Effect of Nano zeolite, Nano micronutrients and biocapsules on plant growth, Head yield and quality of Broccoli (*Brassica oleracea* var italica)

Abstract

The present investigation was conducted at the Vegetable Research Farm, Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology & Sciences (SHUATS), Prayagraj (U.P.), during the Rabi season of the year 2020–21. The experiment was laid out in a randomised block design with three replications and 15 treatments. Plant height, leaf area, and no of leaves. T15 N P K (RDF) + Nanozeolite 50 ppm (Soil drenching) + Biocapsule 500 ppm+ folia application of ZnO and FeO nano particles & T13 N P K (RDF) + Biocapsule 500 ppm (soil drenching) + foliar application of ZnO and FeOnano particles was found to be the best. again In terms of yield parameters, the treatment T15 N P K (RDF) + Nanozeolite 50 ppm (Soil drenching) + Biocapsule 500 ppm+ folia application of ZnO and FeO nano particles performed best in Head diameter(cm), Marketable Head Yield/plot (kg), Marketable Head Yield/hectare (q/ha), Harvest Index (%) (18.68cm, 3.15kg, 212.86qh, 90.65%).

Keywords: Nano Micronutrients,Biocapsules,Nano zeolite,Treatments,Broccoli

1. Introduction

Broccoli (*Brassica oleracea var* italica) is an important cole crop grown worldwide both in temperate and tropical regions of the world. It is a diploid plant (2n=2x=18) and a member of family Brassicaceae. Broccoli is a rich source of sulphoraphane, which has been shown to display potent anti- carcinogenic properties. Eating a few portions of broccoli each week may help to reduce the risk of

cancer. The cancer-fighting properties of broccoli are not new and previous studies have related these benefits to the high levels of active plant chemicals called glucosinolates. These are metabolized by the body into isothiocynates, and evidence suggests these are powerful anti-carcinogens. The main isothiocynate from broccoli is sulforaphane. Eating larger portions may also have additional benefits, since broccoli is also a rich source of other vitamins and minerals, carotenoids, fiber and folic acid . Generally, excessive amounts of inorganic fertilizers are applied to vegetables in order to achieve a higher yield (Stewart *et al*., 2005) and maximum value of growth . However, the use of inorganic fertilizers alone may cause problems for human health and the environment (Arisha&Bardisi, 1999). So, organic manure can serve as alternative practice to mineral fertilizers for improving soil structure and microbial biomass (Suresh *et al*., 2004). Therefore, utilization of locally produced manures by vegetable production operations may increase crop yields with less use of chemical fertilizer (Saleh *et al*., 2010). In recent times, consumers are demanding higher quality and safer food and highly interested in organic products. Like conventional fertilizers, the nanofertilizers are also nutrient fertilizers composed, in whole or part, of nanostructured formulation(s) that can be delivered to the broccoli, allowing for efficient uptake or slow release of active ingredients. The definition of nanofertilizer is debatable. In the literature related to nanotechnology application in agriculture, nanofertilizer is used for both materials of a physical diameter between 1 and 100 nm in atleast one dimension (e.g., ZnO nanoparticles) and those existing at the bulk scale with more than 100 nm in size but that have been modified with nanoscale materials (e.g., bulk fertilizer coated with nanoparticles). The exceptional properties of nanoparticles, such as high surface area/volume size ratio and enhanced optoelectronic and physicochemical properties, compared to their bulk counterparts, is now emerging as a promising strategy to promote plant growth and productivity. As a result of their unique properties, nanoparticles may influence metabolic activities of the plant to different degrees compared to conventional materials and have the potential to mobilize native nutrients, such as phosphorus, in the rhizosphere.

Role of ZnO: Zinc oxide nanoparticles (ZnO-NPs) are considered a ‘biosafe material’ for stimulation of seed germination and plant growth as well as disease suppression and plant protection by virtue of their antimicrobial activity. Uptake, translocation and accumulation of ZnO-NPs by plants depend upon the distinct features of the NPs as well as on the physiology of the host plant. Zinc

plays an important role in the formation of chlorophyll and some corbohydrates, conversion of starch to sugars and it presence in plant tissue helps the plant to withstand cold temperatures.

Role of FeO: Iron is an essential micronutrient for almost all living organisms because of it plays critical role in metabolic processes such as DNA synthesis, respiration, and photosynthesis. In plants, iron is involved in the synthesis of chlorophyll, and it is essential for the maintenance of chloroplast structure and function.

Role of Nanozeolite: Nanozeolites are complicated silicate minerals with pores and channels within its crystal structure. It has unique higher Cation exchange capacity (CEC) due to which it has high affinity towards cations like Na^{+}, K^{+}, Ca^{2+} . Zeolites are responsible for selective retention of NH^{4+} and K^{+} ions in soil system.

- **Role of Biocapsule:** Recently, IISR-ICAR (Indian Council of Agricultural Research) scientists have developed the technology to pack bio-fertilizers in tiny capsules. This eliminates the need for farmers to carry the sacks of biofertilizers. It consists of a carrier medium rich in live microorganisms. When applied to seed, soil or living plants, it increases soil nutrients or makes them biologically available. It uses a select combination of beneficial microorganisms such as Trichoderma, Pseudomonas and Bacillus.

2. Material and Methods

The details of the various materials used and methods adopted in laid out the experiment are presented below:

2.**1 Experimental Site The present experiment entitled "Effect of Nano zeolite, Nano micronutrients and biocapsules on plant growth,Head yield and quality of Broccoli(*Brassica oleracea* var italica)"**was conducted at the Vegetable Research Farm, Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology & Sciences (SHUATS), Prayagraj (U.P.), during Rabi season of the year 2020-21. The experiment was laid out in randomized block

design with three replications and 15 Treatments ,Sam Higginbottom University of Agriculture, Technology And Sciences, Prayagraj(U.P.) which is situated at about 25.41’21.3”N, longitude of 81.84’72.5”E and an altitude of 101m above mean sea level This region has a sub

tropical climate prevailing in the South-East part of Uttar Pradesh with both the extremes in temperature, i.e., the winter and the summer. In cold winters, the temperature sometimes is as low as 320F in December – January and very hot summer with temperature reaching up to 1150F in the months of May and June. During winter, frosts and during summer, hot scorching winds are also common. The average rainfall is around 1013.4 (mm) with maximum concentration during July to September months with occasional showers in winters.The treatment details are **T1 Control (Without treatment), T2 N P K (RDF), T3Biocapsule 500ppm (Soil drenching), T4 Nanozeolite 50 ppm (Soil drenching), T5 Nanozeolite 50 ppm (Soil drenching) + Biocapsule 500ppm,T6 N P K (RDF) + Biocapsule 500ppm (Soil drenching),T7 N P K (RDF) + Nanozeolite 50 ppm (Soil drenching),T8 N P K (RDF) + Nanozeolite 50 ppm (Soil drenching) + Biocapsule 500ppm,T9 N P K (RDF) – foliar application of ZnO and FeO nano particles (NPs),T10Biocapsule 500ppm (Soil drenching)+ foliar application of ZnO and FeO nano particles, T11 Nanozeolite 50 ppm (Soil drenching) + foliar application of ZnO and FeO nano particles,12 Nanozeolite 50 ppm (Soil drenching) + Biocapsule 500ppm + foliar application of ZnO and FeO nano particles,T13 N P K (RDF) + Biocapsule 500ppm (Soil drenching) + foliar application of ZnO and FeO nano particles,T14 N P K (RDF) + Nanozeolite 50 ppm (Soil drenching) + foliar application of ZnO and FeO nano particles,T15 N P K (RDF) + Nanozeolite 50 ppm (Soil drenching) + Biocapsule 500ppm + foliar application of ZnO and FeO nano particles (NPs)**

3. Results and Discussion

3.1 Growth parameter

Maximum plant height at 40 days (40.25) cm was Recorded in the Treatment 15. N P K RDF) + Nanozeolite 50 ppm (Soil drenching) + Biocapsule 500ppm + foliar application of ZnO and FeO nano particles minimum plant height at 40day (30.33)cm was Recorded in the Treatment T4 Nanozeolite50ppm (Soil drenching) The maximum plant height 60 days (79.1)cm was Recorded in the Treatment 15N P K (RDF) + Nanozeolite 50 ppm (Soil drenching) + Biocapsule 500ppm + foliar application of ZnO and FeO nano particles minimum plant height at (51.3) cm was Recorded in The Treatment 2 N P K (RDF) The biofertilizer treatment increases the height of plant this finding was concluded by (Khan *et al.,*2017). NPs helps in regulating aquaporins, the water channels, which regulate the permeability of water in the seeds and enhance the rate of seed germination and plant growth (**Heinen** *et al.,*2009; **Khodakovskaya** *et al.,*2009; **Mahakham** *et al.,*2017).khati *et al.,*2019 nanozeolite is better for the survival of soil microorganisms which is involved in nutrient cycling and improved plant growth.

Maximum no.of leaves 40 days is (14.6) leaves in Treatment 15. N P K (RDF) + Nanozeolite 50 ppm (Soil drenching) + Biocapsule 500ppm + foliar application of ZnO and FeO nano particles Minimum no of leaves 40 days is (10.26) leaves in Treatment 4 (Nanozeolite50ppm (Soil drenching).Maximum no of leaves 60 days is (23.6) leaves in Treatment 13 N P K (RDF) + Biocapsule 500ppm (Soil drenching) + foliar application of ZnO and FeO nano particles Minimum no of leaves 60days is (17.46) leaves in Treatment 1 (Control With out Treatment) Improvement in yield characters and yields as a result of foliar application of micronutrients might be due to the enhancement in photosynthesis and other metabolic activity which led to an increase in various plant metabolites responsible for cell division and elongation reported by **Singh *et al.*,**in 2018 The biofertilizer treatment increases number of leaves per plant this finding was concluded by **Khan *et al.*, 2017.**

Maximum leaf area at 40 days 136.5cm in T14 is observed and Minimum leaf area 45.9cm in T1 (control without Treatments), Maximum leaf area at 60days 324.9cm in T15 and minimum leaf area 128.1cm inT2 (RDF npk) is observed. The significant increase in plant height, number of leaves per plant, and leaf area were observed due to inoculation of bio-fertilizers **Wang** and **Kale** 2004, ZnO-NPs on vegetative growth of Broccoli plants. It resulted in higher germination percentage (when treated with 200

mg ZnO-NPs), enhanced number of leaves, larger leaf area and increased plant height when supplemented with 800mg L ZnO-NPs. **Burman *et al* 2013**

Table 1: Effects of Different Treatments on growth parameters of Broccoli

Treatment notations	Treatment Combinations	Plant height 40 days and 60 days		No of leaves 40 days and 60 days		Leaf area 40days and 60 days	
N-T1	Control (Without treatment)	32.58	52.2	11.06	17.46	45.9	145.3
T2	N P K (RDF)	33.25	51.3	10.66	19.93	56.21	128.1
T3	Biocapsule 500ppm (Soil drenching)	32	54.6	10.93	19.26	68.67	150.3

T4	Nanozeolite 50 ppm (Soil drenching)	30.33	54.4	10.26	20.2	61.74	136.4
T5	Nanozeolite 50 ppm (Soil drenching) + Biocapsule 500ppm	31.3	58.8	10.33	20.06	67.8	152.7
T6	N P K (RDF) + Biocapsule 500ppm (Soil drenching)	31.79	52.1	10.66	18.66	70.4	128.1
T7	N P K (RDF) + Nanozeolite 50 ppm (Soil drenching)	33	65.2	10.93	18.73	90.67	180.2
T8	N P K (RDF) + Nanozeolite 50 ppm (Soil drenching) + Biocapsule 500ppm	33.37	69.6	11.2	19.66	87.4	185.3
T9	N P K (RDF) – foliar application of ZnO and FeOnano particles (NPs)	32.41	66.1	10.53	19.26	83.8	182.5
T10	Biocapsule 500ppm (Soil drenching)+ foliar application of ZnO and FeOnano particles	33	67.3	11.2	19.2	103.8	171.1
T11	Nanozeolite 50 ppm (Soil drenching) + foliar application of ZnO and FeOnano particles	37.6	63.7	11.66	19.73	110.9	206.9
T12	Nanozeolite 50 ppm (Soil drenching) + Biocapsule 500ppm + foliar application of ZnO and FeOnano particles	35.97	73.6	12.23	20.43	109.5	193.9
T13	N P K (RDF) + Biocapsule 500ppm (Soil drenching) + foliar application of ZnO and FeOnano particles	35.65	72.2	12.93	23.6	119.2	249.6
T14	N P K (RDF) + Nanozeolite 50 ppm (Soil drenching) + foliar application of ZnO and FeOnano particles	34.33	67.2	13.46	22.36	136.5	235.3
T15	N P K (RDF) + Nanozeolite 50 ppm (Soil drenching) + Biocapsule 500ppm + foliar application of ZnO and FeOnano particles (NPs)	40.25	79.1	14.16	21.43	99.2	324.9
	F VALUE	S	S	S	S	S	S
	SE(d)	2.19	3.73	0.45	1.20	12.47	32.19
	CD at 5%	4.49	7.64	0.91	2.45	25.54	65.95
	CV	7.94%	7.23%	4.75	7.34%	17.46	21.34

3.2 Yield parameters

1. Treating plants with biofertilizers had the highest chlorophyll and protein contents. As, N is the chief constituent of Protein, Essential for Protoplasm formation, which leads to cell enlargement, cell division and ultimately resulting in increased plant growth and fruit yield. Improvement in yield characters and yields as a result of foliar application of micronutrients might be due

to the enhancement in photosynthesis and other metabolic activity which led to an increase in various plant metabolites responsible for cell division and elongation.. similar finding in **Jett *et al.*,1995.** The Yield parameters of Broccoli was influenced by Different Treatment .The maximum Readings was Recorded in Treatment15 N P K (RDF) + Nanozeolite 50 ppm (Soil drenching) + Biocapsule 500ppm + foliar application of ZnO and FeO nano particles (NPs)

1 Maxmimum Net Head weight (518.56) gm in T15. N P K (RDF) + Nanozeolite 50 ppm (Soil drenching) + Biocapsule 500ppm + foliar application of ZnO and FeO nano particles. Minimum net Head weight (111.3)gm in T1. Control(without treatment

2 Maximum gross Head weight is (634)gm in T15.N P K (RDF) + Nanozeolite 50 ppm (Soil drenching) + Biocapsule 500ppm + foliar application of ZnO and FeO nano particles. Minimum gross Head weight (234.16) gm inT1. Control(without treatment.)

3 Maximum Marketable Head weight (574.74)gm in T15. N P K (RDF) + Nanozeolite 50 ppm (Soil drenching) + Biocapsule 500ppm + foliar application of ZnO and FeO nano particles. Minimum Marketable Head weight (174.83)gm in T1 Control(without treatment).

4 Maximum yield per plot in Kg (3.15)in T15N P K (RDF) + Nanozeolite 50 ppm (Soil drenching) + Biocapsule 500ppm + foliar application of ZnO and FeO nano particles. Minimum yield per plot in Kg (0.93)in T1Control(without treatment).

5 Maximum Quintals per hectare(212.86) is observed in T15. N P K (RDF) + Nanozeolite 50 ppm (Soil drenching) + Biocapsule 500ppm + foliar application of ZnO and FeO nano particles Minimum Quintals per hectare(64.75) is observed in T1 Control(without treatment).

6 Maximum Harvesting Index is observed (90.65%) in T15. N P K (RDF) + Nanozeolite 50 ppm (Soil drenching) + Biocapsule 500ppm + foliar application of ZnO and FeO nano particles Minimum Harvesting Index is observed(74.68%) in T1. Control(without treatment).

7 Maximum Head diameter (18.68)cm in T15 N P K (RDF) + Nanozeolite 50 ppm (Soil drenching) + Biocapsule 500ppm + foliar application of ZnO and FeO nano particles Minimum curd diameter (8.65)cm in T1. Control(without treatment

Application of zeolite in soil enhances crop yield by improving nutrient use efficiency of the plants. Properties like water retention due to large internal porosity, easy incorporation due to uniform particle-size distribution and better nutrient retention due to high cation-exchange capacity make this compound desirable for improving soil properties **Ok *et al.*, 2003**,Using metagenomics reported that nanozeolite is better for the survival of soil microorganisms which is involved in nutrient cycling and improved plant growth. Nanozeolite can be used to support the growth of PGPR for a longer time due to the slow release of nutrients and offers an environmentally sustainable approach to increase crop production which is easily degradable and do not affect microbial activity in the soil **Khati *et al.*, 2019**

Table 2: Effects of Different Treatments on yield parameters of Broccoli

S.NO	Treatments	Gross head weight (gm) MEAN	Net head weight (gm) MEAN	Marketable head weight (gm) MEAN	Marketable Head Yield/plot(kg) MEAN	Marketable Head Yield (q\h) MEAN	Marketable Head diameter (cm)	Harvest index
T1	Control (Without treatment)	234.16	111.3	174.83	**0.92**	64.75	8.65	74.68
T2	N P K (RDF)	323.8	202.8	264.46	**1.47**	97.95	9.758	81.71
T3	Biocapsule 500ppm (Soil drenching)	431.36	238.6	372.03	**2.08**	137.78	12.65	86.26

T4	Nanozeolite 50 ppm (Soil drenching)	368.50	265.33	309.17	**1.83**	114.50	11.54	83.82
T5	Nanozeolite 50 ppm (Soil drenching) + Biocapsule 500ppm	436.99	314.6	377.65	**2.11**	139.87	11.92	86.45
T6	N P K (RDF) + Biocapsule 500ppm (Soil drenching)	439.33	312.06	380	**2.11**	140.74	12.25	86.51
T7	N P K (RDF) + Nanozeolite 50 ppm (Soil drenching)	367.55	259.03	308.2	**1.64**	114.15	10.28	83.89
T8	N P K (RDF) + Nanozeolite 50 ppm (Soil drenching) + Biocapsule 500ppm	428.8	300.33	369.46	**1.97**	136.83	10.81	86.15
T9	N P K (RDF) – foliar application of ZnO and FeOnano particles (NPs)	353.1	236.43	293.76	**1.61**	108.80	9.83	83.22
T10	Biocapsule 500ppm (Soil drenching)+ foliar application of ZnO and FeOnano particles	492.92	385.2	433.59	**2.40**	160.58	13.98	87.99
T11	Nanozeolite 50 ppm (Soil drenching) + foliar application of ZnO and FeOnano particles	372.10	266.2	312.75	**1.70**	115.84	11.09	84.08
T12	Nanozeolite 50 ppm (Soil drenching) + Biocapsule 500ppm + foliar application of ZnO and FeOnano particles	506.65	402	447.32	**2.49**	165.67	15.70	88.29
T13	N P K (RDF) + Biocapsule 500ppm (Soil drenching) + foliar application of ZnO and FeOnano particles	600.34	480.2	541	**3.00**	200.37	17.58	90.13
T14	N P K (RDF) + Nanozeolite 50 ppm (Soil drenching) + foliar application of ZnO and FeOnano particles	495.05	313.73	424.37	**2.31**	157.17	12.6	86.00
T15	N P K (RDF) + Nanozeolite 50 ppm (Soil drenching) + Biocapsule 500ppm + foliar application of ZnO and FeOnano particles (NPs)	634.0	518.56	574.74	**3.15**	212.86	18.68	90.65
	F VALUE	**S**	**S**	**S**	**S**	**S**	**S**	**S**
	SE(d)	**23.0**	21.21	**20.04**	**0.11**	**7.42**	**1.59**	**0.65**
	CD at 5%	**46.8**	42.76	**41.05**	**0.21**	**15.20**	**3.26**	**1.32**
	CV	**6.52%**	**8.47%**	**6.59**	**6.34%**	**6.59**	**15.34**	**0.94 %**

4. Conclusion

The results from the present investigation concluded that Treatment15 N P K (RDF) + Nanozeolite 50 ppm (Soil drenching) + Biocapsule 500ppmss + foliar application of ZnO and FeO nano particles (NPs) was identified as desirable with high Head yield per plant and plant growth .The increase in higher values of yield attributes might be due to the higher production of leaf, leaf

area, and height of plant, branches, flowers and fruits produced per plant. Increased foliage might have resulted in production of more Photosynthates enhancing the yield potential. **Ramakrishnan** and **Selvakumar (2012)** showed that Azotobacter and Azospirillum treated plants had the highest chlorophyll and protein contents. As, N is the chief constituent of Protein, Essential for Protoplasm formation, which leads to cell enlargement, cell division and ultimately resulting in increased plant growth and fruit yield.

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