The Pharma Innovation Journal 2022; 11(1): 463-467

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(1): 463-467

www.thepharmajournal.com
Received: 18-12-2021
Accepted: 28-01-2022

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Effect of potting media on vigour of seedlings for grafting in chilli (*Capsicum annum* L.): A review

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Abstract
The literature on effect of potting media on vigour of seedlings for grafting in chilli (*Capsicum annum* L.) has been well documented in this article, efforts have been made to review the literature available on Days required for germination, Shoot observations of rootstock and scion seedlings, Root observations of rootstock and scion seedlings, Fresh weight and Dry weight of rootstock and scion seedlings, Growth rate observations, Number of days required for Rootstock and Scion seedling for Graftable stage and Graftable seedling percentage of Rootstock and Scion seedlings (%).

Keywords: Chilli, germination, potting media, grafting, rootstock, scion

Introduction
Chilli (*Capsicum annum* L.) is one of the important commercial vegetable crop in India as well as important spice and condiment crop all over the world. It belongs to the family Solanaceae and the chromosome number of chilli is 2n=2x=24. Growing media affects the growth of vegetable seedlings, it provides the mechanical support water and mineral nutrients for growth and development of vegetable seedlings. Microorganisms are either beneficial or harmful to eliminate soil borne pathogens and weed, it is essential to sterilize media.
To eliminate soil-borne pathogens and weed to obtain healthy growth of seedling, it is essential to sterilize the soilless media. The adoption method of the sterilization depends on the quantity of media and availability of the material used for sterilization. For seedlings production and creation of physical union by physical manipulation there is requirement of quality scion and rootstocks seedling to make easy and successful grafting. To tackle most of biotic and abiotic stresses, grafting in chilli can be the effective solution. Awareness regarding vegetable grafts of solanaceous crop is increasing in farmers from Konkan region for avoiding the soil born-diseases, nematodes, sucking pest and viruses of various vegetables.

Days required for germination
Demir *et al.* (2010) [7] noticed that, 60% turf + 40% zeolite media has highest germination ratio with percentage of 86.35% followed by 80% turf + 20% perlite (83.85%) and lowest in 100% turf (79.93%) in hot pepper. Muhammad *et al.* (2016) [17] showed that in tomato minimum days (15.33) required for seed germination in media containing peat, compost and traditional practicing media in 1:1:1 proportion whereas, maximum days (23.67) in traditional growing media *i.e.* (soil, sand and FYM in 1:1:1 ratio).
Mathowa *et al*. (2017) [16] recorded in sweet pepper seedlings, the emergence of seedlings from hygromix and germination mix was significantly higher than cocopeat in the first 15 days whereas non-significant results where observed from 16 to 20 DAS in all treatments.
Vivek and Duraisamy (2017) [30] studied the tomato seedling germination percentage after 4 days of sowing in protray with different growing media and noticed that the maximum germination% was found (99%) with coir pith media. whereas, minimum germination% was recorded (87%) in vermicomposting.
Radha *et al*. (2018) [23] reported that the maximum seed germination of chilli 30 DAS was recorded in 75% raw coir dust + 25% rice husk (96.87%) followed by media 90% raw coir dust + 10% rice husk (95.83%), 90% raw coir dust + 10% saw dust (94.27%), 75% raw coir dust + 25% saw dust and rice husk (79.68%), 90% raw coir dust + 10% saw dust and rice husk (78.12%). Bantis *et al*. (2019) [4] recorded the seed germination of watermelon and squash after 72 and 48 hrs, respectively, when sown in plug tray for grafting in cocopeat.

Bhardwaj *et al*. (2019) reported that in brinjal the best seed germination per cent was observed in cocopeat media followed by vermicompost and soil after 10 days of sowing.
Uttekar (2021) [29] noticed that less number of days was required in potting media M_2 – Cocopeat @ 75% + Vermicompost @ 25% (8.00) which was at par with M_1 – Cocopeat @ 100% (8.67) while, more number of days was required for germination in M_4 – Cocopeat @ 75% + Saw dust @ 25% (9.33).

Biometric observations

Shoot observations of rootstock and scion seedlings

Markovic *et al*. (1995) [15] reported that the maximum number of leaves (5.5) in sweet pepper seedling were recorded in media Peat + zeolplant (2:1) and lower (3.6) in the media peat.
Adediran (2005) [1] studied the growth of tomato and lettuce seedlings in soilless media and the highest seedling height (10.8 cm) was recorded in hygromix media whereas, lowest seedling height (4.35 cm) in cabbage waste media while cow dung and poultry manure media recorded the seedling height of 8.25 cm and 8.35 cm, respectively.
Rivard and Louws (2006) opined that the method of hole grafting can be used for grafting in tomato on eggplant, melon or cucumber so that the scion diameter is less than the diameter of the rootstock used for grafting.
Palada and Wu (2008) [22] observed in sweet peppers that the seedling with 1.6 – 1.8 mm stem diameter of scion and rootstock were suitable for grafting. In sweet peppers for grafting in the hot-wet season seedling required 2-3 true leaves.
Demir *et al*. (2010) [7] recorded that the highest values of seedling height in 50% turf + 25% zeolite + 25% perlite (6.60 cm) followed by 80% turf + 20% perlite (6.11 cm) whereas shortest seedling height in 100% perlite (2.55 cm) at 35 day after sowing in pepper. Highest values for stem diameter of pepper seedlings were recorded in 60% turf + 40% zeolite and 50% turf + 25% zeolite + 25% perlite (0.22 mm) followed by 80% turf + 20% zeolite (0.21 mm) and 100% turf (0.21 mm) however, lowest diameter was recorded in 100% perlite (0.12 mm) at 35 days after sowing. Maximum number of leaves in pepper seedlings was recorded in 60% turf + 40% zeolite (6.53/plant), 50% turf + 25% zeolite + 25% perlite (6.35/plant), 80% turf + 20% zeolite (5.95/plant) and 100% turf (5.78/Plant) and lowest in 100% perlite at transplanting stage after 45 days after germination.
Khah (2011) [12] reported that aubergine seedlings were grafted by hand applying the splice grafting method when number of real leaves developed on scion and rootstock were 2 and 2.5-3, respectively. Rahimi *et al*. (2013) [24] reported in sweet pepper that height of transplant 6.5 cm in field soil, peat moss (9.1 cm), peat moss + sand (8.5 cm), cocopeat (6.7 cm), cocopeat + sand (6.8 cm), field soil + sand (6.3 cm), cocopeat (5.2 cm,), caca peat + sand (5.6 cm), sand (6.3 cm) at transplanting stage. Diameter of seedlings at transplant was recorded in field soil (1.4 mm), peat moss (2.1 mm), peat moss + sand (1.8 mm), cocopeat (1.5 mm), cocopeat + sand (1.6 mm), field soil + sand (1.4 mm), cocopeat (1.2 mm), caca peat + sand (1.3 mm), sand (1.5 mm).
Unal *et al*. (2013) [28] noticed the highest seedling height (8.78 cm) in peat: stable manure (2:2) whereas lowest height (1.50 cm) was recorded in Peat: Zeolite (2:2) in pepper seedling. In tomato seedling highest seedling height (16.50 cm) was recorded in peat and lowest seedling height (5.30 cm) in Peat: Stable manure: perlite: Zeolite (2:1:1:5g/kg).
Kumar *et al*. (2015) [13] observed that grafting was done when the rootstock ans scion seedlings attained 4-5 leaf stage and 4 leaf stage respectively.
Muhammad *et al*. (2016) [17] reported that in tomato the highest seedling height (35 cm) was recorded in peat, compost and traditional practicing media in proportional in 1:1:1 and lowest (19 cm) in traditional growing media i.e. (soil, sand and FYM in 1:1:1 ratio).
Mathowa *et al*. (2017) [16] showed that there were non-significant effect of growing medium for three weeks. The significant effect on seedling height was recorded after 4 week of sowing and seedling grown in hygromix attain maximum height (130.27 mm) followed by germination mix (99.83 mm) and cocopeat (90 mm). Number of leaves recorded were 4.29 and 4.32 in hygromix and germination mix respectively which was significantly higher than those in cocopeat (3.35) at 4th week of sowing of sweet pepper.
Vivek and Duraisamy (2017) [30] noticed that, the tomato seedlings produced maximum shoot length (89.3 mm) in coir pith at 30 DAS whereas, minimum shoot length (82.9 mm) was recorded in vermicompost at 30 DAS. In 30 days old seedlings of tomato, highest stem diameter was recorded in vermicompost (1.77 mm) and minimum stem diameter (1.08 mm) was in coir pith. Whereas highest number of leaves (4) was recorded in coir pith and minimum leaves found in vermicompost (2). Ziest (2017) [31] reported that, grafting was done 24 days after emergence of scion seedling when seedling had 3-4 leaves in tomato.
Razzak *et al*. (2018) [26] reported that, highest height of tomato (30.9 cm), hot pepper (24.5 cm), cucumber (34 cm) and summer squash (40 cm) seedlings in peat containing 5% tomato waste compost whereas, height of tomato (28.4 cm), hot pepper (24.1 cm), cucumber (29 cm) and summer squash (36 cm) in 100% peat. Maximum diameter of tomato (3.26 mm), hot pepper (1.91 mm), cucumber (3.53 mm) and summer squash (3.50 mm) seedlings was reported in 5% tomato waste compost than 0% tomato waste compost in peat. Non-significant effect of media on number of leaves was recorded in tomato, hot pepper, cucumber and summer squash seedlings and maximum in 5% tomato waste compost.
Nirmal *et al*. (2019) [21] reported that the highest plant spread of chilli seedlings were observed in U shaped tunnel covered with 25% shade net (21.77 cm), while that of the lowest plant spread (12.37 cm) was recorded in U shaped tunnels covered with low density polyethylene paper. Nagma Surve (2019) [19] recorded that in brinjal, girth of rootstock ranged from 1.46 to 3.15 mm and scion 1.65 to 3.15 mm up to the 30 DAS in cocopeat: vermicompost (3:1). Number of leaves on scion ranged from 4.67 to 9.53 and on rootstock 4.33 to 6.87 upto 30 DAS in cocopeat + vermicompost (3:1).
Rayker (2020) [25] noticed that in brinjal, girth of rootstock was in the range of 1.02 mm to 1.43 mm and the scion 1.11 mm to 1.21 mm 30 days after sowing in cocopeat + vermicompost (3:1). Number of leaves on rootstock was in range from 3.10 to 3.43 and on scion 3.07 to 3.37 30 days after sowing in cocopeat + vermicompost (3:1).
Uttekar (2021) [29] reported that 49 days after sowing significantly highest diameter at collar region observed in M_2 – Cocopeat @ 75% + Vermicompost @ 25% (1.70 mm) whereas, lowest diameter at collar region (1.19 mm) noticed in M_1 – Cocopeat @ 100%.

Root observations of rootstock and scion seedlings

Rahimi *et al*. (2013) [24] recorded the adventitious root number 15 in field soil, peat moss (40.8), peat moss + sand (28.8), cocopeat (15.2), cocopeat + sand (14), field soil + sand (11.8), cocopeat (10), caca peat + sand (12.2), sand (17) at transplanting stage in sweet pepper.

Unal *et al*. (2013) [28] recorded the highest root length (7.95 cm) in Peat: stable manure (2:2) and lower (1.40 cm) in Peat: Zeolite (2:2) in pepper seedlings while in tomato seedling recorded the highest root length (13.87 cm) in peat: stable manure: perlite (2:1:1) and lowest (3.30 cm) in peat: stable manure: perlite: zeolite (2:1:1:5g/kg).

Vivek and Duraisamy (2017) [30] stated that tomato seedlings grown in different media recorded highest root length (37.9 mm) in coir pith whereas minimum was recorded (34 mm) in vermicompost 30 days after sowing. Razzak *et al*. (2018) [26] reported maximum length of root of seedlings in 5% tomato waste compost i.e. tomato (12.8 cm), hot pepper (10.53 cm), cucumber (11.40 cm) and summer squash (14.1 cm) whereas in peat media tomato (9.40 cm), hot pepper (7.00 cm), cucumber (8.34 cm) and summer squash (8.83 cm). Uttekar (2021) [29] reported that maximum length of tap root was recorded in M_2 – Cocopeat @ 75% + Vermicompost @ 25% (6.01 cm) while, minimum length of tap root observed in M_1 – Cocopeat @ 100% (4.60 cm) at 49 DAG.

Fresh weight and Dry weight of rootstock and scion seedlings

Markovic *et al*. (1995) [15] stated that in pepper and tomato, maximum fresh weight of sweet pepper seedling (2.5 gm) was noted in media peat + zeolplant (2:1) followed by compost + zeoplant (2:1) (1.4gm), compost (0.5gm) while lower (0.4gm) in peat. Maximum dry matter of sweet pepper seedling (16.5%) was reported in peat + zeolplant (2:1) and lowest (11.8%) in compost. Atiyeh *et al*. (2000a) [2] observed that the higher shoot dry weight of greenhouse tomato (*Lycopersicon esculentum*) was observed in media metro-mix 360 substituted with 40% vermicompost as compared to metro-mix 360 alone (control) and MM360 substituted with other concentrations of vermicompost (0–100%).

Dasgan and Abak (2003) [6] reported the increase of plant biomass with vermicompost, cocopeat and FYM based growing media and wider plant spacing in pepper.

Adediran (2005) [1] reported that, highest fresh weight 1.75 gm was recorded in hygromix and lowest fresh weight (1.20 gm.) was recorded in cabbage waste while in poultry manure (1.33 gm) and cow dung (1.20 gm) observed in tomato and lettuce. Highest dry weight (275.5 mg) was recorded in cow dung and lowest (190.5 mg) in cabbage waste while in poultry manure (195.5 mg) and pig dung (215.5 mg) observed.

Nadia *et al*. (2007) recorded that the fresh weight of seedlings was higher (2.37 gm) in media containing rice straw + banana waste + poultry manure + tea compost while lower (1.96 gm) in the control (peat moss) in tomato. Dry weight of seedling recorded higher (223.45 mg) in the media containing rice straw + banana waste + poultry manure + tea compost while, lower (164.88 mg) in the control peat moss at 45 days after sowing. Demir *et al*. (2010) [7] revealed that in pepper, the highest fresh weight (0.906 gm) was measured in 60% turf + 40% perlite, 50% turf + 25% zeolite + 25% perlite, 80% turf + 20% zeolite and 100% turf media and lowest in 100% perlite media (0.137 gm.).

Rahimi *et al*. (2013) [24] recorded the fresh weight of seedling 0.12 gm in field soil, 0.34 gm in peat moss, 0.25 gm in peat moss + sand, 0.12 gm in cocopeat, 0.17 gm in cocopeat + sand, 0.10 gm in field soil + sand, 0.07 gm in cocopeat, 0.39 gm in caca peat + sand and 0.14 gm in sand at transplanting stage in sweet pepper. Dry weight was recorded in field soil (0.02 gm), peat moss (0.05 gm), peat moss + sand (0.03 gm), cocopeat (0.02 gm), cocopeat + sand (0.02 gm), field soil + sand (0.01 gm), cocopeat (0.00 gm), caca peat + sand (0.00 gm.), sand (0.02 gm.) at transplanting stage in sweet pepper.

Kandemir (2013) [11] noticed that the highest leaf weight ratio and root weight ratio was measured 0.56 gm and 0.15 gm in cucumber seedlings, respectively.

Mathowa *et al*. (2017) [16] recorded that in sweetpepper seedling, significantly higher fresh weight was recorded in hygromix (0.63 gm) than germination mixes (0.57 gm) whereas cocopeat does not support any seedling growth. Dry weight was reported 0.48 gm in hygromix and 0.46 gm in germination mix at 4 week of sowing.

Bantis *et al*. (2020) [3] divided the watermelon scion seedling and squash rootstock seedling as low, optimum and high quality seedling and recorded dry weight 0.07, 0.08, 0.09 gm. and 0.017, 0.018, 0.019 g of watermelon scion seedling and squash rootstock seedlings, respectively.

Growth rate observations

Nirmal *et al.* (2019) [21] reported that, highest absolute growth rate of chilli seedlings were observed in U shaped tunnel covered with 25% shade net (1.955 cm.day^{-1}) while that of the lowest absolute growth rate (0.964 cm.day^{-1}) was recorded in U shaped tunnel without coverings (control). Highest relative growth rate of chilli seedlings were found in U shaped tunnel covered with 25% shade net (0.041 cm. cm-1day^{-1}) while the lowest was in treatment U shaped tunnel covered with gunny bags (0.021 cm cm^{-1}day^{-1}).

Uttekar (2021) [29] reported that in potting media M_2 – Cocopeat @ 75% + Vermicompost @ 25% maximum AGR was recorded between 42-49 DAG (0.38 cm/day) whereas, the smaller AGR was recorded in M_3 – Cocopeat @ 75% + Rice husk @ 25% (0.28 cm/day).

Number of days required for Rootstock and Scion seedling for graftable stage

Palada and Wu (2008) [22] recorded that, in sweet peppers for production in the hot-wet season seedling required 35- 40 days for grafting.

Lee *et al*. (2010) reported that, grafting is performed in the case of tomato and aubergine, rootstock seeds are sown 5–10 days before sowing of scion seeds and grafting is performed 20–25 days after sowing the scion seeds. Johnson *et al*. (2011) [10] reported that, in brinjal and tomato seed both scion and rootstock are ready for grafting in 14–21 days. Eltayb *et al*. (2013) [8] reported that the splice grafting was followed when the tomato, brinjal and capsicum seedling became 3 weeks old. Nagma Surve (2019) [19] observed that the survival rate of graft at 30 DAG was higher (75.33%) when 25 days old scion grafted on 25 days old rootstock and lower (70.33%) when 30 days old scion grafted on 20 days old rootstock and 20 days old scion grafted on 30 days old rootstock.

Bantis *et al*. (2020) [3] reported that number of days required for grafting after sowing of watermelon scion seedling and squash rootstock seedling were 12, 13, 14 and 11, 12, 13 respectively and were categorized as low, optimum and high quality seedlings for grafting accordingly the low, optimum

and high quality seedling for grafting.

Rayker (2020) [25] revealed that the maximum percentage of survival of brinjal grafts at transplanting (82.25%) were recorded in treatment 25 days Manjiri scion grafted on 25 days Konkan prabha rootstock whereas, minimum (63.50%) when 25 days Bandhtiware local scion was grafted on 60 days *Solanum torvum* rootstock.

Graftable seedling percentage of Rootstock and Scion seedlings (%)

Radha *et al*. (2018) [23] reported that the survival rate of chilli at 30 days after sowing was higher in 90% raw coir dust + 10% saw dust (90.50%) followed by 90% raw coir dust + 10% rice husk (92%), 75% raw coir dust + 25% rice husk (93%), 90% raw coir dust + 10% saw dust and rice husk (75%), 75% raw coir dust + 25% saw dust and rice husk (76.50%).

Uttekar (2021) [29] reported that highest graftable seedling percentage was registered in M_2 – Cocopeat @ 75% + Vermicompost @ 25% (89.55%) with lowest M_1 – Cocopeat @ 100% (78.13%).

Pest and Disease Incidence

Gohler and Molitor (2002) [9] reported that, there is lesser infection of *Fusarium oxysporum f.* sp. *dianthi* at pH 7.5 than at 5.5. Cucumbers are faster infested by *Pythium* sp. at pH 5 than at the higher pH value of 6.

Borrero *et al*. (2004) [5] noticed that, there is 91% variation is attack of Fusarium wilt in tomato with media pH 6.26 to 7.97 and high beta-glucosidase.

Nelson (2012) [12] observed that, formalin is a widely used chemical for soil and compost disinfection. It is normally diluted with water 1:50–100, at a rate of 10 litres/m^2 for the control of bacteria and fungi.

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