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Effect of different fertigation levels on yield and chemical attributes of custard apple

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Abstract
A study was conducted during 2022-23 and 2023-24 at Central Research Station, Dr. PDKV, Akola to find out effect of application of NPK through different fertigation levels on yield and chemical attributes of custard apple. The custard apple plants of five-year old were given eleven treatments replicated three times in Randomized Block Design. Experimental findings revealed that, the application of 180-108-216 kg ha^{-1} through fertigation recorded maximum number of fruits per plant as well as yield (kg plant^{-1}) along with chemical attributes viz., TSS and TSS: acidity ratio.

Keywords: Custard apple, fertigation, NPK levels, fruit yield, chemical attributes, TSS

Introduction
Custard apple (*Annona squamosa* L.), commonly known as sitaphal or sugar apple, belongs to the family Annonaceae and is an important fruit crop of arid and semi-arid regions due to its adaptability to marginal and degraded soils. The fruits are rich in sugars, iron, calcium, phosphorus and ascorbic acid and have high market demand (Gopalan *et al.*, 1987) [2]. In India, the area under custard apple cultivation is increasing on a commercial scale, however, fully grown plants often exhibit wide variability in yield and produce small-sized fruits resulting in poor market value. In the Vidarbha region of Maharashtra, custard apple is a climate-resilient dryland fruit crop, yet it is sensitive to moisture and nutrient stress during flowering and fruit development. Although the crop possesses an extensive root system capable of exploring large soil volumes, the natural fertility of marginal soils is rarely sufficient to sustain economic yields (Priya *et. al.*, 2022) [9]. Imbalanced and inadequate nutrient management, remains a major constraint limiting productivity and fruit quality. Continuous removal of nutrients without proper replenishment further leads to soil nutrient depletion and threatens long-term sustainability.

Conventional soil application of fertilizers often results in low nutrient-use efficiency due to losses through leaching and volatilization. Drip fertigation with water-soluble fertilizers enables precise and timely delivery of nutrients directly to the root zone, thereby improving nutrient-and water-use efficiency, reducing losses and enhancing yield and fruit quality. Despite its increasing adoption, region-specific information on optimum fertigation levels and schedules for custard apple, particularly for 'cv. Balanagar' under Vidarbha conditions is limited. Therefore, the present study was undertaken to evaluate the effect of different NPK fertigation levels on yield and chemical attributes of custard apple 'cv. Balanagar' under dryland conditions, with the objective of identifying an optimum nutrient management strategy for sustainable commercial cultivation.

Materials and Methods
The present investigation entitled "Effect of different fertigation levels on yield and chemical attributes of custard apple" on five-year old custard apple plants *cv.* Balanagar having spacing 4mx4m at Central Research Station, Dr. PDKV, Akola during 2022-23 and 2023-24. The study aimed to assess the influence of different fertigation levels on yield and chemical attributes of custard apple and to determine the optimum fertigation dose.

The experiment was laid out in a Randomized Block Design comprising eleven treatments *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.

Results and Discussions

Table 1: Effect of different fertigation levels on yield and chemical attributes of custard apple

Treatments	Number of fruits per plant	Yield (kg plant^{-1})	TSS (^{0}B)	Titratable acidity	TSS: acidity ratio
T_1	53.43	14.22	19.70	0.396	49.75
T_2	56.66	16.19	19.81	0.390	50.79
T_3	58.34	18.21	20.37	0.373	54.61
T_4	59.94	18.88	20.47	0.374	54.73
T_5	56.43	16.63	20.29	0.396	51.24
T_6	56.64	15.47	20.19	0.374	53.98
T_7	63.71	19.91	20.98	0.372	56.40
T_8	70.44	24.15	21.55	0.363	59.37
T_9	68.10	22.50	21.05	0.372	56.59
T_{10}	58.17	17.79	20.24	0.372	54.41
T_{11}	56.00	15.00	20.40	0.381	53.54
F-test	Sig	Sig	Sig	NS	
SE(m)±	2.47	1.42	0.25	0.020	
CD 5%	6.62	4.18	0.74	-	

The highest fruit yield per plant (24.15 kg plant^{-1}) was recorded in treatment T_8 (180-108-216 kg NPK ha^{-1} applied through fertigation), which was statistically at par with treatment T_9 (22.50 kg plant^{-1}). Whereas, the lowest fruit yield per plant (14.22 kg plant^{-1}) was observed in treatment T_1 (156-78-78 kg NPK ha^{-1}) applied through soil application). Similarly, the maximum fruit yield per hectare (15.10 t ha^{-1}) was obtained in treatment T_8, which was at par with treatments T_7 (12.62 t ha^{-1}) and T_9 (14.06 t ha^{-1}). While, the minimum fruit yield per hectare (8.89 t ha^{-1}) was recorded under treatment T_1. Higher levels of NPK fertigation resulted in a significant increase in the number of fruits per branch and per plant. This response may be attributed to enhanced nutrient availability, leading to increased metabolite synthesis and their efficient translocation towards developing fruits. Drip irrigation maintained optimum soil moisture in the root zone, reduced fruit drop and improved fruit set, thereby increasing fruit number. Maximum fruit yield in terms of number of fruits per plant and yield per plant, as well as graded yield was recorded under higher fertigation levels. The yield enhancement appears to be a combined effect of improved vegetative growth and physiological efficiency under elevated nutrient supply. Increased leaf area enhanced photosynthetic activity and photosynthate availability, while synchronized water and nutrient supply improved fruit retention and fruit development, resulting in superior fruit size and weight. Enhanced carbohydrate metabolism, protein synthesis and maintenance of a favourable C:N ratio further supported reproductive growth and fruiting (Kotoky *et al.*, 2005) [4]. The superior performance of treatments T_8 (180-108-216 kg NPK ha^{-1}) and T_9 (203-122-244 kg NPK ha^{-1}) through fertigation may therefore be attributed to efficient synchronization of nutrient and water availability with the physiological requirements of custard apple during critical growth and fruiting stages. These findings are in agreement with earlier reports in mandarin (Shirgure and Shrivastava, 2001) [12], banana (Mahalakshmi *et al.*, 2001) [6] and guava (Thakur and Singh, 2004) [16] and custard apple (Suresh *et al.*, 2011 and Raut *et al.*, 2020) [15, 11].

The treatment T_8 (180-108-216 kg NPK ha^{-1} through fertigation) recorded the maximum total soluble solids (21.55 °Brix), which was statistically at par with treatments T_9 (21.05 °Brix) and T_7 (20.98 °Brix). The lowest TSS (19.70 °Brix) was observed in treatment T_1 (156-78-78 kg NPK ha^{-1} applied through soil application). Also, the highest TSS: acidity ratio (59.37) was recorded under treatment T_8 (180-108-216 kg NPK ha^{-1} through fertigation), followed by treatment T_9. While, the minimum TSS: acidity ratio (49.75) was observed in treatment T_1. An increasing trend in total soluble solids (TSS) was observed in custard apple fruits with increasing levels of NPK application through fertigation, which may be attributed to enhanced metabolic activity and accumulation of soluble sugars and other constituents, as reported earlier by Suresh *et al.* (2011) [15] and Raut *et al.* (2020) [11]. Increased level of potassium application results in reduced acid content of fruits. Under low potassium levels, phosphoenol pyruvate (PEP) is diverted into alternative metabolic pathways, which leads to reduced formation of acetyl Co-A (Sohnika *et al.*, 2017) [14] in mango. As a result, PEP is preferentially converted into oxaloacetate, causing accumulation of organic acids in plant tissues. While, adequate potassium supply helps in neutralizing these organic acids, thereby reducing acidity in fruits (Suresh *et al.*, 2011; Kumar *et al.*, 2017) [15, 5]. With advancing fruit maturity, acidity declined proportionately with increasing TSS, producing a desirable sugar-acid balance a key quality attribute. Higher NPK levels applied through fertigation significantly improved biochemical quality, particularly TSS and the TSS: acid ratio. The superior performance of treatment T_8 (180-108-216 kg NPK ha^{-1} through fertigation) can be attributed to the role of potassium in carbohydrate metabolism, sucrose transport and starch-sugar interconversion (Dheware *et al.*, 2020; Purnendra and Sahu, 2020) [1, 10]. Enhanced osmotic potential and sap flow under adequate potassium further facilitated sugar translocation into fruits (Jeykumar *et al.*, 2012) [3], while improved vegetative growth and photosynthetic efficiency under treatments T_8 and T_9 (203-122-244 kg NPK ha^{-1} through fertigation) promoted greater assimilate partitioning towards fruits. Similar inverse relationships between sugars and acidity have been reported in apple (Neilsen *et al.*, 2000) [7] and pomegranate (Prasad and Mali, 2000 and Singh *et al.*, 2006) [8, 13].

Conclusion

Based on the findings, it can be concluded that the fertigation level of 180-108-216 kg ha^{-1} NPK through fertigation significantly improved the yield and chemical quality parameters of custard apple. This treatment enhanced yield in terms of number of fruits per plant and kg $plant^{-1}$ as well as chemical attributes *viz.*, TSS and TSS: acid ratio.

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