Effect of Nano Nutrients (N, Zn and Cu) on Growth of Capsicum (Capsicum annuum L. var. grossum)

J. Sam Ruban, B. Gayathri and
M. Nandhinidevi

Research Journal of Agricultural Sciences
An International Journal

P- ISSN: 0976-1675
E- ISSN: 2249-4538

Volume: 12
Issue: 05

Res Jr of Agril Sci (2021) 12: 1742–1746

CARAS

Res. Jr. of Agril. Sci. (Sep-Oct 2021) 12(5): 1742–1746
www.rjas.org

Full Length Research Article

Effect of Nano Nutrients (N, Zn and Cu) on Growth of Capsicum (*Capsicum annuum* L. var. grossum)

J. Sam Ruban*[1], B. Gayathri[2] and M. Nandhinidevi[3]

Received: 16 Jun 2021 | Revised accepted: 05 Sep 2021 | Published online: 04 Oct 2021

ABSTRACT

Vegetables are the prime source of vitamins and minerals. As the population increases there is also increase in demand for nutritional vegetables, but in the conventional method of horticulture the production and productivity is considerably less. Thus, to increase the productivity and to feed the over burgeoning population there is a need for novel fertilizers such as Nano fertilizers. An experiment was hence conducted in Chinapettai village, Panruti to investigate the Bio-efficacy of Nano nutrients (Nano Nitrogen, Zinc and Copper) on growth and yield of Capsicum. The experiment was carried out in RBD design (Randomized block design) with three replications and ten treatments. Results showed that the treatment with 100% RD-N + 100% RD-P + 100% RD-K + Nano N + Nano Cu + Nano Zn followed by 100% RD-N + 100% RD-P + 100% RD-K + Nano N and 75% RD-N + 100% RD-P + 100% RD-K + Nano N + Nano Cu + Nano Zn recorded maximum growth parameters. In contrast 50% RD-N + 100% RD-P + 100% RD-K + Nano N showed increase in growth than the control (100% RDF (-N: -P: -K) (250:150:150 kg/ha)) to conclude that Nano nitrogen could have compensated the 50% urea recommendation in conventional fertilizer and also had enhanced effect than control.

***Key words*:** Nano fertilizers, Conventional fertilizers, Capsicum, Nano nitrogen, Nano zinc, Nano copper

Vegetables are economic engines for productive, profitable agricultural economics. India is the second largest producer of vegetables in the world (surpassed only by China). In 2018-2019 India produced 187474 metric tons of vegetables in 10436 ha of land area [1]. Its production provides a promising economic opportunity for reducing rural poverty and unemployment in developing countries and is a key component of farm diversification strategies [2]. India is the second largest producer of vegetables in the world (surpassed only by China). Vegetables are the human race most accessible sources of vitamins and minerals for wholeness. This era trapper the need of vegetable production for economic and nutritional security and to achieve the millennium development goals in a timely fashion.

Bell pepper is rich in Vitamin A (8493 IU), Vitamin C (283 mg) and minerals like Calcium (13.4 mg), Magnesium (14.9 mg), Phosphorus (28.3 mg) and Potassium (263.7 mg) per100 g^{-1} fresh weight. Capsicum is a cool season crop, but it can be grown round the year using protected structures where temperature and relative humidity (RH) can be manipulated. This crop requires a day temperature of 25-30°C and night temperature of 18-20°C with relative humidity of 50-60%. If temperature exceeds 35°C or falls below 12°C, fruit setting is affected. Bell pepper has attained a status of high value crop in India. Its rich content of ascorbic acid and other vitamins and minerals coupled with pleasant flavor and its delicacy in Indian cuisine attained a pride place among other vegetables. They are also frequently used both chopped and raw in salads, or cooked in stir-fries or other mixed dishes. They can be preserved in the form of a jam or by drying, pickling, or freezing. Dried peppers may be reconstituted whole, or processed into flakes or powders. Pickled or marinated peppers are frequently added to sandwiches or salads. Frozen peppers are used in stews, soups, and salsas. Extracts can be made and incorporated into hot sauces.

However, India has many growing concerns. In the Indian economy the horticultural contribution to GDP has steadily declined while achieving enough food production, India still reports for a one fourth of the world's hungry people and home to over million undernourished people. Indian horticulture feels the pain of fatigue of green revolution, the yield in many crops have been stagnated due to over use of fertilizers. Also, low nutrient use efficiency due to leaching, declining soil organic matter, multi nutrient deficiencies, shrinking arable land, shortage of labor are results of evacuation of people from farming [3].

When minimized to the nanoscale, these nutrients show some characteristics that differ from the presence of

* J. Sam Ruban
✉ samrubanjones@yahoo.com

[1-3] Department of Horticulture, Faculty of Agriculture, Annamalai University, Annamalai Nagar - 608 002, Chidambaram, Tamil Nadu, India

the nutrients in the macro scale, allowing unique applications [4]. Compared with chemical fertilizers, Nano-fertilizers has larger specific surface area, which makes nutrients more easily absorbed by plants, which significantly improves its fertilizer use efficiency and has significant economic benefits. The application of nano-fertilizer can improve the physical and chemical properties of soil and improve the ability of water and fertilizer conservation [5]. With the above background, the present study is initiated to know the Bio efficacy of Nano nutrients (Nano N, Nano Zn and Nano Cu) on growth and yield of capsicum with the objective To study the effect of Nano N, Zn and Cu on crop growth.

MATERIALS AND METHODS

The current studies on Bio efficacy of nano nutrients on growth of capsicum were carried out in a farmer's field at Chinnapettai village in Panruti, Cuddalore district of Tamil Nadu during 2019-2020. The details of materials used and the methods adopted during the course of investigation are presented below:

The experimental site is geographically situated at 11°.49' North latitude and 76.97° East longitude at an average elevation of 23 meters above mean sea level in the Cuddalore district of Tamil Nadu. The weather of Panruti is moderately warm and hot Summer. The maximum mean temperature of the location ranges from 20.6°C to 34. 4°C.while the minimum mean temperature ranges from 20°C to 27°C. The average Precipitation is about 1030.35 mm annually, of which 547.14mm is received during north east monsoon (Oct-Dec), 340.04mm is received during south west monsoon (June-Sept) and 143 mm is received as summer shower.

Experimental details

Location	:	Chinnapettai, Panruti
Number of treatments	:	10
Number of replications	:	3
Plot size	:	4 × 5 m²
Total number of plants		1500 plants
Total number of plants per plot (20 m²)		37 plants
Area	:	18 cents
Spacing	:	90×60×60 cm (Paired row system)
Variety	:	Priyanka 55

Treatment details

T_1: 100% RDF(-N:-P:-K)(250:150:150kg/ha)(Control)
T_2: 0%N+100% RD-P + 100% RD-K
T_3: 100% RD-N +100% RD-P + 100% RD-K + Nano N
T_4: 75% RD-N +100% RD-P + 100% RD-K + Nano N
T_5: 50% RD-N + 100% RD-P + 100% RD-K + Nano N
T_6: 100% RD-N +100% RD-P + 100% RD-K Nano N + Nano Cu + Nano Zn
T_7: 75% RD-N+100% RD-P + 100% RD-K Nano N + Nano Cu + Nano Zn
T_8: 50% RD-N+100% RD-P + 100% RD-K Nano N + Nano Cu + Nano Zn
T_9: 100% RDF(-N:-P:-K) Nano Zn
T_{10}: 100% RDF(-N:-P:-K) + Nano Cu

Source of nano nutrients

The nano nutrients such as nano nitrogen, nano zinc and nano copper used in this study were obtained from IFFCO (Indian Farmers Fertilizer Cooperative Limited). These Environment Friendly products have been introduced for the first time in India and were launched at an event at its unit in Kalol, Gujarat by Union Chemical and Fertilizer Minister. Drip irrigation was used for irrigation with a capacity of two liters per hour. Thus, each plant receives about 310ml per irrigation for 10 minutes. Life irrigation is given three days after transplanting and subsequent irrigation were done for every three days. The recommended dose of phosphorus and potassium were applied at basal (150:150 kg/ha) as SSP (Single super phosphate) and MOP (Murate of potash) at 1.875 kg and 500 g per plot. Nitrogen was applied in the form of urea as per the treatments as 100% ,75% and 50% .500 g of urea was applied as basal dose to all the treatment except T_2 (denied of Nitrogen) and subsequent application of Nitrogen was given at 30th, 60th and 90th day after transplanting to 100% RDN: - treatments. For 75% RDN: - treatments nitrogen was given at 30th and 60th days after transplanting alone and for 50% RDN: - treatments nitrogen was given at 30th days after transplanting alone at 180 grams (urea) per plot per application as top dressing. Pruning was done on 30 days after transplanting to retain two stems. The plants are trained by jute ropes tied to the horizontal gauge wire in the top. Training is done at 4 weeks after transplanting.

Application of nano fertilizers

Application of nano nutrients such as nano nitrogen, nano zinc and nano copper was applied by foliar application at three stages (Vegetative stage, flowering stage and fruiting stage) which also accord with 10 days after top dressing. The Foliar application of Nano nutrients was given as per the treatments at the rate of 4ml per liter with power sprayer. Harvesting was done 60 days after transplanting and when fruits show waxy coating and ideal size. Harvesting was done at 10 days' interval. The fruits harvested from tagged plants were used for taking yield parameters.

Observation

In each treatment, five randomly selected plants were tagged for recording the observations on growth, yield, quality and physiological parameters.

Plant height

The plant height was measured from the base of the plant at ground level to the tip of main stem on 30th, 60th and 90th day after transplanting and expressed in centimeters (cm).

Number of branches

The number of branches arising from the main branch was recorded on the final harvest of randomly tagged five plants on each treatment plot and expressed in numbers.

Days to 50% flowering

The days taken from planting to 50% flowering was recorded in each plot and then the mean value was expressed in days.

RESULTS AND DISCUSSION

Field experiment was carried out in farmer field at Chinnapettai, Panruti during 2019-2020, to study the bio efficacy of nano nutrients (N, Zn and Cu) on growth of capsicum. The influence of treatments was studied in terms of morphological and yield components. All the components were recorded in between 30 and 120 days after transplanting and the yield characters were recorded at the time of harvest. The data were statistically analyzed and the details of the experimental results are presented below.

The data featured in (Table 1) on plant height at 45th, 75th days after treatment (DAT) and at final harvest brought in view a significant variation in plant height. Among the treatments, the utmost plant height was recorded in T_6 - 100% RD-N+100% RD-P + 100 % RD-K + Nano N + Nano Cu + Nano Zn (55.95 cm) followed by T_7 -75% RD-N+100% RD-P + 100% RD-K + Nano N + Nano Cu + Nano Zn (55.71 cm) and T_8- 50% RD-N+100% RD-P + 100% RD-K + Nano N + Nano Cu + Nano Zn(55.64cm) which recorded on par values at 45th days after transplanting followed by T_3 - 100% RD-N +100% RD-P + 100 % RD-K + Nano N (54.18 cm) , T_4 -75% RD-N +100% RD-P + 100 % RD-K + Nano N(54.04cm) and T_5-50% RD-N +100% RD-P + 100 % RD-K + Nano N(53.99cm) which is also on par. Treatment T_5 - 50% RD-N + 100% RD-P + 100 % RD-K + Nano N and T_8 - 50% RD-N+100% RD-P + 100 % RD-K Nano N + Nano Cu + Nano Zn recorded the plant height of 53.99 cm and 55.64 cm which is greater than T_1 - 100% RDF (-N: -P: -K) 250:150:150kg/ha (46.12cm). The lowest plant height was recorded in T_2 - 0%N+100% RD-P + 100 % RD-K (43cm). The same trend was observed on 75th days after treatment (DAT) and at final harvest.

Table 1 Bio efficacy of nano N, Zn and Cu on plant height at 45th day ,75th day and at final harvest in capsicum

Treatments	Plant height (cm)		
	45 DAT	65 DAT	At harvest
T_1: 100% RDF (-N:-P:-K)(250:150:150kg/ha)(Control)	46.1	60.7	92.0
T_2: 0%N+100% RD-P + 100% RD-K	43.0	56.1	83.0
T_3: 100% RD-N +100% RD-P + 100% RD-K + Nano N	54.1	72.2	109.0
T_4: 75% RD-N +100% RD-P + 100% RD-K + Nano N	54.0	72.0	108.9
T_5: 50% RD-N + 100% RD-P + 100% RD-K + Nano N	53.9	71.7	108.6
T_6: 100% RD-N +100% RD-P + 100% RD-K Nano N + Nano Cu + Nano Zn	55.9	73.1	111.1
T_7: 75% RD-N+100% RD-P + 100% RD-K Nano N + Nano Cu + Nano Zn	55.7	73.0	110.9
T_8: 50% RD-N+100% RD-P + 100% RD-K Nano N + Nano Cu + Nano Zn	55.6	72.9	110.5
T_9: 100% RDF(-N:-P:-K) Nano Zn	50.9	67.5	102.5
T_{10}: 100% RDF(-N:-P:-K) + Nano Cu	51.9	64.1	97.2
S.ED	1.3	1.3	2
CD(p=0.05)	2.7	2.8	4.1

The data on number of branches is presented in (Table 2) revealed that there is a significant variation in Nano nutrients treatment plots compared to the control (RDF)**.**Among the various treatments tested, T_6-100% RD-N+100% RD-P + 100 % RD-K+ Nano N + Nano Cu + Nano Zn (13.59), T_7 -75% RD-N+100% RD-P + 100 % RD-K+ Nano N + Nano Cu + Nano Zn (13.54) and T_8 -50% RD-N+100% RD-P + 100% RD-K + Nano N + Nano Cu + Nano Zn (13.47) which recorded on par values showed the utmost number of branches followed by T_3 - 100% RD-N +100% RD-P + 100 % RD-K + Nano N (13.28), T_4 -75% RD-N +100% RD-P + 100 % RD-K + Nano N (13.2) and T_5-50% RD-N +100% RD-P + 100 % RD-K + Nano N(13.14) which is also on par . The lowest number of branches was recorded in T_1 - 100% RDF (-N: -P: -K) 250:150:150kg/ha (11.2) followed by T_2 -0%N+100% RD-P + 100 % RD-K (10.16).

The data presented in (Table 2) shows a significant difference in days to 50 percent flowering. The early flowering was recorded in T_6-100% RD-N+100% RD-P + 100 % RD-K Nano N + Nano Cu + Nano Zn (39 days), T_7 - 75% RD-N+100% RD-P + 100 % RD-K Nano N + Nano Cu + Nano Zn (42 days) and T_8 -50% RD-N+100% RD-P + 100 % RD-K Nano N + Nano Cu + Nano Zn (43.5 days) which was on par followed by T_3 - 100% RD-N +100% RD-P + 100 % RD-K + Nano N (41.2 days) , T_4 -75% RD-N +100% RD-P + 100 % RD-K + Nano N(43 days) and T_5-50% RD-N +100% RD-P + 100 % RD-K + Nano N (44.6 days)which also recorded on par values .Delayed 50% flowering was recorded in T_2 -0%N+100% RD-P + 100 % RD-K (50 days).

Growth is a major indicator of fertilizer uptake and adsorption. Among various treatments tested, plants which are treated with 100% RD-N+100% RD-P + 100 % RD-K Nano N + Nano Cu + Nano Zn (T_6), 75% RD-N+100% RD-P + 100 % RD-K Nano N + Nano Cu + Nano Zn (T_7) and 50% RD-N+100% RD-P + 100 % RD-K Nano N + Nano Cu + Nano Zn (T_8) recorded highest and utmost plant height at 45th, 75th DAT and final harvest which registered on par values (55.95,55.71 and 55.64 cm) and increase in height by 20.8 % than T_1 -100% RDF (-N: -P: -K) 250:150:150kg/ha followed by T_3 - 100% RD-N +100% RD-P + 100 % RD-K + Nano N (54.18 cm), T_4 -75% RD-N +100% RD-P + 100 % RD-K + Nano N(54.04cm) and T_5-50% RD-N +100% RD-P + 100 % RD-K + Nano N(53.99cm) which were also on par and also registered an increase in height by 18.4% than T_1-100% RDF (-N: -P: -K) 250:150:150kg/ha [6].

Nitrogen positively affects the plant height [7]. The rise might be due to cell growth under nitrogen. Several studies indicated that foliar application of some nanoparticles can significantly improve plant growth [8-9]. Moreover, plant height was more magnified when Nano

fertilizer was mixed with the conventional ones, even at a lower application rate [10]. Also, the combination of other Nano Nitrogen with Nano Zinc might also be a reason for increase in plant height [11].

The physiological mechanisms through which Nano nitrogen in combination with conventional fertilizers and Nano zinc and Nano copper exerts their effects may depend on enzymes for hormone synthesis. Zinc plays an important role in many biochemical functions within plants. Zinc is an essential component of over 300 enzymes. Also, zinc is involved in synthesis of tryptophan which is a precursor of IAA (indole acetic acid) [12]. Nitrogen in Nano form results in better absorption and less nutrient loss and more nutrient use efficiency due to small size to large surface area volume also nitrogen plays chief role in protein and chlorophyll synthesis which result in dark green leaves and promotes leaves stem and vegetative parts of plant [13]. Nano fertilizers are aimed to make nutrients more available to leaves, consequently increasing nutrient use efficiency [14]. Some characteristics of nanoparticles, including the large specific surface area, unique magnetic/optical properties, electronic states, and catalytic reactivity confer nanoparticles a better reactivity than the equivalent bulk materials [15].

Table 2 Bio efficacy of nano nutrients (N, Zn and Cu) on number of branches and days to 50% flowering (days) in capsicum

Treatments	No. of branches plant^{-1}	Days to 50% flowering (days)
T_1: 100% RDF(-N:-P:-K)(250:150:150kg/ha)(Control)	11.2	46
T_2: 0%N+100% RD-P + 100% RD-K	10.1	50
T_3: 100% RD-N +100% RD-P + 100% RD-K + Nano N	13.2	41.2
T_4: 75% RD-N +100% RD-P + 100% RD-K + Nano N	13.2	43
T_5: 50% RD-N + 100% RD-P + 100% RD-K + Nano N	13.1	44.2
T_6: 100% RD-N +100% RD-P + 100% RD-K Nano N + Nano Cu + Nano Zn	13.5	39
T_7: 75% RD-N+100% RD-P + 100% RD-K Nano N + Nano Cu + Nano Zn	13.5	42
T_8: 50% RD-N+100% RD-P + 100% RD-K Nano N + Nano Cu + Nano Zn	13.4	43.5
T_9: 100% RDF(-N:-P:-K) Nano Zn	12.1	44.8
T_{10}: 100% RDF(-N:-P:-K) + Nano Cu	11.5	46
S.ED	0.2	0.9
CD(p=0.05)	0.5	1.9

Number of branches plant^{-1} was also influenced by the nano nutrients. T_6 -100% RD-N+100% RD-P + 100 % RD-K Nano N + Nano Cu + Nano Zn, (13.59), T_7 -75% RD-N+100% RD-P + 100 % RD-K Nano N + Nano Cu + Nano Zn (13.54) and T_8 -50% RD-N+100% RD-P + 100 % RD-K Nano N + Nano Cu + Nano Zn (13.47) which is also on par showed the utmost number of branches and an increase in number of branches by 21.3% than T_1- 100% RDF (-N: -P: -K) 250:150:150 kg/ha followed by T_3 - 100% RD-N +100% RD-P + 100% RD-K + Nano N (13.28), T_4 -75% RD-N +100% RD-P + 100% RD-K + Nano N (13.2) and T_5- 50% RD-N +100% RD-P + 100% RD-K + Nano N (13.14) which is also on par and increase in number of branches by 18.57% than T_1. The results are in close agreement with the finding of Khospeyak *et al*. [16], (2016) who reported that the plant height, number of lateral branches, number of umbels per plants, number of grains per plant, 1000-grain weight were significantly higher with Nano fertilizer treatment over conventional fertilizers.

Among the ten treatments, T6 -100% RD-N+100% RD-P + 100% RD-K Nano N + Nano Cu + Nano Zn (39 days), T_7 -75% RD-N+100% RD-P + 100% RD-K Nano N + Nano Cu + Nano Zn (42 days) and T_8 -50% RD-N+100% RD-P + 100% RD-K Nano N + Nano Cu + Nano Zn (43.5 days)which is also on par and increased by 17.94 % than T_1-100% RDF (-N: -P: -K) 250:150:150kg/ha followed by T_3 - 100% RD-N +100% RD-P + 100 % RD-K + Nano N (41.2 days), T_4 -75% RD-N +100% RD-P + 100% RD-K + Nano N(43 days) and T_5-50% RD-N +100% RD-P + 100% RD-K + Nano N (44.6 days)which is also on par has 11.65% increase than T_1-100% RDF (-N: -P: -K) 250:150:150kgha^{-1}.Delayed 50% flowering was recorded in T_2 -0%N + 100% RD-P + 100% RD-K (50 days). The results are similar with [17]. Flowering is controlled by four main pathways promoting flowering phase: photoperiodic, vernalization, autonomous, and hormonal [18]. Autonomous and hormonal pathways are thought to be independent from environmental factors, but connected with plant development and age [19-20]. Nano zinc enhances cation-exchange capacity of the roots, which in turn enhances absorption of essential nutrients, especially nitrogen which is responsible for higher protein content. Nitrogen is the main component of protein, and all types of enzymes are mainly composed of proteins. Nucleic acid, nucleotides, coenzymes, phospholipids, and cytokinins contain nitrogen. Previous studies have also confirmed that many hormones such as gibberellin and cytokinin are closely related to the regulation of flowering [21].

CONCLUSION

The results conclude that Nano nutrients significantly influence growth and yield parameters. The best treatment recorded is T_5-50% RD-N+100% RD-P + 100% RD-K Nano N followed considering cost of economics and growth and yield parameters. Also, by reducing almost 50% of the

conventional fertilizer (UREA) the soil and environment pollutions can be controlled.

LITERATURE CITED

1. Anonymous. 2019. National Horticulture Board.
2. Schreinemachers P, Simmons EB, Wopereis MCS. 2018. Tapping the economic and nutritional power of vegetables. *Glob. Food Sec.* 16: 36-45.
3. Godfray HCJ, Garnett T. 2014. Food security and sustainable intensification. *Philosophical Transactions of the Royal Society B* 369: 1-10.
4. Naderi MR, Danesh-Shahraki A. 2013. Nano fertilizers and their roles in sustainable agriculture. *Int. Jr. Agric. Crop Science* 5(19): 2229-2232.
5. Yu ZQ, Ren FP. 2014. Material properties in advances in organic fertilizer. *Applied Mechanics and Materials* 730: 235-240.
6. Abdel W, Abdelaziz MM, El-mogy SM, Abdeldaym EA. 2019. Effect of foliar ZnO and FeO Nano particles application on growth and nutritional quality of red radish and assessment of their accumulation on human health. *Agriculture* 65(1): 16-29.
7. Bahmaniar MA, Sooaee-Mashaee S. 2010. Influence of nitrogen and potassium top dressing on yield and yield components as well as well as their accumulation in rice *Oryza sativa*. *African Journal of Biology* 9: 2648-2653.
8. Mandeh M, Omidi M, Rahaie M. 2012. In vitro influences of TiO_2 nanoparticles on barley (*Hordeum vulgare* L.) tissue culture. *Biological Trace Element Research* 150: 376-380.
9. Song U, Jun H, Waldman B, Roh J, Kim Y, Yi J. 2013. Functional analyses of nanoparticle toxicity: a comparative study of the effects of TiO_2 and Ag on tomatoes (*Lycopersicon esculentum*). *Ecotoxicol. Environ. Saf.* 93: 60-67.
10. Benzon HRL, Rubenecia MRU, Jr, VUU, Lee SC. 2015. Nano-fertilizer affects the growth, development and chemical properties of rice. *International Journal of Agronomy and Agricultural Research* 7: 105-117.
11. Railya R, Nair R, Chavalmane S, Biswas P, 2015. Mechanistic evaluation of translocation and physiological impact of titanium dioxide and zinc oxide nanoparticles on the tomato (*Solanum lycopersicum* L.) plant. Washington University in St. Louis on 14/10/2015 18:09:20.
12. Spiegel-Roy P, Goldschmidt E. 2008. *Biology of Citrus*. Cambridge University Press. pp 140-184.
13. Bloom AJ. 2015. The increasing importance of distinguishing among plant nitrogen sources. *Current Opinion in Plant Biology* 25: 10-16.
14. Suppan S. 2013. Nanomaterials in soil: Our future food chain? The institute of agriculture and trade policy, Minneapolis, MN.
15. Agrawal S, Rathore P. 2014. Nanotechnology pros and cons to agriculture: A review. *Intl. Jr. Curr. Microbiol. Appl. Sciences* 3: 43-55.
16. Khospeyak S, Haghi RS, Ahmadiyan A., 2016. The effect of application of nano organic fertilizer and nitrogen fertilizer on yield, yield components and essential oil content of fennel. *Ira. Jr. of Field Crop Research* 14(4): 775-787.
17. Laware SL, Raskar S. 2014. Influence of zinc oxide nanoparticles on growth, flowering and seed Productivity in onion. *International Jr. Curr. Microbiol. App. Sciences* 3(7): 874-881.
18. Zeevaart JAD. 2006. Florigen coming of age after 70 years. *Plant Cell* 18: 1783-1789.
19. Mouradov A, Cremer F, Coupland G. 2002. Control of flowering time: interacting pathways as a basis for diversity. *Plant Cell* 14: S111-S130.
20. Wang WY, Xu J, Liu XJ, Yu Y, Ge Q. 2012. Cadmium induces early flowering in *Arabidopsis*. *Biol Plantarum* 56: 117-120.
21. Bernier G, Perilleux C. 2005. A physiological overview of the genetics of flowering time control. *Plant Biotech. Journal* 31: 3-16.