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Impact of nano zeolite and bio capsules on growth, yield and quality of cucumber (*Cucumis sativus* L.) cv. Krish F_1 hybrid under shade net

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Abstract
The present experiment was carried out during 2021-22 at the Horticulture Research Farm of the Department of Horticulture, Shuats, Prayagraj. The experiment was conducted in Randomized Block Design with 09 treatments replicated thrice. The treatments were T_1 NPK (RDF), T_2 (Biocapsule 250 ppm (Soil drenching)), T_3 (Biocapsule 500 ppm (Soil drenching)), T_4 (Nanozeolite 50 ppm (Soil drenching)), T_5 (Nanozeolite 100 ppm (Soil drenching)), T_6 (Nanozeolite 100 ppm (Soil drenching) + Biocapsule 500 ppm), T_7 (Nanozeolite 50 ppm (Soil drenching) + Biocapsule 250 ppm), T_8 (NPK (RDF) + Biocapsule 500 ppm), T_9 (NPK (RDF) + Nanozeolite 100 ppm (Soil drenching)). On the basis of our experimental findings, it was concluded that the treatment T_6 ((Nanozeolite 100 ppm (Soil drenching) + Biocapsule 500 ppm) was found to be best in the terms of Vegetative growth, Yield and Yield parameters, Quality parameters, Shelf life and Benefit-cost ratio.

Keywords: Biocapsule, nanozeolite, cucumber, growth, quality and economics

Introduction
Vegetables are protective food. They are rich in vitamins and minerals which are most essential for maintaining the good health of humans. Among the vitamins, vitamins A, B, C, D and E are important.

Cucurbitaceous plants have a variable range of male and female flowers. The production of male flowers is greater than that of female flowers and ultimately only the female flowers contribute towards yields. An increase in a number of female flowers per vine would obviously result in more production of fruits. The expression of different sex forms is influenced by genetic factors, the manifestation of which is influenced by environmental conditions. On the basis of flowering habit cucumber has three types of varieties (i) gynoecious, which produces only female flowers (ii) pre-dominantly gynoecious, which also bears some male flowers, and (iii) the monoecious, which produces both male and female flowers. At the early stages of development, flower buds contain primordia of both stamen and pistil and sex determination occurs due to the selective arrest of development of either the staminate or pistillate primordia just after the bisexual stage. Cucurbits exhibit different constraints in increasing the production of these, sex expression is the most important one.

Cucumber is a very good source of vitamins A, C, K, B6, potassium, pantothenic acid, magnesium, phosphorus, copper and manganese (Vimala, *et al.*, 1999) [15]. The edible portion of cucumber contains 0.4% protein, 2.5% carbohydrates and 0.1% fat and 7.0 mg vitamin C, 25 mg phosphorus, 10 mg calcium and 1.5 mg iron per 100 g edible fruit.

Plant growth regulators, commonly known as phytohormones, are those chemical compounds that control all aspects of growth and development within plants. There are five major classical phytohormones which consist of more than 20 types of PGRs; they are auxin, Cytokinins, gibberellins, abscise acid, and ethylene. In addition, cucumber also contains a diverse variety of biologically active, non-nutritive compounds regarded as phytochemicals like alkaloids, flavonoids, tannins, phlobatannins, steroids, Saponins and many others.

Materials and Methods
The present investigation entitled "Impact of Nano zeolite and Biocapsules on Growth, yield and Quality of Cucumber (*Cucumis sativus* L.) cv. Krish F_1 hybrid under shade net" was conducted at the Horticulture research farm of Department of Horticulture, Sam Higginbottom University of Agriculture, Technology and Sciences Prayagraj during 2022.

Climatic condition

The area of Prayagraj district comes under a subtropical belt in the southeast of Utter Pradesh, which experiences extremely hot summers and fairly cold winters. The maximum temperature of the location reaches up to 46 °C - 48 °C and seldom falls as low as 4 °C - 5 °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.

The experiment was conducted in Randomized Block Design with 09 treatments replicated thrice. The treatments were T_1 NPK (RDF), T_2 (Biocapsule 250 ppm (Soil drenching)), T_3 (Biocapsule 500 ppm (Soil drenching)), T_4 (Nanozeolite50 ppm (Soil drenching)), T_5 (Nanozeolite100 ppm (Soil drenching)), T_6 (Nanozeolite 100 ppm (Soil drenching) + Biocapsule 500 ppm), T_7 (Nanozeolite 50 ppm (Soil drenching) + Biocapsule 250 ppm), T_8 (NPK (RDF) + Biocapsule 500 ppm), T_9 (NPK (RDF) + Nanozeolite 100 ppm (Soil drenching)).

Results and Discussion

The maximum vine length was recorded in the Treatment T_6 ((Nanozeolite 100 ppm (Soil drenching) + Biocapsule 500 ppm) with (131.74) cm followed by Treatment T_7 (Nanozeolite 50 ppm (Soil drenching) + Biocapsule 250 ppm) with (128.23) cm and the minimum was recorded in the treatment T_0 (NPK (RDF)) with (119.74) cm. This is clearly indicated that the integrated use of nutrients helpful in cell elongation of leaves uses to the development of cells and rapid cell division and cell elongation in the meristematic region of the plant due to the production of plant growth substance and this may be due to an abundant supply of plant nutrients and nitrogen which led in the growth of Cucumber. Similar findings of (Mujahid *et al*., 2010) [16] in lettuce and (Bano and Kale, 1987) [19] in brinjal and radish were also observed.

The maximum number of leaves was recorded in the Treatment T_6 ((Nanozeolite 100 ppm (Soil drenching) + Biocapsule 500 ppm) with (50.83) followed by Treatment T_7 (Nanozeolite 50 ppm (Soil drenching) + Biocapsule 250 ppm) with (49.55) and minimum was recorded in the treatment T_0 (NPK (RDF)) with (45.33). This is clearly indicated that the integrated use of nutrients helpful in the cell elongation of leaves uses to the development of cell and rapid cell division and cell elongation in the meristematic region of plant due to the production of plant growth substance and this may be due to an abundant supply of plant nutrients and nitrogen which led in the growth of Cucumber. Similar findings of (Mujahid *et al*., 2010) [16] in lettuce and (Bano and Kale, 1987) [19] in Brinjal and radish were also observed.

The maximum Leaf area was recorded in the Treatment T_6 ((Nanozeolite 100 ppm (Soil drenching) + Biocapsule 500 ppm) with (280.02) cm^2 followed by Treatment T_7 (Nanozeolite 50 ppm (Soil drenching) + Biocapsule 250 ppm) with (277.02) cm^2 and minimum was recorded in the treatment T_0 (NPK (RDF)) with (259.35) cm^2.

This is clearly indicated that the integrated use of nutrients helpful in cell elongation of leaves uses to the development of cell and rapid cell division and cell elongation in the meristematic region of plant due to the production of plant growth substance and this may be due to abundant supply of plant nutrients and nitrogen which led in the growth of Cucumber. Similar findings of (Mujahid *et al*., 2010) [16] in lettuce and (Bano and Kale, 1987) [19] in Brinjal and radish were also observed.

The minimum Days to 1st flowering was recorded in the Treatment T_6 ((Nanozeolite 100 ppm (Soil drenching) + Biocapsule 500 ppm) with (35.08 days) followed by Treatment T_7 (Nanozeolite 50 ppm (Soil drenching) + Biocapsule 250 ppm) with (35.50 days) and the minimum was recorded in the treatment T_0 (NPK (RDF)) with (35.78 days). The decrease in the number of days taken for the appearance of the first flower in the best treatment of organic and inorganic fertilizers in Cucumber is due to the combined effect of the organic manures and Chemical fertilizers. The Similar results were also obtained by (Bano and Kale, 1987) [19] in the cucurbits.

The effect of suitable doses of Nanozeolite and Biocapsules on the Number of flowers per plant of cucumber is very obvious and consistent. There was a significant difference among the doses of the different treatments, among the treatment applied the maximum Number of flowers per plant was recorded in T_6 (Nanozeolite 100 ppm (Soil drenching) + Biocapsule 500 ppm) with (34.45) which was followed by T_7 (Nanozeolite 50 ppm (Soil drenching) + Biocapsule 250 ppm) with (32.80) which was significantly superior over T_0 (NPK (RDF)) with (25.58).

The effect of suitable doses of Nanozeolite and Biocapsules on the Number of fruit per plant of cucumber is very obvious and consistent. There was a significant difference among the doses of the different treatments, among the treatment applied the maximum Number of fruit per plant was recorded in T_6 (Nanozeolite 100 ppm (Soil drenching) + Biocapsule 500 ppm) with (14.38) which was followed by T_7 (Nanozeolite 50 ppm (Soil drenching) + Biocapsule 250 ppm) with (13.72) which was significantly superior over T_0 (NPK (RDF)) with (10.83). The maximum number of fruits and flowers in Cucumber is due to the combined effect of the bio capsule and Nanozeolite. The Similar results were also obtained by (Bano and Kale, 1987) [19] in the cucurbits.

The effect of suitable doses of Nanozeolite and Biocapsules on Male female ratio of cucumber is very obvious and consistent. There was a significant difference among the doses of the different treatments, among the treatment applied the minimum Male female ratio was recorded in T_6 (Nanozeolite 100 ppm (Soil drenching) + Biocapsule 500 ppm) with (8:1) which was followed by T_7 (Nanozeolite 50 ppm (Soil drenching) + Biocapsule 250 ppm) with (9:1) which was significantly superior over T_0 (NPK (RDF)) with (17:1).

The maximum Fruit diameter was recorded in T_6 (Nanozeolite 100 ppm (Soil drenching) + Biocapsule 500 ppm) with (46.35 mm) which was followed by T_7 (Nanozeolite 50 ppm (Soil drenching) + Biocapsule 250 ppm) with (45.65) which was significantly superior over T_0 (NPK (RDF)) with (41.65 mm). The integrated use of nano fertilizer along with N.P.K. significantly influenced the length-diameter ratio of fruit. The results are in conformity with the findings of (Abusaleh, 1992) [20] in okra.

The Maximum Average weight of the fruit was recorded in T_6 (Nanozeolite 100 ppm (Soil drenching) + Biocapsule 500 ppm) with (190.47 g) which was followed by T_7 (Nanozeolite 50 ppm (Soil drenching) + Biocapsule 250 ppm) with (189.35 g) which was significantly superior over T_0 (NPK (RDF)) with (181.38 g). The integrated use of nano-fertilzer along with N.P.K. significantly influenced the length-diameter ratio of fruit. The results are in conformity with the findings of (Abusaleh, 1992) [20] in okra.

The maximum Total yield (q/ha) was recorded in T_6 (Nanozeolite 100 ppm (Soil drenching) + Biocapsule 500 ppm) with (172.55 q) which was followed by T_7 (Nanozeolite 50 ppm (Soil drenching) + Biocapsule 250 ppm) with (171.46 q) which was significantly superior over T_0 (NPK (RDF)) with (166.55 q). The fruit weight was significant effect by nano fertilizer and NPK the Similar result has been obtained by (Vadiraj *et al.*, 1993) [21] in cardamom and (Sekhar and Rajashree, 2009) [22] in tomato.

The maximum Total soluble solids was recorded in T_6 (Nanozeolite 100 ppm (Soil drenching) + Biocapsule 500 ppm) with (5.35 ^{0}B) which was followed by T_7 (Nanozeolite 50 ppm (Soil drenching) + Biocapsule 250 ppm) with (5.15) ^{0}B which was significantly superior over T_0 (NPK (RDF)) with (4.14) ^{0}B. The maximum Ascorbic acid (mg/100g) was recorded in T_6 (Nanozeolite 100 ppm (Soil drenching) + Biocapsule 500 ppm) with (9.26) (mg/100g) which was followed by T_7 (Nanozeolite 50 ppm (Soil drenching) + Biocapsule 250 ppm) with (9.24) (mg/100g) which was significantly superior over T_0 (NPK (RDF)) with (7.65) (mg/100g). Maximum ascorbic acid and TSS might be due to increased availability of major as well as minor nutrients especially nitrogen and potassium because they play a vital role in enhancing the quality. The minimum TSS in T_0 (Control) might be to a lack of availability of nutrients. Similar findings were also reported by Singh *et al.* (2018) [17]; Swetha *et al.* (2018) [18] and Shnain *et al.* (2021) [23] in field-grown tomatoes.

The minimum Acidity% was recorded in T_6 (Nanozeolite 100 ppm (Soil drenching) + Biocapsule 500 ppm) with (0.35%) which was followed by T_7 (Nanozeolite 50 ppm (Soil drenching) + Biocapsule 250 ppm) with (0.31%) which was significantly superior over T_0 (NPK (RDF)) with (0.26%). Maximum acidity might be due to increased availability of major as well as minor nutrients especially nitrogen and potassium because they play a vital role in enhancing the quality. The minimum TSS in T_0 (Control) might be to a lack of availability of nutrients. Similar findings were also reported by Singh *et al.* (2018) [17]; Swetha *et al.* (2018) [18] and Shnain *et al.* (2021) [23] in field-grown tomatoes.

The maximum NPK before the treatment was recorded in T_6 (Nanozeolite 100 ppm (Soil drenching) + Biocapsule 500 ppm) with N (%) (0.712%), P (mg/kg) (15.90 mg/kg), K (mg/kg) (13.08 mg/kg) which was followed by T_7 (Nanozeolite 50 ppm (Soil drenching) + Biocapsule 250 ppm) with N (%) (0.708%), P (mg/kg) (15.15 mg/kg), K (mg/kg) (12.17 mg/kg) which was significantly superior over T_0 (NPK (RDF)) with N (%) (0.679%), P (mg/kg) (12.62 mg/kg), K (mg/kg) (10.88 mg/kg).

The maximum NPK after the treatment was recorded in T_6 (Nanozeolite 100 ppm (Soil drenching) + Biocapsule 500 ppm) with N (%) (0.072%), P (mg/kg) (14.56 mg/kg), K (mg/kg) (11.26 mg/kg) which was followed by T_7 (Nanozeolite 50 ppm (Soil drenching) + Biocapsule 250 ppm) with N (%) (0.068%), P (mg/kg) (13.81 mg/kg), K (mg/kg) (10.35 mg/kg) which was significantly superior over T_0 (NPK (RDF)) with N (%) (0.039%), P (mg/kg) (11.28 mg/kg), K (mg/kg), (9.06 mg/kg).

Future Scope

The main components of the technology are the microbial strain, protecting agent, buffering agent, essential nutrients and a bulking agent packed in a hard gelatine capsule. The formulation involves culturing of PGPR, pelleting the cells at the appropriate growth phase, treating with buffering agent, followed by mixing with protecting agent, inert bulking agent and nutrients. The major attraction for biocapsules are smart and precise microbial delivery to crops, maintaining a high microbial population, green technology low production cost, ease to handle and store, high shelf life, production and storage at normal temperatures, does not require sophisticated equipment for manufacture, can be used to deliver all agriculturally important microorganisms.

Conclusions

On the basis of our findings, it is concluded that the treatment T_6 (Nanozeolite 100 ppm (Soil drenching) + Biocapsule 500 ppm (foliar application)) was found to be best in the terms of Vegetative growth *viz.* plant height, number of leaves, leaf area, plant spread, yield parameters *viz* days to first flowering, no. of flower per plant, no. of fruit per plant, fruit diameter, the average weight of fruit, and total yield, quality parameters *viz.* ascorbic acid, TSS, acidity% and total sugar and economics with B: C ratio 2.02.

Table 1: Impact of Nanozeolite and Biocapsules on Vine Length, No. of leaves, leaf area, days to first flowering, no. of flower/plant and no. of fruit/plant of Cucumber

Treatment	Vine Length (cm)			Number of leaves			Leaf area (cm^2)			Days to 1st flowering	No. of flowers /plant	No. of fruits/ plant
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS			
T_1	60.30	89.77	119.74	10.56	25.62	45.33	132.92	193.37	259.35	35.78	25.58	10.83
T_2	65.22	94.6	124.66	11.67	26.6	46.46	133.35	193.86	260.08	36.19	29.13	12.25
T_3	62.12	92.04	121.65	13.56	28.6	48.45	134.62	196.01	262.08	36.68	27.45	11.58
T_4	65.01	95.03	125.92	13.76	28.94	48.26	135.85	198.63	250.08	34.64	32.38	13.55
T_5	63.75	93.8	123.92	12.96	27.38	47.39	139.02	202.3	293.71	35.54	30.85	12.94
T_6	70.97	100.8	131.74	14.57	30.52	50.83	137.62	200.6	280.02	35.08	34.45	14.38
T_7	67.82	97.39	128.23	14.17	29.72	49.55	136.96	198.83	277.02	35.5	32.80	13.72
T_8	67.08	96.5	126.22	12.74	28.37	48.52	137.1	196.96	271.02	37.08	31.60	13.24
T_9	65.9	95.98	126.74	13.23	28.08	47.27	136.26	199.61	268.77	35.89	29.95	12.58
F Test	S	S	S	S	S	S	S	S	S	S	S	S
S.Ed	1.41	1.16	1.3	1.41	1.31	1.07	1.09	1.06	1.15	1.54	2.03	1.41
C.D.@ 5%	2.19	2.09	2.33	2.66	2.24	1.92	2.12	2.19	2.34	2.65	4.05	2.22

Table 2: Impact of Nanozeolite and Biocapsules on sex ratio, fruit diameter, av. Fruit weight, yield, TSS, ascorbic acid, titrable acidity, NPK before and after the experiment of Cucumber

Treatment	Male: Female	Fruit Diameter (mm)	Average Weight (g)	Yield (q/ha)	TSS (Brix)	Ascorbic Acid (mg/ 100g)	Titrable Acidity (%)	NPK Before Experiment			NPK After Experiment		
								N (%)	P (mg/kg)	K (mg/kg)	N (%)	P (mg/kg)	K (mg/kg)
T_1	17:1	41.65	181.38	166.55	4.14	7.65	0.26	0.679	12.62	10.88	0.039	11.28	9.06
T_2	16:1	42.35	188.76	167.69	4.91	7.98	0.28	0.682	13.59	11.33	0.042	12.25	9.51
T_3	13:1	44.46	179.07	169.02	4.88	8.05	0.30	0.681	13.99	11.43	0.041	12.65	9.61
T_4	15:1	47.62	195.38	169.15	5.81	8.54	0.27	0.685	12.4	11.64	0.045	11.06	9.82
T_5	14:1	44.89	186.38	169.79	4.43	9.06	0.32	0.688	12.69	11.87	0.048	11.35	10.05
T_6	8:1	46.35	190.47	172.55	5.35	9.26	0.35	0.712	15.9	13.08	0.072	14.56	11.26
T_7	9:1	45.65	189.35	171.46	5.15	9.24	0.31	0.708	15.15	12.17	0.068	13.81	10.35
T_8	12:1	43.65	189.03	170.02	3.97	8.68	0.28	0.695	13.68	12	0.055	12.34	10.18
T_9	11:1	45.46	187.50	170.57	4.61	8.99	0.29	0.691	13.93	12.06	0.051	12.59	10.24
F Test	S	S	S	S	S	S	S	S	S	S	S	S	S
S.Ed	0.025	1.42	2.24	3.52	0.4	0.614	0.007	0.003	0.71	0.98	0.002	0.68	0.95
C.D.@ 5%	0.052	2.86	4.47	6.95	1.34	1.26	0.015	0.007	1.35	1.86	0.004	1.21	1.75

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