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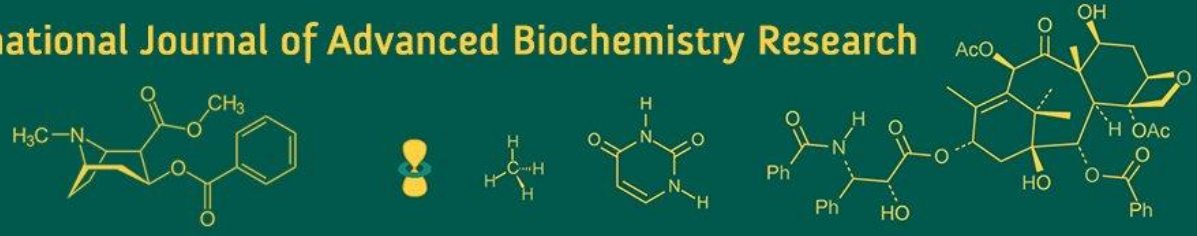

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Rutuja N Deshmukh
Ph.D. Scholar, Department of Fruit Science, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India

Dr. SG Bharad
Professor of Horticulture and Head, Department of Fruit Science, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India

Dr. SR Patil
Professor, Department of Fruit Science, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India

Dr. GG Jadhav
Deputy Director (Horticulture), Central Research Station, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India

Dr. VK Kharche
Ret. Director of Research, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India

Dr. SB Wadatkar
Ret. Professor and Head, Department of Irrigation and Drainage, College of Agricultural Engineering Technology, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India

Shivaji N Kolekar
Ph.D. Scholar, Department of Fruit Science, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India

Corresponding Author:
Rutuja N Deshmukh
Ph.D. Scholar, Department of Fruit Science, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India

Effect of different levels of fertigation on growth and yield of custard apple

Rutuja N Deshmukh, SG Bharad, SR Patil, GG Jadhav, VK Kharche, SB Wadatkar and Shivaji N Kolekar

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Abstract
An investigation entitled "Effect of different levels of fertigation on growth and yield of custard apple" was carried out at Central Research Station during two consecutive years 2021-22 and 2022-23 on five-year old custard apple plants cv. Balanagar. The experiment was conducted to evaluate the effect of different levels of fertigation on growth and yield parameters, and to find out the optimum fertigation level custard apple. The experiment was laid out in Randomized Block Design with eleven treatments. The results indicated that, growth was significantly influenced by different fertigation levels. The maximum growth *viz.*, number of shoots per branch, leaf area and minimum days required for emergence of new shoot was observed with the application of 180-108-216 NPK kg ha^{-1} through fertigation while, the number of leaves per shoot and leaf area was recorded maximum with the application of 203-122-144 NPK kg ha^{-1} through fertigation. The maximum fruit yield (kg per plant and tons per ha) was observed with the application of 180-108-216 NPK kg ha^{-1} through fertigation.

Keywords: Custard apple, *Annona squamosa*, fertigation, NPK levels

Introduction
Custard apple (*Annona squamosa* L.) commonly known as sitaphal or sugar apple, is a member of the family Annonaceae and is valued as a delicacy in arid and semi-arid regions due to its sweet, tender pulp. Native to tropical America, it is now widely cultivated across tropical and subtropical regions. Custard apple is generally classified as semi wild fruit by virtue of its spontaneous spread in forests, wastelands and other uncultivated places. It is hardy, tolerant to drought, salinity and saline irrigation water to certain extent. In India, custard apple occupies about 6.25 lakh ha with an annual production of 8.29 lakh MT, predominantly in dryland areas (*Anon.*, 2024) [9]. Maharashtra is the leading producer with 2.72 lakh ha area and 4.99 lakh MT production, followed by Madhya Pradesh and Telangana. Major producing districts in Maharashtra include Beed, Aurangabad, Ahmednagar, Jalgaon, Nashik, Satara, Amravati, Buldhana and Wardha. Nutritionally, custard apple pulp provides 104 kcal per 100 g edible portion, containing 23.5 g carbohydrates, 1.6 g protein, 3.1 g fibre, 17 mg calcium, 47 mg phosphorus, 1.5 mg iron and 37 mg vitamin C (Gopalan *et al.*, 1987) [12]. The fruit is consumed fresh and processed into value-added products such as jams, jellies, ice creams and yogurts, enhancing its commercial scope (Patil *et al.*, 2024) [6]. Seeds, containing 26–27% oil, alkaloids and acetogenins, are utilized in industrial applications, bio-fertilizers and natural insecticides (Mahmoud *et al.*, 2022) [19]. Considering the increasing area under custard apple cultivation in Vidarbha, nutrient optimization through fertigation is critical for sustaining productivity and profitability. Fertigation offers distinct advantages over conventional fertilizer application by ensuring controlled and efficient delivery of nitrogen, phosphorus and potassium, thereby supporting superior vegetative growth, fruit set, yield and quality traits such as fruit size, total soluble solids and sugar:acid ratio (Priya *et al.*, 2022). However, accurate timing and dosage are essential to prevent nutrient imbalances affecting plant health and fruit quality.
Custard apple (*Annona squamosa* L.) is an emerging dryland fruit crop valued for its adaptability to marginal and rainfed lands, drought resilience, low input requirements, and nutritional, medicinal, and industrial significance. Its expanding demand for fresh and value-added products enhances its economic potential, particularly in semi-arid regions like

Vidarbha, Maharashtra, where it serves as a profitable alternative to traditional fruit crops. Despite its adaptability, productivity remains low due to inadequate adoption of improved management practices, especially balanced nutrition and efficient irrigation. As custard apple trees extract substantial nutrients from the soil, balanced fertilization is essential for sustaining yield and fruit quality. Rising fertilizer costs necessitate efficient use, which can be achieved through fertigation—a technique of applying soluble fertilizers via drip irrigation that ensures precise, stage-specific nutrient supply, enhances fertilizer and water use efficiency, and improves soil and crop health. As the area under custard apple cultivation is increasing and the absence of systematic fertigation studies in custard apple, the present investigation was undertaken to evaluate the effects of different levels of fertigation levels on growth and yield of custard apple

Materials and Methods

The present investigation entitled "Effect of different levels of fertigation on growth and yield of custard apple" on five-year old custard apple plants cv. Balanagar having spacing 4mx4m at Central Research Station, Dr. PDKV, Akola during 2021-22 and 2022-23. The experiment was conducted to evaluate the effect of different levels of fertigation on growth and yield parameters, and to find out the optimum fertigation levels custard apple. The experiment was laid out in Randomized Block Design with eleven treatments replicated thrice *viz*., RDF through soil application 156-78-78 kg ha^{-1} (T_1), 156-78-78 kg ha^{-1} (T_2), 180-90-90 kg ha^{-1} (T_3), 203-102-102 kg ha^{-1} (T_4), 133-66-66 kg ha^{-1} (T_5), 109-55-55 kg ha^{-1} (T_6), 156-94-188 kg ha^{-1} (T_7), 180-108-216 kg ha^{-1} (T_8), 203-122-144 kg ha^{-1} (T_9), 133-80-159 kg ha^{-1} (T_{10}) and 109-66-131 kg ha^{-1} (T_{11}) NPK through fertigation were used in present study.

Table 1: Effect of different levels of fertigation on incremental growth parameters (pooled mean).

Treatments	Days for emergence of new shoot	Number of shoots per branch	Number of leaves per shoot	Leaf area (cm^2)
T_1	15.52	10.77	16.82	43.77
T_2	14.17	11.13	18.69	50.14
T_3	12.61	11.25	18.70	51.02
T_4	11.06	11.40	19.17	53.92
T_5	12.35	10.59	18.31	48.87
T_6	13.67	11.79	16.91	47.89
T_7	11.03	12.92	19.59	51.48
T_8	10.58	13.03	19.56	54.59
T_9	10.70	12.64	20.25	57.18
T_{10}	12.31	11.11	17.74	49.85
T_{11}	12.33	11.02	17.18	48.14
F test	NS	Sig	Sig	Sig
SE (m) ±	1.08	0.51	0.52	1.82
CD at 5%	-	1.53	1.53	5.49

It is evident from the data that, the growth parameters *viz*., number of shoots per branch, number of leaves per shoot and leaf area were significantly increased in with different levels of fertigation (Table 1). The results indicated that the pooled mean of two-year data, minimum number of days (10.58) was recorded for the treatment T_8 (180-108-216 NPK kg ha^{-1} through fertigation). The maximum number of shoots branch^{-1} (13.03) were observed in treatment T_8 (180-108-216 NPK kg ha^{-1} through fertigation) which was at par with treatment T_6 (11.79), T_7 (12.92) and T_9 (12.64), however, the minimum number of shoots branch^{-1} (10.77) were recorded for treatment T_1 (156-78-78 NPK kg ha^{-1} through soil application). The maximum leaf area (57.18 cm^2) was recorded for the treatment T_9 (203-122-144 NPK kg ha^{-1} through fertigation) which was at par with treatment T_4 (203-102-102 NPK kg ha^{-1} through fertigation) and T_8 (5180-108-216 NPK kg ha^{-1} through fertigation) for pooled mean whereas, minimum leaf area (43.77 cm^2) was observed for treatment T_1 (156-78-78 NPK kg ha^{-1} through soil application).

In the present investigation the incremental parameters were increased with the higher levels of fertigation. The significant increase in leaf area observed under fertigation can be attributed to improved nutrient availability and enhanced assimilate translocation resulting from the continuous and uniform supply of NPK. Precise nutrient delivery directly to the root zone minimizes losses through leaching and volatilization ensuring that essential elements are readily available for uptake. This promotes vigorous cell division and elongation, leading to enhanced shoot growth and frequent bud break, which further stimulates the development of lateral shoots. The production of denser foliage increases the photosynthetic surface area, thereby supporting higher assimilate production and improved fruit yield (Sharma and Choudhary, 2012;). Similar positive responses to fertigation have been documented in guava (Singh *et al.*, 2008; Kumawat *et al.*, 2017) [17], kinnow mandarin, litchi and banana (Kavino *et al.*, 2004) [15]. Nitrogen plays a pivotal role in enhancing vegetative growth by promoting the synthesis of proteins and amino acids, which are vital for new tissue development. The increased nitrogen uptake under fertigation also stimulates auxin biosynthesis, which accelerates cell elongation and contributes to enhanced leaf area (Mahaveer, 2020). Furthermore, the continuous availability of nutrients reduces the likelihood of deficiencies, ensuring sustained leaf expansion and shoot development. Enhanced leaf area contributes to greater photosynthetic capacity, which in turn supports the plant's metabolic demands during the growth and fruiting phases. These physiological responses reflect the plant's improved capacity to utilize available nutrients more efficiently under fertigation compared to conventional soil application.

The synergistic interaction of nitrogen, phosphorus and potassium was particularly evident at higher fertigation doses (203-122-144 kg ha^{-1}), where significant improvements in shoot elongation, leaf expansion and overall plant vigor were recorded. These nutrients collectively enhance root proliferation, stimulate cell division, regulate stomatal activity and facilitate ADP-

related metabolic processes, all of which contribute to accelerated growth and improved physiological performance. Adequate nutrient availability also supports consistent metabolic activity throughout the growth cycle, thereby enhancing orchard productivity. Similar findings have been reported in custard apple (Palepad *et al.,* 2020) [20], guava (Baviskar *et al.,* 2018) [10] and cashew, confirming that fertigation is a superior nutrient management strategy for optimizing vegetative growth and sustaining high yield potential in custard apple.

Table 2: Effect of different levels of fertigation on yield and yield attributing parameters (pooled mean).

Treatments	Number of fruits per plant	Fruit yield (kg per plant)	Fruit yield (t per ha)
T_1	53.43	14.22	8.89
T_2	56.66	16.19	10.12
T_3	58.34	18.21	11.38
T_4	59.94	18.88	11.80
T_5	56.43	16.63	10.40
T_6	56.64	15.47	9.67
T_7	63.71	19.91	12.62
T_8	70.44	24.15	15.10
T_9	68.10	22.50	14.06
T_{10}	58.17	17.79	11.12
T_{11}	56.00	15.00	9.37
F test	Sig	Sig	Sig
SE (m) ±	2.47	1.42	1.12
CD at 5%	6.62	4.18	3.30

As regards to different fertigation levels, treatment T_8 (180-108-216 NPK kg ha^{-1} through fertigation) produced significantly maximum number of fruits per plant (70.44), fruit yield (24.15 kg $plant^{-1}$ and 15.10 t ha^{-1}). The treatment T_9 (203-122-244 NPK kg ha^{-1} through fertigation) was at par for number of fruits per plant, fruit yield (kg per plant) While, the treatment T_7 (156-94-188 NPK kg ha^{-1} through fertigation) and T_9 (203-122-244 NPK kg ha^{-1} through fertigation) was at par for fruit yield (tons per hectare) based on pooled mean. Higher fertigation rates resulted in the maximum number of fruits per branch, likely due to improved nutrient status enhancing metabolite production and their efficient translocation to developing fruits. Fertigation ensures precise delivery of nutrients to regions with active feeder root growth at the right time and in the right amounts, optimizing vegetative growth and providing a strong physiological basis for flowering, fruit set and reduced fruit drop (Priya *et al.,* 2022). Similar positive effects of NPK fertigation on fruit number have been reported in guava (Kumar *et al.,* 2008) [16], aonla (Suresh *et al.,* 2018) and pomegranate (Jadhav *et al.,* 2020) [14]. The observed improvements in yield attributes, such as fruit size, weight, percentage fruit set, were closely associated with enhanced vegetative growth and consistent nutrient availability. The increase in custard apple yield under fertigation can be attributed to higher nutrient-use efficiency, better physiological activity, and efficient translocation of photosynthates to reproductive organs (Dalal *et al.,* 2019) [11]. Nitrogen and phosphorus not only enhance their own availability but also facilitate translocation from roots to flowers, promoting flower development and fruit set. These results are consistent with earlier reports in pomegranate (Haneef *et al.,* 2014) [13] and aonla.

Conclusion

Based on the findings, it can be concluded that the 180-108-216 NPK kg ha^{-1} through fertigation significantly improved the growth and yield performance of custard apple. This treatment enhanced key growth parameters, including leaf area, number of shoots per branch and early shoot initiation ultimately resulted in the highest fruit yield per plant (kg) and per hectare (t ha^{-1}).

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