Original Research Article

The Role of Nanozeolite and Biocapsule in improving growth, yield and fruit quality of low chilling Apple (*Malus* × *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 and sciences, Prayagraj, on 30-month-old plant during January 2021 to July 2021 with the objective to find out suitable treatment of Biocapsule and Nanozeolite with combination of NPK in relation to plant growth, yield and quality of apple. The statistical design adopted for the experiment was randomized block design (RBD) with three replications and nine treatment combinations. viz, T_1 (NPK (RDF)), T_2 (Biocapsule 500 ppm), T_3 (Nanozeolite 250 ppm), T_4 (Nanozeolite 250 ppm + Biocapsule 500 ppm), T_5 (Nanozeolite 250 ppm + Biocapsule 250 ppm), T_6 (NPK (RDF) + Biocapsule 500 ppm), T_7 (NPK (RDF) + Nanozeolite 250 ppm), T_8 (NPK (RDF) + Nanozeolite 250 ppm + Biocapsule 500 ppm), T_9 (NPK (RDF) + Nanozeolite 250 ppm + Biocapsule 250 ppm). The treatments were applied by soil drenching at initiation of experiment, pre-flowering stage and the last one at the fruit setting stage to assess the effect on growth, yield and quality of apple. The results of present investigation revealed that, the treatment T_8 (NPK (RDF) + Nanozeolite 250 ppm + Biocapsule 500 ppm) outstand in all the aspects like Maximum plant height (2.8 m), Maximum no of Primary and Secondary branch (3), (28) respectively, maximum no. of flower (319), maximum no. of fruit (63.6), maximum yield $Plant^{-1}$(7.2 kg) and quality parameters like Maximum TSS (11.56 ^{o}Brix) and Maximum acidity (0.71 %) followed by T_9 (NPK (RDF) + Nanozeolite 250 ppm + Biocapsule 250 ppm). The lowest observation was recorded in T_3 (Nanozeolite 250 ppm).

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

INTRODUCTION

The "King of Temperate Fruit," the Apple (Malus X domestica Borkh), originated in Central Asia near Turkey. It is an internationally cultivated deciduous and valuable fruit tree of the rosaceae family. Apples have been farmed for thousands of years in Asia and Europe, and the tree was imported to North America by European colonists. Because 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 around the world. Its attractive look, crispy flesh, agreeable flavour, and sweet taste entice customers and bring in premium prices (Ali et al., 2004). Apples are abundant in minerals such calcium, potassium, phosphorus, and magnesium, as well as vitamins C, K, and B-6, folate, protein, thiamin, riboflavin, and pantothenic acid. It also contains a high amount of choline, dietary fibre, omega-3 fatty acids, and biotin. It also consists of various phytochemicals including flavonoids (e.g., catechins, flavanols, and quercetin) and other phenolic compounds (e.g., epicatechin and procyanidins) found in the skin, core, and pulp of the apple. Certain phytochemicals found in apples may also help to reduce the incidence of certain cancers. When eaten raw, apples provide health advantages and are a good source of antioxidants. "An apple a day keeps the doctor away," according to a well-known proverb.

HRMN – 99 Apples are cultivated at a lower elevation of 1800 feet above sea level and do not require chilling hours. Average yield (1 quintal/plant from a 7-year-old plant), ready to harvest in early June (after three years of transplanting), and scab-resistant. During 2015-2017, the National Innovation Foundation-India (NIF) planted roughly 10,000 seedlings in 1190 farmers' fields and 25 organisations across 29 states and 5 union territories to investigate the HRMN-99's compatibility and adaptation in diverse agro-climatic conditions across the country. Farmers in Manipur, Madhya Pradesh, Uttar Pradesh, Bihar, Maharashtra, Gujarat, Dadra and Nagar Haveli, Karnataka, Haryana, Rajasthan, Jammu, Kerala, Uttarakhand, Telangana, Himachal Pradesh, and Delhi have reported successful fruiting, resulting in an increase in the demand for saplings on a large scale. (NIF, Database)

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 microorganism. When applied to seed, soil or living plants, its increases oil and nutrients or makes them biologically available. The formulation involves culturing of PGPR, pelleting the cells at appropriate growth phase, treating with buffering agent, followed by mixing with protecting agent, inert bulking agent and nutrients. The mixture with a PGPR population of 1010 CFU/g is then packed in the capsule. The whole process is done at a temperature range between 20-30^{0}C. The total weight of the biocapsule is just 1g. The process of making the formulation is simple and does not require any sophisticated equipment and conditions except basic facilities. The capsule formulation contains PGPR 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. The remaining suspension can be used as soil drench

Nanozeolites are silicate minerals that have pores and channels in their crystal structure. It has a high affinity for cations like Na+, K+, and Ca2+ due to its unique increased Cation

exchange capacity (CEC). In the soil system, zeolites are responsible for the selective retention of NH4+ and K+ ions.

METHODS AND MATERIALS

The present research work was carried out in randomized block design (RBD) with three replications and nine treatment combinations. viz, T_1 (NPK (RDF)), T_2 (Biocapsule 500 ppm), T_3 (Nanozeolite 250 ppm), T_4 (Nanozeolite 250 ppm + Biocapsule 500 ppm), T_5 (Nanozeolite 250 ppm + Biocapsule 250 ppm), T_6 (NPK (RDF) + Biocapsule 500 ppm), T_7 (NPK (RDF) + Nanozeolite 250 ppm), T_8 (NPK (RDF) + Nanozeolite 250 ppm + Biocapsule 500 ppm), T_9 (NPK (RDF) + Nanozeolite 250 ppm + Biocapsule 250 ppm) and about 30 months old Apple plant were taken for research purpose.

Experimental Site:

The experiment was conducted at the Research farm, Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of agriculture, technology and sciences, Prayagraj, for a period lasting from January 2021 to July 2021.

Geographical location of the experimental site:

The location of experimental site is situated at an elevation of 98 meters above mean sea level (MSL) at 25.45^0 North latitude and 81.84^0 East longitudes.

Climate:

This region falls under the sub-tropical zone. Prevailing in the South-Eastern part of the U.P. and has both the extremities in temperatures, *i.e.*, winter and summer. In winters, the temperature sometimes is as low as 32^oF in December to January, and in summer the temperatures reach up to 115^oF in the months of May to June. During winter, frosts and during summer, hot scorching winds are pretty common. The average rainfall is around 1013.4 (mm) with maximum concentration during July to September months with occasional showers in winters.

Preparation of Biocapsule solution

Biocapusules were purchased from the ICAR licensed company CADAGU Agritech. Karnataka. Each biocapsules having 1gm wgt. or 1000 ppm concentration of $PGPR_s$ and the ability of dissolving in 100 ltr of water. So according to the concentration of capsules are first dissolve in 1 ltr of luke warm water before 12 hours of application and then after that 1 ltr of solution was dissolve in 50 ltr. (For 500 ppm) and 25 ltr. (For 250 ppm) of water. After that Apple plants were drenched with 1 ltr of that solution. The biocapsule drenching were applied at different interval during the research.

Preparation of Nanozeolite solution

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

RESULT AND DISSCUSSION

Growth Parameters

In case of plant height, table 1. and graph 1. showed that the Treatment T_8 ((NPK (RDF) + Nanozeolite 250 ppm + Biocapsule 500 ppm) have maximum plant height (2.8 m) after 3 years of transplanting followed by T_9 (NPK (RDF) + Nanozeolite 250 ppm + Biocapsule 250 ppm) (2.76 m) and minimum plant height (2.47 m) was observed in treatment T_3 (Nanozeolite 250 ppm) after 3 years of transplanting. Increament in plant height might be due to Biocapsules and nanozeolite with the combination of NPK. Biocapules increases the nutrient fixation in the root and nanozeolite played an important role to make availability of nutrient in the soil. These results are in support with **Bandana and Chandel (2017)** and **Padhan *et. al.* (2019).**

Table 1. and graph 1. showed that the maximum primary branches (3.66) were observed in treatment T_8 (NPK (RDF) + Nanozeolite 250 ppm + Biocapsule 500 ppm) followed by treatment T9 (NPK (RDF) + Nanozeolite 250 ppm + Biocapsule 250 ppm) which was (3) and the lowest primary branches (2) was recorded in treatment T_3 after 3 years of transplanting. Increased number of primary branches, might be due to the application of Biocapsule and nanozeolite with the combination of NPK. Biocapsule has an antipathogen effect and nanozeolite reduces the disease incidence to the Apple plant. These findings are in accordance with **Treder (2007)** and **Padhan *et. al.* (2019).**

Table 1. and graph 1. showed that the number of secondary branches was noticed maximum (30.33) after 3 years of transplanting with treatment T_8 (NPK (RDF) + Nanozeolite 250 ppm + Biocapsule 500 ppm), followed by treatment T_9 (NPK (RDF) + Nanozeolite 250 ppm + Biocapsule 250 ppm) (28), while minimum number of secondary branches observed with treatment T_3 (Nanozeolite 250 ppm) (14.33) after 3 years of transplanting. Increased number of secondary branches, might be due to the application of Biocapsule and nanozeolite with the combination of NPK. Biocapsule has an antipathogen effect and nanozeolite reduces the disease incidence to the Apple plant. Similar findings were reported by **Treder (2007)** and **Padhan *et. al.* (2019).**

Table 1. and graph 1. showed that in terms of stem diameter, maximum stem diameter was witnessed in T8 (NPK (RDF) + Nanozeolite 250 ppm + Biocapsule 500 ppm) (10.66 cm), followed by T_9 (NPK (RDF) + Nanozeolite 250 ppm + Biocapsule 250 ppm) (10.2 cm) and minimum stem diameter was witnessed in treatment T_3 (Nanozeolite 250 ppm) (6.86 cm) after 3 years of transplanting. Increament in stem diameter, might be due to Biocapsules and nanozeolite with the combination of NPK. Biocapules increases the nutrient fixation in the root and nanozeolite played an important role to make availability of nutrient in the soil. Similar results were achieved by **Bandana and Chandel (2017)** and **Padhan *et. al.* (2019).**

In case of leaf area, table 1. and graph 1. showed that treatment T_8 ((NPK (RDF) + Nanozeolite 250 ppm + Biocapsule 500 ppm) have the maximum leaf area which was (40.56 cm^2) followed by T_9 (NPK (RDF) + Nanozeolite 250 ppm + Biocapsule 250 ppm) (38.26 cm^2) and lowest was reported in T_3 (Nanozeolite 250 ppm) (35.4 cm^2) after 3 years of transplanting. Increament in leaf area, might be due to Biocapsules and nanozeolite with the combination of NPK. Biocapules increases the nutrient fixation in the root and nanozeolite played an important role to make availability of nutrient in the soil. These findings are in accordance with **Treder (2007)** and **Padhan *et. al.* (2019).**

Flowering And Fruiting Parameter

Table 1. and graph 1. showed that the longest time period form bud burst to first flowering was observed in treatment T_3 (Nanozeolite 250 ppm) was (19.33 days), followed

by T_2 (Biocapsule 500 ppm) (18 days) and least time period was observed in treatment T_8 (NPK (RDF) + Nanozeolite 250 ppm + Biocapsule 500 ppm) which was (12.33 days) after 3 years of transplanting. Biocapsules and nanoziolite with combination of NPK enhanced the reproductive growth that's why this type of result has to be seen. These results are in support with **Bandana and Chandel (2017)** and **Padhan *et. al.* (2019).**

Table 1. and graph 1. showed that the longest time period form bud burst to first fruiting was observed in treatment T_3 (Nanozeolite 250 ppm) was (34 days), followed by T_2 (Biocapsule 500 ppm) (33.66 days) and least time period was observed in treatment T_8 (NPK (RDF) + Nanozeolite 250 ppm + Biocapsule 500 ppm) which was (27.66 days) after 3 years of transplanting. Biocapsules and nanoziolite with combination of NPK enhanced the reproductive growth that's why this type of result has to be seen. These results are in support with **Bandana and Chandel (2017)** and **Padhan *et. al.* (2019).**

In terms of no flowers per plant, Table 2. and graph 2. showed that the maximum no. of flowers was witnessed in Treatment T_8 (NPK (RDF) + Nanozeolite 250 ppm + Biocapsule 500 ppm) which was (319.66), followed by T_9 (NPK (RDF) + Nanozeolite 250 ppm + Biocapsule 250 ppm) (303.33) and lowest was recorded in T_3 (Nanozeolite 250 ppm) which was (229.33) after 3 years of transplanting. Biocapsules and nanoziolite with combination of NPK enhanced the reproductive growth that's why this type of result has to be seen. These findings are in accordance with **Sharma *et. al.* (2005)** and **Padhan *et. al.* (2019).**

Table 2. and graph 2. showed that in terms of numbers of fruit per plant, maximum no. of fruits per tree was observed in Treatment T_8 (NPK (RDF) + Nanozeolite 250 ppm + Biocapsule 500 ppm) (63.66), followed by T_9 (NPK (RDF) + Nanozeolite 250 ppm + Biocapsule 250 ppm) (59.66) and minimum no of fruits per plant is observed in treatment T_3 (Nanozeolite 250 ppm) which was (31.66) after 3 years of transplanting. These results are in support with **Prilak *et. al.* (2007)** and **Fediala *et. al.* (2018).**

Coming to the fruit weight, Table 2. and graph 2. showed that the maximum fruit weight was witnessed in T_8 (NPK (RDF) + Nanozeolite 250 ppm + Biocapsule 500 ppm) (113.33 g), followed by T_9 (NPK (RDF) + Nanozeolite 250 ppm + Biocapsule 250 ppm) (109.11 g) and minimum fruit weight was witnessed in treatment T_3 (Nanozeolite 250 ppm) which was (73.66 g) after 3 years of transplanting. Biocapsules and nanoziolite with combination of NPK enhanced the reproductive growth that's why this type of result has to be seen. Similar findings were reported by **Verma *et. al.* (2009)** and **Hany *et. al.* (2020)**

In terms of polar diameter, Table 2. and graph 2. showed that the highest polar diameter was noticed in treatment T_8 (NPK (RDF) + Nanozeolite 250 ppm + Biocapsule 500 ppm) (7.3 cm), followed by T_9 (NPK (RDF) + Nanozeolite 250 ppm + Biocapsule 250 ppm) (7.03 cm) and lowest polar diameter was noticed in T_3 (Nanozeolite 250 ppm) which was (5 cm) after 3 years of transplanting. Biocapsules and nanoziolite with combination of NPK enhanced the reproductive growth that's why this type of result has to be seen. These findings are in accordance with **Prilak *et. al.* (2007)** and **Fediala *et. al.* (2018).**

Table 2. and graph 2. showed that in terms of radial diameter, the highest radial diameter was noticed in treatment T_8 (NPK (RDF) + Nanozeolite 250 ppm + Biocapsule 500 ppm) (6.73 cm), followed by T_9 (NPK (RDF) + Nanozeolite 250 ppm + Biocapsule 250 ppm) (6.53 cm) and lowest radial diameter was noticed in T_3 (Nanozeolite 250 ppm) which was (4.4 cm) after 3 years of transplanting. Biocapsules and nanoziolite with combination of NPK enhanced the reproductive growth that's why this type of result has to be seen. These results are in support with **Verma *et. al.* (2009)** and **Fediala *et. al.* (2018).**

Table 2. and graph 2. showed that the maximum fruit yield (kg/plant) was recorded in treatment T_8 (NPK (RDF) + Nanozeolite 250 ppm + Biocapsule 500 ppm) (7.22 kg), followed by T_9 (NPK (RDF) + Nanozeolite 250 ppm + Biocapsule 250 ppm) (6.51 kg) and the minimum fruit yield (kg/plant) was recorded in T_3 (Nanozeolite 250 ppm) which was

(2.33 kg) after 3 years of transplanting. Similar findings were reported by **Verma *et. al.* (2009)** and **Prilak *et. al.* (2007).**

Table 2. and graph 2. showed that in terms the fruit yield (t/ha), maximum fruit yield was witnessed in treatment T_8 (NPK (RDF) + Nanozeolite 250 ppm + Biocapsule 500 ppm) (16.05 t.), followed by T_9 (NPK (RDF) + Nanozeolite 250 ppm + Biocapsule 250 ppm) (14.48 t.) and the minimum fruit yield was witnessed in treatment T_3 (Nanozeolite 250 ppm) which was (5.19 t.) after 3 years of transplanting. These findings are in accordance with **Prilak *et. al.* (2007) and Verma *et. al.* (2009).**

Fruit Quality Parameters

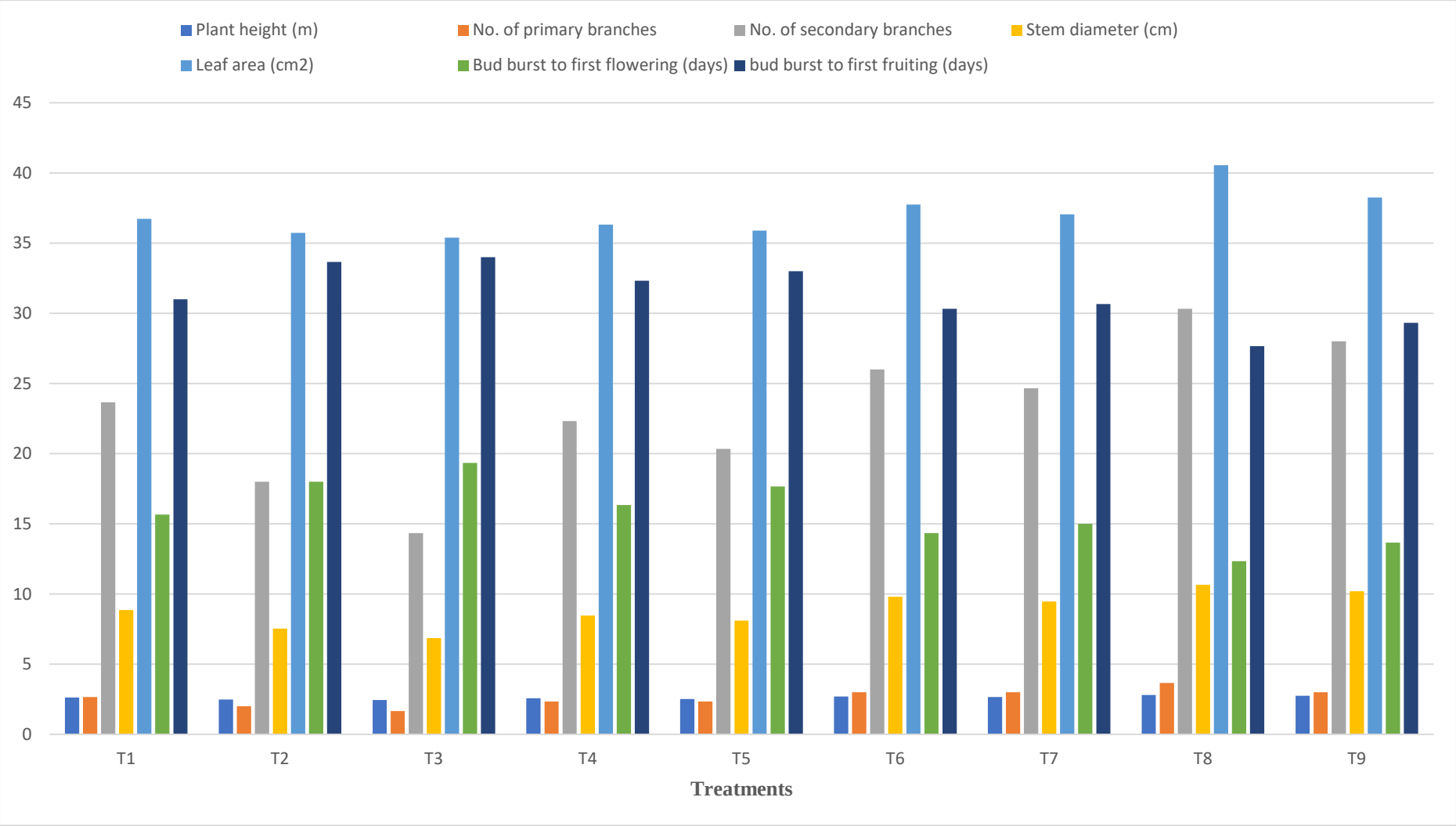
Table 2. and graph 2. showed that the maximum T.S.S was noticed in treatment T_8 (NPK (RDF) + Nanozeolite 250 ppm + Biocapsule 500 ppm) (11.56^0), followed by T_9 (NPK (RDF) + Nanozeolite 250 ppm + Biocapsule 250 ppm) (10.63^0) and the minimum T.S.S was noticed in T_3 (Nanozeolite 250 ppm) which was (8.53^0). These results are in support with **Singh *et. al.* (2011) and Emadpour *et. al.* (2015).**

In case of acidity, table 2. and graph 2. showed that the highest acidity was witnessed in the treatment T_8 (NPK (RDF) + Nanozeolite 250 ppm + Biocapsule 500 ppm) (0.71%), followed by T_9 (NPK (RDF) + Nanozeolite 250 ppm + Biocapsule 250 ppm) (0.63%) and the lowest acidity was witnessed in T_3 (Nanozeolite 250 ppm) which was (0.49%). Similar findings were reported by **Drake *et. al.* (2002) and Roussos and Gasparatos (2009).**

Coming to the T.S.S: Acid ratio, table 2. and graph 2. showed that highest ratio was found in T_3 (Nanozeolite 250 ppm) (17.30), followed by T_2 (Biocapsule 500 ppm) (17.16) and lowest T.S.S: Acid ratio was found in T_6 (NPK (RDF) + Biocapsule 500 ppm) which was (15.01). These findings are in accordance with **Drake *et. al.* (2002) and Singh *et. al.* (2011).**

Table.1 Impact of biocapsule and nanozeolite on growth and development of apple.

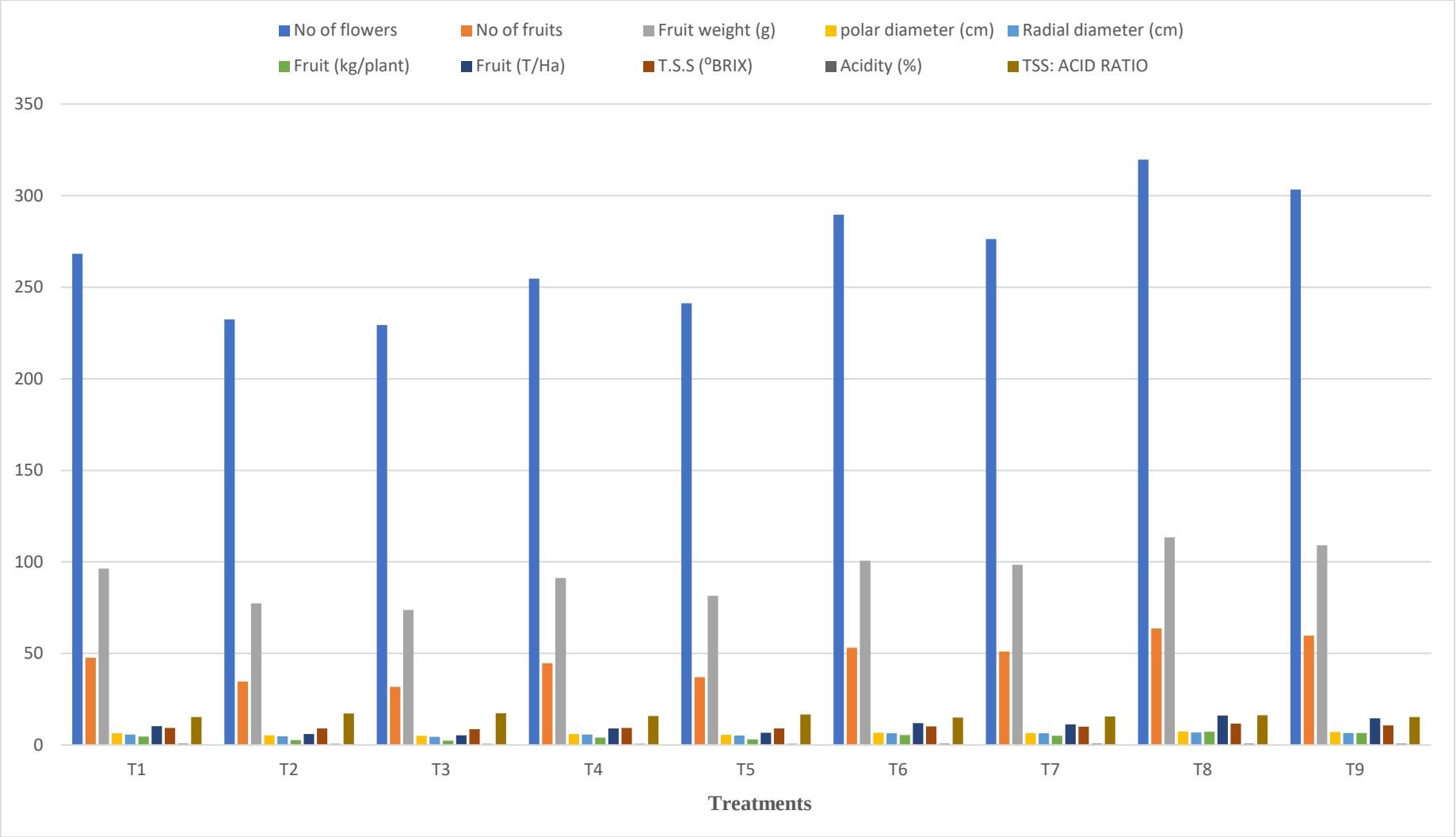
Treatment notations	Treatments	Plant height (m)	No. of primary branches	No. of secondary branches	Stem diameter (cm)	Leaf area (cm^2)	Bud burst to first flowering (days)	bud burst to first fruiting (days)
T_1	NPK (RDF)	2.61	2.66	23.66	8.86	36.73	15.66	31
T_2	Biocapsule 500 ppm	2.47	2	18	7.53	35.73	18	33.66
T_3	Nanozeolite 250 ppm	2.44	1.66	14.33	6.86	35.4	19.33	34
T_4	Nanozeolite 250 ppm + Biocapsule 500 ppm	2.56	2.33	22.33	8.46	36.33	16.33	32.33
T_5	Nanozeolite 250 ppm + Biocapsule 250 ppm	2.52	2.33	20.33	8.1	35.9	17.66	33
T_6	NPK (RDF) + Biocapsule 500 ppm	2.69	3	26	9.8	37.76	14.33	30.33
T_7	NPK (RDF) + Nanozeolite 250 ppm	2.66	3	24.66	9.46	37.06	15	30.66
T_8	NPK (RDF) + Nanozeolite 250 ppm + Biocapsule 500 ppm	2.8	3.66	30.33	10.66	40.56	12.33	27.66
T_9	NPK (RDF) + Nanozeolite 250 ppm + Biocapsule 250 ppm	2.74	3	28	10.2	38.26	13.66	29.33
F-test		S	NS	S	S	S	NS	S
S. Ed		0.02	0.55	2.90	0.19	0.40	2.51	1.76
CD at 5%		0.05	1.18	6.15	0.41	0.85	5.34	3.73



Graph 1. Impact of biocapsule and nanozeolite on growth and development of apple.

Table.2 Impact of biocapsule and nanozeolite on yield and quality of apple.

Treatment notations	Treatments	No of flowers	No of fruits	Fruit weight (g)	polar diameter (cm)	Radial diameter (cm)	Fruit (kg/plant)	Fruit (T/Ha)	T.S.S (^{0}BRIX)	Acidity (%)	TSS: ACID RATIO
T_1	NPK (RDF)	268.33	47.66	96.33	6.4	5.7	4.59	10.21	9.3	0.62	15.23
T_2	Biocapsule 500 ppm	232.33	34.66	77.33	5.2	4.7	2.68	5.96	8.93	0.52	17.16
T_3	Nanozeolite 250 ppm	229.33	31.66	73.66	5	4.4	2.33	5.19	8.53	0.49	17.30
T_4	Nanozeolite 250 ppm + Biocapsule 500 ppm	254.66	44.66	91.22	5.96	5.66	4.06	9.04	9.23	0.58	15.79
T_5	Nanozeolite 250 ppm + Biocapsule 250 ppm	241.33	37	81.44	5.53	5.13	3.01	6.68	9	0.54	16.62
T_6	NPK (RDF) + Biocapsule 500 ppm	289.66	53	100.66	6.7	6.4	5.33	11.85	10.06	0.67	15.01
T_7	NPK (RDF) + Nanozeolite 250 ppm	276.33	51	98.44	6.53	6.33	5.01	11.14	9.96	0.64	15.49
T_8	NPK (RDF) + Nanozeolite 250 ppm + Biocapsule 500 ppm	319.66	63.66	113.33	7.3	6.73	7.22	16.05	11.56	0.71	16.15
T_9	NPK (RDF) + Nanozeolite 250 ppm + Biocapsule 250 ppm	303.33	59.66	109.11	7.03	6.53	6.51	14.48	10.63	0.69	15.29
F-test		S	S	S	S	S	S	S	S	S	NS
S. Ed		5.29	3.14	1.09	0.06	0.07	0.29	0.65	0.34	0.04	1.71
CD at 5%		11.21	6.66	2.32	0.14	0.15	0.62	1.37	0.72	0.10	3.63



Graph 2. Impact of biocapsule and nanozeolite on yield and quality of apple.

Fig 1- Apple flower and fruit

CONCLUSION

On the basis of the present investigation, it is concluded that the various treatments biocapsule and nanozeolite has been applied to enhance the vegetative and reproductive growth of apple cv. HRMN-99, where treatment T_8 (NPK (RDF) + Nanozeolite 250 ppm + Biocapsule 500 ppm) is found superior among others, followed by T_9 NPK (RDF) + Nanozeolite 250 ppm + Biocapsule 250 ppm) and the lowest was T_3 (Nanozeolite 250 ppm) in every aspect of growth, yield and quality parameters.

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