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Effect of Different Spacing and NPK Combination on Plant Growth, Fruit Yield and Fruit Quality of Strawberry (*Fragaria ananassa* Duch.) cv. Winter Dawn

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The present investigation entitled "Effect of different Spacing and NPK (Nitrogen, Phosphorus, Pottasium) combination on plant growth, fruit yield and fruit quality of Strawberry (*Fragaria ananassa* Duch.) Winter Dawn" was carried out in the department of Horticulture, Prayagraj, Naini

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Agriculture Institute, Sam Higginbottom Institute of Agriculture, Technology and sciences, Prayagraj in the year 2023-2024. The goal of the experiment was to determine the best treatment combination for increasing farmer profitability and yield. A Factorial Randomized Complete Block Design including three replications and twelve treatment combinations was used to set up the experiment. The treatments consist of varying spacing combined with various NPK concentrations. Result obtained in present investigation showed that the treatmentT8(25×45cm+125:160:110NPKkg/ha) was determined to have the finest growth features, including petiole length (12.04 cm), plant spread (32.55 cm), plant height (14.91 cm), and number of leaves (16.33). In terms of fruit quality and yield, T5 (25 x 30 cm + 100 x 120 g NPK kg/ha) was found to be the best. These factors included the number of flowers per plant (12.13), the number of days it took for a fruit bud to develop (60.87 days), the number of fruits per plant (9.53), fruit set (79.33%), the weight of the fruit (32.81 g), the length diameter (1.56 cm), the fruit yield per plant (176.15 g), the fruit yield per plot (1.17 kg), TSS (9.98 brix), the pH of the juice (3.53), and the acidity percentage (0.67%). T3 had the lowest observation, (25 x 15 cm and +125:160:110 NPK kg/ha).

Keywords: NPK; pH; yield; quality; winter dawn; strawberry.

1. INTRODUCTION

Strawberry (Fragaria ananassa Duch.) is one of the most popular soft fruit crops cultivated in temperate regions of the world for its fresh fruits. It is a member of family Rosaceae, with a chromosome number of 2n = 56 is a hybrid of genus Fragaria. Strawberry is an example of aggregate fruit. Strawberry keeps unique taste, flavour, and excellent source of vitamins, potassium, fibre and sugars. As compared to other berry fruits, strawberries contain a higher percentage of vitamin C, phenolics and flavonoids [1]. Strawberry fruit size, which includes length and width as well as color development, taste, texture, and flavor, determines both the fruit's quality and the level of client acceptability. Since their balance determines the fruit's attractiveness and delectable flavor, sugar and organic acid are the fruit elements that contribute to the overall strawberry flavor [2]. 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 [3]**.** 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 [4]**.** 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 [5]. Potassium increases crop yield and improves quality. It is required for numerous plant growth processes such as enzyme activation and stomatal activity [6]. The majority of strawberry cultivars are extremely vulnerable to a wide range of phytopathogens, such as nematodes, viruses, bacteria, and fungi in particular. The fungal necrotrophic one of the most dangerous fungi that appears to have no host specificity is Botrytis cinerea, the causative agent of the grey mold illness [7]**.** By utilizing NPK combination, which helps to decrease fruit drops and boost fruit production and quality, you can improve the fruit's quality and yield. Fruits physical and chemical characteristics, as well as raising their marketability and demand. Therefore, the purpose of this inquiry is to improve fruit quality and increase profitability [8].

2. MATERIALS AND METHODS

From November 1, 2023, to March 3, 2024, field experiments were conducted 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) in India to investigate the effects of varying spacing and NPK combination on plant growth, fruit yield, and fruit quality of strawberries. The area has both

loam and sandy loam soil. With a subtropical climate, the Prayagraj district experiences typical maximum temperatures of 43°C to 47°C, with the possibility of reaching 48°C during the hottest summer months. Factorial Randomized Complete Block Design was used to set up the experiment, and twelve treatments were reproduced three times. 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, (25×30 cm+75:80:50 NPK kg/ha) T4, (25×30 cm+100:120:80NPKkg/ha) T5, (25×30 cm+125:160:110NPK kg/ha) T6, (25×45 cm+75:80:50NPK kg/ha) T7, (25×45 cm+100:120:80NPK kg/ha) T8, (25×45 cm+125:160:110NPKkg/ha) T9, (45×45 cm+75:80:50NPK kg/ha) T10, (45×45 cm+100:120:80NPK kg/ha) T11,

(45×45cm+125:160:110NPK kg/ha) T12. 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, length diameter. The statistical procedure for agricultural research states that an analysis of variance will be performed on the data's mean values. Factorial Randomized Complete Block Design. A method and algorithms were used to compute different statistical parameters. The Analysis of Variance (ANNOVA) method was used to compare the means of the attributes [9].

2.1 Factor

2.1.1 Spacing:

S1=25×15 cm
S2=25×30 cm
S3=25×45 cm
S4=45×45 cm

2.1.2 Fertilizer:

F1=75:80:50 NPK Kg/ha
F2=100:120:80 NPK Kg/ha
F3=125:160:110 NPK Kg/ha

2.1.3 Abbreviations

C.D. = Critical difference
F = Fertilizer
F test S = F test significant
S = Spacing
SE (d) = Standard error of difference

List 1. Treatment details

Treatment	Treatment Details
T1	25×15cm+75:80:50NPK Kg/ha
T2	25×15cm+100:120:80NPK kg/ha
T3	25×15cm+125:160:110 NPK kg/ha
T4	25×30cm+75:80:50 NPK kg/ha
T5	25×30cm+100:120:80NPK kg/ha
T6	25×30cm+125:160:110NPK kg/ha
T7	25×45cm+75:80:50NPK kg/ha
T8	25×45cm+100:120:80NPK kg/ha
T9	25×45cm+125:160:110NPKkg/ha
T10	45×45cm+75:80:50NPK kg/ha
T11	45×45cm+100:120:80NPK kg/ha
T12	45×45cm+125:160:110NPK kg/ha

2.2 Vegetative Characters

2.2.1 Plant Height (cm)

The height of plants was measured by using a measuring scale from crown level of plants to the apex of primary leave at was recorded at 30, 60 and 90 DAP and results were expressed in cm.

2.2.2 Plant Spread (cm)

The spread of the tagged plants was recorded at 30, 60 and 90 DAP in east-west and north-south direction separately with the help of a meter scale and the average for each direction was calculated.

2.2.3 Petiole length (cm)

The petiole is the stalk of the entire leaf, but for the operation of this key this feature is applied also to the leaflet stalk of compound leaves. It is measured at 30, 60 and 90. Their average was calculated and subjected to statistical analysis.

2.2.4 Numbers of leaves per plant

Total number of leaves was counted from tagged plants in each replication at 30, 60 and 90 DAP and expressed as average number of leaves per plant.

2.3 Floral Characters

2.3.1 Days to first flowering

It was recorded after planting when 5-6 plants in each replication started to flower. The average number of days from planting date was calculated to make the observation.

2.3.2 No of flowers/plants

The total number of flowers per plant was recorded on the five tagged plants. The number of flowers was counted from first flower initiation after planting till last harvesting and the value was expressed as number of flowers per plant.

2.4 Fruit and Yield Attributes

2.4.1 Days to fruit bud development

It was recorded after planting when 5-6 plants in each replication started to fruiting. The average number of days from planting date was calculated to make the observation.

2.4.2 Number of fruits/plants

The number of fruits per plant was recorded on the same three tagged plants on which fruit set was studied. The number of fruits reaching harvestable maturity was counted at each harvest and the value was expressed as number of fruits per plant.

2.4.3 Fruit set (%)

For each stem, calculate the percent fruit set as follows: divide the number of fruits by the number of blossoms, then multiply by 100.

2.4.4 Fruit yield (g/plant)

The weight of entire fruits harvested from each plant were recorded for each treatment and the result was exposed in grams (g).

2.4.5 Fruit yield (kg/plot)

The weight of entire fruits harvested from each plot were recorded for each treatment and the result was exposed in kilograms (kg).

2.5 Quality Parameters

2.5.1 Total soluble solid (°Brix)

Total soluble solids (TSS) were recorded with the help of digital refractometer. Fully ripe fruits of each treatment were taken and few (2-3) drops of juice from 5 fruits were taken separately and dropped over the prism of the refractometer. The value as observed was averaged to record the TSS (°Brix).

2.5.2 pH of the juice

pH of fruit juice was measured by pH meter. The pH electrode is first calibrated with standard buffer solution with known pH values that span the range being measured. To make a pH measurement, the electrode is immersed into the sample solution until a steady reading is reached.

2.5.3 Acidity (%)

Titratable acidity (% malic acid) was measured by using a standard procedure of Hortwitz (1980) with a slight modification. For this, a known weight of the fruit sample was crushed and taken in a 100ml volumetric flask and the volume was made up by adding distilled water. Add filtration, 10 ml of the filtrate was taken in a separate conical flask and titrated against 0.1 N sodium hydroxide (NaOH) using phenolphthalein dye as an indicator. The end point was determined by the appearance of a faint pink colour. Titratable acidity was calculated by using the formula given below:

Titrable acidity (%) = Titre volume × Normality of alkali × volume made up × Equivalent weight of acid X 100 / Volume of aliquot sample × weight of sample × 1000

2.5.4 Fruit weight (g)

Selected fruit were harvested from each replication to measure the fruit weight. The weight was measured on electronic balance and average berry weight was calculated and expressed in grams (g).

2.5.5 Length – diameter of the fruit (cm)

The length diameter ratio is the ratio of the flighted length of the fruit to its outside diameter of the fruit. The ratio calculation is calculated by dividing the flighted length of the fruit by its nominal diameter.

3. RESULTS AND DISCUSSION

Plant height, petiole length, number of leaves and plant spread all showed in the data (Table 1-4). 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).

Result on different spacing and NPK combination indicated that 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).

Result on different spacing and NPK combination indicated that 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).

Result on different spacing and NPK combination indicated that 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 proliferation of plants may result from the inoculation of nitrogen fixers, which increases chlorophyll production. It might also result from the growth of plants. regulators produced by rhizosphere-dwelling bacteria that the roots absorb. As a result, higher biological nitrogen fixation may be the cause of greater vegetative development [10]. The current findings in strawberries are consistent with those of Mohandas [11].

Days to first flowering, number of flowers per plant, days taken to fruit bud development, number of fruits per plant, fruit set (%) all showed in the data (Table 5-9). 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).

Result on different spacing and NPK combination indicated that T5 (25×30cm +100:120:80 NPK kg/ha) recorded maximum number of flowers per plant of 3.93 (60DAT), 4.80 (75DAT),12.13 (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).

Result on different spacing and NPK combination indicated that T5 (25×30cm +100:120:80 NPK kg/ha) recorded maximum days taken to fruit bud development 75.13 whereas minimum days taken to fruit bud development 60.87 recorded in T3 (25×15cm +125:160:110 NPK kg/ha).

Result on different spacing and NPK combination indicated that 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),

Result on different spacing and NPK combination indicated that 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) [11].

The outcomes support the observation, that composts included phosphate and nitrogen, which promoted the commencement of floral buds and vegetative growth.[12] and [13], the application of vermicompost improved strawberry flowering and fruiting because it improves soil qualities such as nutrient availability and cation exchange capacity [14], the optimal concentration of nutrients like N, P, and K as well as hormones from vermicompost significantly increased the amount of Gibberellic acid in roots, breaking bud dormancy and boosting flowering buds. Applications of vermicompost improved strawberry flowering and fruiting [12].

Fruit yield per plant, fruit yield per plot, fruit weight all showed in the data (Table 10-12). 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).

Result on different spacing and NPK combination indicated that 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).

Result on different spacing and NPK combination indicated that 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).

Table 1. Effect of different spacing and NPK levels on plant height (cm) at (30,60,90 DAT)

	F1	F2	F3	Mean S	F1	F2	F3	Mean S	F1	F2	F3	Mean S
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 F	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 S	F1	F2	F3	Mean S	F1	F2	F3	Mean S
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 F	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 S	F1	F2	F3	Mean S	F1	F2	F3	Mean S
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 F	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.**	

	F1	F2	F3	Mean S	F1	F2	F3	Mean S	F1	F2	F3	Mean S
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 S	F1	F2	F3	Mean S	F1	F2	F3	Mean S
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 F	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	

Table 5. Effect of different spacing and NPK levels on days taken to first flower appearance

	F1	F2	F3	Mean S
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 F	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 S	F1	F2	F3	Mean S	F1	F2	F3	Mean S
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	12.13	7.13	8.73
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 F	1.12	1.97	1.33		3.70	4.82	4.55		6.08	8.53	7.16	
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 S
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 F	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 8. Effect of different spacing and NPK levels on number of fruits per plant at (75,90,105 DAT)

	F1	F2	F3	Mean S	F1	F2	F3	Mean S	F1	F2	F3	Mean S
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 F	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 S
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 F	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 S
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 F	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 S
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 F	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 S
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 F	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 S
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 F	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 S
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 F	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 S
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 F	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 S
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 F	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	

It was found that the relationship between the output of fruits per unit area and plant spacing was inverse; that is, the closer the plants were spaced, the higher the yield of fruits per plot and per hectares [15] and [16] both revealed similar kinds of results. Thus, a bigger plant population per unit area with closer spacing was the primary factor contributing to the higher fruit yield. The

experiment's outcome revealed similarities to [17] findings. The plants treated with vermicompost had the highest yield per plant. Increased dry matter accumulation increased the capacity to yield more.

pH of the juice, TSS of the juice, acidity % all showed in the data (Table 13-16). 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).

Result on different spacing and NPK combination indicated that 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).

Result on different spacing and NPK combination indicated that 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).

Result on different spacing and NPK combination indicated that T5 (25×30cm +100:120:80 NPK kg/ha) recorded maximum length diameter 1.56 cm whereas minimum length diameter 1.29 cm recorded in T3 (25×15cm +125:160:110 NPK kg/ha).

Applying NPK may result in a rise in TSS and total sugar levels. This could be because of the swift metabolic conversion of pectin and starch into soluble substances and speedy movement of sugars from leaves to the fruit that is forming. The highest ascorbic acid level of 54.98 mg per 100 g fresh fruit weight was found in the berries that were grown on plants treated with NPK (80:100:100) + Azotobacter (7 kg per ha) + Vermicompost (30 tons per ha). This outcome was corroborated strawberry research [18]. Strawberry plants require a balance of N, P, and K for optimal nutritional availability, while potassium encourages the accumulation of sugar in berries [19].

4. 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, weight of fruit 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.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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