Effect of Biocapsule and Nanozeolite in improving Growth, Development and Yield of Low chilling Apple (*Malus x domestica* Borkh.) cv. HRMN-99 in Prayagraj agro-climatic Condition

ABSTRACT

The present investigation was conducted at the research farm of Department of Horticulture, Sam Higginbottom University of Agriculture, Technology & Sciences, Prayagraj on 4 year old plant from Dec 2023- May 2024 to find the suitable treatment of Biocapsule and Nanozeolite with a combination of NPK in relation to plant growth, development and yield of apple. The statistical design adopted for the experiment was randomized block design (RBD) having03 replications and 09 treatment combinatios. viz, T_0 (Control), T_1 Biocapsule 600ppm, T_2 Nanozeolite300ppm, T_3 Biocapsule 600ppm + Nanozeolite 300ppm, T_4 Biocapsule 300ppm +Nanozeolite 300ppm, T_5 NPK+ Biocapsule 600ppm, T_6 NPK+ Nanozeolite 300ppm, T_7 NPK+ Biocapsule 600ppm+ Nanozeolite 300ppm, T_8 NPK+ Biocapsule 300ppm+ Nanozeolite 300ppm. The Treatments were applied by soil drenching at initiation of the experiment, the pre-flowering stage and the last one at the fruit setting stage to assess the effect on growth, development and yield of apple. The result of present investigation revealed that the treatment T_7 NPK+ Biocapsule 600ppm+ Nanozeolite 300ppm (Soil drenching) was found significantly superior compared to other treatment combinations, which recorded highest mean value of plant height (3.41 m), primary branches (4.87), secondary branches (37.88), stem diameter (25.10 cm), leaf area (38.75 cm^2), fruit set (36.12 %), number of fruits per plant (92.3) and average fruit weight (47.83 g). The highest yield per plant (9.84 kg) and yield per hectare (9.23 t/ha) were also obtained from treatment NPK+ Biocapsule 600ppm+ Nanozeolite 300ppm (Soil drenching) followed by T_8NPK+ Biocapsule 300ppm+ Nanozeolite 300ppm (Soil drenching) and lowest yield was obtained from T_0 (control). Biocapsule and Nanozeolite with combination of NPK played an important role in fixing the nutrients is the soil and protecting the apple plant against the pathogen effect. That's why a positive response has to be seen in particular treatment during the research trail.

Keywords: biocapsule, nanozeolite, low-chilling apple, subtropical region, HRMN-99

INTRODUCTION

"Apple (*Malus x domestica*Borkh.) is one of the most important temperate fruit crops of Northwestern Himalayan region in India. It belongs to family Rosaceae. It is liked throughout the world by all people due to its pleasant taste and nutritional value and of its excellent taste and nutritious content; it is popular all over the world. Apple is one of the most popular fruits grown in temperate climates worldwide. Its attractive look, crispy flesh, agreeable flavor, and sweet taste entice customers and bring in premium prices" (Ali *et al*., 2004).[1]"Apples are a fantastic source of fiber, healthy vitamins, and minerals. Apples are part in all food diets and its therapeutic value is well known for different illnesses (determines the absorption of gastric secretions, the elimination of toxins and has diuretic effect). Organic acids are an important component of fruit flavour and malic acid is the predominant organic acid in apple fruits" (Campeanu et al., 2009)[2]. "Malic acid is the major component of apple that is found to

maintain liver in a healthy condition and it helps in the digestion process" (Suni *et al.,* 2000) [3].

"In the past it was generally regarded as a crop of the temperate zones but is increasingly cultivated under sub-tropical and even tropical conditions" (Luck will 1984) [4]. "The potential for low-chilling apple production in India's subtropical and tropical climates will improve if apple can be grown effectively in India's plains, where the climate is primarily subtropical. The choice of adaptable cultivars, as well as developments in technology and science, have made this possible"[5].

"HRMN-99 it is a low chilling apple variety noticed the resistance of an apple plant to climatic changes in 1999 by Hariman Sharma. This new variety is resistant to scab disease. Due to a higher sugar acid ratio, higher total soluble solids, attractive colour and higher self-life this variety overcomes almost all the demerits of low chilling apple variety"[6].

"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. The capsule contains the microorganism in an immobilized/inactive condition and the cells can be activated by dissolving the capsule in water. This suspension can be diluted and the seeds or seedlings or rhizomes are soaked in the suspension for 30 minutes before sowing/transplanting into the main field".[7]

Nanozeolites are silicateminerals thathave pores and channelsin their crystal structure.It has a high affinity for cations like Na^+, K^+, and Ca_2^+ due to its unique increased Cationexchangecapacity(CEC).Inthesoilsystem,zeolitesareresponsibleforthe selectiveretention of NH_4^+ and K^+ ions.

METHODS AND MATERIALS

The present investigation was conducted at Research farm of Department of Horticulture, SHUATS, Prayagraj, on 4- a years-old plant during Dec 2023 to May 2024. The experiment was conducted in randomized block design with three replications and nine treatments T_0 (Control), T_1 Biocapsule 600ppm, T_2 Nanozeolite300ppm, T_3 Biocapsule 600ppm + Nanozeolite 300ppm, T_4 Biocapsule 300ppm +Nanozeolite 300ppm, T_5 NPK+ Biocapsule 600ppm, T_6 NPK+ Nanozeolite 300ppm, T_7 NPK+ Biocapsule 600ppm+ Nanozeolite 300ppm, T_8 NPK+ Biocapsule 300ppm+ Nanozeolite 300ppm the treatments were applied by soil drenching and data were analyzed statistically.Data was analyzed using OPSTAT.

Preparation of Biocapsule Solution.

Biocapsules were purchased from the ICAR licensed company CODAGU Agritech. Karnataka. Each biocapsule has 1gm wt. or 1000 ppm concentration and the ability to dissolve in 100 lt of water. So, according to concentration and the ability to dissolve in 100 lt of luke warm water before 12hrs of application and then after that 1 lt of solution was dissolved in 60 lt (for 600ppm) and 30 lt (for 300ppm) of water. After that apple plants were drenched with 1 lt of that solution. The biocapsule drenching was applied at different intervals during the research.

Preparation of Nanozeolite Solution.

Nanozeolite were purchased from the Nano research element Haryana. According to their concentration of ppm they are first dissolved in 5ml ethyl alcohol solution after that it dissolved in the 1 lt of water and then drenched in the apple plant. The nanozeolite drenching was applied at different interval during the research.

RESULT AND DISCUSSION

1. Growth Parameters.

The data about the effect of Biocapsule and Nanozeolite on growth parameters of Apple are presented in Table 1. In case of plant height, the maximum plant height (3.41m) was found in treatment T_7 NPK+ Biocapsule 600ppm+ Nanozeolite 300ppm (Soil drenching) Whereas the minimum plant height (2.69m) was found in treatment T_0(control). Increment in plant height due to the unique properties of zeolites, which affect plant cell division as well as growth. These findings are in accordance with**Bandana and Chandel,Vats *et al.*, (2022), Jangid *et al.*, (2023)**.

The maximum plant spread (227.25) cm was found in treatment T_7 NPK+ Biocapsule 600ppm+ Nanozeolite 300ppm (Soil drenching) Whereas the minimum plant spread (184.58) cm was found in treatment T_0(control). Increament in plant spread due to the unique properties of zeolites, which affect plant cell division as well as growth. Similar findings were reported by**H. Singh and A. Mirza (2020)**, **Devi*et al.*,(2022), Jangid *et al.*, (2023)**.

The maximum No. of primary branches (4.87) was found in treatment T_7 NPK+ Biocapsule 600ppm+ Nanozeolite 300ppm (Soil drenching) Whereas the minimum No. of primary branches (3.54) was found in treatment T_0(control). This might be due to rapid increase in cell division and cell elongation. Similar findings were reported by**Padhan*et al.*, (2019)**,**Vats*et al.*,(2022), Jangid *et al.*, (2023)**.

The maximum No. of secondary branches (37.88) was found in treatment T_7 NPK+ Biocapsule 600ppm+ Nanozeolite 300ppm (Soil drenching) Whereas the minimum No. of secondary branches (20.58) was found in treatment T_0(control). This might be due to rapid increase in cell division and cell elongation. The present findings are in close agreement with the finding of**Padhan*et al.*, (2019)**,**Vats*et al.*,(2022), Jangid *et al.*, (2023)**.

In terms of stem diameter, the maximum stem diameter (25.10) cm was found in treatment T_7 NPK+ Biocapsule 600ppm+ Nanozeolite 300ppm (Soil drenching) Whereas the minimum stem diameter (18.83) cm was found in treatment T_0(control). Increment in stem diameter due to different treatments of biocapsule and nanozeolite. This might be due to the unique properties of zeolites enable the prolonged and controlled introduction of necessary nutrients such as potassium, ammonium, and phosphates into the soil, which affect plant cell division as well as growth. Similar results were achieved by **Padhan *et al.*, (2019)**, **Vats *et al.*,(2022), Jangid *et al.*, (2023)**.

2. Flowering and Fruiting Parameters.

The data pertaining to effect of Biocapsule and Nanozeolite on growth parameters of Apple are presented in Table 2.

In terms of number of flowers, the maximum No. of flowers (255.49) was found in treatment T_7 NPK+ Biocapsule 600ppm+ Nanozeolite 300ppm (Soil drenching) Whereas the minimum No. of flowers (187.44) was found in treatment T_0(control). after 4 years of transplanting. This might be due to the different treatments of biocapsule and nanozeolite with combination

of NPK-enhanced reproductive growth. The present findings are in close agreement with the finding of**Sharma *et al.*, (2005),Padhan *et al.*, (2019), Vats *et al.*, (2022)**.

In terms of number of fruits per plant, the maximum No. of fruits (255.49) was found in treatment T_7NPK+ Biocapsule 600ppm+ Nanozeolite 300ppm (Soil drenching) Whereas the minimum No. of fruits (187.44) was found in treatment T_0 (control) after 4 years of transplanting. This might be due to the different treatments of biocapsule and nanozeolite with combination of NPK enhanced reproductive growth. These findings are in accordance with**Padhan *et al.*, (2019), Vats *et al.*, (2022), Jangid *et al.*, (2023)**.

Coming to the fruit weight, the maximum fruit weight (255.49) g was found in treatment T_7 NPK+ Biocapsule 600ppm+ Nanozeolite 300ppm (Soil drenching) followed by T_8 NPK+ Biocapsule 300ppm+ Nanozeolite 300ppm (Soil drenching) (247.98) gWhereas the minimum fruit weight (187.44) g was found in treatment T_0(control) after 4 years of transplanting. This might be due to the different treatments of biocapsule and nanozeolite with a combination of NPK-enhanced the reproductive growth. Similar findings were reported by**Verma *et al.*, (2009), Singh *et al.*, (2011), Vats *et al.*, (2022)**.

The maximum fruit yield (kg/plant) (9.83) kg was found in treatment T_7 NPK+ Biocapsule 600ppm+ Nanozeolite 300ppm (Soil drenching) followed by T_8 NPK+ Biocapsule 300ppm+ Nanozeolite 300ppm (Soil drenching) (9.53) kg Whereas the minimum fruit yield (4.16) kg was found in treatment T_0(control) after 4 years of transplanting. Similar findings were reported by **Padhan *et al.*, (2019), Vats *et al.*, (2022), Jangid *et al.*, (2023)**.

The maximum fruit yield (t/ha) (9.23) tonnes was found in treatment T_7 NPK+ Biocapsule 600ppm+ Nanozeolite 300ppm (Soil drenching) followed by T_8 NPK+ Biocapsule 300ppm+ Nanozeolite 300ppm (Soil drenching) (9.05) tonnsWhereas the minimum fruit yield (3.19) tonns was found in treatment T_0(control) after 4 years of transplanting. Similar findings were reported by **Padhan *et al.*, (2019), Vats *et al.*, (2022), Jangid *et al.*, (2023)**.

3. Fruit Quality Parameters.

The data pertaining to effect of Biocapsule and Nanozeolite on growth parameters of Apple are presented in Table 3. The maximum T.S.S (11.63) brix was found in treatment T_7 NPK+ Biocapsule 600ppm+ Nanozeolite 300ppm (Soil drenching) followed by treatment T_8 NPK+ Biocapsule 300ppm+ Nanozeolite 300ppm (Soil drenching) (11.16) brix Whereas the minimum T.S.S (8.08) brix was found in treatment T_0(control). These results are in support with **Singh *et al.*, (2011), Vats *et al.*, (2022), Jangid *et al.*, (2023)**.

In case of acidity, the highest acidity (0.74) % was found in treatment T_7 NPK+ Biocapsule 600ppm+ Nanozeolite 300ppm (Soil drenching) followed by T_8 NPK+ Biocapsule 300ppm+ Nanozeolite 300ppm (Soil drenching) (0.72) %Whereas the lowest acidity (0.49) % was found in treatment T_0(control). Similar findings were reported by **H.A. Hifny*et al.*, (2017), Vats *et al.*, (2022), Jangid *et al.*, (2023)**.

Coming to T.S.S: Acid ratio, the highest ratio (18.77) was found in treatment T_1 Biocapsule 600ppm (Soil drenching) followed by treatment T_4 Biocapsule 300ppm +Nanozeolite 300ppm (Soil drenching) (17.00)are found statistically at par to Biocapsule 600ppm (Soil drenching)Whereas the minimum T.S.S:Acid ratio (15.55) was found in treatment T_8 NPK+ Biocapsule 300ppm+ Nanozeolite 300ppm (Soil drenching). These findings are are in accordance with **Singh*et al.*, (2011), Vats *et al.*, (2022), Jangid *et al.*, (2023)**.

Table 1: Growth Parameters.

		Growth Parameters				
Symbol	**Treatment**	**Plant height (m)**	**Plant Spread (cm)**	**Primary Branches**	**Secondary Branches**	**Stem Diameter (cm)**
T0	Control	2.69	184.58	3.54	20.58	18.83
T1	Biocapsule 600ppm (Soil drenching)	2.84	196.8	3.76	24.94	19.36
T2	Nanozeolite 300ppm (Soil drenching)	2.75	191.36	3.6	23.46	19.78
T3	Biocapsule 600ppm + Nanozeolite 300ppm (Soil drenching)	3.16	219.69	4.72	33.88	24.35
T4	Biocapsule 300ppm +Nanozeolite 300ppm (Soil drenching)	2.87	198.03	3.85	27.82	21.52
T5	NPK+ Biocapsule 600ppm (Soil drenching)	3.05	208.65	4.59	31.12	23.37
T6	NPK+ Nanozeolite 300ppm (Soil drenching)	2.98	201.26	4.23	28.22	22.87
T7	NPK+ Biocapsule 600ppm+ Nanozeolite 300ppm (Soil drenching)	3.41	227.25	4.87	37.88	25.1
T8	NPK+ Biocapsule 300ppm+ Nanozeolite 300ppm (Soil drenching)	3.31	225.38	4.8	35.97	24.84
	F Test	**S**	**S**	**S**	**S**	**S**
	SE(d)±	**0.086**	**0.099**	**0.109**	**0.3**	**0.109**
	CD0.05	**0.184**	**0.212**	**0.232**	**0.642**	**0.233**
	CV	**3.507**	**0.059**	**3.155**	**1.253**	**0.602**

Table 2: Flowering and Fruiting Parameters.

		Flowering & Fruiting Parameters				
Symbol	**Treatment**	**Number of Flowers/Plant**	**Number of Fruits/Plant**	**Fruit Weight (g)**	**Fruit Yield (kg/plant)**	**Fruit Yield (t/ha)**
T0	Control	187.44	44.75	28.92	4.16	3.19
T1	Biocapsule 600ppm (Soil drenching)	204.62	68.71	31.38	6.42	5.41
T2	Nanozeolite 300ppm (Soil drenching)	199.76	60.82	30.3	5.93	5.11
T3	Biocapsule 600ppm + Nanozeolite 300ppm (Soil drenching)	236.49	84.37	44.9	8.69	8.87
T4	Biocapsule 300ppm +Nanozeolite 300ppm (Soil drenching)	218.79	73.47	32.7	6.82	6.77
T5	NPK+ Biocapsule 600ppm (Soil drenching)	229.51	79.98	40.29	7.45	8.15
T6	NPK+ Nanozeolite 300ppm (Soil drenching)	221.63	77.86	37.18	7.11	7.64
T7	NPK+ Biocapsule 600ppm+ Nanozeolite 300ppm (Soil drenching)	255.49	92.3	47.83	9.84	9.23
T8	NPK+ Biocapsule 300ppm+ Nanozeolite 300ppm (Soil drenching)	247.98	87.85	45.2	9.53	9.05
	F Test	**S**	**S**	**S**	**S**	**S**
	SE(d)±	**0.214**	**0.189**	**0.468**	**0.082**	**0.43**
	CD0.05	**0.458**	**0.404**	**1.001**	**0.176**	**0.92**
	CV	**0.118**	**0.311**	**1.524**	**1.376**	**7.476**

Table 3: Fruit Quality Parameters.

		Fruit Quality Parameters		
Symbol	**Treatment**	**T.S.S °Brix**	**Acidity %**	**T.S.S: Acid**
T0	Control	8.08	0.49	16.38
T1	Biocapsule 600ppm (Soil drenching)	9.63	0.51	18.77
T2	Nanozeolite 300ppm (Soil drenching)	9.35	0.56	16.69
T3	Biocapsule 600ppm + Nanozeolite 300ppm (Soil drenching)	10.85	0.68	15.87
T4	Biocapsule 300ppm +Nanozeolite 300ppm (Soil drenching)	9.86	0.58	17.00
T5	NPK+ Biocapsule 600ppm (Soil drenching)	10.68	0.65	16.35
T6	NPK+ Nanozeolite 300ppm (Soil drenching)	10.01	0.61	16.4
T7	NPK+ Biocapsule 600ppm+ Nanozeolite 300ppm (Soil drenching)	11.63	0.74	15.65
T8	NPK+ Biocapsule 300ppm+ Nanozeolite 300ppm (Soil drenching)	11.16	0.72	15.55
	F Test	**S**	**S**	**S**
	SE(d)±	**0.043**	**0.014**	**0.068**
	CD0.05	**0.093**	**0.03**	**0.146**
	CV	**0.523**	**2.829**	**0.507**

CONCLUSION

On the basis of present investigation, it is concluded that the various treatments of Biocapsule and Nanozeolite has been applied to enhance the vegetative and reproductive growth of apple cv. HRMN-99, where treatment T_7 NPK+ Biocapsule 600ppm+ Nanozeolite 300ppm (Soil drenching) is found superior among others, followed by T_8 NPK+ Biocapsule 300ppm+ Nanozeolite 300ppm (Soil drenching) and the lowest was T_0 (control). In every aspect of growth, development and yield parameters.

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