

## TITLE

# Effect of different spacing and NPK combination on plant growth, fruit yield and fruit quality of strawberry (*Fragaria × ananassa*) cv. Winter dawn

Article type: *Original Research Article*

## 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 Agriculture Institute, Sam Higginbottom Institute of Agriculture, Technology and sciences, Prayagraj in the year 2023-2024. The experiment was performed to find out the most suitable treatment combination for better yield and profitability to farmers. The experiment was laid out in a Factorial Randomized Complete Block Design with twelve treatments combination and three replications. The treatments comprise of different spacing with the combination of different NPK levels. Result obtained in present investigation showed that the treatment T<sub>8</sub> (25×45cm+125:160:110NPKkg/ha) was found to be best in terms of growth attributes viz, Plant height (14.91 cm), number of leaves (16.33), plant spread (32.55 cm), petiole length (12.04 cm) and treatment T<sub>5</sub> (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 (45.66 Days), number of flowers per plant (12.13), days taken to fruit bud development (60.87 Days), number of fruits per plant (9.53), fruit set (79.33 %), weight of fruit (32.81 g), length diameter (1.56 cm), fruit yield per plant (176.15 g), fruit yield per plot (1.17 kg), TSS (9.98 brix), pH of the juice (3.53), acidity % (0.67%). The lowest observation was recorded in T<sub>3</sub>(25×15cm +125:160:110 NPK kg/ha).

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

## 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 (**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 (Maharashtra), Haryana, Punjab, Uttar Pradesh, Jammu and Kashmir, Uttarakhand and low hills of Himachal Pradesh.

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 (**Takehisa et 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 and 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**).

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 (**Sharma et al. (2020)**)

## 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 1<sup>st</sup> November 2023 to 3<sup>rd</sup> 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+100:120:80NPK kg/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. 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.

| <b>Treatment</b> | <b>Treatment Details</b>      |
|------------------|-------------------------------|
| 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  |

**Factor:**

**Spacing:**

S1=25×15 cm

S2=25×30 cm

S3=25×45 cm

S4=45×45 cm

**Fertilizer:**

F1=75:80:50 NPK Kg/ha

F2=100:120:80 NPK Kg/ha

F3=125:160:110 NPK Kg/ha

**Abbreviations**

C.D. = Critical difference

F = Fertilizer

F test S = F test significant

S = Spacing

SE (d) = Standard error of difference

**Vegetative characters**

**. Plant Height (cm)**

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

#### **. 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.

#### **. 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.

#### **. 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.

#### **Floral characters**

##### **. 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.

##### **. 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.

#### **Fruit and yield attributes**

##### **.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.

##### **. 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.

##### **. 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.

##### **.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).

##### **. 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).

### **Quality parameters**

#### **. 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).

#### **. 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.

#### **. Acidity (%)**

Titrateable 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. Titrateable acidity was calculated by using the formula given below:

Titrateable acidity (%)

$$= \frac{\text{Titre volume} \times \text{Normality of alkali} \times \text{volume made up} \times \text{Equivalent weight of acid} \times 100}{\text{Volume of aliquot sample} \times \text{weight of sample} \times 1000}$$

#### **. 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).

#### **.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.

### **Result and Discussion**

Plant height, petiole length, number of leaves and plant spreadall 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).

**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 |
|--------------------|--------|-------|-------|--------|--------|-------|-------|--------|--------|-------|-------|--------|
| <b>S1</b>          | 3.95   | 7.95  | 7.25  | 6.38   | 5.97   | 9.51  | 8.56  | 8.01   | 9.19   | 11.99 | 10.90 | 10.28  |
| <b>S2</b>          | 7.4    | 6.4   | 6.95  | 6.95   | 8.67   | 7.83  | 8.22  | 8.24   | 10.87  | 10.13 | 10.53 | 10.51  |
| <b>S3</b>          | 10.29  | 10.91 | 6.77  | 9.33   | 11.66  | 12.52 | 8.33  | 10.84  | 13.92  | 14.91 | 10.62 | 13.15  |
| <b>S4</b>          | 7.49   | 9.57  | 8.55  | 8.54   | 8.72   | 10.80 | 9.71  | 9.74   | 11.13  | 13.16 | 11.96 | 12.08  |
| <b>Mean F</b>      | 7.28   | 8.72  | 7.19  |        | 8.76   | 10.16 | 8.70  |        | 11.28  | 12.55 | 11.00 |        |
| <b>Factors</b>     | F test | SE(d) | C.D.  |        | F test | SE(d) | C.D.  |        | F test | SE(d) | C.D.  |        |
| <b>Factor S</b>    | S      | 0.157 | 0.328 |        | S      | 0.162 | 0.339 |        | S      | 0.168 | 0.351 |        |
| <b>Factor F</b>    | S      | 0.136 | 0.284 |        | S      | 0.141 | 0.294 |        | S      | 0.146 | 0.304 |        |
| <b>Factor(S×F)</b> | 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 |
|--------------------|--------|-------|-------|--------|--------|-------|-------|--------|--------|-------|-------|--------|
| <b>S1</b>          | 2.53   | 3.80  | 3.20  | 3.18   | 5.26   | 11.40 | 10.33 | 9.00   | 7.26   | 13.40 | 12.33 | 11.00  |
| <b>S2</b>          | 3.87   | 3.67  | 3.73  | 3.76   | 11.20  | 10.53 | 10.80 | 10.84  | 13.93  | 13.20 | 14.00 | 13.71  |
| <b>S3</b>          | 3.93   | 4.80  | 4.00  | 4.24   | 11.06  | 12.93 | 11.33 | 11.78  | 13.80  | 16.33 | 14.27 | 14.80  |
| <b>S4</b>          | 4.07   | 4.13  | 3.40  | 3.87   | 11.53  | 11.13 | 10.93 | 11.20  | 14.13  | 14.20 | 13.33 | 13.89  |
| <b>Mean F</b>      | 3.60   | 4.10  | 3.58  |        | 9.77   | 11.50 | 10.85 |        | 12.28  | 14.28 | 13.48 |        |
| <b>Factors</b>     | F test | SE(d) | C.D.  |        | F test | SE(d) | C.D.  |        | F test | SE(d) | C.D.  |        |
| <b>Factor S</b>    | S      | 0.167 | 0.349 |        | S      | 0.353 | 0.738 |        | S      | 0.385 | 0.804 |        |
| <b>Factor F</b>    | S      | 0.145 | 0.302 |        | S      | 0.306 | 0.639 |        | S      | 0.334 | 0.696 |        |
| <b>Factor(S×F)</b> | 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 |
|-----------|-------|-------|-------|--------|-------|-------|-------|--------|-------|-------|-------|--------|
| <b>S1</b> | 8.38  | 13.06 | 12.53 | 11.32  | 9.67  | 18.28 | 17.83 | 15.26  | 15.49 | 28.85 | 29.12 | 24.48  |
| <b>S2</b> | 14.15 | 14.03 | 11.94 | 13.38  | 19.13 | 18.45 | 17.15 | 18.24  | 30.21 | 29.01 | 27.65 | 28.96  |

|                    |               |              |             |       |               |              |             |       |               |              |             |       |
|--------------------|---------------|--------------|-------------|-------|---------------|--------------|-------------|-------|---------------|--------------|-------------|-------|
| <b>S3</b>          | 13.12         | 16.26        | 11.88       | 13.75 | 17.98         | 21.52        | 16.96       | 18.82 | 28.59         | 32.55        | 26.69       | 29.27 |
| <b>S4</b>          | 14.10         | 11.38        | 12.45       | 12.64 | 19.31         | 16.64        | 14.65       | 16.87 | 29.59         | 27.32        | 25.86       | 27.59 |
| <b>Mean F</b>      | 12.44         | 13.68        | 12.20       |       | 16.52         | 18.72        | 16.65       |       | 25.96         | 29.43        | 27.33       |       |
| <b>Factors</b>     | <b>F test</b> | <b>SE(d)</b> | <b>C.D.</b> |       | <b>F test</b> | <b>SE(d)</b> | <b>C.D.</b> |       | <b>F test</b> | <b>SE(d)</b> | <b>C.D.</b> |       |
| <b>Factor S</b>    | S             | 0.277        | 0.578       |       | S             | 0.262        | 0.547       |       | S             | 0.468        | 0.977       |       |
| <b>Factor F</b>    | S             | 0.240        | 0.500       |       | S             | 0.227        | 0.473       |       | S             | 0.405        | 0.846       |       |
| <b>Factor(S×F)</b> | 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)**

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

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).

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

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

|                    | <b>F1</b>     | <b>F2</b>    | <b>F3</b>   | <b>Mean S</b> | <b>F1</b>     | <b>F2</b>    | <b>F3</b>   | <b>Mean S</b> | <b>F1</b>     | <b>F2</b>    | <b>F3</b>   | <b>Mean S</b> |
|--------------------|---------------|--------------|-------------|---------------|---------------|--------------|-------------|---------------|---------------|--------------|-------------|---------------|
| <b>S1</b>          | 0.53          | 1.60         | 1.20        | 1.11          | 1.60          | 4.33         | 4.33        | 3.40          | 3.13          | 6.47         | 6.80        | 5.47          |
| <b>S2</b>          | 1.53          | 3.93         | 1.47        | 2.31          | 4.53          | 4.80         | 4.80        | 4.91          | 6.93          | 12.13        | 7.13        | 8.73          |
| <b>S3</b>          | 1.33          | 1.40         | 1.67        | 1.47          | 4.20          | 4.67         | 4.67        | 4.58          | 6.87          | 7.93         | 7.53        | 7.44          |
| <b>S4</b>          | 1.07          | 0.93         | 1.00        | 1.00          | 4.47          | 4.40         | 4.40        | 4.53          | 7.40          | 7.60         | 7.20        | 7.40          |
| <b>Mean F</b>      | 1.12          | 1.97         | 1.33        |               | 3.70          | 4.82         | 4.55        |               | 6.08          | 8.53         |             |               |
| <b>Factors</b>     | <b>F test</b> | <b>SE(d)</b> | <b>C.D.</b> |               | <b>F test</b> | <b>SE(d)</b> | <b>C.D.</b> |               | <b>F test</b> | <b>SE(d)</b> | <b>C.D.</b> |               |
| <b>Factor S</b>    | S             | 0.124        | 0.258       |               | S             | 0.225        | 0.470       |               | S             | 0.292        | 0.609       |               |
| <b>Factor F</b>    | S             | 0.107        | 0.224       |               | S             | 0.195        | 0.407       |               | S             | 0.253        | 0.527       |               |
| <b>Factor(S×F)</b> | 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.**

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

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

|           | <b>F1</b> | <b>F2</b> | <b>F3</b> | <b>Mean S</b> | <b>F1</b> | <b>F2</b> | <b>F3</b> | <b>Mean S</b> | <b>F1</b> | <b>F2</b> | <b>F3</b> | <b>Mean S</b> |
|-----------|-----------|-----------|-----------|---------------|-----------|-----------|-----------|---------------|-----------|-----------|-----------|---------------|
| <b>S1</b> | 0.267     | 1.07      | 0.80      | 0.71          | 1.53      | 3.73      | 4.00      | 3.09          | 2.73      | 5.93      | 5.87      | 4.84          |
| <b>S2</b> | 1.00      | 1.73      | 0.73      | 1.16          | 3.80      | 4.93      | 4.13      | 4.29          | 6.13      | 9.53      | 6.60      | 7.42          |
| <b>S3</b> | 1.20      | 0.93      | 1.13      | 1.09          | 3.67      | 4.33      | 4.27      | 4.09          | 6.20      | 7.13      | 6.67      | 6.67          |
| <b>S4</b> | 1.27      | 0.53      | 0.60      | 0.80          | 4.40      | 3.87      | 4.07      | 4.11          | 6.80      | 6.47      | 6.07      | 6.44          |

|                    |        |       |       |  |        |       |       |  |        |       |       |  |
|--------------------|--------|-------|-------|--|--------|-------|-------|--|--------|-------|-------|--|
| <b>Mean F</b>      | 0.93   | 1.07  | 0.82  |  | 3.35   | 4.22  | 4.12  |  | 5.47   | 7.27  | 6.30  |  |
| <b>Factors</b>     | F test | SE(d) | C.D.  |  | F test | SE(d) | C.D.  |  | F test | SE(d) | C.D.  |  |
| <b>Factor S</b>    | S      | 0.102 | 0.213 |  | S      | 0.209 | 0.437 |  | S      | 0.257 | 0.536 |  |
| <b>Factor F</b>    | S      | 0.088 | 0.184 |  | S      | 0.181 | 0.379 |  | S      | 0.222 | 0.464 |  |
| <b>Factor(S×F)</b> | 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 (%)**

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

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

|                 | <b>F1</b>     | <b>F2</b>    | <b>F3</b>   | <b>Mean S</b> |
|-----------------|---------------|--------------|-------------|---------------|
| <b>S1</b>       | 94.97         | 164.78       | 145.05      | 139.94        |
| <b>S2</b>       | 162.58        | 176.15       | 181.37      | 173.37        |
| <b>S3</b>       | 155.47        | 150.85       | 148.48      | 151.60        |
| <b>S4</b>       | 136.17        | 123.93       | 116.76      | 125.62        |
| <b>Mean F</b>   | 137.30        | 153.93       | 147.92      |               |
| <b>Factors</b>  | <b>F test</b> | <b>SE(d)</b> | <b>C.D.</b> |               |
| <b>Factor S</b> | S             | 1.952        | 4.074       |               |
| <b>Factor F</b> | S             | 1.690        | 3.528       |               |

|                     |   |       |       |  |
|---------------------|---|-------|-------|--|
| <b>Factor (S×F)</b> | S | 3.381 | 7.056 |  |
|---------------------|---|-------|-------|--|

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

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

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

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

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 °Brix whereas minimum TSS of the juice 8.38 °Brix 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).

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

|           | <b>F1</b> | <b>F2</b> | <b>F3</b> | <b>Mean S</b> |
|-----------|-----------|-----------|-----------|---------------|
| <b>S1</b> | 3.42      | 4.95      | 4.01      | 4.13          |

|                     |               |              |             |      |
|---------------------|---------------|--------------|-------------|------|
| <b>S2</b>           | 3.59          | 3.53         | 3.40        | 3.60 |
| <b>S3</b>           | 4.34          | 3.72         | 3.91        | 3.99 |
| <b>S4</b>           | 4.34          | 2.87         | 3.73        | 3.65 |
| <b>Mean F</b>       | 3.92          | 3.77         | 3.84        |      |
| <b>Factors</b>      | <b>F test</b> | <b>SE(d)</b> | <b>C.D.</b> |      |
| <b>Factor S</b>     | S             | 0.175        | 0.365       |      |
| <b>Factor F</b>     | NS            | 0.151        | -----       |      |
| <b>Factor (S×F)</b> | S             | 0.303        | 0.632       |      |

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

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

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

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

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

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

## Discussion

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 (Mohandas, 1987). The current findings in strawberries are consistent with those of Niyati et al., (2016).

The outcomes support the observation made by Herencia et al. (2011) that composts included phosphate and nitrogen, which promoted the commencement of floral buds and vegetative growth. According to Arancon et al. (2003), the application of vermicompost improved strawberry flowering and fruiting because it improves soil qualities such as nutrient availability and cation exchange capacity. According to Tagliavini et al. (2005), 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, according to (Arancon et al., 2003).

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. Shukla et al. (2013) and Ughade and Madhavkar (2015) 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 Manchanda et al. (1993) findings. The plants treated with vermicompost had the highest yield per plant. Increased dry matter accumulation increased the capacity to yield more.

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 by Tripathi et al. (2015) strawberry research. Strawberry plants require a balance of N, P, and K for optimal nutritional availability, while potassium encourages the accumulation of sugar in berries Ali et al. (2003).

## 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.

## References

- Ali YM, Iqbal SZA, Shah, Ahmed MJ. Effect of different combinations of nitrogen phosphorous and farm yard manure on yield and quality of strawberry. *Sarhad Journal Agriculture*. 2003; 19(6):185-188.
- Arancon NQ, Edwards CA, Bierman P, Metzger LD, Lee S, Welch CS. Effects of vermicompost on growth and marketable fruits of field grown tomatoes, peppers and strawberries. *Pedobiologia*. 2003; 47(2):731-735.
- Gastal, F., & Lemaire, G. (2002). N uptake and distribution in crops: an agronomical and ecophysiological perspective. *Journal of experimental botany*, 53(370), 789-799.
- Häkkinen, S. H., & Törrönen, A. R. (2000). Content of flavonols and selected phenolic acids in strawberries and *Vaccinium* species: influence of cultivar, cultivation site and technique. *Food research international*, 33(6), 517-524.
- Herencia JF, Garcia-Galavisa PA, Doradoa JAR, Maqueda C. Comparison of nutritional quality of the crops grown in an organic and conventional fertilized soil. *Sciences of Horticulturae*. 2011; 129(5):882-888.
- Hummer, K. E., & Janick, J. (2009). Rosaceae: taxonomy, economic importance, genomics. *Genetics and genomics of Rosaceae*, 1-17.
- Li, Y., Han, D., Hu, G., Sommerfeld, M., & Hu, Q. (2010). Inhibition of starch synthesis results in overproduction of lipids in *Chlamydomonas reinhardtii*. *Biotechnology and bioengineering*, 107(2), 258-268.
- Manchanda AK, Bhopal S, Singh B. Effect of plant density on growth and fruit yield of Bell Pepper (*Capsicum annum* L). *Indian Journal of Agronomy*. 1993; 33(4):445-447.
- Mohandas S. Field response of tomato (*Lycopersicon esculentum* Mill cv. Pusa Ruby) to inoculation with VAM fungus *Glomus fasciculatum* and with azotobacter. *Plant Soil*. 1987; 98(4):288-73.
- Niyati J, Bahadur V, Singh D, Kumar P. Effect of integrated nutrient management on Growth, Yield and Quality of strawberry (*Fragaria × ananassa* Duch.) cv. Sweet Charlie. *International Journal of Pharma and Bio sciences*. 2016; 7(2):345-349.
- Prajapati, K., & Modi, H. A. (2012). The importance of potassium in plant growth—a review. *Indian journal of plant sciences*, 1(02-03), 177-186.
- Sharma, K., & Negi, M. (2020). Impact of different spacing and combination with organic manures on growth and yield attributes of strawberry (*Fragaria × ananassa*) cv. Jutoh special under mid-hill conditions of Uttarakhand. *Journal of Pharmacognosy and Phytochemistry*, 9(2), 1014-1018
- Shukla UN, Khaksar MS, Srivastava VK, Rakesh K, Smita KV, Kumar K. Effect of spacings and fertility levels on growth, yield and quality of Cotton (*Gossypium Hirsutisms*) hybrids under rainfed condition of Vidarbha. *The Bioscan*. 2013; 8(2):561-567.

Tagliolini ME, Baldi E, Lucchi P, Antonelli M, Sorrenti G, Baruzzi G et al. Dynamics of nutrient uptake by strawberry plants (*Fragaria × ananassa* Duch.) Grown in ~ 1018 ~ Journal of Pharmacognosy and Phytochemistry <http://www.phytojournal.com> soil and soilless culture. European Journal of Agronomy. 2005; (23):15-25.

Takehisa, H., Sato, Y., Antonio, B. A., & Nagamura, Y. (2013). Global transcriptome profile of rice root in response to essential macronutrient deficiency. *Plant signaling & behavior*, 8(6), e24409.

Tripathi VK, Kumar S, Gupta AK. Influence of Azotobacter and Vermicompost on Growth, Yield and Quality of Strawberry cv. Chandler. Indian Journal Horticulture. 2015; 72(2):201-255.

Ughade SK, Mahadkar UV. Effect of different Planting density, irrigation and fertigation levels on growth and yield of Brinjal. The Bioscan. 2015; 10(3):1205-1211.

Ughade, S. R., & Mahadkar, U. V. (2015). Effect of different planting density, irrigation and fertigation levels on growth and yield of Brinjal. *Journal of progressive agriculture*, 6(1), 103-109.



