



Effect of Different Media on Germination and Seedlings Performance of Chili Pepper (*Capsicum annum*)

P. D. Kaledzi¹, P. K. Tandoh^{1*} and S. Asana¹

¹*Department of Horticulture, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana.*

Authors' contributions

This work was carried out in collaboration among all authors. Author PDK designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors SA and PKT managed the analyses of the study. Author PKT managed the literature searches. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJPSS/2020/v32i830319

Editor(s):

(1) Prof. Marco Trevisan, Catholic University of the Sacred Heart, Italy.

Reviewers:

(1) Janie Mendes Jasmim, Universidade Estadual do Norte Fluminense, Brazil.

(2) Ahmed Ibrahim Jessim, Iraq.

Complete Peer review History: <http://www.sdiarticle4.com/review-history/58579>

Original Research Article

Received 25 April 2020

Accepted 02 July 2020

Published 16 July 2020

ABSTRACT

The production of vegetable seedlings is an important business for some farmers in most parts of the world with poor media being a major constraint. An experiment was conducted to investigate the effect of different media on germination and nursery performance of chili pepper at the Department of Horticulture, Kwame Nkrumah University of science and Technology (KNUST). A Randomized Complete Block design with six treatments and three replications was used in the study. Media treatments were used either alone or in combination and they were: topsoil only, rice hull ash only, rabbit waste only, topsoil and rice hull ash (1:1), topsoil and rabbit waste (1:1) and topsoil and river sand (1:1). There were significant differences in germination percentage, seedling height, number of leaves and stem girth as function of the media treatments. The different media however did not affect days to 50% germination significantly. Comparatively, the highest and the lowest germination percentages (77.50% and 62.00%) were obtained by nursing seeds in the mixture of topsoil and rice hull ash as well as rabbit waste only respectively. In terms of growth characteristics, plant height and number of leaves were highest in seedlings nursed in topsoil and rice hull ash mixture (18.36 cm and 13.23 cm) respectively at the end of the study period. The

*Corresponding author: E-mail: paulusnow@gmail.com;

highest stem girth was seedlings nursed in topsoil (3.129 mm) at the end of the experiment. Plants nursed in rabbit waste only had the lowest growth performance in terms of plant height (2.75 cm), number of leaves (4.50) and stem girth (1.27 mm) at the end of the experiment. Growth medium consisting of a mixture of proportion of topsoil and rice hull ash is therefore recommended for growing chili pepper seedlings since this combination improved both germination and subsequent growth as compared to the other media used in the experiment. Rice hull ash is not recommended to be used alone in raising chili pepper seedlings since it has a high pH which decreases seedling growth. Partially decomposed rabbit waste is also not suitable to be used as nursery medium because it retards seedling growth.

Keywords: *Cotyledon; emergence; sprouting; radical; vegetative; residue.*

1. INTRODUCTION

Chili pepper is among the most widely grown and consumed vegetables worldwide. It has many culinary advantages and contains chemicals such as steam-volatile oils, fatty oils, capsaicinoids, carotenoids, vitamins, protein, fiber and mineral elements [1]. Pepper is a vital commercial crop, cultivated for spice and value-added processed products [2]. It is an important constituent of diets, adding flavour, colour, vitamins A and C and pungency and is, therefore, indispensable to Ghana and world food industries. It can be used medically for the treatment of fevers, colds, indigestion, constipation and pain killing [3]. Peppers also provide good income to farmers who produce them. Major chilli pepper producing countries include China, Mexico, Turkey, which produce about 70% of the total worldwide production [4]. Ghana was ranked the 11th largest producer of pepper in the world and the 2nd largest producer in Africa with an estimated total production of 88,000 metric tons in 2011 accounting for \$96,397 [5].

Production of healthy and vigorous pepper seedlings is the key factor in successful commercial pepper production and yield of quality pepper fruits. Moreover, germination of the seed is a critical stage, because the rest of the plant life is directly dependent upon the rate of its germination [6]. Seed germination and seedling growth is affected by the type of medium used for sowing seeds [7]. However, top soils (which are the most widely used media) are generally unsatisfactory for the production of plants, especially for container grown plants. This is primarily because they do not provide the aeration, drainage and water holding capacity required [8]. Rice hull and rabbit waste are agricultural by-product which are poorly utilized. More than 100 million tons of rice hull is

generated annually in the world [9]. The collection and disposal of rice hull and rabbit waste is becoming more difficult and expensive, therefore left unused as waste or burned in the field [10]. For any planting activity to be successful, there is the need for a growing medium which forms the basis for farming. The use of suitable growing medium is very vital for the production of quality horticultural crops [11]. It directly affects the development and maintenance of the extensive functional rooting system [7]. A good growing medium must provide sufficient support to the plants, serves as a reservoir for nutrients and water, allow oxygen diffusion to the roots and gaseous exchange between the roots and atmosphere the outside the root substrate [12]. Rice hull ash is natural and cheap to obtain and is significantly used in increasing the pH of soils. It increases available phosphorous content, improves the aeration in crop root zone and also increases exchangeable potassium and magnesium [13]. These mineral elements enrich the soil and improve yield and quality of plants. Generally, ashes have finer texture that can improve soil structure and maintain high moisture around germinating seeds [14]. Rabbit waste is made up of sawdust as bedding, droppings and urine of rabbit. Sawdust enhances early germination of seeds and contains all the minor elements essential for plant growth [15]. According to Bell [16], animal dropping contain all essential plant nutrients and have been well documented as excellent fertilizers. Rabbit manure is higher in nitrogen, phosphorus and potassium and manure mixed with urine soaked bedding is very high in nitrogen [14]. It therefore becomes necessary to find out the most appropriate media for growing seedlings to enhance seed emergence, seedling growth, field establishment and yield of pepper plants. This study therefore investigated the effect of different media on the performance of chili pepper under nursery conditions.

2. MATERIALS AND METHODS

2.1 Location of Experiment

The experiment was carried out at the Department of Horticulture, Kwame Nkrumah University of Science and Technology, Kumasi, from January to March, 2018. The study area has two distinct rainfall patterns, the major rainfall season from March to July. The minor season rains start from September to November.

2.2 Sources of Materials

The rice hull ash was obtained from a mill at Ejisu in the Ashanti Region of Ghana. The rabbit waste was also obtained from a rabbit farmer at Ayigya, Kumasi. The Chili pepper seeds (Bird's eye variety) were obtained from the Crop Research Institute of Ghana.

2.3 Experimental Design, Procedure and Determination of Media Constituents

The experiment was laid out in a Randomized Complete Block design with four replicates and six treatments. The four replication of each treatment were allocated at random. The treatments were; Topsoil only (Control), Rice husk ash only, Rabbit waste only, Topsoil (50%) + Rice husk ash (50%), Topsoil (50%) +Rabbit waste (50%) and Topsoil (50%) + River sand (50%). Top soil was thoroughly sieved and sterilized. The rabbit waste was decomposed in a pit for a month. Samples of media were taken for analysis at the laboratory of the Department of Soil Science, KNUST. Media samples were analyzed for nitrogen, phosphorus, potassium, calcium and magnesium, pH, organic carbon and organic matter. Plastic bowls were used to nurse the seeds. The plastic bowls were first perforated at the bottom with a perforator to create five holes to facilitate drainage of excess water before filling with the respective media. For each treatment four plastic bowls were filled with each medium and hundred seeds sown per bowl. The bowls were then arranged on a platform under shade to prevent direct sunlight and rainfall. Watering was done daily with approximately equal amounts of water.

2.4 Data Collected

Emerged seedlings were counted daily until emergence ceased. Ten seedlings were randomly selected and tagged for physiological and morphological data measurements. The following were the data collected:

2.4.1 Emergence percentage

The total number of seedlings that emerged per treatment was counted three weeks after sowing and expressed as a percentage of the hundred seeds initially sown.

2.4.2 Days to 50% emergence

This was determined by recording the number of days taken for half the number of seeds in each treatment to germinate.

2.4.3 Plant height

Plant height was measured at weekly intervals, starting from the base of each seedling to the very terminal growth point using a ruler. The height was recorded for the seedlings and the mean determined by dividing the total heights by the number of seedlings.

2.4.4 Number of leaves

This was determined by singly counting the leaves of each sampled seedling per treatment. The total of all the seedlings was determined by adding up all the counts and the average number of leaves per treatment was calculated

2.4.5 Stem girth

A pair of vernier caliper was used to measure the stem girth. All the sampled seedlings per treatment were added up to obtain the total stem girth, and the average stem girth determined by dividing the total stem girth by the number of sampled seedlings.

2.5 Data Analysis

Data was subjected to analysis of variance (ANOVA) using Statistix Software version 10.0.

The differences between the means were compared using the Tukey's Honest Significant Differences (HSD) at 5%. Data transformation was done for the count data using square root transformation.

3. RESULTS

3.1 Laboratory Analysis of Media Samples

Table 1 shows the result for the laboratory analysis of the various media samples used in

the experiment. Rice hull ash had the highest pH value with 10.62. This means it was very basic.

Also mixture of topsoil and rice hull ash, mixture of topsoil and rabbit waste as well as rabbit waste only were also basic with pH values of 8.24, 8.35 and 8.63 respectively. However, topsoil only and topsoil and river sand mixture were nearly neutral with pH values of 6.89 and 7.23 respectively. The highest nitrogen content was detected in topsoil and rabbit waste mixture with a value of 0.14%. It again had the highest organic carbon content of 3.65% but had the lowest phosphorus content of 0.002%. Rice hull ash only had the lowest nitrogen and organic carbon contents of 0.07% and 0.32% but had the highest potassium content of 0.47%. Topsoil and rice hull ash mixture had the highest phosphorus content of 0.06%. However, it had the least value for potassium with 0.13%. The highest calcium content was recorded by topsoil and river sand mixture with 3.63% and the least by rabbit waste only with 1.65%. Topsoil only had the highest value for magnesium (0.32%). However, topsoil and rice hull ash mixture as well as rice hull ash only had the least value for magnesium with 0.09% each. Rabbit waste only had the highest organic matter content of 4.32% and the least value was attained by rice hull ash only with 0.55%.

3.2 Effects of Different Media on Germination % and Days to 50% Germination

There were significant differences among the various treatments: topsoil and rice hull ash mixture recorded the highest germination percentage (77.50%) of seeds sown whereas the seeds sown in rabbit waste only recorded the lowest germination percentage (62.00%). However, there were no significant differences in germination percentage among seeds sown in topsoil only and those in the mixture of topsoil and river sand and in rice hull ash only. There were no significant difference in Days to 50% germination among the various media treatments.

3.3 Effects of Different Media on Seedling Height of Chili Pepper

From Table 3, there were significant differences among the treatments for seedling height in all weeks. Mixture of topsoil and rice hull ash produced the tallest seedlings (4.14 cm, 8.21cm, 13.26cm and 18.36cm) whereas those in rabbit waste only recorded the shortest (2.23cm, 2.56cm, 2.86cm and 3.21cm) However, there were no significant differences among the treatments for seedling height in week 3 and 4.

Table 1. Chemical analysis of media samples

Medium type	Soil properties							
	pH	%N	%P	%K	% Ca	%Mg	%OC	%OM
Topsoil and rice hull ash	8.24	0.11	0.057	0.36	2.02	0.09	1.12	1.93
Topsoil only	6.89	0.11	0.003	0.16	2.45	0.32	1.24	2.13
Topsoil and river sand	6.97	0.09	0.012	0.13	3.63	0.27	0.96	0.90
Rice hull ash only	10.62	0.07	0.054	0.47	2.03	0.09	0.32	0.55
Topsoil and rabbit waste	8.35	0.14	0.002	0.20	2.63	0.32	3.65	3.52
Rabbit waste only	8.63	0.12	0.051	0.21	1.65	0.28	2.65	4.32

Table 2. Effect of different media on germination percentage and days to 50% germination of chili pepper

Media type	Germination %	Days to 50 % germination
Topsoil and rice hull ash	77.50a	11.00a
Topsoil only	73.25b	11.00a
Topsoil and river sand	72.75b	11.75a
Rice hull ash only	69.75b	11.00a
Topsoil and rabbit waste	62.50c	12.25a
Rabbit waste only	62.00c	12.50a
HSD (0.05)	4.14	2.03

**Means with the same letter(s) are not significantly different at P<0.05*

3.4 Effects of Different Media on Number of Leaves of Chili Pepper

There were significant differences among the treatments for number of leaves where topsoil and rice hull ash mixture obtained the highest number of leaves in all the weeks, thus 5.08 in week 3, 8.25 in week 4, 11.45 in week 5 and 13.23 in week 6. However, rabbit waste only had the least number of leaves in all the weeks with 3.25 in week 3, 3.70 in week 4, 3.95 in week 5 and 4.50 in week 6. There were no significant differences among topsoil and rice hull ash mixture, topsoil only and topsoil and river sand mixture in week 3, week 5 and week 6. There were also no significant difference between topsoil and rabbit waste mixture and rabbit waste only in all the weeks. Again, there were no significant differences among rice hull ash only,

topsoil and rabbit waste mixture and rabbit waste only in the final week 6.

3.5 Effects of Different Media on Stem Girth of Chili Pepper

There were significant differences among the treatments in all the weeks where topsoil and rice hull ash mixture had the highest stem girth in week 3 (1.17 mm), week 4 (2.17 mm) and week 5 (2.49 mm). However, topsoil only obtained the highest stem girth in week 6 with 3.13 mm. In week 3 and 4, there was no significant difference between topsoil only and topsoil and river sand mixture. Moreover, there were also no significant differences among rice hull ash only, topsoil and rabbit waste mixture and rabbit waste only in week all the weeks.

Table 3. Effects of different media on seedling height (cm) of chili pepper

Media type	Weeks after sowing (WAS)			
	Week 3	Week 4	Week 5	Week 6
Topsoil and rice hull ash	4.14a	8.21a	13.256a	18.36a
Topsoil only	3.73a	7.31a	13.025ab	17.01ab
Topsoil and river sand	3.70a	7.02a	11.80b	15.46b
Rice hull ash only	2.64b	3.27b	3.998c	4.72c
Topsoil and rabbit waste	2.23bc	2.56b	2.856cd	3.21c
Rabbit waste only	2.02c	2.42b	2.60d	2.75c
HSD (0.05)	0.59	1.34	1.34	2.84

*Means with the same letter(s) within each week are not significantly different at $P < 0.05$

Table 4. Effect of different media on number of leaves of chili pepper

Media type	Weeks after sowing (WAS)			
	Week 3	Week 4	Week 5	Week 6
Topsoil and rice hull ash	5.08a	8.25a	11.45a	13.23a
Topsoil only	4.73a	7.53b	10.58a	11.83a
Topsoil and river sand	4.72a	7.73ab	10.03a	13.08a
Rice hull ash only	4.15b	5.40c	5.93b	6.70b
Topsoil and rabbit waste	3.50c	3.95d	4.18c	5.00b
Rabbit waste only	3.25c	3.70d	3.95c	4.50b
HSD (0.05)	0.49	0.56	1.61	2.20

*Means with the same letter(s) within each week are not significantly different at $P < 0.05$

Table 5. Effects of different media on stem girth (mm) in chili pepper

Medium type	Weeks after sowing (WAS)			
	Week 3	Week 4	Week 5	Week 6
Topsoil and rice hull ash	1.17a	2.1735a	2.4920a	2.9542ab
Topsoil only	1.10ab	1.8417b	2.3530ab	3.1293a
Topsoil and river sand	1.04ab	1.8350b	2.1795b	2.6065b
Rice hull ash only	0.86b	1.0852c	1.4323c	1.4858c
Topsoil and rabbit waste	0.90b	1.3462c	1.1585c	1.2425c
Rabbit waste only	0.88b	1.0965c	1.2268c	1.2685c
HSD(0.05)	0.25	0.32	0.31	0.43

*Means with the same letter(s) within each week are not significantly different at $P < 0$

4. DISCUSSION

4.1 Effect of Different Media on Germination Percentage

Germination percentage of chili pepper seeds was affected by the media type significantly. Topsoil and rice hull ash mixture caused the highest germination% (77.50%), followed by topsoil only (73.25%), topsoil plus river sand (72.75%), rice hull ash only (69.75%), topsoil and rabbit waste (62.50%) and rabbit waste, which had the lowest germination (62.00%). Best performance of topsoil and rice hull ash mixture in terms of germination percentage could be attributed to its medium texture. Growing media with medium texture as that of loamy soils are well drained, well aerated and have good water holding capacity which are prerequisite for germination of seeds [17]. The observed better performance of topsoil only may be due to its high organic matter content which increases the water holding capacity and improves soil structure, water absorption and maintain the cell turgidity and thus increased respiration at optimum level, leading to favorable seed sprouting. Topsoil and river sand mixture as well as rice hull ash only also had good texture which might have contributed to their better performance in terms of germination percentage. The poor performance of seeds sown in topsoil and rabbit waste mixture could probably be

attributed to the compact nature of the mixture. The compactness of the mixture resulted in poor drainage and aeration which might have affected germination percentage negatively. The reason for the lowest germination percentage of seeds sown in rabbit waste only was probably that, it had coarser texture which did not retain moisture well enough around the germinating seed.

4.2 Effect of Different Media on Plant Height, Number of Leaves and Stem Girth

There were significant differences in plant height, number of leaves as well as stem girth in the seedlings as affected by the different media treatments. Topsoil and rice hull ash mixture recorded the best growth performance in terms of plant height, number of leaves and stem girth. The highest performance of topsoil and rice husk ash mixture on plant height, stem girth number of leaves might probably be due to the higher phosphorus content in this medium. Phosphorus is considered a primary nutrient for plant growth and is important in cell division and development of new tissues [18]. Topsoil only and topsoil and river sand mixture also performed better. They performed better probably due to their optimal pH (6.89 and 6.97 respectively). Nutrients are most available to plants for growth in the optimum 5.5 to 7.0 range [19]. Poor growth performance was however observed in rice hull ash only, rabbit



Plate 1. Plant heights at 3 WAS



Plate 2. Plant heights at 4 WAS



Plate 3. Plant heights at 5 WAS

waste only and topsoil and rabbit waste mixture. The poor performance of rice hull ash only could be possibly attributed to its high pH (10.62). According to Dobermann and Fairhurst (2000), alkalinity impairs plant growth by restricting water supply to the roots, thus obstructing root development. Again, when pH is too high, the plant's ability to absorb certain nutrients is disturbed, as a result some nutrients are not

absorbed properly [19]. The poor growth performance of seedlings in the rabbit waste only as well as topsoil and rabbit waste mixture could be probably due to the fact that the sawdust present in the rabbit waste was not well decomposed. Partially decomposed sawdust tie up nitrogen as it decomposes, and also microorganism that break down the high carbon sawdust uses the nitrogen present [20].



Plate 4. Plant heights at 6 WAS

5. CONCLUSION

The study demonstrated that mixture of topsoil and rice hull ash mixture is the most appropriate medium for growing chili pepper seedlings as their combination improved germination and subsequent growth in terms of germination percentage, seedling height, number of leaves and stem girth. Rice hull ash alone is not a suitable medium to be used in raising chili pepper seedlings since it has a high pH which probably lowers seedling growth. Partially decomposed rabbit waste is not suitable to be used as a nursery medium as it retards seedling growth.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Bosland PW, Votava EJ. Vegetable and Spice Capsicums. England: CAB International. 2003;233.
2. Kumar S, Rai M. Chile in India. Pepper Institute. 2005;xxii:1-3.
3. Dagnoko S, Yaro-Diarisso N, Sanogo PN, Adetula O, Dolo-Nantoume A, Gamby Toure K, Diallo-Ba D. Overview of pepper breeding in west Africa. African Journal of Agricultural Research. 2013;8(13):1108-1112.
4. MIDA. Millenium Development Goal. Chili pepper, investment opportunities in Ghana; 2010.
5. FAOSTAT. Chillis peppers and greens; 2011. Available:<http://faostat.fao.org>
6. Gama PBS, Lubago BW, Philip WMd' Ragga, Beatrice CM. Effect of soil media on growth of tomato seedlings (*Solanum lycopersicum* L.) under nursery (Greenhouse) conditions. International Journal of Agriculture Research and Review. 2015;3(10):432-439.
7. Bhardwaj RL. Effect of growing media on seed germination and seedling growth of papaya CV. 'Red lady'. African Journal of Plant Science. 2014;178-184.
8. Adams CR, Bamford KM, Early MP. Principles of Horticulture. Routledge; 2008.
9. Okafor, Okonkwo UN. Effects of rice husk ash on some geochemical properties of lateritic soil. Leonardo Electron J Practech. 2009;15:67-74.
10. Mansuray KG, Ghaly AE. Physical and Thermochemical properties of rice husk. Energy Sources. 1997;989-1004.
11. Zude-Sasse M, Fountas S, Gemtos TA, Abu-Khalaf N. Application of precision Agriculture crops. European Journal of Horticulture Science; 2016.
12. Abad M, Noguera P, Puchades R, Maquieria A, Noguera V. Physio-chemical and chemical properties of some coconut dusts for use as a peat substitute for

- containerized ornamental plants. Biores. Technol. 2002;82:241-245.
13. Nwite JC, Igwe CA, Obalum SE. The contributions of different ash sources to the improvement in properties of a degraded Ultisol and maize production in Southeastern Nigeria. American-Eurasian Journal of Sustainable Agriculture. 2011; 5(1):34-41.
 14. Traunfeld J, Nibali E. Soil amendments and fertilizers: Fertilizing. 2013;4.
 15. Peter-Onoh CA, Obiefuna JC, Ngwuta AA, Onoh PA, Ibeawuchi II, Ekwugha EU, Emma-Okafor LC, Nze EO, Orji JO, Onyeji EC. Efficacy of five different growth media on seedling emergence and juvenile phenology of *Monodora myristica* (African nutmeg, Ehuru) in the nursery. J Agric Vet Sci. 2014;7:60-63.
 16. Bell DD. Waste management. In: Chicken meat and egg production, fifth edition. Kluwer Academic Publisher. Massachusetts; 2002.
 17. Douglass FJ, Thomas DL, Tara L. In nursery manual for native plants. 2009;Chapter 5:77.
 18. Epstein E, Bloom AJ. Mineral nutrition of plants: Principles and perspectives. 2004; 402.
 19. Ward E. Gardening: The pH of your soil can affect plant growth and health; 2015.
 20. Dobermann A, Fairhurst T. Rice: Nutrient disorder and nutrient management; 2000.

© 2020 Kaledzi et al.; This is an Open Access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Peer-review history:
The peer review history for this paper can be accessed here:
<http://www.sdiarticle4.com/review-history/58579>