Original Research Article

Effect of Zinc Sulphate and Zinc oxide Nanoparticles on Economic Returns from Strawberry (Frangaria × ananassa Duch.) cv. Camarosa Cultivation under Protected Conditions of Mid Hills of Himachal Pradesh

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A B S T R A C T

The present experiment was conducted at Experimental farm Chhapang, Department of Horticulture, Dr, Khem Singh Gill Akal College of Agriculture, Eternal university, Baru Sahib during the year 2019-20. The experiment comprised of ten different treatment combinations with three replications. The treatments included ZnSO₄ at three levels (0.1, 0.3 and 0.5%) and ZnO nanoparticles at three levels (100, 150 and 300 ppm) with their combinations as well as one control (water application). The results revealed that sprays of ZnSO₄ and ZnO nanoparticles improved the net economic returns from strawberry cultivation and the treatment T₈ (ZnSO₄ @ 0.3% + ZnO NPs @ 150 ppm) recorded maximum selling price of Rs. 4620, profit of Rs. 2157.65 and Benefit cost ratio (0.87%).

Keywords

Cultivation, Benefit, Nanoparticles

Introduction

Strawberry (Frangaria × ananassa Duch.) is the most important berry fruit in the world. It is a man made hybrid produced by crossing two American species Fragaria chiloensis and Fragaria virginiana. It belongs to family Rosaceae. It is a shallow rooted crop and is cultivated in plains as well as in hills up to an elevation of 3000 m above mean sea level in humid or dry regions. This crop is sensitive to water deficiency in soil. Strawberry is a short day plant and is grown all over the world. It is the most delicious berry fruit which is cultivated for its aroma, juicy texture, bright red color and sweetness. It is a complete fruit, which contains 98 per cent edible portion with vitamin C (30-100mg/100g) (Ayub et al., 2010). Characteristic aroma of fruit is due to the presence of volatile esters like ethyl hexanoate, methyl hexanoate and linalool etc. It also contains an anticancerous compound called ellagic acid. Ripe fruit contains more lipids than unripe fruits with more oleic acid and low linoleic acid. Red color of fruits is due to the presence of compounds like anthocyanin, pelarogonodin-3-monoglucoside and traces of cyanidin. Essential oil is also
extracted from leaves which contain linalool and nonanal.

Among different micronutrients, zinc plays an important role in cultivation of horticultural crops. Zinc plays structural and functional role in plants and also helps in hormone production in buds (Pandey, 2010). It helps in formation of structural components of a large number of proteins with catalytic or regulatory functions. Zinc is critical for reproductive development of plants as it helps in floral induction that converts vegetative meristem into reproductive one. Foliar application of zinc increase sugars and decreases acidity. It is required for synthesis of tryptophan which is a precursor of auxin and hence helps in reducing fruit drop (Stiles, 2004).

Nanoparticles are naturally occurring or engineered material with at least one dimension and less than 100 nm in size. Nanoparticles are used for the growth and disease control in plants. Nanoparticles when applied to plants results into many morphological and physiological changes depending upon their properties (Siddiqui et al., 2015). Efficacy of nanoparticles depends upon the chemical composition, size, surface covering, reactivity and dose at which they are used (Kumar et al., 2017). Nanotechnology in horticulture is used for extension of shelf life of many fruits, increasing strength and quality of the produce as well as helps to control growth and development of various microorganisms (Yadollahi et al., 2014).

Application of micronutrient fertilizers in the form of nanoparticles is proved to be an important source to provide nutrients to plants in a controlled way that is essential to mitigate the pollution problems related to fertilizer application (Naderi and Abedi 2012). Nanoparticles can be beneficial or harmful to plants but, zinc nanoparticles have found to be beneficial to the horticulture crops.

Zinc nanoparticles generally increase plant growth and development in certain ways. They are used in agriculture to enhance seed germination and various other properties, yield and quality of fruits, vegetables and other crops are affected by zinc concentration when applied to some extent.

Zinc oxide is most commonly used metal oxide engineered nanomaterials for effective growth in various plants (Aslani et al., 2014). Zinc also improves the shelf life of the crop, which helps in protecting the strawberry crop from post harvest losses and thus the profit could be increased.

The aim of the study is to know about the treatment combination giving maximum profit along with the Benefit cost ratio so that the technology could reach the farmers and improve their livelihood.

Materials and Methods

The experiment was laid out under protected conditions at experimental farm Chhapang, Department of Horticulture, Dr. Khem Singh Gill Akal College of Agriculture, Eternal University, Baru Sahib, Sirmour during 2019-20 in Randomized Block Design. The beds of 2×1 m were prepared and mixed with 10 kg farm yard manure. The runners of 35-40 days old of variety Camarosa were transplanted at a distance of 45×30 cm after dipping into 0.2% Bavistin solution for 5 minutes. During experimental period, plants were fertilized with half dose of Nitrogen (Urea @ 17.39 g/plot) along with full doze of Phosphorus (SSP @ 50 g/plot) and Potassium (MOP @ 13.33 g/plot) and remaining half dose of Nitrogen (Urea @ 17.39 g/plot) was given after flowering period. Experiment comprises
of 10 treatments of different concentrations of ZnSO$_4$ (0.1, 0.3 and 0.5%) and ZnO nanoparticles (100, 150 and 200 ppm) individually or in combination along with one control which was replicated thrice. Beds were mulched with wheat straw during experiment to conserve soil moisture and also to protect fruits from any soil borne pathogen. At the end of the experiment the cost price, selling price, profit and benefit cost ratio was calculated.

**Results and Discussion**

The expenses incurred and income generated plays an important role in cultivation of any crop and is considered with respect to input applied and output generated. Benefit cost ratio is an important aspect in terms of cultivation of any crop. During the present experiment, the total fixed cost was Rs 11500/- and total variable cost was Rs.12763.43/- (Table 1–3).

**Table 1** Details of the fixed cost parameters under study

| Sr. No. | Treatment code | Cost of land (Rs.) | Management cost (5%) | Risk Margin (10%) | Total (Rs.) |
|---------|----------------|-------------------|----------------------|-------------------|-------------|
| 1.      | T$_1$          | 1000              | 50                   | 100               | 1150        |
| 2.      | T$_2$          | 1000              | 50                   | 100               | 1150        |
| 3.      | T$_3$          | 1000              | 50                   | 100               | 1150        |
| 4.      | T$_4$          | 1000              | 50                   | 100               | 1150        |
| 5.      | T$_5$          | 1000              | 50                   | 100               | 1150        |
| 6.      | T$_6$          | 1000              | 50                   | 100               | 1150        |
| 7.      | T$_7$          | 1000              | 50                   | 100               | 1150        |
| 8.      | T$_8$          | 1000              | 50                   | 100               | 1150        |
| 9.      | T$_9$          | 1000              | 50                   | 100               | 1150        |
| 10.     | T$_{10}$       | 1000              | 50                   | 100               | 1150        |
| Total   |                | 10000             | 500                  | 1000              | 11500       |

**Table 2** Details of the variable cost parameters under study

| Sr. No. | Treatment code | Human labour (Rs.) | Planting material (Rs.) | Fertilizers (Rs.) | Spray material (Rs.) | Land preparation (Rs.) | Plant protection (Rs.) | Total (Rs.) |
|---------|----------------|--------------------|-------------------------|------------------|----------------------|------------------------|------------------------|-------------|
| 1.      | T$_1$          | 1000               | 100                     | 2.34             | 0.0028               | 45                     | 75                     | 1222.34     |
| 2.      | T$_2$          | 1000               | 100                     | 2.34             | 0.0084               | 45                     | 75                     | 1222.35     |
| 3.      | T$_3$          | 1000               | 100                     | 2.34             | 0.014                | 45                     | 75                     | 1222.35     |
| 4.      | T$_4$          | 1000               | 100                     | 2.34             | 90                   | 45                     | 75                     | 1312.34     |
| 5.      | T$_5$          | 1000               | 100                     | 2.34             | 90                   | 45                     | 75                     | 1312.34     |
| 6.      | T$_6$          | 1000               | 100                     | 2.34             | 90                   | 45                     | 75                     | 1312.34     |
| 7.      | T$_7$          | 1000               | 100                     | 2.34             | 90.0028              | 45                     | 75                     | 1312.34     |
| 8.      | T$_8$          | 1000               | 100                     | 2.34             | 90.0084              | 45                     | 75                     | 1312.35     |
| 9.      | T$_9$          | 1000               | 100                     | 2.34             | 90.014               | 45                     | 75                     | 1312.35     |
| 10.     | T$_{10}$       | 1000               | 100                     | 2.34             | 0                    | 45                     | 75                     | 1222.34     |
| Total   |                | 10000              | 23.40                   | 540.050          | 450                  | 750                    | 12763.44    |
### Table 3: Treatment wise details of total cost price and selling price

| Sr. No. | Treatment code | Total cost price (Rs.) | Total selling price (Rs.) |
|---------|----------------|------------------------|--------------------------|
|         |                | Fixed cost | Variable cost | Total | Yield (Kg) | Rate/Kg | Total |
| 1.      | T₁             | 1025       | 1222.34      | 2372.34 | 2.83    | 1000     | 2830   |
| 2.      | T₂             | 1025       | 1222.35      | 2372.35 | 3.14    | 1000     | 3140   |
| 3.      | T₃             | 1025       | 1222.35      | 2372.35 | 3.91    | 1000     | 3910   |
| 4.      | T₄             | 1025       | 1312.34      | 2464.34 | 2.62    | 1000     | 2620   |
| 5.      | T₅             | 1025       | 1312.34      | 2462.34 | 3.55    | 1000     | 3550   |
| 6.      | T₆             | 1025       | 1312.34      | 2462.34 | 3.55    | 1000     | 3550   |
| 7.      | T₇             | 1025       | 1312.34      | 2462.34 | 2.89    | 1000     | 2890   |
| 8.      | T₈             | 1025       | 1312.34      | 2462.34 | 4.92    | 1000     | 4620   |
| 9.      | T₉             | 1025       | 1312.34      | 2462.34 | 4.13    | 1000     | 4130   |
| 10.     | T₁₀            | 1025       | 1222.34      | 2372.34 | 2.78    | 1000     | 2780   |
|         | Total          | 11500      | 12763.44     | 24263.44 | 34.32  |          | 34020  |

### Table 4: Treatment wise details showing benefit and Benefit: Cost (B:C ratio)

| Sr. No. | Treatment code | Cost price (Rs.) | Selling price (Rs.) | Benefit (Rs.) | B:C ratio |
|---------|----------------|------------------|---------------------|---------------|-----------|
| 1.      | T₁             | 2372.34          | 2830                | 457.66        | 0.19      |
| 2.      | T₂             | 2372.35          | 3140                | 767.65        | 0.32      |
| 3.      | T₃             | 2372.35          | 3910                | 1537.65       | 0.65      |
| 4.      | T₄             | 2464.34          | 2620                | 157.66        | 0.06      |
| 5.      | T₅             | 2462.34          | 3550                | 1087.66       | 0.44      |
| 6.      | T₆             | 2462.34          | 3550                | 1087.66       | 0.44      |
| 7.      | T₇             | 2462.34          | 2890                | 427.66        | 0.17      |
| 8.      | T₈             | 2462.34          | 4620                | 2157.65       | 0.87      |
| 9.      | T₉             | 2462.35          | 4130                | 1667.65       | 0.67      |
| 10.     | T₁₀            | 2372.34          | 2780                | 407.66        | 0.17      |
|         | Total          | 24263.44         | 34020               | 9756.56       |           |

Among the different treatment combinations maximum profit was Rs 2157.65/- and benefit cost ratio (0.87:1) was recorded from treatment T₈ comprising ZnSO₄ @ 0.1% + ZnO nanoparticles @ 150 ppm, whereas the minimum value was observed from treatment T₄ (ZnO nanoparticles @ 100 ppm). The benefit cost ratio is worked out under table 4.

The reason for the maximum cost benefit ratio in treatment combination T₈ comprising ZnSO₄ @ 0.3% + ZnO NPs @ 150 ppm could be the role of zinc in increasing fruit yield resulting into more returns and ultimately leading to more benefit cost ratio. The results obtained from the present experiment are in accordance with Kumar et al., (2017), Guvvali et al., (2017) and Ekka et al., (2018). From the study, it may be concluded that the maximum benefit cost ratio (0.87) was observed under treatment combination of ZnSO₄ @ 0.3% + ZnO NPs @ 150 ppm (T₈), whereas the least benefit cost ratio (0.05) was observed under treatment T₄ (ZnO NPs @ 100 ppm). Therefore, the treatment...
combination T8 (ZnSO4 @ 0.3% + ZnO NPs @ 150 ppm) must recommended to farmers of mid hill region of Himachal Pradesh as they can get maximum returns from strawberry cultivation under protected cultivation.

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