Effect of Biocapsule and Nano micronutrients on Growth,Quality and Yield of Lettuce (*Lactuca sativa*).

Abstract :

The present experiment was carried out during 2021-22 in Central Horticulture Research Farm of Department of Horticulture, SHUATS, Prayagraj, India. The experiment was conducted in aRandomized CompleteBlocks Design with 10 treatment replicated thrice. The treatments were T_0 (Control),T_1(NPK (RDF) 15:5:20),T_2 (Biocapsule 500ppm (Soil drenching)),T_3 (NPK (RDF) 15:5:20 + Biocapsule 500ppm (Soil drenching)),T_4 (NPK (RDF)15:5:20+ Foliar application of Zno (12%) and Feo (12%) Nano particles (NPs)),T_5(Biocapsule 500ppm (Soil drenching) + Foliar application of Zno (12%) and Feo(12%) Nano particles (NPs)),T_6(NPK (RDF) 15:5:20 + Biocapsule 500ppm (Soil drenching) + Foliar application of Zno (12%) and Feo (12%) Nano particles (NPs)),T_7 (NPK (RDF) 15:5:20 + Biocapsule 250ppm (Soil drenching)),T_8(Biocapsule 250ppm (Soil drenching) + Foliar application of Zno (12%) and Feo (12%) Nano particles (NPs)),T_9 (NPK (RDF) 15:5:20 + Biocapsule 250ppm (Soil drenching) + Foliar application of Zno (12%)and Feo (12%) Nano particles (NPs)).From our experiment it was concluded that the treatment T_5 (Biocapsule 500ppm (Soil drenching) + Foliar application of ZnO (12%) and FeO (12%) Nano particles (NPs)) was found to be best in the terms of germination percentage, vegetative growth, yield parameters, quality parameters and economics with B:C ???ratio 2.67.

Keywords: Lettuce,Biocapsule, Zinc, Iron, Nano particles, Growth, Yield andDevelopment.

Abbreviations must be explained in the abstract

Introduction

Lettuce (*Lactuca sativa*) is an annual plant of the daisy family, Asteraceae. It is most often grown as a leaf vegetable, but sometimes for its stem and seeds. Lettuce is most often used for salads, although it is also seen in other kinds of food, such as soups, sandwiches and wraps; it can also be grilled. One variety, the celtuce (*asparagus lettuce*), is grown for its stems, which are eaten either raw or cooked. In addition to its main use as a leafy green, it has also gathered religious and medicinal significance over centuries of human consumption.

Lettuce was originally farmed by the ancient Egyptians, who transformed it from a plant whose seeds were used to obtain oil into an important food crop raised for its succulent leaves and oil-rich seeds. In world, lettuce and chicory is cultivated over an area of 1.27 million hectare with the production of 27.25 million tonnes. In India, production of lettuce and chicory is around 1.22 million tonnes over an area of 0.19 million hectare (FAO, 2018). Not written in the references chapter

Lettuce is a rich source of vitamin K and vitamin A, and a moderate source of folate and iron. In India, it is gaining popularity with the change in food habit and health increasing consciousness among the people . There is an increasing demand by consumers for safe and nutritious foods that improves the physical performance, reduces the risk of diseases and increases the life span (Ogden *et al.*, 2007). Not written in the references chapter

The nutritional content varies with the degree of leaf colour, green outer leaves having more nutritional value than whitish inner leaves. The regular intake of lettuce helps in lowering cholesterol level, thereby avoiding cardiovascular diseases. Extracts from *Lactuca virosa* are used sleep inducers and cough suppressants in Europe (Ryder, 1929). Not written in the references chapter

It is a native of Europe and Asia and introduced in India by the Britishers. Lettuce is an annual and belongs to family composite. The leaves and heads are used as salad. There are about 150 varieties of Lettuce.

Role of Biocapsule: Recently, 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.

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 carbohydrates, 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.

Materials and Methods

The present investigation ~~entitled "**Effect of Biocapsule and Nano micronutrients on Growth,Quality and Yield of Lettuce (*Lactuca sativa*).**"~~ was conducted at the central research farm of Department of Horticulture, Sam Higginbottom University of Agriculture, Technology and Sciences Prayagraj, Indiaduring 2022.Planting seeds toke place on ?????using … cultivar. Seeds were planted in rows, .. cm in wide, ..mlong and at spacing of .. cm within rows.

Climatic condition

The area of Prayagraj district comes under subtropical belt in the south east of Utter Pradesh, which experience extremely hot summer and fairly cold winter. The maximum temperature of the location reaches up to 46^{o} C-48^{o} C and seldom falls as low as 4^{o}C- 5^{o}C. The relative humidity ranges between 20 to 94 %. The average rainfall in this area is around 1013.4 mm annually. However, occasional precipitation is also not uncommon during winter months.

Treatments

~~The experiment was conducted in a~~Randomized ~~Complete~~Block~~s Design with 10 treatment replicated thrice.~~ The treatments were **T_0**(Control), **T_1**(NPK (RDF) 15:5:20),T_2(Biocapsule 500ppm (Soil drenching)), **T_3**(NPK (RDF) 15:5:20 + Biocapsule 500ppm (Soil

drenching)),**T_4**(NPK (RDF) 15:5:20)+ Foliar application of Zno (12%) and Feo (12%) Nano particles (NPs)), **T_5**(Biocapsule 500ppm (Soil drenching) + Foliar application of Zno (12%) and Feo(12%) Nano particles (NPs)), **T_6**(NPK (RDF) 15:5:20 + Biocapsule 500ppm (Soil drenching) + Foliar application of Zno (12%) and Feo (12%) Nano particles (NPs)), **T_7**(NPK (RDF) 15:5:20 + Biocapsule 250ppm (Soil drenching)), **T_8**(Biocapsule 250ppm (Soil drenching) + Foliar application of Zno (12%) and Feo (12%) Nano particles (NPs)), **T_9**(NPK (RDF) 15:5:20 + Biocapsule 250ppm (Soil drenching) + Foliar application of Zno (12%)and Feo (12%) Nano particles (NPs)).

Measurements and data recorded

Vegetative characters:

Plant samples per plot were randomly taken, for the determination of the vegetative growth (plant height (cm) and number of leaves/plant, length of leaves (cm) , width of leaves (cm), leaf area cm^2andleaf area index).

Yield parameters:

Average fresh weight (g) character was calculatedby dividing lettuce yield per plot area by its growing lettuce plant number. Lettuce yield (Kg) was calculated for plot area then attributed to the hectare (Kg).

Lettuce quality characteristics:

The dry matter was calculated by weighting a certain fresh weight before drying and reweighting after drying. Dry matter percentage (%) was found to be the ratio of the certain weight of sample after drying and its weight before drying multiplied by 100.

Ascorbic acid (mg/100g) was determined using

Total soluble solids was determined by

Chlorophyll content(mg/100g)

Organoleptic evaluation:

Organoleptic evaluation were done for all treatments to evaluate color, flavor, taste ,texture and overall acceptability.The judges use score from one to ten in which one indicating very poor while 10 indicates excellent. The mean score for each item was calculated and recorded.

Economics with B:C ratio: ????????What is meant by this term? And how it was calculated

Experimental design and statistical analysis

The experiment was conducted in aRandomized CompleteBlocks Design with 10 treatment replicated thrice.Collected data of the experiment was statistically analyzed, using the analysis of variance method. Comparisons among the means of different treatments were done, using least significant differences (L.S.D) test procedure at $p \leq$

0.05 level of probability, as illustrated bySnedecor and Cochran (1980) using Co-Stat software program (2004).

Results and Discussion

~~The maximum germination % was observed in the Treatment T_5 with (90.56) % followed by T_8 with (90.26) % and the minimum was observed in the T_0 with (82.56) %.~~(There are no data showing the germination percentage values??????????)

The maximum plant height was observed in the Treatment T_5 with (20.92) cm followed by T_8 with (20.82) cm and the minimum was observed in the T_0 with (18.85) cm.

~~The maximum plant height was observed in the Treatment T_5 with (20.92) cm followed by T_8 with (20.82) cm and the minimum was observed in the T_0 with (18.85) cm.~~

The maximum number of leaves was observed in the Treatment T_5 with 9.79 followed by T_8 with 9.64 and the minimum was observed in the T_0 with 6.59.

The maximum length of leaves was observed in the Treatment T_5 with (18.39) cm followed by T_8 with (18.23) cm and the minimum was observed in the T_0 with (15.36) cm.

~~The plant spread was observed in the Treatment T_5 with (16.30) cm followed by T_8 with (16.06)cm and the minimum was observed in the T_0 with (13.35) cm.~~(There are no data showing the germination percentage values??????????)

The maximum width of leaf was observed in the Treatment T_5 with (7.35) cm followed by T_8 with (6.67) cm and the minimum was observed in the T_0 with (5.02) cm.

The maximum leaf area was observed in the Treatment T_5 with (126.34) cm^2 followed by T_8 with (125.36) cm^2 and the minimum was observed in the T_0 with (75.26) cm^2.

The maximum Average Fresh Weight (g) was observed in the Treatment T_5 with (119.69) g followed by T_8 with (117.49) g and the minimum was observed in the T_0 with (90.26) g.

The maximum Yield/plot was observed in the Treatment T_5 with (8.65) kg followed by T_8 with (8.02) kg and the minimum was observed in the T_0 with (6.92) kg.

The maximum yield per hectare was observed in the Treatment T_5 with (23.84) t/ha followed by T_8 with (23.05) t/ha and the minimum was observed in the T_0 with (17.56) t/ha.

The maximum dry matter was observed in the Treatment T_5 with (10.56) % followed by T_8 with (10.56) % and the minimum was observed in the T_0 with (7.59) %.

The maximum ascorbic acid was observed in the Treatment T_5 with (14.89) mg/100 g followed by T_8 with (14.12) mg/100 g and the minimum was observed in the T_0 with (10.35) mg/100 g.

The maximum chlorophyll content was observed in the Treatment T_5 with (28.62) followed by T_8 with (28.19) and the minimum was observed in the T_0 with (26.35) .

The maximum TSS was observed in the Treatment T_5 with (4.68) ^{0}B followed by T_8 with (4.60) ^{0}B and the minimum was observed in the T_0 with (3.32) ^{0}B.

The maximum fresh weight was observed in the Treatment T_5 with (140.65)g followed by T_8 with (135.62)g and the minimum was observed in the T_0 with (115.62) g.

The maximum score for Color and appearance was observed in the Treatment T_5 with (140.65) followed by T_8 with (135.62) and the minimum was observed in the T_0 with (115.62) .

The maximum score for flavor was observed in the Treatment T_5 with (8.61)g followed by T_8 with (7.92) and the minimum was observed in the T_0 with (6.13)

The maximum score for taste was observed in the Treatment T_5 with (8.59) followed by T_8 with (8.48) and the minimum was observed in the T_0 with (6.45).

The maximum score for texture was observed in the Treatment T_5 with (8.49) followed by T_8 with (8.37) and the minimum was observed in the T_0 with (6.55).

The maximum score for overall acceptability was observed in the Treatment T_5 with (8.70) followed by T_8 with (8.49) and the minimum was observed in the T_0 with (6.58).

Average Fresh Weight (g) character and fresh weight (g) character What is the difference between them ???????

Where is the discussion ??????????????????

Conclusion?????

From our experiment it was concluded that the treatment T_5 (Biocapsule 500ppm (Soil drenching) + Foliar application of ZnO

(12%) and FeO (12%) Nano particles (NPs)) was found to be best in the terms of germination percentage, vegetative growth, yield parameters, quality parameters and economics with B:C ratio 2.67.

(This is not a conclusion, it is just a result!!)

Table 1 Effect of Biocapsule and Nano micro nutrients plant height, no. of leaves, length of leaves and width of leaves of lettuce.

Treatment	Plant Height (cm)			No. of leaves			Length of leaves (cm)			Width of leaves (cm)		
	30 DAS	45 DAS	60 DAS	30 DAS	45 DAS	60 DAS	30 DAS	45 DAS	60 DAS	30 DAS	45 DAS	60 DAS
T_0	4.65	14.95	18.85	1.59	3.26	6.59	7.89	12.35	15.36	2.09	3.15	5.02
T_1	5.52	15.26	19.36	2.09	3.86	7.32	8.05	13.56	16.57	2.38	3.67	5.24
T_2	5.89	15.76	19.86	2.53	3.98	7.59	8.28	13.79	16.78	2.46	3.75	5.64
T_3	6.25	15.88	19.78	2.49	4.12	8.23	8.89	14.02	17.09	2.76	3.86	5.89
T_4	6.34	15.65	19.66	2.54	4.38	8.65	9.46	14.34	17.36	2.53	3.98	6.88
T_5	6.89	16.87	20.92	2.89	4.68	9.79	10.35	15.36	18.39	2.95	4.35	7.35
T_6	6.56	16.52	20.48	2.12	4.49	9.35	9.32	13.82	16.83	2.65	4.1	6.98
T_7	6.66	16.62	20.63	2.29	4.09	9.34	8.65	14.56	17.58	2.71	4.08	7.09
T_8	6.72	16.72	20.82	2.76	4.56	9.64	9.75	15.19	18.23	2.9	4.12	7.16
T_9	6.68	16.67	20.65	2.38	4.37	8.92	9.05	15.02	17.92	2.88	4.09	6.66
F Test	S	S	S	S	S	S	S	S	S	S	S	S
C.D.@5%	0.86	1.265	1.568	0.562	0.628	0.759	0.86	0.85	1.02	0.39	0.49	0.56
S.E.d	0.412	0.561	0.726	0.247	0.324	0.351	0.412	0.413	0.514	0.153	0.215	0.251

Table 2 Effect of Biocapsule and Nano micro nutrients leaf area, leaf area index, average fresh weight, yield/plot, yield/ha, dry matter content, ascorbic acid and chlorophyll content of lettuce.

Treatment	Leaf area cm^2			Leaf area index			Average fresh weight (g)	Yield per plot (kg)	Yield per hectare (kg)	Dry matter content %	Ascorbic acid (mg/100g)	Chlorophyll content (kg)
	30 DAS	45 DAS	60 DAS	30 DAS	45 DAS	60 DAS						
T_0	14.72	36.26	75.26	1.02	1.85	3.08	90.26	6.92	6.92	7.59	10.35	26.35
T_1	16.15	39.35	80.32	1.31	1.92	3.45	112.64	7.12	7.12	8.09	11.95	26.56
T_2	16.46	39.56	80.56	1.26	2.03	3.52	111.89	7.35	7.35	8.37	13.64	26.78
T_3	16.58	42.05	84.36	1.38	2.12	3.78	109.56	7.05	7.05	8.19	12.82	26.91
T_4	18.35	42.35	102.35	1.51	2.35	3.64	112.38	7.89	7.89	8.65	12.65	27.62
T_5	20.89	60.35	126.34	1.72	2.86	3.95	119.69	8.65	8.65	10.56	14.89	28.62
T_6	18.65	52.65	96.59	1.46	2.45	3.8	115.68	7.38	7.38	9.46	13.08	27.59
T_7	16.71	56.95	119.26	1.55	2.64	3.71	114.82	7.52	7.52	9.64	13.28	28.05
T_8	19.24	59.32	125.36	1.68	2.78	3.83	117.49	8.02	8.02	10.51	14.12	28.19
T_9	18.32	58.62	103.75	1.6	2.71	3.76	115.37	7.65	7.65	9.85	13.76	28.1
F Test	S	S	S	S	S	S	S	S	S	S	S	S
C.D.@5%	1.851	4.235	8.659	0.59	0.62	0.82	3.68	1.235	1.235	0.65	1.12	2.91
S.E.d	0.921	2.231	4.319	0.312	0.312	0.0415	1.862	0.623	0.623	0.31	0.62	1.43

Table 3 Effect of Biocapsule and Nano micro nutrients Total soluble solid, fresh weight, organoleptic evaluation (Color, Flavor, Taste, Texture, and Acceptance) and B:C ratio of lettuce.

Treatment	Total soluble solid ^{0}B	Fresh weight (g)	Organoleptic evaluation					B:C Ratio
			Color	Flavor	Taste	Texture	Acceptance	
T_0	3.32	115.62	6.57	6.13	6.45	6.55	6.58	1.97
T_1	3.98	119.64	7.95	7.18	8.17	7.9	8.33	2.20
T_2	4.25	120.38	6.89	6.59	7.09	7.35	7.59	2.33
T_3	4.35	125.43	7.26	6.79	7.19	7.26	7.43	2.28
T_4	4.42	128.64	7.62	7.09	7.4	7.64	7.7	2.42
T_5	4.68	140.65	8.95	8.61	8.59	8.49	8.7	2.67
T_6	4.51	129.46	7.64	7.38	7.19	7.91	7.82	2.48
T_7	4.59	130.26	7.08	6.6	6.85	7.09	6.83	2.55
T_8	4.6	135.62	8.43	7.92	8.48	8.37	8.49	2.58
T_9	4.55	131.52	7.6	7.17	7.57	7.44	7.63	2.39
F Test	S	S	S	S	S	S	S	
C.D.$_{@5\%}$	0.94	2.369	1.01	0.989	0.89	0.866	0.177	
S.E.d	0.437	1.215	2.188	2.141	1.927	1.875	0.383	

ReferencesThese references are not included in the text

Almaliotis, D., Bladenopoulou, S., Chatzissavvidis, C.H. and Karagiannidis, N. (2007). Broccoli (*Brassica oleracia* L. Var. Italica) yield as affected by soil fertility parameters in northern greece. *Acta Horticulture* 729, 409-413.

Al-Turki, A. and R.R.H. Abdullah, 2021. Native plant growth-promoting rhizobacteria for growth promotion of lettuce from Qassim, Saudi Arabia. Pak. J. Biol. Sci., 24: 773-779.

Anderson J.P.E., Domasch, K.H. (1958): A physiological method for the quantitative measurement of microbial biomas in soil. Soil Boil. Biochem., 10: 215-221.

Anderson, G.R. (1965): Ecology of Azotobacter in soil of the palouse region, I: Occurrence. Soil Science, 86: 57-65.

Belanović, S., Knežević, M., Miličić, B., Đorović, M. (2004): Contens of heavy metals and micro-flora in some soil of mt. Stara planina. Bulletin of the Faculty of Forestry, University of Belgrade, 89: 53-61.

Garcia, J.A.L., Probanza, A., Ramos, B., Palomino, M.R., Manero, F.J.G. (2004): Effect of inoculation of Bacillus licheniformis on tomato and pepper. *Agronomie for Sustainable Development*, 24(4): 169-176.

Ghanbarian, D., Youneji, S., Fallah, S., & Farhadi, A. (2008). Effect of broiler litter on physical properties, growth and yield of two cultivars of Cantaloupe (*Cucumis melo* L.). International Journal of Agriculture and Biology, 10: 697-700.

Govedarica, M., Jarak, M. (1995): Soil microbiology. University of Novi Sad, Faculty of Agriculture, Novi Sad, 1-212.

Islam S, Akanda AM, Prova A, Sultana F and Hossain MM (2015) Isolation and identification of plant growth promoting rhizobacteria from cucumber rhizosphere and their effect on plant growth promotion and disease suppression. *Front. Microbiol*.6:1360. doi:10.3389/fmicb.2015.01360.

Jarak, M., Colo, J. (2007): Soil microbiology. University of Novi Sad, Faculty of Agriculture, Novi Sad, 209.

Khan, Insaf, Singh, Devendra and Jat, Bhanwar Lal (2017). Effects of biofertilizers on plant growth and yield characters of *Pisum sativum L. Adv. Res. J. Crop Improv.*, 8 (1) : 99-108.These references are not included in the text

Kumar U.J., Bahadur Vijay, Prasad V.M., Mishra Saket and Shukla P.K (2017): effect of different concentrations of iron oxide and zinc oxide nano particles on growth and yield of strawberry. *International journal of current microbiology and applied science*. Pp. 2440-2445

Masarirambi, M. T., Hlawe, M. M., Oseni, O. T. & Sibiya, T. E. (2010). Effects of organic fertilizers on growth, yield, quality and sensory evaluation of red Lettuce (*Lactuca sativa* L.) Veneza Roxa. Agriculture and Biology Journal of North America, 1(6): 1319-1324.

Metin Turan, Furkan Orhan & Medine Gulluce (2014) Use of Plant-Growth-PromotingRhizobacteria (PGPR) Seed Inoculation as Alternative Fertilizer Inputs in Wheat and Barley Production, *Communications in Soil Science and Plant Analysis*, 45:18, 2457-2467.

Muralidharan, R., Saravanan, A., Muthuvel, P. (2000): Influence of biostimulants on yield and quality of tomato (*Lycopersicon esculentum* Mill.). *Madras Agricultural Journal*, 87 (12): 625-628.

Orhan, E., Esitken, A., Ercisli, S., Turan, M., Sahim, F. (2006): Effect of Plant Growth Promoting Rhizobacteria (PGPR) on yield, growth and nutrient contents in organically growing raspberry. *Science Horticulturae*, 111: 38-43.

SUBRAMANIAN and TARAFDAR (2011), Tamil Nadu Agricultural University, Coimbatore 641-003. Prospects of nanotechnology in Indian farming. *Indian Journal of Agricultural Science*. 81(10): 887–893.

Uddin, M. J., Ali, M. S., Hossain, M. A., Ahmed, M. U. & Haque, M. M. (1995). Effect of boron grainset, yield and some other parameters of wheat cultivars. Bangladesh Journal of Agricultural Sciences, 2: 179-184.

Xu, H. L., Wang, R., Xu, R.Y., Mridha, M. A. U. & Goyal, S. (2005). Yield and quality of leafy vegetables grown with organic fertilizations. Acta Horticulturae, 627: 25-33.

J ošić, D. (2004): Diversity among indigenous population bacteria that nodulate clover (*Rhizobium legominusarum* bv.trifolii). PhD thesis, University of Novi Sad, Faculty of Agriculture.

These references are not included in the text