Effect of different spacing and NPK combination on plant growth, fruit yield and fruit quality of strawberry [(Fragaria × ananassa Duchesne ex Weston) Duchesne ex Rozier)] cv. Winter dawn

Abstract

The study titled "Impact of Varied Spacing and NPK Combinations on Growth, Yield, and Quality of Strawberry (Fragaria ×ananassa Duchesne ex Weston)Duchesne ex Rozier) cv. Winter Dawn" was conducted at the Department of Horticulture, Prayagraj, Naini Agriculture Institute, Sam Higginbottom Institute of Agriculture, Technology and Sciences, during the period of 2023-2024. The primary objective was to determine the most effective treatment combination to enhance yield and profitability for strawberry farmers. Employing a factorial Randomized Complete Block Design, the experiment comprised twelve treatments, each replicated three times. These treatments involved different spacing configurations coupled with varying NPK levels.The findings of the study revealed that Treatment 5 (25×30cm spacing with 100:120:80 NPK kg/ha) exhibited the most favorable outcomes in terms of both yield and fruit quality parameters. Notably, Treatment 5 showcased superior results in various aspects including the duration for first flower appearance, flower count per plant, duration for fruit bud development, fruit count per plant, fruit set, fruit yield, Total Soluble Solids (TSS), juice pH, acidity levels, fruit weight, and dimensions.

Keywords*:*NPK, pH, Yield, Quality, Winter Dawn, Strawberry

Introduction

Strawberry (Fragaria × ananassa Duchesne ex Weston) Duchesne ex Rozier) holds its place as one of the most sought-after soft fruit crops cultivated in temperate regions worldwide, prized for its luscious fresh fruits. Belonging to the esteemed Rosaceae family, this hybrid plant bears a chromosome count of 2n = 56 and is a distinguished member of the Fragaria genus. Noteworthy for its aggregate fruit structure, the strawberry presents a unique composition and aesthetic appeal.

Beyond its visual allure, the strawberry boasts a distinctive taste and aroma, rendering it a favorite among consumers. Renowned for its nutritional richness, strawberries stand out as an excellent source of vital nutrients including vitamins, potassium, fiber, and sugars. Notably, when compared to other berry fruits, strawberries exhibit elevated levels of essential nutrients such as vitamin C, phenolics, and flavonoids. This nutritional superiority underscores the strawberry's significance in promoting health and well-being, making it a prized addition to any diet.(**Hakkinen and Torronen, 2000)**.

The favourable soil pH range for strawberry is about 4.6-6.5. Strawberry is the most important fruit plants for both fresh consumption and food processing in the temperate and subtropical areas. In North India, area under strawberry is increasing rapidly due to its remunerative prices. Annual world production of strawberry is increasing from 3 to more than 4 thousand MT. About 98% of the production occurs in the Northern Hemisphere, though production is expanding in the South (**Hummer, 2009**). In India it is commercially grown in Mahabaleshwar (Maharastra), Haryana, Punjab, Uttar Pradesh, Jammu and

Kashmir, Uttarakhand and low hills of Himachal PradeshOptimal plant spacing is crucial for ensuring proper growth and development, leading to maximum crop yield and efficient land use. In the practice of planting runners, they are typically positioned along rows with approximately 0.9 meters of spacing between rows and 0.45 meters between individual plants. Organic manures such as vermicompost, farmyard manure (FYM), compost, and biofertilizers play a significant role in agriculture as vital sources of organic nutrients. These manures not only help bridge the gap between nutrient removal and supply but also ensure a balanced nutrient ratio, enhance response efficiency, and maximize crop productivity while maintaining desired quality.Vermicompost are the result of accelerated biological degradation of organic waste by earthworms and microorganisms. Through this process, earthworms consume and break down organic matter into finer particles within their grinding gizzard. They derive nourishment from the microorganisms that proliferate on these particles. This accelerated decomposition alters the physical and chemical properties of the material, leading to humification, wherein unstable organic matter is fully oxidized and stabilized.The application of FYM and vermicompost has been found to enhance fruit quality and yield. These organic amendments help reduce fruit drop, increase fruit yield and quality, and improve the physicochemical properties of fruits. As a result, they also enhance the marketability and demand for fruits. Therefore, this investigation aims to optimize fruit quality and increase profitability in fruit farming.

Strawberry has rapid growth (two to three months) and is extremely affected by environmental conditions such as temperature, light, salinity, water quality and nutrient availability. Because of its speed of development, the crop needs adequate macronutrient absorption to meet photosynthetic demand and fruit growth. The need for photosynthesis and rapid growth of strawberry plants is reported to require a high acquisition of macronutrients. Knowledge of crop nutritional requirement is important in developing profitable crop with better quality **(Li et al.2010).** In plant growth and development, nitrogen (N), phosphorus (P) and potassium (K) are essential macronutrients. Playing a particular role in various physiological and morphological aspects as essential molecules associated with various fundamental metabolic processes **(Takehisaet al. 2013).** Nitrogen (N) is known as the most limiting nutrient to plant growth and development and its availability determines crop yield and quality. Phosphorus is an important nutrient and plays an important role in reproduction, vigor and general health of all plants. It is often referred as an energy source because during the photosynthesis it helps to store and transfer energy in plants **Gastal & Lemaire (2002**). Potassium increases crop yield and improves quality. It is required for numerous plant growth processes such as enzyme activation and stomatal activity **Prajapati and Modi (2012**). The research objectives, To evaluate the effect of different spacing and NPK levels on growth, yield and quality parameters of Strawberry.

Materials and Methods

Field experiments for studying effect of different spacing and NPK combination on plant growth, fruit yield and fruit quality of strawberry were performed during 1st November2023 to 3rd March 2024 at the Horticultural Research Field, Naini Agricultural Institute, Sam Higginbottom University of Agriculture Technology and Sciences, Prayagraj (25.43° N latitude 81.84° E longitude) India. The soil at the location is Loam and Sandy Loam. Prayagraj district has a sub-tropical climate and the average maximum temperature ranges

between 43°C - 47°C which may go as high as 48°C during peak summers. The experiment was laid out in Factorial Randomized Complete Block Design with twelve treatments replicated three. The twelve treatments consist of (25×15cm+75:80:50NPK Kg/ha) T1, (25×15cm+100:120:80NPK kg/ha) T2, (25×15cm+125:160:110 NPK kg/ha) T3, (25×30cm+75:80:50 NPK kg/ha) T4, (25×30cm+100:120:80NPKkg/ha) T5, (25×30cm+125:160:110NPK kg/ha) T6, (25×45cm+75:80:50NPK kg/ha) T7,

(25×45cm+100:120:80NPKkg/ha) T8, (25×45cm+125:160:110NPKkg/ha) T9, (45×45cm+75:80:50NPK kg/ha) T10, (45×45cm+100:120:80NPK kg/ha) T11,

(45×45cm+125:160:110NPK kg/ha) T12. In experiment, I had taken 5 samples with 3 repetitions. All the doses of NPK combination were applied at the time of planting and during flowering initiation and observations were recorded on plant height (cm), number of leaves per plant, plant spread (cm), petiole length (cm), days taken to first flower appearance, number of flowers per plant, days to fruit bud development, number of fruits per plant, fruit set, fruit yield, TSS, pH of the juice, acidity, weight of fruit, and length diameter.

Result and Discussion

Growth Characters

Result on different spacing and NPK combination indicated that T8 (25×45cm +100:120:80 NPK kg/ha) recorded maximum plant height (cm) of 10.91cm (30DAT), 12.52cm (60DAT), 14.91cm (90DAT) whereas minimum plant height (cm) of 7.25cm (30DAT), 8.56cm (60DAT), 10.90cm (90DAT) was recorded in T3 (25×15cm +125:160:110 NPK kg/ha), T8 (25×45cm +100:120:80 NPK kg/ha) recorded maximum number of leaves per plant of 4.80 (30DAT), 12.93(60DAT), 16.33 (90DAT) whereas minimum number of leaves per plant of 3.20 (30DAT), 10.33 (60DAT), 12.33 (90DAT) was recorded in T3 (25×15cm +125:160:110 NPK kg/ha), T8 (25×45cm +100:120:80 NPK kg/ha) recorded maximum plant spread (cm) of 16.26cm (30DAT), 21.52cm (60DAT), 32.55cm (90DAT) whereas minimum plant spread (cm) of 12.53cm (30DAT), 17.83cm (60DAT), 29.12cm (90DAT) was recorded in T3 (25×15cm +125:160:110 NPK kg/ha), T8 (25×45cm +100:120:80 NPK kg/ha) recorded maximum plant spread (cm) of 16.26cm (30DAT), 21.52cm (60DAT), 32.55cm (90DAT) whereas minimum plant spread (cm) of 12.53cm (30DAT), 17.83cm (60DAT), 29.12cm (90DAT) was recorded in T3 (25×15cm +125:160:110 NPK kg/ha), T8 (25×45cm +100:120:80 NPK kg/ha) recorded maximum petiole length (cm) of 8.51cm (30DAT), 10cm (60DAT), 12.04cm (90DAT) whereas minimum petiole length (cm) of 4.36cm (30DAT), 5.61cm (60DAT), 7.71cm (90DAT) was recorded in T3 (25×15cm +125:160:110 NPK kg/ha). The probable reason for increased plant height, number of leaves per plant, plant spread and petiole length was possibly due to the readily available nitrogen, which might have encouraged more vegetative growth and development. The similar findings were also reported by (Ali *et al.*2023). The application of NPK fertilizer (Bhagat *et al.* 2022) in strawberry (Table 1-4).

Flowering and fruiting characters

Result on different spacing and NPK combination indicated that T5 (25×30cm +100:120:80 NPK kg/ha) recorded maximum days to first flowering 68.13 whereas minimum days to first flowering 45.66 recorded in T3 (25×15cm +125:160:110 NPK kg/ha), T5 (25×30cm +100:120:80 NPK kg/ha) recorded maximum number of flowers per plant of 3.93 (60DAT), 4.80 (75DAT),8.13 (85DAT) whereas minimum number of flowers per plant of 1.20

(60DAT), 4.20 (75DAT), 6.80 (85DAT) was recorded in T3 (25×15cm +125:160:110 NPK kg/ha), T5 (25×30cm +100:120:80 NPK kg/ha) recorded maximum days taken to fruit bud development 75.13 whereas minimum days to first flowering 60.87 recorded in T3 (25×15cm +125:160:110 NPK kg/ha), T5 (25×30cm +100:120:80 NPK kg/ha recorded maximum number of fruits per plant of 1.73 (75DAT), 4.93 (90DAT), 9.53 (105DAT) whereas minimum number of fruits per plant of 0.80 (75DAT), 4.00 (90DAT), 5.87 (105DAT) was recorded in T3 (25×15cm +125:160:110 NPK kg/ha), T5 (25×30cm +100:120:80 NPK kg/ha) recorded maximum fruit set (%) 79.33 whereas minimum fruit set (%) 53.33 recorded in T3 (25×15cm +125:160:110 NPK kg/ha). The probable reason for this might be due to increased photosynthetic efficiency and rate of assimilation due to nitrogen and phosphorus application which reflects on vigorous growth of plant and ultimately remitting profuse flowering. Similar results were also found by (Chandra *et al.* 2021) reported effect of nitrogen, phosphorus and potassium on growth and yield which enhanced flower bud initiation (Dar *et al.* 2013)reported of organic, inorganic fertilizers and plant spacing on the growth and yield (Islam *et al.* 2017). Enhanced flowering and fruiting in strawberry (Table5-6).

Yield parameters

Result on different spacing and NPK combination indicated that T5 (25×30cm +100:120:80 NPK kg/ha) recorded maximum fruit yield per plant 176.15g whereas minimum fruit yield per plant 145.05g recorded in T3 (25×15cm +125:160:110 NPK kg/ha), T5 (25×30cm +100:120:80 NPK kg/ha) recorded maximum fruit yield per plot 1.17kg whereas minimum fruit yield per plot 0.71kg recorded in T3 (25×15cm +125:160:110 NPK kg/ha), T5 (25×30cm +100:120:80 NPK kg/ha) recorded maximum fruit yield (t/ha) 13.27 whereas minimum fruit yield (t/ha) 9.43 recorded in T3 (25×15cm +125:160:110 NPK kg/ha), T5 (25×30cm +100:120:80 NPK kg/ha) recorded maximum fruit weight 32.81g whereas minimum fruit weight 19.42g recorded in T3 (25×15cm +125:160:110 NPK kg/ha). It was observed that the yield of fruits per unit area was inversely related to the plant spacing i.e., the closer plant spacing produced the higher yield of fruits per plot and per hectare. Similar kind of findings was reported by (Ughade and Mahadkar 2015). Thus higher yield of fruits was mainly contributed by the higher plant population per unit area in closer spacing. The result of integrated nutrient management on growth, yield reported by (Wani *et al. 2013*). The maximum yield per plant was recorded in the plants treated with NPK levels conferred greater ability to produce higher yield (Table 7-11).

Chemical parameters

Result on different spacing and NPK combination indicated that T5 (25×30cm +100:120:80 NPK kg/ha) recorded minimum pH of the juice 3.53 whereas maximum pH of the juice 4.01 recorded in T3 (25×15cm +125:160:110 NPK kg/ha), T5 (25×30cm +100:120:80 NPK kg/ha) recorded maximum TSS of the juice 9.98 ºBrix whereas minimum TSS of the juice 8.38 ºBrix recorded in T3 (25×15cm +125:160:110 NPK kg/ha), T5 (25×30cm +100:120:80 NPK kg/ha) recorded minimum acidity (%) of the juice 0.67% whereas maximum acidity (%) of the juice 0.79% recorded in T3 (25×15cm +125:160:110 NPK kg/ha). The plants grown with luxuriant supply nitrogen and phosphorus, prolonged their bio-chemical process and exhibited pH of the fruit juice. The acidity% and TSS was significantly influenced by different levels of nitrogen treatment. Similar finding have been reported by(Sharma *et al.*2020) in strawberryeffect of different tree spacingsand combined doses of poultry manure and vermicompost on growth and yield(Kar *etal.* 2019) Table (12-16)

Table 1Effect of different spacing and NPK levels on Plant Height (cm) at (30,60,90 DAT)

	F1	F2	F3	Mean	F1	F2	F3	Mean	F1	F2	F3	Mean
S1	3.95	7.95	7.25	6.38	5.97	9.51	8.56	8.01	9.19	11.99	10.90	10.28
S2	7.4	6.4	6.95	6.95	8.67	7.83	8.22	8.24	10.87	10.13	10.53	10.51
S3	10.29	10.91	6.77	9.33	11.66	12.52	8.33	10.84	13.92	14.91	10.62	13.15
S4	7.49	9.57	8.55	8.54	8.72	10.80	9.71	9.74	11.13	13.16	11.96	12.08
Mean	7.28	8.72	7.19		8.76	10.16	8.70		11.28	12.55	11.00	
Factors	F test	SE(d)	C.D.		F test	SE(d)	C.D.		F test	SE(d)	C.D.	
Factor S	S	0.157	0.328		S	0.162	0.339		S	0.168	0.351	
Factor F	S	0.136	0.284		S	0.141	0.294		S	0.146	0.304	
Factor(S×F)	S	0.272	0.568		S	0.281	0.587		S	0.292	0.609	

Table 2 Effect of different spacing and NPK levels on Number of leaves per plant at (30,60,90 DAT)

	F1	F2	F3	Mean	F1	F2	F3	Mean	F1	F2	F3	Mean
S1	**2.53**	**3.80**	**3.20**	**3.18**	**5.26**	**11.40**	**10.33**	**9.00**	**7.26**	**13.40**	**12.33**	**11.00**
S2	**3.87**	**3.67**	**3.73**	**3.76**	**11.20**	**10.53**	**10.80**	**10.84**	**13.93**	**13.20**	**14.00**	**13.71**
S3	**3.93**	**4.80**	**4.00**	**4.24**	**11.06**	**12.93**	**11.33**	**11.78**	**13.80**	**16.33**	**14.27**	**14.80**
S4	**4.07**	**4.13**	**3.40**	**3.87**	**11.53**	**11.13**	**10.93**	**11.20**	**14.13**	**14.20**	**13.33**	**13.89**
Mean	**3.60**	**4.10**	**3.58**		**9.77**	**11.50**	**10.85**		**12.28**	**14.28**	**13.48**	
Factors	F test	SE(d)	C.D.		F test	SE(d)	C.D.		F test	SE(d)	C.D.	
Factor S	**S**	**0.167**	**0.349**		**S**	**0.353**	**0.738**		**S**	**0.385**	**0.804**	
Factor F	**S**	**0.145**	**0.302**		**S**	**0.306**	**0.639**		**S**	**0.334**	**0.696**	
Factor(S×F)	**S**	**0.290**	**0.605**		**S**	**0.612**	**1.278**		**S**	**0.667**	**1.393**	

Table 3 Effect of different spacing and NPK levels on plant spread (cm) at (30.60,90 DAT)

	F1	F2	F3	Mean	F1	F2	F3	Mean	F1	F2	F3	Mean
S1	**8.38**	**13.06**	**12.53**	**11.32**	**9.67**	**18.28**	**17.83**	**15.26**	**15.49**	**28.85**	**29.12**	**24.48**
S2	**14.15**	**14.03**	**11.94**	**13.38**	**19.13**	**18.45**	**17.15**	**18.24**	**30.21**	**29.01**	**27.65**	**28.96**
S3	**13.12**	**16.26**	**11.88**	**13.75**	**17.98**	**21.52**	**16.96**	**18.82**	**28.59**	**32.55**	**26.69**	**29.27**
S4	**14.10**	**11.38**	**12.45**	**12.64**	**19.31**	**16.64**	**14.65**	**16.87**	**29.59**	**27.32**	**25.86**	**27.59**
Mean	**12.44**	**13.68**	**12.20**		**16.52**	**18.72**	**16.65**		**25.96**	**29.43**	**27.33**	
Factors	F test	SE(d)	C.D.		F test	SE(d)	C.D.		F test	SE(d)	C.D.	

Factor S	**S**	**0.277**	**0.578**		**S**	**0.262**	**0.547**		**S**	**0.468**	**0.977**	
Factor F	**S**	**0.240**	**0.500**		**S**	**0.227**	**0.473**		**S**	**0.405**	**0.846**	
Factor(S×F)	**S**	**0.480**	**1.001**		**S**	**0.454**	**0.947**		**S**	**0.811**	**1.693**	

Table 4 Effect of different spacing and NPK levels on petiole length (cm) at (30,60,90 DAT)

	F1	F2	F3	Mean	F1	F2	F3	Mean	F1	F2	F3	Mean
S1	**2.51**	**5.63**	**4.36**	**4.17**	**3.69**	**6.74**	**5.61**	**5.35**	**5.87**	**8.89**	**7.77**	**7.51**
S2	**4.77**	**4.29**	**4.81**	**4.62**	**6.21**	**5.45**	**5.93**	**5.88**	**8.36**	**7.66**	**8.03**	**8.02**
S3	**8.05**	**8.51**	**4.55**	**7.04**	**9.39**	**10**	**5.91**	**8.34**	**11.54**	**12.04**	**7.83**	**10.47**
S4	**5.16**	**7.14**	**6.20**	**6.17**	**6.42**	**8.41**	**7.47**	**7.44**	**8.39**	**10.47**	**9.63**	**9.50**
Mean	**5.12**	**6.39**	**4.98**		**6.43**	**7.66**	**6.23**		**8.54**	**9.76**	**8.31**	
Factors	F test	SE(d)	C.D.		F test	SE(d)	C.D.		F test	SE(d)	C.D.	
Factor S	**S**	**0.165**	**0.344**		**S**	**0.158**	**0.330**		**S**	**0.149**	**0.311**	
Factor F	**S**	**0.143**	**0.298**		**S**	**0.137**	**0.285**		**S**	**0.129**	**0.269**	
Factor(S×F)	**S**	**0.285**	**0.596**		**S**	**0.273**	**0.571**		**S**	**0.258**	**0.538**	

Table5 Effect of different spacing and NPK levels on days taken to first flower appearance

	F1	F2	F3	Mean
S1	54.93	58.20	45.66	52.60
S2	53.93	68.13	57.93	60.33
S3	51.13	58.67	56.27	55.36
S4	53.00	53.27	52.46	52.91
Mean	53.57	59.57	53.08	
Factors	**F test**	**SE(d)**	**C.D.**	
Factor S	S	2.037	4.251	
Factor F	S	1.764	3.682	
Factor(S×F)	S	3.258	7.364	

Table 6 Effect of different spacing and NPK levels on number of flowers per plant at (60,75,85 DAT)

	F1	F2	F3	Mean	F1	F2	F3	Mean	F1	F2	F3	Mean
S1	**0.53**	**1.60**	**1.20**	**1.11**	**1.60**	**4.33**	**4.33**	**3.40**	**3.13**	**6.47**	**6.80**	**5.47**
S2	**1.53**	**3.93**	**1.47**	**2.31**	**4.53**	**4.80**	**4.80**	**4.91**	**6.93**	**8.13**	**7.13**	**7.48**
S3	**1.33**	**1.40**	**1.67**	**1.47**	**4.20**	**4.67**	**4.67**	**4.58**	**6.87**	**7.93**	**7.53**	**7.44**
S4	**1.07**	**0.93**	**1.00**	**1.00**	**4.47**	**4.40**	**4.40**	**4.53**	**7.40**	**7.60**	**7.20**	**7.40**
Mean	**1.12**	**1.97**	**1.33**		**3.70**	**4.82**	**4.55**		**6.08**	**7.53**	**7.17**	
Factors	F test	SE(d)	C.D.		F test	SE(d)	C.D.		F test	SE(d)	C.D.	
Factor S	**S**	**0.124**	**0.258**		**S**	**0.225**	**0.470**		**S**	**0.292**	**0.609**	
Factor F	**S**	**0.107**	**0.224**		**S**	**0.195**	**0.407**		**S**	**0.253**	**0.527**	
Factor(S×F)	**S**	**0.214**	**0.448**		**S**	**0.390**	**0.813**		**S**	**0.505**	**1.055**	

Table 7 Effect of different spacing and NPK levels on days taken to fruit bud development.

	F1	F2	F3	Mean
S1	66.60	70.87	60.87	69.11
S2	67.87	75.13	64.93	69.31
S3	64.60	71.47	68.80	68.29
S4	66.93	66.80	65.88	66.53
Mean	66.50	71.07	65.12	
Factors	**F test**	**SE(d)**	**C.D.**	
Factor S	NS	2.060	------	
Factor F	S	1.784	3.723	
Fator(S×F)	NS	3.567	-------	

Table 8 Effect of different spacing and NPK levels on number of fruits per plant at (75,90,105 DAT)

	F1	F2	F3	Mean	F1	F2	F3	Mean	F1	F2	F3	Mean
S1	**0.267**	**1.07**	**0.80**	**0.71**	**1.53**	**3.73**	**4.00**	**3.09**	**2.73**	**5.93**	**5.87**	**4.84**
S2	**1.00**	**1.73**	**0.73**	**1.16**	**3.80**	**4.93**	**4.13**	**4.29**	**6.13**	**9.53**	**6.60**	**7.42**
S3	**1.20**	**0.93**	**1.13**	**1.09**	**3.67**	**4.33**	**4.27**	**4.09**	**6.20**	**7.13**	**6.67**	**6.67**
S4	**1.27**	**0.53**	**0.60**	**0.80**	**4.40**	**3.87**	**4.07**	**4.11**	**6.80**	**6.47**	**6.07**	**6.44**
Mean	**0.93**	**1.07**	**0.82**		**3.35**	**4.22**	**4.12**		**5.47**	**7.27**	**6.30**	
Factors	F test	SE(d)	C.D.		F test	SE(d)	C.D.		F test	SE(d)	C.D.	
Factor S	**S**	**0.102**	**0.213**		**S**	**0.209**	**0.437**		**S**	**0.257**	**0.536**	
Factor F	**S**	**0.088**	**0.184**		**S**	**0.181**	**0.379**		**S**	**0.222**	**0.464**	
Factor(S×F)	**S**	**0.177**	**0.369**		**S**	**0.363**	**0.757**		**S**	**0.444**	**0.928**	

Table 9 Effect of different spacing and NPK levels on fruit set (%)

	F1	F2	F3	Mean
S1	66.60	70.87	60.87	69.11
S2	67.87	75.13	64.93	69.31
S3	64.60	71.47	68.80	68.29
S4	66.93	66.80	65.88	66.53
Mean	66.50	71.07	65.12	
Factors	**F test**	**SE(d)**	**C.D.**	
Factor S	NS	2.060	------	
Factor F	S	1.784	3.723	
Factor (S×F)	NS	3.567	-------	

Table 10 Effect of different spacing and NPK levels on fruit yield per plant (g)

	F1	F2	F3	Mean
S1	94.97	164.78	145.05	139.94
S2	162.58	176.15	181.37	173.37
S3	155.47	150.85	148.48	151.60

S4	136.17	123.93	116.76	125.62
Mean	137.30	153.93	147.92	
Factors	**F test**	**SE(d)**	**C.D.**	
Factor S	S	1.952	4.074	
Factor F	S	1.690	3.528	
Factor (S×F)	S	3.381	7.056	

Table 11 Effect of different spacing and NPK levels on fruit yield per plot (kg)

	F1	**F2**	**F3**	**Mean**
S1	0.50	0.92	0.71	0.71
S2	1.05	1.17	0.67	0.96
S3	0.65	0.89	0.79	0.77
S4	0.74	0.53	0.84	0.72
Mean	0.73	0.89	0.75	
Factors	**F test**	**SE(d)**	**C.D.**	
Factor S	S	0.040	0.083	
Factor F	S	0.034	0.072	
Factor (S×F)	S	0.069	0.144	

Table 12 Effect of different spacing and NPK levels on fruit weight (g)

	F1	**F2**	**F3**	**Mean**
S1	11.26	26.43	20.43	19.34
S2	22.05	32.81	25.87	26.91
S3	19.42	27.52	16.79	21.24
S4	24.82	16.28	19.48	20.19
Mean	19.39	25.76	20.76	
Factors	**F test**	**SE(d)**	**C.D.**	
Factor S	S	0.620	1.294	
Factor F	S	0.537	1.121	
Factor (S×F)	S	1.074	2.241	

Table 13 Effect of different spacing and NPK levels on pH of the juice

	F1	F2	F3	Mean
S1	3.42	4.95	4.01	4.13
S2	3.59	3.53	3.40	3.60
S3	4.34	3.72	3.91	3.99
S4	4.34	2.87	3.73	3.65
Mean	3.92	3.77	3.84	
Factors	**F test**	**SE(d)**	**C.D.**	
Factor S	S	0.175	0.365	
Factor F	NS	0.151	-------	
Factor (S×F)	S	0.303	0.632	

Table 14 Effect of different spacing and NPK levels on TSS of the juice

	F1	F2	F3	Mean
S1	7.72	8.20	8.38	8.10
S2	11.25	9.45	8.86	10.54
S3	9.98	10.66	10.23	10.29
S4	6.39	10.76	9.62	8.23
Mean	8.83	9.77	9.27	
Factors	**F test**	**SE(d)**	**C.D.**	
Factor S	S	0.227	0.474	
Factor F	S	0.197	0.410	
Factor (S×F)	S	0.393	0.821	

Table 15 Effect of different spacing and NPK levels on acidity (%) of the juice

	F1	F2	F3	Mean
S1	0.82	0.95	0.79	0.85
S2	0.76	0.67	0.73	0.69
S3	0.72	0.78	0.70	0.74
S4	0.71	0.76	0.81	0.73
Mean	0.75	0.74	0.76	
Factors	**F test**	**SE(d)**	**C.D.**	
Factor S	S	0.040	0.083	
Factor F	NS	0.034	-------	
Factor (S×F)	S	0.069	0.143	

Table 16 Effect of different spacing and NPK levels on length diameter

	F1	F2	F3	Mean
S1	1.05	1.34	1.29	1.23
S2	1.62	1.56	1.26	1.47
S3	1.25	1.32	1.72	1.43
S4	1.42	1.55	1.39	1.45
Mean	1.33	1.44	1.41	
Factors	**F test**	**SE(d)**	**C.D.**	
Factor S	S	0.033	0.068	
Factor F	S	0.028	0.059	
Factor (S×F)	S	0.056	0.118	

Conclusion

From the above experiment finding it is concluded that the treatment T5 (25×30cm+100:120:80 NPK kg/ha) was found to be best in terms of yield and fruit quality viz, Days taken to first flower appearance, number of flowers per plant, days to fruit bud development, number of fruits per plant, fruit set, fruit yield, TSS, pH of the juice, acidity, weightoffruit and length diameter. As regard the NPK levels (100:120:80 NPK kg/ha) and (25×30cm) was found most suitable under study about all observations. Therefore, all the treatment combinations as such significantly affect all the parameters, however T5 (25×30cm+100:120:80 NPK kg/ha) gave the most superior result.

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