Original Research Article

"Effects of different growing media and biocapsules on seed germination, seedling growth and survival percentage of papaya (*Carica papaya*) cv.PusaNanha"

Comment [m1]: The title is too long and it is recommended for a title of a maximum of 12 words, so it needs to be simplified without changing the research topic

ABSTRACT

Thestudy entitled, **Effects of different growing media and biocapsules on seed germination, seedling growth and survival percentage of papaya (*Carica papaya*) cv.PusaNanha** was carried out during March – June 2022 at Department of Horticulture, Naini Agricultural Institute, SHUATS, Prayagraj. The experiment was carried out to see the performance of the most suitable soil media for growth and establishment of Papaya seedlings. There were nine treatments including control viz, M0 Control (Garden soil), M1(Soil + FYM), M2 (Soil+FYM+biocapsules), M3 (Soil+FYM+Neemcake), M4 (Soil+FYM+Neemcake+biocapsules), M5 (Soil+FYM+Vermicompost), M6 (Soil+Sand+Vermicompost+biocapsules), M7 (Soil+FYM+Sand) M8 (Soil+FYM+Sand+Biocapsules) replicated three times with 10 seeds per replication. Growth medium significantly affected the growth, biomass, and root morphological indexes of papaya seedlings. The results reveal that the treatment M6 (Soil+Sand+Vermicompost+biocapsules) was the most suitable treatment over all the other treatments in relation to germination and growth parameters.

Comment [m2]: In the abstract, you should not rewrite the title

Keywords: Papaya, growing media, FYM, Vermicompost, Biocapsule, Neemcake

Comment [m3]: The keywords listed are no more than five words

INTRODUCTION:

Comment [m4]: No need to mark ":" and apply to the next sub-chapter

Papaya *(Carica papaya L.)* belongs to caricaceae family and its native place is Tropical America. It is an important fruit crop of tropical and sub-tropical countries of the world, covering 32 °N and 32 °S on the Globe mainly grown in America, Brazil, Columbia, Costa Rica, Hawaii, India, Mexico, Nigeria, Phillipines and Bangladesh. Papaya is called papaw or pawpaw, an ideal fruit for growing in kitchen gardens, backyards of homes as well as field, especially near the cities or big towns. It is also grown extensively as a filer plant in orchards. It is a quick growing typically single-stemmed, short lived, large, perennial herb, and starts bearing within 8-10 months of transplanting. It is one the most popular commercial fruit in India.

In India papaya is extensively grown throughout the country viz. Andhra Pradesh, Tamil Nadu, Assam, Bihar, Maharashtra, Gujarat, Haryana, M.P. etc. occupying an area of 132.18 thousand hectares with annual production of 5381.73 thousand tones. Whereas, it is grown on 0.40 thousand hectares with annual production of 13.2 thousand tones in Rajasthan **(Anonymous,2014).** Among the various varieries of papaya Pusa Dwarf, Taiwan, PusaDelecious, CO-1, CO-2, CO-3, CO-5, CO-6, Coorg Honey Dew, Pant C-1, Sunrise Solo, Red Lady have attained the commercial status throughout the country.

Comment [m5]: It is not recommended to use the cited library "Anonymous"

Papaya is a very wholesome, refreshing and delicious fruit and rich source of vitamins. Immature papya fruit is a rich source of papain, whereas mature fruit is rich source of carbohydrates(7.2%), minerals, Vitamin A (2020 IU/100g) and Vitamin C (85mg/100g) **(Gupta and Naik.,2007).** It has high medicinal value. Papain prepared from dried latex of its immature fruits is used in meat tenderizing, manufacture of chewing gum, cosmetics, degumming of natural silk and to give shrink resistance to wool. Papaya has an in vitro antiproliferative effect in liver cancer cells, possibly due to lycopene **(Asmah*et al.*, 2002).**Its fruits are consumed fresh as well as processed commercially into jam, jelly, nectar, squash, cheese, puree, etc. papaya is highly remunerative due to high yield potential and good filler fruit crop that provide extra income to the orchardist. By adopting proper management practices and selection of suitable varieties a gross income of Rs 1.90 lac can be obtained within a year of planting from papaya crop. **(Shukla *et al.*,2008)**

Papaya is a quick growing, continuous fruiting, evergreen plant and requires a good fertile soil or growing media for both growth, development and quality of fruits. The use of suitable growing media or substrates for sowing of seeds directly affects the germination, development and functional rooting system. A good growing medium provides sufficient anchorage or support to the plant, serves as reservoir for nutrients and water, allow oxygen diffusion to the roots and permit gaseous exchange between the root and atmosphere outside the root substratem. The quality of seedlings is very much influenced by growing media under nursery.The quality of seedlings obtained from a nursery influences re-establishment in the field and the eventual productivity of an orchard **(Baiyeri, 2006).**

Since papaya is commonly propagated by seeds, the various factors like type of potting media used, water, oxygen, temperature, light, plant species etc. are the most important for successful production of the crop. **(Hartman *et al*., 2001)**. The germination of papaya seeds was reported slow, erratic and incomplete **(Chako and singh,1966).**

Germination of papaya seed faces certain problems of seedling mortality due to damping off diseases in nursery stage. Initial mortality and improper germination is one of the major causes of reduced survival per cent of papaya plants. The development of root system is suppressed and plants are more susceptible to soil borne diseases in heavy soils without drainage **(Beattie and White, 1992).** The papaya seeds are endorsed within a gelatinous sarcotesta (aril or outer seed coat which is formed from the outer integument).Growing media are an integral part of most horticultural production systems. Generally, media for fruit crop seedlings are composed of soil and different organic matters. The soil is generally used as a basic medium because it is cheapest and easy to procure supplementing of the soil which is aimed to make media more porous while the organic matter (vermicompost, FYM, Neemcake) are added so as to enrich adequate nutrients for the seedlings. A growing medium is a substance though which roots grow to extract water and nutrients. The growing medium also plays an important role in seed germination not only it does act as a support, but also a source of key nutrients for plant growth. The composition of the medium influences the quality of the seedlings **(Wilson *et al*.,2001).**The important media used to raise nursery plants along with their charcters are Soil, vermicopost, FYM, neemcake, sand, biocapsules are included in the present study. Soil having good texture should be preferred for using a propagation media.

Comment [m6]: FYM should be written in full first, and henceforth can use abbreviations

Sand is used as a rooting media for adding the coarse texture needed to induce proper drainage and aeration. Sand is the heaviest of all the rooting media. Therefore it should be a combination with some other organic material.

Farmyard Manure (FYM)is primarily made from cow dung, cow urine, waste grass, and other dairy waste. Properties of FYM are, FYM is nutrient-rich. A small portion of N is available directly to the plants, while a greater portion is made available when FYM decomposes.Farmyard manure has been the main source of organic matter forthe supply of essential minerals needed by the plants. Heavy applications of organicmatter are required for successful production of fruits and vegetables **(Chaudhary, 1996)**.

Neem Cake is the de-oiled residue that can be used after Neem kernels are crushed for their oil. In this seed kernel are nutrients like NPK (nitrogen-phosphorus-potassium). These nutrients are nematicidal in nature so the seed cake ends up with these properties. Neem Cake is used in agriculture, horticulture, floriculture and the turf industry as an organic fertilizer as well as a natural nematicide. Neem Cake is used as an organic fertilizer because of the various micro and macro nutrients which it is composed of. It will control, at the same time, soil based pathogens as well as nematodes. It will also inhibit nitrification of the soil plus enhance the efficiency of nitrogen providing fertilizer.

Comment [m7]: The recommended way of writing the abbreviation is nitrogen-phosphorus-potassium (NPK)

Vermicompost refers to a mixture of worm casting, organic material, humus, living earthworms their cocoons and other organisms. Earthworm reduces C:N ratio, increases humic acid content, cation exchange capacity and water soluble carbohydrates **(Talashilkar*et al.*, 1999)**. Vermicompost is a rich source of nutrients with good water holding capacity.

Biocapsules is a revolutionary technology that ensures the successful delivery of biologically competent beneficial microbes.Biocapsule, a biofertiliser technology developed by - Indian Institute of Spices Research, has started gaining acceptance among the farming community.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.

Comment [m8]: The recommended way of writing abbreviations is the Indian Council of Agricultural Research (ICAR)

- It is being called the **one-gram capsule, which have many advantages**:
    - One-gram capsules are very efficient as it contains the microbial population equivalent to what is present in a one-kg pack of powder-based biofertilizer or a one-litre bottle.
    - Also, as these microbial strains are retained in the dormant stage, there is no issue of their viable loss in room temperatures as is the case with many liquid-based bio formulations.

Unique Benefitsofbiocapsule:

- Each capsule contain 10^9 propagule.
- Enhance seed germination & suppress diseases.
- Low cost, ecologically safe micro for all agriculture and horticulture crop.
- Promote crop growth & increase in yield.
- Long lasting viability up to 2 yrs.
- Easy to use & handling (Drench, seed treatment & use in compost)

Materials and methods:

Comment [m9]: The research methodology chapter should be added above the materials and methods

The experiment entitledwas carried out at Department Nursery and Horticulture Research Farm ,Naini Agriculture Institute, SHUATS, Prayagraj, Uttar Pradesh during the month of March-June 2022. There were nine treatment combination including control viz, M0 Control (Garden soil), M1(Soil + FYM), M2 (Soil + FYM + biocapsules), M3 (Soil + FYM + Neemcake), M4 (Soil + FYM + Neemcake + biocapsules), M5 (Soil + FYM + Vermicompost), M6 (Soil + Sand + Vermicompost + biocapsules), M7 (Soil + FYM + Sand) M8 (Soil + FYM + Sand + Biocapsules) replicated three times with 10 seeds per replication. Seeds were sown in the month of march. The polybags were irrigated after sowing and repeated everyday until emergence and in alternate days after germination.

Experimental design and measured parameters:

The experiment was carried out in a complete random block design with 30 polybags per treatment. All the germination and growth parameters were recorded at the time of germination till transplanting (60 days after sowing).
The days taken for first seed germination were calculated from the date of sowing up to germination of the first seedling. Germination per cent was calculated as the number of seeds sown and the number of seeds germinated, expressed in percentage.

Comment [m10]: Include the reference that is the reference for the formula

$$\text{Germination percent} = \frac{\text{No of seeds germinated}}{\text{Total no. of seeds sown}} \times 100$$

Height of the seedling was recorded by measuring the height of five random seedlings by metric scale from the base to the tip of the shoot of the seedling. The numbers of leaves of five seedlings were counted and average value was calculated. The stem girth of seedlings were measured with the help of vernier caliper at height 1cm above ground level. The fresh weight of seedlings was weighed on digital weighing balance expressed in gram. The primary root of seedlings were measured by metric scale from the base of the shoot to tip of root at the time of transplanting. The Root: Shoot ratio was calculated by dividing dry weight of roots by dry weight of shoots of seedlings at the time of transplanting. The chlorophyll content of the leave of the plant was measured using a SPAD (Soil Plant Analysis Development) meter. Survival percentage of papaya seedlings was observed by transplanting them in the field and was calculated using the formula:

Comment [m11]: The recommended abbreviation writing is Soil Plant Analysis Development (SPAD)

$$\text{Survival percentage} = \frac{\text{Total number of surviving seedlings}}{\text{Total number of seedlings transplanted}} \times 100$$

Results and discussion:

The results shows that growing media and biocapsule had beneficial effects on germination, seedling growth and survival percentage of papaya.

Seed germination parameters:

Effects of growing media and biocapsules on seed germinationparameters are given in table 1. The treatment T6 was found best followed by treatment T2 regarding germination parameters as it had the best water holding capacity, porosity and nutrients which would have enhanced the availability of water, aeration and nutrition during germination of seed. Germination started at 11.3 days after

Comment [m12]: It's better to write a subscript (T_6) and apply for the next sowing on Soil +FYM + Vermicompost (1:1:1) + Biocapsule (T6). Similar findings were found in **Venkatesh*et al.*, (2009)** in Pitsal (*Pterocarpus marsipium*, **Abirami (2010)** in nutmeg, **Bhardwaj (2013)** in papaya, **Bhagat *et al.* (2013)** in rough lemon**, Kumar *et al.*, (2015)** in papaya, **Kaur (2017)** in mango stones and **Gawankar*et al.*, (2021)** in jackfruit. Maximum germination percent 96.67 was also found in T6.This might be because of the media containing organic manures possess organic acid within them. Therefore, more available moisture and some acids may have helped in better germination percentage. Biocapsules also provide microbes that are beneficial to plants. Among the microbes, rhizobacteria, which functions as plant growth promoting rhizobacteria (PGPR) such as Pseudomonas spp. and Bacillus sp., can serve as fertilizer. These organisms have proven to accelerate germination and improve overall growth of the plant.Similar findings were found in **Abirami (2010)** in nutmeg, **Dayeswari*et al.*, (2017)** in papaya, **Chiranjeevi *et al.*, (2018)** in aonla, **Kumararvind*et al.*, (2020)** in papaya, **Irsa*et al*., (2021)** in marigold.

Comment [m13]: What is the germination rate of each study that you use as a comparison?

Comment [m14]: What are the results obtained in each of these studies so that you use them as a comparison for the research you are doing?

Table 1:Effects of different growing media and biocapsule on germination parameters of papaya plant.

Treatments	Initiation period	Germination percent %
T0	18.8	56.67
T1	18.4	63.33
T2	11.6	93.33
T3	15.6	73.33
T4	13.8	83.33
T5	12.7	86.67
T6	11.3	96.67
T7	16.23	66.67
T8	15.4	80.00
C.D.(P=0.05)	0.68	17.90
C.V	2.64	13.30

Comment [m15]: It's better to write a subscript (T_0) and apply for the next

Seedling growth parameters:

Growth increase in papaya seedling significantly affected by growing media and biocapsule is presented in the data in table 2 and 3. Highest seedling height (23.41 cm) was recorded in T6. Maximum number of leaves (10.8) was recorded in T6 which was at par with T2 (10.2). Soil, vermicompost, FYM provides adequate nutrients and enhances both the physical and biological properties and the water holding capacity of soil while iocapsule provide PGPR (plant growth-promoting rhizobacteria) which results in acceleration of plant growth and protection against plant pathogens.Similar findings were found in **R.M. Atiyeh *et al.*,(2004)** in tomato, **Annapurna *et al.*, (2005)** in Santalum album L, **Asciutto*et al.*, (2006)** in Impatiens wallerana, **Samir *et al.*, (2016)** in Khirni, **Dayeswari*et al.*, (2017)** in papaya, **Kumar *et al* ., (2018)** in Albizia lebbeck

Comment [m16]: What are the results obtained in each of these studies so that you use them as a comparison for the research you are doing?

Maximum stem girth (7.09mm), longest root length (12.83cm), highest seedling vigour (3503.33), highest chlorophyll content (38.37 µmol per m²) and highest fresh weight of seedling (14.74 g) were recorded in treatment T6.This might be due to vermicopost which contains plant growth regulations like auxis, gibberllins and cytokinins which are responsible for increase in plant growth and biocapsule which provide PGPR (plant growth-promoting rhizobacteria) which results in acceleration of plant growth.Similar findings were found in **Prabha *et al.*, (2007)** in banana, **Bachman and Metzger (2008)** in tomato, **Parasana*et al.*, (2012)** in mango, **Chiranjeevi *et al.*, (2018)** in aonla.

Comment [m17]: What are the results obtained in each of these studies so that you use them as a comparison for the research you are doing?

Similarly highest fresh weight of shoot (10.56 g) and root(4.29 g), highest dry weight of shoot (4.02) and root (0.73), highest total biomass (4.73 g) was recorded in treatment T6. The highest root:shoot ratio (0.18) was recorded in treatment T6 and T2. This maybe attributed to general improvement in the physical and chemical properties of the rooting media which improved the fresh and dry weight of the seedling.Similar findings were found in **Annapurna *et al.*, (2005)** in *Santalum album*, **Asciutto*et al.*, (2006)** in Impatiens wallerana.

Comment [m18]: What are the results obtained in each of these studies so that you use them as a comparison for the research you are doing?

The maximum survival percentage (82.67) was recorded with treatment M6, followed by M2 (81.33) while minimum was observed under M0(control) (58.67). Better survival percentage might be due to the reason that the media combination was helpful in reducing damping off diseases in seedling due to preparation in root zone. Good physical and biological conditions in FYM and vermicompost along with biocapsules had positive effect on root and shoot growth which helps in better survival.Similar findings were found in **Bhardwaj (2013)** in papaya, **Ritesh*et al.*,** (2016) in papaya, **Chiranjeevi *et al.*, (2018)** in aonla, **Irsa*et al.*, (2021)** in marigold.

Comment [m19]: What are the results obtained in each of these studies so that you use them as a comparison for the research you are doing?

Table 2: Effects of different growing media and biocapsule on growth of papaya seedlings.

Treatments	Seedling height (cm)	No. of leaves	Stem girth (cm)	Root length(cm)	Seedling vigour index	Chlorophyll content(µmol per m²)	Fresh weight of seedling (g)
T0	11.71	5.7	5.21	6.35	1023.8	29.24	4.24
T1	11.93	6.2	5.40	7.88	1255.33	31.41	4.71
T2	22.05	10.2	6.15	12.73	3338.6	37.88	14.18
T3	19.23	8.8	5.72	10.06	2149.57	30.34	9.72

T4	21.09	9.4	6.21	12.38	2789.67	33.05	13.58
T5	22.19	10.03	6.44	12.52	3007.60	34.16	13.77
T6	23.41	10.8	7.09	12.83	3503.33	38.37	14.74
T7	12.93	7.8	5.57	8.871	1454.43	30.23	8.95
T8	19.81	9.2	6.06	10.75	2445.20	33.77	13.75
C.D.(P=0.05)	0.30	0.18	0.31	1.36	669.35	8.77	0.33
C.V	0.94	1.21	3.04	13.30	12.05	5.04	1.80

Table 3: Effects of different growing media and biocapsule on biomass production and survival per cent of papaya plant.

Treatments	**Fresh weight of shoot (g)**	**Fresh weight of root(g)**	**Dry weight of shoot (g)**	**Dry weight of root(g)**	**Root:Shoot ratio**	**Total biomass (g)**	**Survival percentage%**
T0	3.1	1.32	0.8	0.21	0.24	1.03	58.67
T1	3.42	1.29	1.6	0.26	0.17	1.86	61.33
T2	10.04	4.09	3.88	0.72	0.18	4.6	81.33
T3	7.69	2.48	2.4	0.32	0.12	2.8	69.33
T4	9.62	3.61	3.26	0.46	0.14	3.72	74.7
T5	10.03	3.78	3.60	0.52	0.14	4.11	77.33
T6	10.56	4.29	4.02	0.73	0.18	4.73	82.67
T7	6.59	2.24	2.11	0.26	0.13	2.36	65.33
T8	7.72	3.13	2.84	0.36	0.12	3.2	69.33
C.D.(P=0.05)	0.51	0.25	0.23	0.06	0.04	0.21	10.29
C.V	3.87	4.96	4.77	8.34	15.61	3.79	8.36

Conclusion:

On the basis of present investigation, it is concluded that the treatment M6 (Soil+FYM+Vermicompost+Biocapsule) was found to be the most suitable over all the other treatments in relation to germination and seedling growth parameters (seedling height, no. of leaves, stem girth, fresh and dry weight of seedling) of Papaya.

The treatment M6 (Soil+FYM+Vermicompost+Biocapsule) also recorded the maximum survival percentage after transplanting.

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Comment [m20]: Writing of list reference should be according to scientific rules and what kind of specify methods that used such (Harvard method, Vancouver method, or American Psychology Association method (APA))

Comment [m21]: Citiated reference should be use the latest journal at least 5 years (minimum 80%) and not recommend to using old reference such in 1979, 1992, 1996,1999