal	42.39	8.03	1.18	4.12	3.77	41.12
T_8: 75 % RDN, P & K fertigation with no basal	43.15	8.84	1.22	4.74	3.96	43.83
T_9: 19 % RDNPK as basal and 56 % RDNPK fertigation	43.67	9.23	1.28	4.88	4.10	44.12
T_{10}: 37.5 % RDNPK as basal and 37.5 % RDNPK fertigation	42.92	8.65	1.20	4.68	3.92	43.62
T_{11}: 100 % RDNPK through conventional fertilizers and method (Control)	37.20	7.63	1.15	4.00	3.34	37.56
T_{12}: Absolute control (No fertilizer)	29.26	6.85	1.00	3.69	3.10	20.57
SE.m ±	1.73	0.39	0.05	0.21	0.13	1.42
C.D @ 5 %	5.17	1.15	0.14	0.60	0.38	4.18

Table 3: Effect of split application of major nutrients through fertigation on nutrient uptake

Treatments	Nitrogen uptake (kg ha^{-1})	Phosphorous uptake (kg ha^{-1})	Potassium uptake (kg ha^{-1})
T_1: 100 % RDN fertigation with 100 % RDP & K basal	127.44	20.14	80.89
T_2: 100 % RDN & K fertigation with 100 % RDP basal	132.48	20.91	83.82
T_3: 100 % RDN, P & K fertigation with no basal	144.12	23.27	96.94
T_4: 25 % RDNPK as basal and 75 % RDNPK fertigation	162.78	26.70	114.18
T_5: 50 % RDNPK as basal and 50 % RDNPK fertigation	143.30	22.96	96.31
T_6: 75 % RDN fertigation with 75 % RDP & K basal	112.02	16.65	71.20
T_7: 75 % RDN & K fertigation with 75 % RDP basal	115.48	17.28	73.17
T_8: 75 % RDN, P & K fertigation with no basal	125.10	19.20	79.01
T_9: 19 % RDNPK as basal and 56 % RDNPK fertigation	130.78	20.18	82.41
T_{10}: 37.5 % RDNPK as basal and 37.5 % RDNPK fertigation	124.61	19.07	78.67
T_{11}: 100 % RDNPK through conventional fertilizers and method (Control)	99.53	15.38	64.52
T_{12}: Absolute control (No fertilizer)	66.31	10.95	42.31
SE.m ±	5.55	0.86	3.64
C.D @ 5 %	16.27	2.54	10.68

Table 4: Effect of split application of major nutrients through fertigation on pH, organic carbon and available nutrients after harvest

Treatments	pH	O C g kg^{-1}	Nitrogen (kg ha^{-1})	Phosphorous (kg ha^{-1})	Potassium (kg ha^{-1})
T_1: 100 % RDN fertigation with 100 % RDP & K basal	8.12	3.5	160.50	22.32	564.10
T_2: 100 % RDN & K fertigation with 100 % RDP basal	8.11	3.6	157.52	21.62	552.13
T_3: 100 % RDN, P & K fertigation with no basal	8.0	3.5	147.88	19.26	523.77
T_4: 25 % RDNPK as basal and 75 % RDNPK fertigation	7.90	3.7	135.21	15.86	492.23
T_5: 50 % RDNPK as basal and 50 % RDNPK fertigation	8.10	3.4	148.70	19.57	525.06
T_6: 75 % RDN fertigation with 75 % RDP & K basal	8.10	3.5	146.73	18.13	534.30
T_7: 75 % RDN & K fertigation with 75 % RDP basal	8.12	3.6	144.27	17.50	526.77
T_8: 75 % RDN, P & K fertigation with no basal	8.11	3.5	136.64	15.58	496.90
T_9: 19 % RDNPK as basal and 56 % RDNPK fertigation	8.10	3.5	130.97	14.52	478.53
T_{10}: 37.5 % RDNPK as basal and 37.5 % RDNPK fertigation	8.12	3.6	137.14	15.70	498.23
T_{11}: 100 % RDNPK through conventional fertilizers and method (Control)	8.12	3.5	186.47	24.00	592.47
T_{12}: Absolute control (No fertilizer)	8.11	3.5	104.68	11.25	457.71
SE.m ±	0.38	0.02	7.17	0.91	11.54
C.D @ 5 %	NS	NS	21.02	2.67	33.85

Table 5: Effect of split application of major nutrients through fertigation on quality parameter of onion

Treatments	TSS (° Brix)	Ascorbic acid (mg 100 g^{-1})	Pyruvic acid (µmol g^{-1})	Phenol (mg 100 g^{-1})
T_1: 100 % RDN fertigation with 100 % RDP & K basal	11.26	12.04	3.36	46.06
T_2: 100 % RDN & K fertigation with 100 % RDP basal	11.63	12.05	3.38	46.12
T_3: 100 % RDN, P & K fertigation with no basal	12.56	12.24	3.48	50.26
T_4: 25 % RDNPK as basal and 75 % RDNPK fertigation	13.67	12.58	3.54	52.54
T_5: 50 % RDNPK as basal and 50 % RDNPK fertigation	12.45	12.20	3.46	50.13
T_6: 75 % RDN fertigation with 75 % RDP & K basal	10.58	11.50	3.25	42.98
T_7: 75 % RDN & K fertigation with 75 % RDP basal	10.74	11.56	3.28	43.24
T_8: 75 % RDN, P & K fertigation with no basal	11.36	12.00	3.35	45.57
T_9: 19 % RDNPK as basal and 56 % RDNPK fertigation	11.96	12.04	3.39	46.08
T_{10}: 37.5 % RDNPK as basal and 37.5 % RDNPK fertigation	11.30	11.31	3.32	45.46
T_{11}: 100 % RDNPK through conventional fertilizers and method (Control)	10.26	11.04	3.10	38.04
T_{12}: Absolute control (No fertilizer)	9.06	10.12	2.82	34.64
SE.m ±	0.33	0.33	0.04	2.03
C.D @ 5 %	0.95	0.96	0.12	5.95

Table 6: Effect of split application of major nutrients through fertigation on physiological weight loss, sprouting and rotting onion bulb

Treatments	Physiological weight loss (%)		Sprouting (%)		Rotting (%)	
	30 DAS	60 DAS	30 DAS	60 DAS	30 DAS	60 DAS
T_1: 100 % RDN fertigation with 100 % RDP & K basal	6.24	12.56	0	3.12	2.85	5.46
T_2: 100 % RDN & K fertigation with 100 % RDP basal	5.98	11.91	0	3.09	2.56	5.23
T_3: 100 % RDN, P & K fertigation with no basal	5.16	10.48	0	2.12	1.76	3.56
T_4: 25 % RDNPK as basal and 75 % RDNPK fertigation	4.41	9.15	0	1.62	1.23	2.78
T_5: 50 % RDNPK as basal and 50 % RDNPK fertigation	5.28	10.68	0	2.14	1.78	3.63
T_6: 75 % RDN fertigation with 75 % RDP & K basal	6.42	13.12	0	3.46	2.93	6.23
T_7: 75 % RDN & K fertigation with 75 % RDP basal	6.13	12.52	0	3.28	2.86	5.97
T_8: 75 % RDN, P & K fertigation with no basal	5.86	11.72	0	2.48	1.94	4.12
T_9: 19 % RDNPK as basal and 56 % RDNPK fertigation	5.05	10.52	0	1.96	1.56	3.87
T_{10}: 37.5 % RDNPK as basal and 37.5 % RDNPK fertigation	5.92	11.84	0	2.56	1.97	3.94
T_{11}: 100 % RDNPK through conventional fertilizers and method (Control)	6.98	13.94	0	4.56	3.16	6.53
T_{12}: Absolute control (No fertilizer)	7.32	14.54	0	5.12	3.54	7.24
SE.m ±	0.20	0.35	-	0.16	0.13	0.18
C.D @ 5 %	0.59	1.03	-	0.48	0.37	0.54

Table 7: Effect of split application of major nutrients through fertigation on nutrient use efficiency

Treatments	Nitrogen use efficiency (kg kg^{-1})	Phosphorous use efficiency (kg kg^{-1})	Potassium use efficiency (kg kg^{-1})	Water use efficiency (Kg m^3)
T_1: 100 % RDN fertigation with 100 % RDP & K basal	351.44	552.52	351.44	6.82
T_2: 100 % RDN & K fertigation with 100 % RDP basal	353.84	589.73	353.84	6.86
T_3: 100 % RDN, P & K fertigation with no basal	388.48	647.46	388.48	7.53
T_4: 25 % RDNPK as basal and 75 % RDNPK fertigation	435.20	725.33	435.20	8.44
T_5: 50 % RDNPK as basal and 50 % RDNPK fertigation	386.56	644.26	386.56	7.49
T_6: 75 % RDN fertigation with 75 % RDP & K basal	437.97	729.95	437.97	6.37
T_7: 75 % RDN & K fertigation with 75 % RDP basal	438.61	731.02	438.61	6.38
T_8: 75 % RDN, P & K fertigation with no basal	467.52	779.20	467.52	6.80
T_9: 19 % RDNPK as basal and 56 % RDNPK fertigation	470.61	784.33	470.61	6.84
T_{10}: 37.5 % RDNPK as basal and 37.5 % RDNPK fertigation	465.28	775.46	465.28	6.76
T_{11}: 100 % RDNPK through conventional fertilizers and method (Control)	300.48	500.86	300.48	5.82
T_{12}: Absolute control (No fertilizer)	0.00	0.00	0.00	3.19
SE.m ±	10.62	14.57	10.62	0.22
C.D @ 5 %	31.14	42.73	31.14	0.65

Conflict of interest

The authors declare no conflicts of interest.

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