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SMART FERTILIZERS IN FRUITS-LIMITATIONS AND CHALLENGES

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Abstract

Recently, Nanotechnology has attracted the attention of whole world due to its wide applications and its massive advantages. Generally its use is common in all the fields with great success and it has provided a lot of excellent opportunities in almost all the fields especially agriculture. Nanotechnology has made up of two words- Nano and technology. It is a Greek word which means dwarf and technology means approach techniques. Nano specifies very small dimension which simply elaborates billion parts are comprised in one meter. This type of scale is known as Nano- scale or colloquially nanometer scale. This approach or technology may be defined as new installation of particles or material within nanometer scale (from 1- 100 nanometers).
Keywords- Nanotechnology, Fertilizers, Fruits, Impact, Challenge

Introduction

Thus, term nono technology can be defined as fresh installation of molecules or material in new arrangements of forms but within range of nano scale (from 1-100 nanometers) that may be accompanied with improved, significant and important properties, for instance mechanical, magnetic, electrical physical, optical chemical, and biological etc. (Yogesh *et al.,* 2015).

It is established that Nano-technology can be considered as important bridge between ever rising food requirement for world population and food production. Besides this, it has more additional benefits towards human health, environmental ecology and economics (Ali *et al.* 2014).

To encapsulate different fertilizer materials many approaches are adopted like coating with nano materials, using cover of thin protective layer or delivery as nanoparticles or emulsions. Nano-particles wit good reactivity and better specific surface area, may have important and significant impact on diffusion, solubility and availability of the nutrients to the plant (Singh *et al.,* 2013).

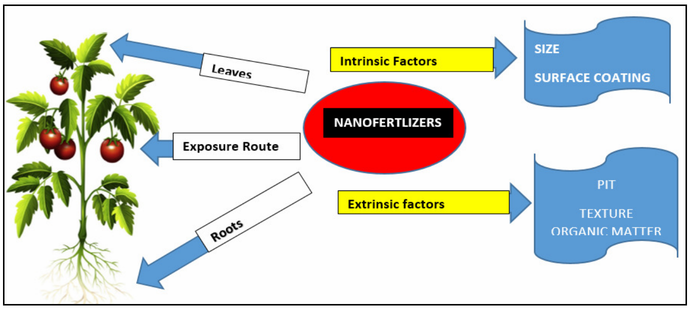

Fig. 1 : Factors which are responsible for up taking, their distribution and accumulation of nanofertilizers in fruit plats.

Nano particles or materials have more surface area to weight ratio, varied shapes and forms, good penetrability and have small size in comparison to conventional materials. They have significant and important influences on growth processes. Moreover, they are able to enter the stomata of leaf tissues, directly (Davarpanah *et al.,* 2015).

Due to increasing population, the pressure for achievement of considerable efficiency concerning food production is increasing day by day even by using chemical insecticides/fertilizers (Georgia *et al.,* 2017). It is clear that if global challenge regarding food demand and production is to be met keeping in view environmentally and economically sustainable approach.

Types of smart fertilizers and properties

Nanomaterials have special features like controlled-release kinetics to targeted locations, high surface-to-volume ratio and improved sorption capacity and these materials have very suitable for development of new fertilizers (Feregrino-Pérez *et al.,* 2018). In nanomaterial various nutrients are encapsulated/coated and same are released in controlled way in order to justify the imperative requirements of the plant (Zuverza-Mena *et al.,* 2017). Today these NF are considered as one of the best option and alternate (Rameshaiah *et al.,* 2015), to the extremethat in severeal cases they are supposed to be best than conventional fertilizers (Iavicoli *et al.,* 2017; Dimkpa *et al.,* 2017). Due to interaction between nanomaterials and fertilizers results in increased essential chemicals and absorption of nutritional elements for plant system (Prasad *et al.,* 2017). The effectiveness of NF depends on several factors.

Impact of NPs, concentration on fertility process and fruit set

It has been established by various research workers that treatment with NMs and nanocomposites encompassing essential nutrients (macro and micro) had encouraging influence on the different processing of fruit setting and production in almost all the fruit trees.

Effect in strawberry

Dehghanipoodeh *et al.* (2016) described that in strawberry fruit crop, treatment with NMs may be applied by foliar spray method or by drenching method. Davarpanah *et al.* (2016) also stated that treatments of fruit crops with NMs can be done by spraying method. It has been established by various research workers that NMs are generally used for packing purpose by various industries. By adopting NMs technology quality of fruit production and shelf life can be improved up to a great extent (Yang *et al.,* 2010 and Song *et al.,* 2016), freshness (Van *et al.,* 2011) and health (Flores-Lopez *et al.,* 2015).

Effect in Pomegranate

In Iran, Davarpanah *et al.* (2016) studied effect of the foliar nanofertilizers of zinc and born as a single spray before full bloom at rate of 5.3 L/tree, on productivity and fruit quality of pomegranate (Cultivar Ardestani). Their results showed increments in concentrations both microelements in August, reflecting the improvements in tree nutrient status. Also, spraying nano-Zn and nano-B led to increase in pomegranate fruit yield, as result of increasing fruit number per tree. Moreover, a significant improvement was noticed in fruit quality, including T.S.S., maturity index, juice and deceases in T.A. (Total acidity). It was established in pomegranate that low concentration spray of B and Zn NPs was more effective than that of high concentration spray (Davarpanah *et al.,* 2016). Treatment with B-NPs had increased fruit number and yield as compare to untreated ones or Zn-NPs**.**

Davarpanah *et al.* (2017) conducted an experiment during (2014-2015) to study effect of spraying nitrogen fertilizer in nano-form (nN) and urea on pomegranate fruits Cultivar Ardestani. Five treatments (four replicates/ treatment) were applied twice at full bloom and one month later as the following two treatments for nN (1.3 & 2.7g N/tree ≈ 0.9 and 1.8kg/ha), two treatments for urea (24.4 and 48.8g/tree ≈ 16.3 and 32.5 kg/ha) and the last one is control (trees sprayed with water). Obtained results indicated that spraying N fertilization (whether nN or urea form) increased fruit yield and number of fruits per tree. Applied nN at (1.8kg/ha) resulted in producing the highest yield and number of fruit/tree. Meanwhile control trees produced the lowest yield and fruit number /tree. Regarding to comparison between nN and urea treatments, results showed that spraying nN at 1.8kg/ha or urea at (16.3kg/ha) produced the highest fruit length, TSS, acidity, sugar and deceased anythocyanins. Applying nitrogen led to increment in leaf content f N, however the rest of nutrients (P, K, Mn, and Zn) did not affected. Finally, spraying nN (1.8kg/ha) gave results very close to that obtained by applying urea at 16.3kg/ha as foliar which mean there is possibility to protect environments with reducing amount of added fertilizer and improving fruit quality by utilizing nano-fertilizers. Zahedi *et al.* (2019) described that foliar application of Se-NPs improved fruit number, diameter and peel thickness in pomegranate.

Effect in Date Palm

In Egypt, Roshdy and Refaai (2016), showed that, nano-NPK had a promising impact on growth rate, yielding and different fruit parameters of (Cultivar *Zaghloul*) date palm comparing with conventional NPK under Minia conditions. Moreover, these positive impacts of nano-NPK produced from low doses in comparison to conventional NPK which revealed that improving nutrient use efficiency (NUE) in nano-form. Besides, they attributed increasing in NUE for another reason whereas through nano-NPK, nutrients will be delivered for plant in a regulated pattern based on crop needs.

It was reported by Davarpanah *et al.,* 2016) that combined treatment of wheat sprout extract and B-NPs resulted in higher bunch weight and improved yield because of better fertilization process in date palm trees. It has been proved that B element enhances the length of pollen tube, fertilization process, setting of fruit, nucleic acids and hormones in the plant system (Marschner, 2012).

Moreover, excessive applications of agro-chemicals (fertilizers and pesticides) have become essentially and necessary to secure high productivity and supplying foods. Such types of agriculture practices have the great negative impacts on the environment and consumer health (Sharma and Singhvi, 2017).

Effect in Fig

Weight and leaf area were increased when Nano-fertilizes were applied at high levels (300 & 400 ppm) as foliar application on —Sultani Fig cultivar compared with conventional fertilizer (500ppm). In respect of nutrient status applying nano-NPK at (300 & 400ppm) recorded similar levels of nutrient that recorded with conventional NPK at 500ppm which may reveal that there is possibility to reduce added fertilizers without negative impact on growth and nutrient status in plants. Nano-NPK resulted in increasing in activities of enzymes (peroxidase and polyphenol oxidase) in comparison with conventional NPK. Current study confirmed the benefits of applying Nano-fertilizers in growth performance and environmental protection by reducing added amounts of minerals.

Effect in Grapes

Abdelhak (2018) showed that adding CNTs at rate (0.6%) with 80% of recommended dose of nitrogen (50gN/vine/year) improved most of vegetative growth parameters, nutrients status and measured fruit quality comparing with other combination of CNTs (0.2, 0.4, 0.6%) and nitrogen (40, 30, 20g N/vine/year). Meanwhile, treating flame seedless grapes with 0.4% (T4) of Nano-zinc produced markedly higher vegetative growth parameters, nutrient content and recorded fruit quality characters in comparison with other treatments (T1 Tap water only (control), T2 zinc sulphate at 565ppm, T3 zinc EDTA at 140 ppm, T5 nano zinc at 0.8 ppm and T6 nano zinc at 1.2 ppm.)

Effect in Washington Navel orange

A research study was conducted by treating Washington Navel orange plants with nano-potassium nanocapsulated decomposable polylactic acid (K-PLA) and conventional potassium oxide or in their mixture (thrice a year) at various levels in orchard located at El-Kalubia Governorate to investigate the benefits on fruit quality and yield. It was concluded that nano-potassium nanocapsulated decomposable polylactic acid significantly improved colour percentage and yield than (K2O) treated plants. Both treatment resulted in lowering of acidity, Hafez *et al.* (2018). Also, mixture (upload K + K – PLA) markedly enhanced both of TSS, V.C. and the highest enhancement was achieved with formulation (25% K2O+75% K-PLA) meanwhile the lowest enhancement was recorded with formulations (75% K_2O+25% K-PLA).

Effect in almond trees

Highest yield was obtained in almond tree where application was done with NF iron chelate plus in three cvs. Monagha, Shokufeh and Sahand while lowest was recorded in control treatment (Kamiab and Zamanibahramabadi, 2016). Application of NF iron chelate plus was reduced fruit abscission compared to the control.

Effect in Mango

Davarpanah *et al.*(2017) proved that foliar application of NF - Nitrogen, Phosphorous, Potassium, and Magnesium fertilizer to mango which resulted in improved fruit production and quality in trees more expressively than foliar application of macronutrients (Saied *et al.*2018).Nitrogen-inclosing in NFs is discharged, when there is shortage of nitrogen element(Naderi and Danesh-Shahraki,2013). Foliar application of N-NPs to pomegranate plants improved fruit yield more than treatment with urea while application of N-containing NFs at the flowering stage and one month later was highly effective, enhancing leaf N concentration by 2-3% relative to control. Normally, nitrogen plays a significant metabolic and physiological role in supply of carbohydrates which is mandatory in flowering and fruit set process (Borghi and Fernie, 2017).

More efforts had been carried out in Egypt whereas in this trend, Zagzog and Gad (2017) reported that, spraying mango trees (Ewasy and Zebda) with nano-zinc at 1g/l before flowering is recommended for improving yield and fruit quality as well as raising resistance of malformation.

Impact of NPs, concentrations on flowering phase

Enough work is not available regarding impact of ZnNPs on fruit flowering. But it has been observed that when grape vines were treated with calcite NF resulted in early flowering and good quality flowers than controlled. Similar reports have been recorded in case of mango where application of Zn NPs resulted into improved number of panicles both flower and matured ones (Zagzog *et al.,* 2017). Si-NPs demonstrated improvement in physical and chemical traits of fruits and raised the tolerance level against various kind of environmental stresses than conventional application of Si (Tripathi *et al.,* 2017) and Cui*et al.,* 2017). Dehghanipoodeh *et al.* (2016) recorded that Si improved the flowering of strawberry when treated with SiO_2 (nanosilica) and treatment was given as foliar spray or soil drench. Normally, Si inclined during transformation of crown buds from growth phase to reproductive stage, treatment may result in quick flowering process of strawberry (Dehghanipoodeh *et al.,* 2018).

Impact of NPs, concentration on fruit growth phase

It has been established that NFs are much better than that of normal fertilizers as for as growth and development, yield and fruit quality is concerned of various fruit plants (Sabir *et al.,* 2014; Refaai, 2014 and Davarpanah *et al.,* 2017). It is reported that when mango tree is treated with Zn-NPs before blossoming resulted in declined malformation, inclined weight of the fruit, and yield the tree is also improved in comparison to control trees (Zagzog and Gad, 2017). They proved that treatment of mango tree with chitosan-NPs resulted in increased fruit number per tree, improved fruit quality including physical and chemical properties with less incidence of malformation (Zagzog, 2017). It has been described by Refaai (2014) that when date palm cv Zaghloul is treated with wheat seed sprout then fruit weight, pulp percentage and TSS have been improved to great extent but seed percentage, percentages of acid, fiber and tannin in fruits were declined. Foliar spray of NPs(zinc, iron, manganese, boron) enhanced the fruit quality and yield than conventional fertilizers in date palm cultivar Sakkoti (El-Sayed, 2018). It was found that TSS and total phenolic compounds in pomegranate fruits were greatly improved while acidity was greatly reduced, when fruits were treated with Zn and B at rate of 120 mg/L and 6.5 mg/L, NPs, respectively (Davarpanah *et al.,* 2016). It was also established that phenolic compounds were also improved due to improved gene expression coding for biosynthesis because of Zn and B element (Liakopoulos *et al.,* 2005 and Song *et al.,* 2015). It has been recorded that application of N-containing NFs also resulted in improvement of quality by enhancing aril juice, total sugars and improving total acidity of fruits (Davarpanah *et al.* (2017). Kumar *et al.* (2014) and Borghi and Fernie, (2017) described that enhancement in the concentration of nitrogen lead to improvement in turgor pressure and carbohydrate supply including translocation of organic acids (Tegeder and Masclaux-Daubresse, 2018). It was recorded by Dehghanipoodeh *et al.* (2016) that fruit firmness was significantly improved in strawberry when treated with Si-NPs.

Impacts of Nanofertlizers

Positive Impact	Negative effect
Slow/Control release of nutrients	Highly reactive and variable
Reduced loss of nutrients	Environmental aspects
Increased bioavailability of nutrients	Safety concern of field workers
Synthesized according to the objective	Safety concern of consumers

Limitation of nanofertilizers

In the adaptation of sustainable agriculture, some recent aspects of environmental issues including human health safety concerns may restrict the use of this approach in production of fruit crop. Various crops also responds in a different way to NP. Response is deeply associated with dose and method of application (Ashkavand *et al.,* 2018). No doubt NM are highly reactive due to improved surface area and small size (Konate *et al.,* 2018). But it is very serious matter to consider benefits of nanofertilizers along with their adverse effects before market implementation. Recent progress made by this approach has established new mile stones of success in field of fruit production. Nevertheless, deliberately wide spread of this approach in agriculture field, may lead to several unintended non-reversible consequences (Kah *et al.* (2015). Reactivity of nanomaterials is a major safety concern as field workers who works with them are frequently exposed to xenobiotics during application under such conditions (Nair, 2018). Similar things may happen in the manufacture unit also. Keeping in view the expected consequences, there is utmost need to evaluate the feasibility and suitability of nanofertilizers in field of agriculture. Actually various factors like bioactivity, toxicity and transport including unintended environmental aspects created to biological systems, due to application of nanofertilizers may limit their acceptance and common use in horticulture sector as well as in sustainable agriculture (Feregrino-Pérez, 2018). Evaluation of risk, hazards and life cycle of nanofertlizers are serious concerns which are mandatory to be established in for toxicological research. It becomes more serious when considering the accumulation of NF in system of plants and potential health issues. In fact application of nanofertilizers (source- nanomaterials) have raised some considerable concerns about food security and safety along with human health (López-Moreno and Cassé, Correa-Torres (2018) and J.C. White and J. Gardea-Torresdey 2018). Phytotoxic effect due to nanoparticles has been established by some research studies. It is important to mention here that uptake of NP including transport, tranlocation, transformation and phytotoxity largely depends on target plant species, doze applied and method adopted along with properties of NM like (composition, shape size and surface properties) (Ebbs *et al.,* 2016). Evaluation of toxicity level because of NP in target crop must be carried out. Also understanding of posiible mechanism of uptale and translocation, transformation during interaction with plant and soil chemicals/compounds and their accumulation in plant system (Priester *et al.,* 2012).

Challenges

Adverse effects of the NPs on fruits are still in dark. Nevertheless, it was described that treatment with high level of SiO_2 (ranging from 500 and 1000 mg/L in irrigation water results in lower xylem water potential, declined transpiration rate and relative water content and catalase activity had inclined in wild pear seedlings up to 65% NM also influenced rate of absorption and transpiration rate of nutrients. It was recorded that after application of SiO_2-NPs, Si was inclined by 40-60%. Moreover uptake of nitrogen and phosphorus was also declined in concerned plants. Maximum amount of potassium was recorded at 1000 mg/L of SiO_2-NPs and it was further inclined by more addition of SiO_2 (Zarafshar *et al.,* 2015). Simaltaneously no adverse effects ware observed at lower concentrations on *Phragmites australis*, describing that it is not a dangerous chemical; in contrast, a sharp decline in rate of transpiration process was a encouraging impact of Si (Schaller *et al.* 2012). Adverse effects concerning NPs may happen at higher concentrations in various fruit species, but still there is lack of expertise on this subject, hence no concrete decision can be made.

Conclusion

Nanotechnology is very popular and helpful in improvement growth process, yield and other parameters of fruit crops. Major and most important form of this technology is NFs and this form is applicable for most fields of the research. Positive results have been recorded when NFs for instance Zn B N, F or its compounds and chelates and chitosan are applied on various fruit trees like grapes, date, almond, mulberry, strawberry and pomegranate including coffee. When NFs are applied on fruit trees in low concentration, these compounds have direct impact on growth, production and quality aspects in a positive way. It has also been observed that when the same NFs applied in higher concentration, may display adverse effects that may lead to toxicity. Till now only one case is highlighted i.e. on wild pear different treatments were performed at young/ seedling stage but before final stage. NMs improved nutrient availability, also created resistance to biological and environmental stresses. Not too much work has been done on this aspect. Mostly research is based on the effects of NPs on plants and to evaluate more varieties because these responses were significantly different in different cultivars and species. Through such type of research, primary procedure, mechanism which leads to positive results and evaluation of any kind of negative potential on growth and development and productivity of fruit plant can be explained.

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