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# Quality Traits and Economic Returns of Broccoli (*Brassica oleracea* Var. *Italica*. Plenck) as Influenced by Different Date of Sowing

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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

This study was conducted at Vegetable Research Farm, Department of Horticulture, Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad (U.P.) during the *rabi* season of 2016 to 2017 to find out the optimum time of sowing and planting spacing for broccoli varieties as Palam Samridhi, Pusa Kanchan and Lufa $F_1$ Hybrid. Seedlings were raised by sowing on three different dates viz. 20th October, 04 November and 19 November were transplanted at spacing viz. 45 cm x 45 cm. Economic return and biochemical traits of broccoli were significantly influenced by the treatments. In view of experimental results obtained during the present investigation, treatment $T_4$ $D_2$ $V_1$ 04 November + $V_1$ Palam Samridhi emerged as superior over all other treatments, in relation to economic return, cost benefit ratio and biochemical traits of broccoli under the agro-climatic condition of Allahabad.

*Keywords: Broccoli; agro-climatic condition; economic return; biochemical traits.*

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## 1. INTRODUCTION

Broccoli is a cool-weather vegetable. When the plants are little and tender, it is more sensitive. The crop is vulnerable to cold damage. Warm temperature is detrimental because the bud cluster falls apart quickly. It is often sown in September and October in northern India, and it is available for harvest from November to early December, with some harvesting continuing into early February. The nutritive value of broccoli per 100 g of edible portion is [1] water -89.3%, protein -3.6%, fats - 0.2 %, carbohydrates -5.5%, fiber- 1.2 g, vitamin A- 900 (I.U.) mg, vitamin B (combined) - 33 (I.U.) mg, vitamin C - 137 (I.U.) mg, vitamin E- 2.3(I.U.) mg,vitamin K- 3.5 (I.U) mg, calcium -1.29 mg, manganese - 20 mg, iron - 1.3 mg, phosphorus- 0.79 mg, sulphur-1.26 mg, chlorine- 40 .0 mg. Broccoli has numerous therapeutic properties. The national research council committee on diet, nutrition and cancer has recommended increased consumption of broccoli to decrease the incidence of cancer. Carotenoids, which are found in abundance in brassica vegetables, are thought to be chemopreventive and have been linked to a lower incidence of several human cancers in epidemiological studies. It has 130 times the vitamin A value of cauliflower and 22 times the vitamin A level of cabbage. It contains sulforaphane, which inhibits tumor growth and lowers cancer risk. Beta-carotene, indoles, and isothiocyanates are among the phytochemicals found in it. Excessive usage of chemical fertilizers has wreaked havoc on the ecosystem. Although chemical fertilizers have become an important aspect of production, a well-balanced fertilizer program is always a must for improved yield. Chemical fertilizers, on the other hand, are more expensive and contaminate the environment through de-nitrification and volatilization, as well as soil water through leaching. Only 50% of the available nitrogen is utilised, while the other 50% is wasted, posing an environmental hazard.

## 2. MATERIALS AND METHODS

The details of various materials used and the methods employed in carrying out the experiment are described in detail under appropriate heading.

### 2.1 Experimental Site

The experiment was conducted at Vegetable Research Farm, Department of Horticulture, Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad.–during the (*Rabi*) season of 2016-2017. All the facilities necessary for conducting the experiment, including labour and resources, which were necessary for normal cultivation were readily available in the department.

### 2.2 Climatic Condition

The area of Allahabad district falls under subtropical belt in the South east of Uttar Pradesh, which experience extremely hot summer and fairly cold winter. The maximum temperature of the location goes up to $32^0$C – $34^0$C and seldom falls as low as $4^0$C – $5^0$C. The relative humidity ranges between 20 to 94 per cent. The average rainfall in this area is around 1013.4 mm annually. The meteorological data (Oct, 2012 to March, 2013) with respect to total rainfall, maximum and minimum temperature, relative humidity are presented in Table 1.

### 2.3 Soil Characteristics of the Experimental Site

The experimental site is fairly level land with sandy loam soil of uniform fertility status with low clay and high sand percentage. Soil sample were collected at random spots from depth of 0-30 cm and the soil was analyzed for electrical conductivity (EC), pH, organic carbon, available nitrogen, available phosphorus and available potassium are presented in Table 2.

### 2.4 Field Preparation

The experimental plot was prepared one month before transplanting. The soil was ploughed manually, levelled and the weeds were rooted out. The experimental area was laid out in raised bed with 1m cm width and 30 cm height. Well decomposed farm yard manure was applied one week before transplanting at the rate of 15 t/ha.

### 2.5 Layout and Design of the Experiment

The experiment has been conducted in a Factorial Randomized Block Design with 3x3 treatments that were each reproduced three times, totaling 27 plots. The plots were 1.8 × 1.5 $m^2$ each. The plants were spaced 45cm apart in rows and 45cm apart in plants. Each plot had a total of nine plants. In each replication, the treatments were assigned to a unit plot at random.

**Table 1. Meteorological data (October 2016 –January 2017)**

| Weeks | Temperature$^0$C | | Rainfall (mm) | Relative humidity (%) | |
|---|---|---|---|---|---|
| | Maximum | Minimum | | Maximum | Minimum |
| **October 2016** | | | | | |
| 1st Week | 36.00 | 26.00 | 0 | 87 | 51 |
| 2nd week | 35.20 | 26.00 | 0 | 90 | 52 |
| 3rd week | 35.20 | 25.40 | 0 | 90 | 53 |
| 4th week | 34.00 | 23.00 | 0 | 90 | 55 |
| **November 2016** | | | | | |
| 1st Week | 33.80 | 18.40 | 0 | 91 | 54 |
| 2nd week | 32.40 | 16.20 | 0 | 93 | 58 |
| 3rd week | 31.80 | 15.80 | 0 | 92 | 50 |
| 4th week | 31.00 | 15.00 | 0 | 92 | 45 |
| **December 2016** | | | | | |
| 1st Week | 23.40 | 14.00 | 0 | 93 | 81 |
| 2nd week | 26.00 | 12.00 | 0 | 94 | 58 |
| 3rd week | 25.80 | 11.80 | 0 | 92 | 46 |
| 4th week | 24.00 | 9.20 | 0 | 91 | 53 |
| **January 2017** | | | | | |
| 1st Week | 22.40 | 11.00 | 0 | 91 | 46 |
| 2nd week | 23.40 | 6.80 | 0 | 91 | 50 |
| 3rd week | 25.40 | 11.40 | 0 | 91 | 44 |
| 4th week | 29.00 | 12.00 | 0 | 90 | 41 |

*Source: Agro-meteorological Observatory Unit, School of Forestry & Environment, Sam Higginbottom University of Agriculture, Technology and Sciences, (Deemed to be University), Allahabad*

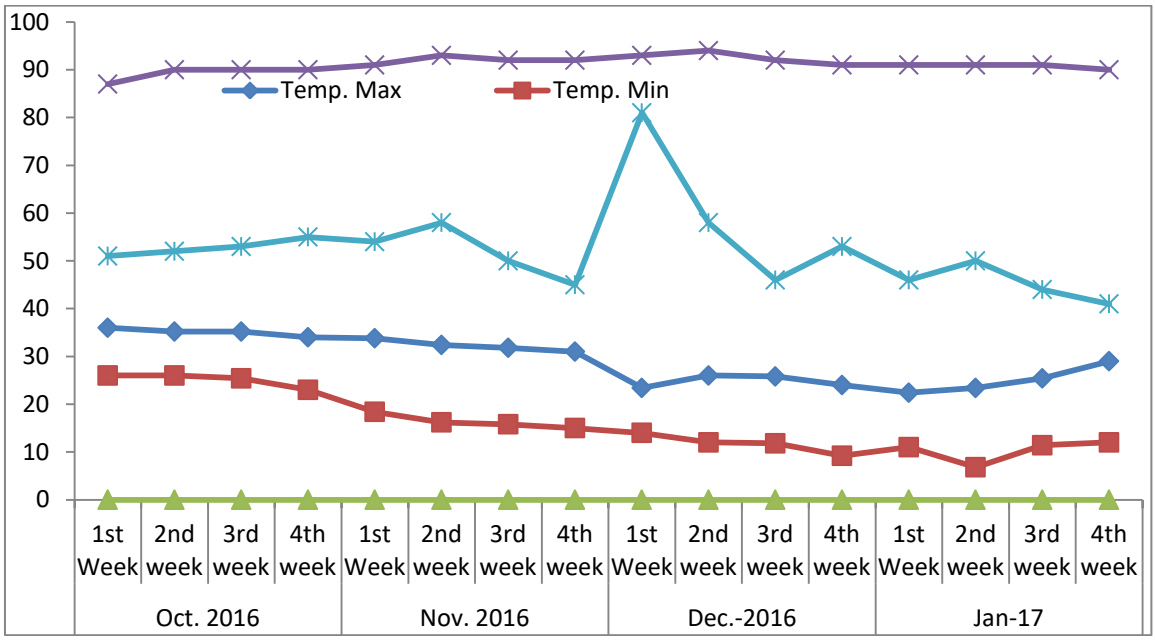


**Fig. 1. Meteorological data (October 2016 – January 2017)**

## 2.6 Nutrient Application

Recommended dose of fertilizer, 120:60:60 kg of NPK per hectare was applied as basal dose. The source of nitrogen, phosphorus and potassium were urea **(**46% nitrogen), single super phosphate (16%) and muriate of potash (60% potassium). Half dose of nitrogen, total phosphorus and potash were well mixed and applied as basal dose before transplanting, according to the treatment. Remaining half quantity of nitrogen was applied as top dressing at 30 days after transplanting.

**Table 2. Physico-chemical properties of soil at experimental site (SHUATS)**

| Sl. No. | Particulars | Value(0-30cm depth) | Methods employed |
|---|---|---|---|
| **Physical properties** | | | |
| 1 | Sand | 60.60% | Hydrometer Method (Bouyoucos, 1952) |
| 2 | Silt | 19.10% | |
| 3 | Clay | 20.30% | |
| 4 | Textural class | Sandy loam | |
| **Chemical properties** | | | |
| 1 | Soil pH | 6.5 | Digital pH meter Mk. IV |
| 2 | EC | 0.26 ($dSm^{-1}$ at $25^0$ C) | Electrical Conductivity Meter |
| 3 | Organic carbon | 0.45 % | Hydrochloric oxidation Method (Walkely and Black,1934) |
| 4 | Available nitrogen | 212.56 kg $ha^{-1}$ | Alkaline permanganate method (Subbaiah and Asija, 1956) |
| 5 | Available phosphorus | 37.32 kg $ha^{-1}$ | Olsen's Colorimetric method (Olsen *et al*., 1954) |
| 6 | Available potassium | 210.05 kg $ha^{-1}$ | Flame photometric method (Jackson, 1958) |

**Table 3. Treatment combination**

| Treatment No. | Treatment Symbol | Treatment combination |
|---|---|---|
| $T_1$ | $D_1V_1$ | 20 October + $V_1$ Palam Samridhi |
| $T_2$ | $D_1V_2$ | 20 October + $V_2$ Pusa Kanchan |
| $T_3$ | $D_1V_3$ | 20 October + $V_3$ Lufa $F_1$ Hybrid |
| $T_4$ | $D_2V_1$ | 04 November + $V_1$ Palam Samridhi |
| $T_5$ | $D_2V_2$ | 04 November + $V_2$ Pusa Kanchan |
| $T_6$ | $D_2V_3$ | 04 November + $V_3$ Lufa $F_1$ Hybrid |
| $T_7$ | $D_3V_1$ | 19 November + $V_1$ Palam Samridhi |
| $T_8$ | $D_3V_2$ | 19 November + $V_2$ Pusa Kanchan |
| $T_9$ | $D_3V_3$ | 19 November + $V_3$ Lufa $F_1$ Hybrid |

## 2.7 Transplanting of Seedlings

Broccoli plant was transplanted in the main field on 22nd November 2012. Thirty days old healthy seedling having two pairs of leaves with a height of 10 to 15 cm were selected from the nursery and roots of the plant were treated first with *Azospirillum* according to treatment before transplanting and transplanted at the experimental plot and given light irrigation.

## 3. OBSERVATIONS TO BE RECORDED

For the following characters, observations were made on three randomly selected plants from each treatment to analyze the effect of different treatments on yield, economic return, and biochemical attributes of broccoli.

## 3.1 Curd Yield (t $ha^{-1}$)

Curd yield of the crop was calculated immediately after removing the heads from the plant from each plot. Thus the total yield in quintals per hectare was worked out and statistically analysed.

## 3.2 Biochemical Traits

After harvesting of matured curds, in order to assess the quality of the curds, tests were carried out at the Laboratory of the Department of Horticulture, to find out the following**.**

## 3.3 Ascorbic Acid (mg/100 g of Edible Portion)

Weigh 100 mg of ascorbic acid on a chemical balance and dissolve in 3 per cent metaphosphoric acid, make the volume up to 500 ml.

## 3.4 Total Soluble Solid (%)

Total soluble solid was determined with the help of Erma hand refractometer (0.32 range) average and analyzed.

## 4. ECONOMICS OF CULTIVATION

As per the existing market prices, the input and output costs were computed treatment wise and different economic parameters *viz.*, cost of cultivation, gross return, net return and cost-benefit ratio were computed.

### 4.1 Cost of Cultivation (t ha$^{-1}$)

The cost of inputs at the time of use was taken into account when calculating the cost of agriculture, which is expressed in rupees per hectare.

### 4.2 Gross Income

Gross income was calculated based on the prevailing market price for the produce.

### 4.3 Net Income

The net income per hectare was calculated on the basis of gross income and cost of cultivation per hectare as follows-

Net income = Gross income - Cost of cultivation

### 4.4 Benefit to Cost Ratio

The benefit to cost ratio was worked out by using the following formula.

Benefit: Cost ratio = (Gross income (Rsha$^{-1}$)) / (Cost of cultivation (Rs/ha))

All the recorded observations were subjected to the statistical analysis methods [2]. The 'F' variance ratio test was used to determine the significance and non- significance of the treatment effect. At a 5% level of significance, the calculated 'F' value was compared to the table value of 'F'. The influence was judged considerable if the estimated value surpassed the table value. At a 5% level of significance, the significant differences between the means were compared to the critical differences.

## 5. RESULTS AND DISCUSSION

### 5.1 Curd Yield (t ha$^{-1}$)

The results of the investigation, regarding the effect of dates of sowing and different varieties on yield, economic return and bio-chemical traits of broccoli have been presented in tables and bar-diagrams. The curd yield (t ha$^{-1}$) as influenced by different treatments are presented in Table 4. The curd yield (t ha$^{-1}$) was found to be significant among the treatments. The maximum curd yield (t ha$^{-1}$) (14.07) was observed in D2- 4 Nov followed by the treatment $D_1$-20 Oct and minimum curd yield (t ha$^{-1}$) (13.08) was found to be in $D_3$-19 Nov. The curd yield (t ha$^{-1}$) was found to be significant among the treatments. The maximum curd yield (t ha$^{-1}$) (14.29) was observed in Palam Samridhi followed by Pusa Kanchan and minimum curd yield (t ha$^{-1}$) (12.85) was found to be in Lufa $F_1$. As far as interaction between date of sowing and different varieties is concerned; the maximum curd yield (t ha$^{-1}$) (16.25) was obtained with treatment $T_4$ $D_2V_1$ 04 November + $V_1$ Palam Samridhi followed by treatments $T_7$ $D_3V_1$19 November + $V_1$ Palam Samridhi and the minimum Curd yield (t ha$^{-1}$) (12.24) remained with treatment $T_9$ $D_3V_3$19 November + $V_3$ Lufa $F_1$ Hybrid. The findings are in agreement with the result of [3-6].

**Table 4. Effect of sowing of dates and different varieties on curd yield (t ha$^{-1}$) of broccoli**

| **Varieties**<br>**Date of sowing** | **Curd yield (t ha$^{-1}$)** | | | |
|---|---|---|---|---|
| | **Palam Samridhi** | **Pusa Kanchan** | **Lufa F-1** | **Mean** |
| D1-20 Oct | 15.22 | 12.43 | 13.27 | **13.64** |
| D2- 4 Nov. | 16.25 | 12.92 | 13.04 | **14.07** |
| D3-19 Nov. | 14.20 | 12.80 | 12.24 | **13.08** |
| **Mean** | **14.29** | **13.65** | **12.85** | |
| | **S.Ed.** | **C.D.** | **F-test** | |
| Due to Date of sowing | 0.023 | 0.048 | S | |
| Due to varieties | 0.023 | 0.048 | S | |
| Due to date of sowing x varieties | 0.039 | 0.084 | S | |

## 5.2 Total Soluble Solids ($^0$Brix)

The total soluble solids ($^0$Brix) as influenced by different treatments are presented in Table 4 and Fig. 1. The total soluble solids ($^0$Brix) was found to be significant among the treatments. The maximum total soluble solids ($^0$Brix) (3.96) was observed in D2- 4 Nov followed by the treatment D3-19 Nov. and minimum total soluble solids ($^0$Brix) (3.59) was found to be in $D_1$-20 Oct. The total soluble solids ($^0$Brix) were found to be significant among the treatments. The maximum Total soluble solids ($^0$Brix) (4.30) was observed in Palam Samridhi followed by Pusa Kanchan and minimum total soluble solids ($^0$3.36) was found to be in Lufa $F_1$. As far as interaction between date of sowing and different varieties is concerned; the maximum total soluble solids ($^0$Brix) (5.17) was obtained with treatment $T_4$ $D_2V_1$ 04 November + $V_1$ Palam Samridhi followed by treatments $T_7$ $D_3V_1$19 November + $V_1$ Palam Samridhi and the minimum total soluble solids ($^0$Brix) (3.15) remained with treatment $T_9$ $D_3V_3$19 November + $V_3$ Lufa $F_1$ Hybrid. The findings are in agreement with the result of [7,8,9].

## 5.3 Ascorbic Acid (mg/100g)

The ascorbic acid (mg/100 g edible portion) as influenced by different treatments are presented in Table 4 and Fig. 2.The ascorbic acid (mg/100 g edible portion) was found to be significant among the treatments. The maximum ascorbic acid (mg/100 g edible portion) (113.04) was observed in $D_2$- 4 Nov followed by the treatment D1-20 Oct and minimum ascorbic acid (mg/100 g edible portion) (110.82) was found to be in D3-19 Nov. The ascorbic acid (mg/100 g edible portion) was found to be significant among the treatments. The maximum ascorbic acid (mg/100 g edible portion 113.98) was observed in Palam Samridhi followed by Pusa Kanchan and minimum ascorbic acid (mg/100 g edible portion) (110.49) was found to be in Lufa $F_1$. As far as interaction between date of sowing and different varieties is concerned; the maximum ascorbic acid (mg/100 g edible portion) (117.97) was obtained with treatment $T_4$ $D_2V_1$ 04 November + $V_1$ Palam Samridhi followed by treatments $T_7$ $D_3V_1$19 November + $V_1$ Palam Samridhi and the minimum ascorbic acid (mg/100 g edible portion) (107.56) remained with treatment $T_9$ $D_3V_3$19 November + $V_3$ Lufa $F_1$ Hybrid. The findings are in agreement with the result of [8,7,10].

## 5.4 Economic Returns

The economic returns as influenced by different treatments are presented in Table 7 and Fig. 2. The economic returns was found to be significant among the treatments. The maximum curd yield t/h (16.25) was observed in $D_2$- 4 Nov followed by the treatment $D_1$-20 Oct and minimum yield t/h (12.24) was found to be in $D_3$-19 Nov. These findings are in agreement with the findings of [4,3,5]. The Gross returns were found to be significant among the treatments. The maximum gross returns Rs./h (26,0000) was observed in $D_2$- 4 Nov followed by the treatment $D_1$-20 Oct and minimum gross return Rs./h (195,840) was found to be in $D_3$-19 Nov. These findings are in agreement with the findings of [11,12,13]. The economic returns were found to be significant among the treatments. The maximum net returns Rs./h (295,860) was observed in $D_2$- 4 Nov followed by the treatment $D_1$-20 Oct and minimum net return Rs./h (131,700) was found to be in $D_3$-19 Nov. These findings are in agreement with the findings of [14]. The economic returns were found to be significant among the treatments. The maximum benefit cost ratio (1:4.05) was observed in $D_2$- 4 Nov followed by the treatment $D_1$-20 Oct and minimum benefit cost ratio (1:3.05) was found to be in $D_3$-19 Nov. These results are consistent with those of [15,16].

**Table 5. Effect of sowing of dates and different varieties on TSS ($^0$Brix) of broccoli**

| **Varieties** | **Total soluble solids ($^0$Brix)** | | | |
|---|---|---|---|---|
| **Date of sowing** | **Palam Samridhi** | **Pusa Kanchan** | **Lufa F-1** | **Mean** |
| D1-20 Oct | 4.07 | 3.18 | 3.53 | **3.59** |
| D2- 4 Nov. | 5.17 | 3.30 | 3.40 | **3.96** |
| D3-19 Nov. | 4.55 | 3.27 | 3.15 | **3.66** |
| | **4.30** | **5.34** | **3.36** | |
| | **S.Ed.** | **C.D.** | **F-test** | |
| Due to Date of sowing | 0.026 | 0.055 | S | |
| Due to varieties | 0.026 | 0.055 | S | |
| Due to date of sowing x varieties | 0.044 | 0.095 | S | |

**Table 6. Effect of sowing of dates and different varieties on ascorbic acid (mg/100 g) of broccoli**

| Varieties | Ascorbic acid (mg/100 g edible portion) | | | |
|---|---|---|---|---|
| **Date of sowing** | **Palam Samridhi** | **Pusa Kanchan** | **Lufa F-1** | **Mean** |
| D1-20 Oct | 110.33 | 109.63 | 108.67 | **112.64** |
| D2- 4 Nov. | 117.97 | 116.90 | 113.57 | **113.04** |
| D3-19 Nov. | 115.32 | 109.60 | 107.56 | **110.82** |
| **Mean** | **113.98** | **112.04** | **110.49** | |
| | **S.Ed.** | **C.D.** | **F-test** | |
| Due to Date of sowing | 0.192 | 0.410 | S | |
| Due to varieties | 0.192 | 0.410 | S | |
| Due to date of sowing x varieties | 0.332 | 0.711 | S | |

**Table 7. Effect of sowing of dates and different varieties on economic returns of broccoli**

| S. No | Treatment Combination | Cost of cultivation (Rs. ha$^{-1}$) | Curd yield (t ha$^{-1}$) | Selling rate (Rs. t$^{-1}$) | Gross return (Rs. ha$^{-1}$) | Net return (Rs. ha$^{-1}$) | Benefit cost ratio |
|---|---|---|---|---|---|---|---|
| $T_1$ | 20 October + $V_1$ Palam Samridhi | 64,140 | 15.22 | 16,000 | 243520 | 179380 | 1:3.80 |
| $T_2$ | 20 October + $V_2$ Pusa Kanchan | 64,140 | 12.43 | 16,000 | 198880 | 134740 | 1:3.10 |
| $T_3$ | 20 October + $V_3$ Lufa $F_1$ Hybrid | 64,140 | 13.27 | 16,000 | 212320 | 148180 | 1:3.31 |
| $T_4$ | 04 November + $V_1$ Palam Samridhi | 64,140 | 16.25 | 16,000 | 260000 | 195860 | 1:4.05 |
| $T_5$ | 04 November + $V_2$ Pusa Kanchan | 64,140 | 12.92 | 16,000 | 206720 | 142580 | 1:3.22 |
| $T_6$ | 04 November + $V_3$ Lufa $F_1$ Hybrid | 64,140 | 13.04 | 16,000 | 208640 | 144500 | 1:3.25 |
| $T_7$ | 19 November + $V_1$ Palam Samridhi | 64,140 | 14.20 | 16,000 | 227200 | 163060 | 1:3.54 |
| $T_8$ | 19 November + $V_2$ Pusa Kanchan | 64,140 | 12.80 | 16,000 | 204800 | 140660 | 1:3.19 |
| $T_9$ | 19 November + $V_3$ Lufa $F_1$ Hybrid | 64,140 | 12.24 | 16,000 | 195840 | 131700 | 1:3.05 |

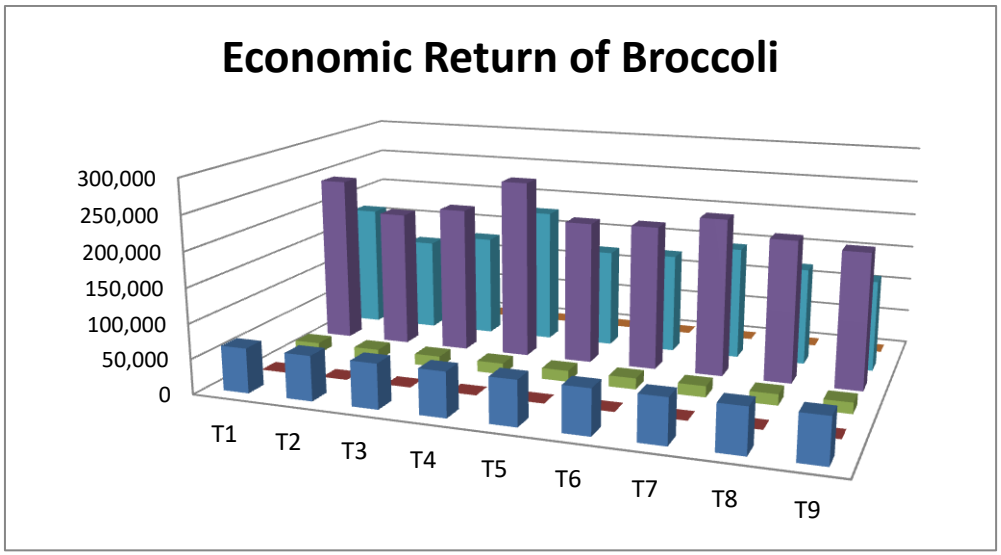


**Fig. 2. Effect of sowing of dates and different varieties on economic returns of broccoli**

## 6. CONCLUSION

It may be concluded from the experimental results obtained during the present investigation, treatment $T_4$ $D_2V_1$ 04 November + $V_1$ Palam Samridhi emerged as superior over all other treatments, in relation to yield, Bio-chemical traits, economic return and cost benefit ratio 1:4.05 of broccoli under the agro- climatic condition of Allahabad. As compared to all other treatments with lowest yield recorded in control**,** since this is based on one – season experiment.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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