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Effect of Zinc Sulphate and Zinc oxide Nanoparticles on Economic Returns from Strawberry (*Fragaria* × *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 $ZnSO_4$ 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 $ZnSO_4$ and ZnO nanoparticles improved the net economic returns from strawberry cultivation and the treatment T_8 ($ZnSO_4$ @ 0.3% + ZnO NPs @ 150 ppm) recorded maximum selling price of Rs. 4620, profit of Rs. 2157.65 and Benefit cost ratio (0.87%).

Introduction

Strawberry (*Fragaria* × *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 cynidin. 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	1000	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.	T_1	1150	1222.34	2372.34	2.83	1000	2830
2.	T_2	1150	1222.35	2372.35	3.14	1000	3140
3.	T_3	1150	1222.35	2372.35	3.91	1000	3910
4.	T_4	1150	1312.34	2464.34	2.62	1000	2620
5.	T_5	1150	1312.34	2462.34	3.55	1000	3550
6.	T_6	1150	1312.34	2462.34	3.55	1000	3550
7.	T_7	1150	1312.34	2462.34	2.89	1000	2890
8.	T_8	1150	1312.35	2462.34	4.92	1000	4620
9.	T_9	1150	1312.35	2462.35	4.13	1000	4130
10.	T_{10}	1150	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.	T_1	2372.34	2830	457.66	0.19
2.	T_2	2372.35	3140	767.65	0.32
3.	T_3	2372.35	3910	1537.65	0.65
4.	T_4	2464.34	2620	157.66	0.06
5.	T_5	2462.34	3550	1087.66	0.44
6.	T_6	2462.34	3550	1087.66	0.44
7.	T_7	2462.34	2890	427.66	0.17
8.	T_8	2462.34	4620	2157.65	0.87
9.	T_9	2462.35	4130	1667.65	0.67
10.	T_{10}	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 T_8 comprising $ZnSO_4$ @ 0.1% + ZnO nanoparticles @ 150 ppm, whereas the minimum value was observed from treatment T_4 (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 T_8 comprising $ZnSO_4$ @ 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 $ZnSO_4$ @ 0.3% + ZnO NPs @ 150 ppm (T_8), whereas the least benefit cost ratio (0.05) was observed under treatment T_4 (ZnO NPs @ 100 ppm). Therefore, the treatment

combination T_8 ($ZnSO_4$ @ 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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