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Effect of Different Concentrations of Iron Oxide and Zinc Oxide Nanoparticles on Growth and Yield of Strawberry (*Fragaria x ananassa* Duch) cv. Chandler

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ABSTRACT

Keywords

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The field experiment was carried out at Department of Horticulture, Sam Higginbottom University of Agriculture, Technology and Sciences, Allahabad, India during *Rabi season (Nov-April)* 2016-17. The experiment was laid out in 4×4 factorial randomized block design with 16 treatments in three replications. It is concluded that the treatments T₁₅ (Z₃F₃: ZnO NPs@150ppm + FeO NPs @150ppm), were found best in terms of highest growth parameters namely plant height (17.24cm), number of leaves (46.67), petiole length (9.22cm), and also found best for yield related traits namely days to 50% flowering (59.40), days to 1st harvesting (97.93), number of fruits plant⁻¹ (32.27), fruit weight (15.71g), fruit diameter (26.21mm), fruit yield plant⁻¹ (478g) and also with highest benefit ratio (5.96) was obtained in T₁₅ (Z₃F₃: ZnO NPs@150ppm + FeO NPs@150ppm).

Introduction

The modern cultivated strawberry (*Fragaria x ananassa* Duch.) is a hybrid of two largely dioecious octoploid species, *Fragaria chelonensis* Duch and *Fragaria virginiana* Duch. *Fragaria* species belongs to family Rosaceae with a basic chromosome number of X=7, the cultivated strawberry *Fragaria x ananassa* Duch. Has chromosome number (2n) of 56. Basically, it is herbaceous perennial and short day plant grows predominantly in the temperate climate. Among all the different types of berries, strawberry gives the quickest return in a shortest possible period (Boriss *et al.*, 2006).

Over the last few years, strawberries have experience one of the highest rate of consumption growth, where it is the highest consumed fresh fruits, rich in proteins, minerals Ca, P and K, fair source of Vit -A, B1, B2, niacin and Vit - C and it is regarded as one of the best natural sources of antioxidant. Besides, strawberry can be processed for making wine, jam, jelly, ice cream and soft drinks etc. In India, strawberry is confined only to the Hilly Tracts of Himachal Pradesh, Uttaranchal, parts of Uttar Pradesh and Kashmir valley. However, its cultivation has spread to tropical and

subtropical zones, where other states like Meghalaya, Sikkim and Mizoram have taken up the cultivation of this viable fruit. So far, Maharashtra is the leading state in the production of strawberry (Lyngdoh, 2014).

The area under fruit production in India is 6405 thousand hectares with a production of 91443.41 thousand metric tons (2015-16). Area under Strawberry production is 1 thousand hectares with production 5 thousand metric tons in (2015-16). Leading states in area and production of strawberry are Meghalaya, Himachal Pradesh and Jammu and Kashmir (Area and Production of Horticulture Crops –Govt. of India).

Nanotechnology research is one of the major emerging areas of research with its application in science and technology for the purpose of manufacturing new materials at the nano-scale level (Albrecht *et al.*, 2006.) The use of nanoparticles on growth of plants and for the control of plant diseases is a rather recent practice (Zheng *et al.*, 2005; Shah & Belozerovala 2009). However, interests in researches have been increasing on the biological effects of nano-particles on higher plants. The prefix nano is derived from the Greek word nanos meaning “dwarf” that refers to things of one billionth (10^{-9} m) in size. The term nanotechnology was coined by Professor Norio Taniguchi of Tokyo Science University in 1974 to describe the precision of the industrialized biomaterials at the nanometer level (Taniguchi, 1974). Nano-fertilizers or nano-encapsulated nutrients have properties effectively to release nutrients and chemical fertilizers on demand that regulate plant growth and enhance target activity (Nair *et al.*, 2010). Nano-scale science and nanotechnology have the potential to transform the agriculture and food system (Norman *et al.*, 2013). Nanoparticles interact with plants causing many morphological and physiological changes, depending on the

properties of NPs. efficacy of NPs is determined by their chemical composition, size, surface covering, reactivity, and most importantly the dose at which they are effective (Khodakovskaya *et al.*, 2012). Researchers from their findings suggested both positive and negative effects on plant growth and development, and the impact of engineered nanoparticles (ENPs) on plants depends on the composition, concentration, size, and physical and chemical properties of ENPs as well as plant species (Ma *et al.*, 2010). Efficacy of NPs depends on their concentration and varies from plants to plants. However, this review covers plausible role NPs in seed germination, roots, plant growth (shoot and root biomass) and photosynthesis (Siddiqui *et al.*, 2014).

In many studies, increasing evidence suggests that zinc oxide nanoparticles (ZnO NPs) increase plant growth and development. Prasad *et al.*, (2012) in pea-nut; (Sedghi *et al.*, 2013) in soybean; (Ramesh *et al.*, 2014) in wheat and Raskar and Laware (2014) in onion reported that lower concentration of ZnO NPs exhibited beneficial effect on seed germination. However, higher dose of ZnO NPs impaired seed germination. The effect of NPs on germination depends on concentrations of NPs and varies from plants to plants. (de la Rosa *et al.*, 2013) applied different concentrations of ZnO NPs on cucumber, alfalfa and tomato, and found that only cucumber seed germination was enhanced (Raliya and Tarafdar, 2013).

Nano iron oxide at the concentration of 0.75g/L increased leaf + pod dry weight and pod dry weight. The highest grain yield was observed by using 0.5g/L nano iron oxide that showed 48% increase in grain yield in comparison with control. Other measured traits were not affected by the iron nanoparticles. Treatments were five levels of nano-iron oxide (0, 0.25, 0.75 & 1 g/L)

(Sheykhabaglou *et al.*, 2010). Keeping in view the role of NPs, the present investigation has taken up to find out the most suitable dose of ZnO NPs and FeO NPs on growth yield and quality of Strawberry.

Materials and Methods

Site Detail

The experiment was conducted during *rabi* season 2016-17 on crop research farm of Department of Horticulture, Naini Agricultural Institute, Allahabad, India.

The area is situated on the south of Allahabad on the right side of the river Yamuna on the South of Rewa road at a distance of about 6 km from Allahabad city. It is situated at 25°24'23" N latitude, 81°05'38" E longitude and at the altitude of 98 meter above the sea level (MSL).

The treatment consisted of different levels of zinc oxide and Iron oxide, T₀ (Control), T₁ Z₁ (50ppm ZnO NPs), T₂ Z₂ (100 ppm ZnO NPs), T₃ Z₃ (150 ppm ZnO NPs), T₄ F₁ (50 ppm FeO NPs), T₅ F₂ (100 ppm FeO NPs), T₆ F₃ (150 ppm FeO NPs), T₇ Z₁ F₁ (50ppm ZnO NPs + 50ppm FeO NPs), T₈ Z₂ F₁ (100ppm ZnO NPs + 50ppm FeO NPs), T₉ Z₃ F₁ (150ppm ZnO NPs+ 50ppm FeO NPs), T₁₀ Z₁F₂ (50ppm ZnO NPs + 100ppm FeO NPs), T₁₁ Z₂ F₂ (100ppm ZnO NPs+ 100ppm FeO NPs), T₁₂ Z₃ F₂ (150ppm ZnO NPs + 100ppm FeO NPs), T₁₃ Z₁F₃ (50ppm ZnO NPs + 150ppm FeO NPs), T₁₄ Z₂F₃ (100ppm ZnO NPs + 150ppm FeO NPs), T₁₅ Z₃F₃ (150ppm ZnO NPs + 150ppm FeO NPs).

The trial was laid out in a factorial randomized block design with three replication (*Fragaria x ananassa* Duch) cv. Chandler, were applied uniformly in all the plots using recommended dose of nitrogen, phosphorus and potassium respectively. Basal dose of fertilizer was applied as Farm Yard

Manure in the plots. All the agronomic practices were carried out uniformly to raise the crop.

Results and Discussion

Growth parameters

Plant height (cm)

Increase in plant height due to increasing of Zinc Oxide and Iron Oxide may be due to adequate a nutrient which is turns help in vigorous vegetative growth of plants and subsequently increase the plant height through cell elongation cell division photosynthesis and turgidity of plant cell. The Maximum plant height (17.24 cm), were recorded with treatment T₁₅, followed by treatment T₇ (13.28) whereas, treatment T₀ shows minimum plant height (9.38 cm). These results are closely confined with (Panwar *et al.*, 2012).

Number of leaves plant⁻¹

The effect of Zinc Oxide and Iron Oxide on number of leaves plant⁻¹ was found significant at 45, 90, and 135 DAP. The Maximum number of leaves was recorded with treatment T₁₅ (46.67), followed by treatment T₇ (39.47) whereas, treatment T₀ shows minimum number of leaves (31.40). These results are closely confined with (Panwar *et al.*, 2012).

Petiole length plant⁻¹ (cm)

The effect of Zinc Oxide and Iron Oxide on Petiole length plant⁻¹ (cm) was found significant at 45, 90 and 135 DAP. The Maximum petiole length was (9.22cm) recorded with treatment T₁₅, followed by treatment T₇ (7.79 cm) whereas, treatment T₀ shows minimum petiole length (9.22). These results are closely confined with (Panwar *et al.*, 2012 and Dhoke *et al.*, 2013) (Table 1).

Table.1 Effect of various treatments on growth parameters of Strawberry

Treatment	Plant height (cm)			Number of leaves plant ⁻¹			Petiole length plant ⁻¹ (cm)		
	45 DAP	90 DAP	135 DAP	45 DAP	90 DAP	135 DAP	45 DAP	90 DAP	135 DAP
T ₀	3.32	6.16	9.38	10.60	28.93	31.40	2.88	5.19	6.98
T ₁	4.77	8.72	11.43	13.40	34.13	38.33	3.53	6.27	7.59
T ₂	5.53	10.95	14.65	14.27	36.20	41.53	3.78	6.73	8.23
T ₃	5.97	13.17	16.31	15.87	39.13	44.27	3.97	7.40	8.45
T ₄	3.90	6.64	9.77	11.67	31.93	32.13	3.45	5.80	7.28
T ₅	4.13	7.43	10.65	12.20	32.60	34.53	3.63	5.95	7.37
T ₆	4.47	7.83	11.23	12.73	33.33	36.87	3.39	6.23	7.48
T ₇	4.95	9.37	13.28	13.47	34.33	39.47	3.57	6.42	7.79
T ₈	5.11	9.60	13.86	13.80	34.60	40.60	3.63	6.45	7.97
T ₉	5.27	10.23	14.29	14.27	34.93	41.40	3.54	6.51	8.05
T ₁₀	5.60	11.49	14.87	14.67	37.33	42.33	3.81	6.80	8.32
T ₁₁	5.74	11.71	14.93	15.07	38.20	43.13	3.84	7.09	8.16
T ₁₂	5.89	12.21	15.15	14.73	38.60	43.73	3.85	7.19	8.35
T ₁₃	6.32	13.64	16.55	16.13	40.53	45.00	4.10	7.65	8.67
T ₁₄	6.45	14.59	16.60	16.0	41.80	45.97	4.21	7.79	9.11
T ₁₅	6.63	14.93	17.24	16.67	42.27	46.67	4.38	8.17	9.22
F-test	S	S	S	S	S	S	S	S	S
S.Ed. (±)	0.06	0.11	0.33	0.23	0.19	1.12	0.09	0.09	0.10
C.D. (at 05%)	0.19	0.33	0.96	0.68	0.56	3.26	0.25	0.25	0.29

Table.2 Influence of various treatments on yield attributes of Strawberry

Treatment	Days to 50% flowering	Days to 1 st harvesting	Number of fruits plant ⁻¹	Yield (g plant ⁻¹)	Fruit yield (t ha ⁻¹)	B:C Ratio
T ₀	66.44	105.07	19.40	191	2.39	1:2.17
T ₁	64.13	102.67	22.53	338	4.22	1:2.76
T ₂	62.71	101.13	25.47	382	4.77	1:3.58
T ₃	61.08	98.90	28.47	427	5.34	1:3.95
T ₄	65.28	104.93	20.60	239	2.99	1:3.90
T ₅	64.80	104.80	21.00	305	3.81	1:4.02
T ₆	64.52	102.93	22.13	332	4.15	1:4.24
T ₇	63.80	102.00	22.87	343	4.29	1:4.29
T ₈	63.50	101.70	23.73	356	4.45	1:4.55
T ₉	63.17	101.53	24.40	366	4.57	1:4.75
T ₁₀	62.42	100.73	26.20	393	4.91	1:4.74
T ₁₁	62.03	100.27	26.73	398	4.97	1:4.93
T ₁₂	61.58	99.80	26.87	408	5.10	1:5.24
T ₁₃	60.60	98.50	29.07	436	5.45	1:5.27
T ₁₄	60.25	98.37	30.20	447	5.59	1:5.49
T ₁₅	59.40	97.93	32.27	478	5.97	1:5.96
F-test	S	S	S	S	S	-
S.Ed. (±)	0.13	0.22	0.22	15.02	0.19	-
C.D. (at 5%)	0.37	0.66	0.64	43.83	0.55	-

Yield parameters

Higher yield response in comparison of Zinc Oxide and Iron Oxide was recorded with balanced application of Zinc Oxide and Iron Oxide nanoparticles. Minimum days to 50% flowering was recorded with treatment T₁₅ (59.40) followed by treatment T₇ (63.80) whereas, treatment T₀ shows maximum days to 50% flowering (66.44). Maximum days to 1st harvesting was recorded with treatment T₁₅ (97.93) followed by treatment T₇ (102.00) whereas, treatment T₀ shows minimum days to 1st harvesting (105.07). Maximum number of fruits plant⁻¹ was recorded with treatment T₁₅ (32.27) followed by treatment T₇ (22.87) whereas, treatment T₀ shows minimum number of fruits plant⁻¹ (19.40). Maximum yield (g) plant⁻¹ was recorded with treatment T₁₅ (478.00) followed by treatment T₇ (343.00) whereas; treatment T₀ shows minimum yield (g) plant⁻¹ (191.00). Maximum fruit yield t ha⁻¹ was recorded with treatment T₁₅ (5.97) followed by treatment T₇ (4.29) whereas; treatment T₀ shows minimum fruit yield t ha⁻¹ (2.39). Maximum cost benefit ratio (1:5.96) was recorded under treatments T₁₅ followed by treatment T₇ (1:4.29) whereas; treatment T₀ shows minimum cost benefit ratio (1:2.17). These results are closely confined with (Chowdappa *et al.*, 2013, Dhoke *et al.*, 2013 and Davarpanah *et al.*, 2013) (Table 2).

Based on the findings of present investigation, it is concluded that the combined application of Zinc oxide and Iron oxide nanoparticles @ 150ppm each resulted in better growth, higher yield in treatment T₁₅ (Z₃F₃ (150ppm ZnO NPs + 150ppm FeO NPs).

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