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Influence of container type and colour on the emergence, growth and yield of tomatoes (*Solanum lycopersicum* L.)

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ABSTRACT

Container or pot farming is a popular alternative and viable way of cropping in rural, semi-urban and urban homes. This study aimed to assess optimum crop production with pot farming by examining the influence of the container type and colour on the emergence, growth and yield of tomatoes (*Solanum lycopersicum* L.) at the greenhouse of the Department of Crop Science and Technology, School of Agriculture and Agricultural Technology, Federal University of Technology, Owerri, Nigeria. The treatments involved four container types (metal, wood, clay, and polyethylene) and four container colours (black, yellow, green and red), in a 2 × 4 factorial experiment performed with a completely randomised design (CRD) and 3 replications. The following data were collected: days to emergence; days to 50% emergence; plant height at 3, 6 and weeks after planting (WAP); number of leaves at 3, 6 and 9 WAP; number of branches at 3, 6 and 9 WAP; days to flowering; and number of fruits per plant. All parameters except for those related to emergence differed among the container types. The container colour only had a significant effect on the yield-related parameters. Overall, black wooden containers had the best performance, while clay pots resulted in the worst performance. Hence, black wooden containers can support an appreciable increase in tomato production.

Keywords: Pot attributes, Pot farming, Crop performance, Tomato production.

Influência do tipo de recipiente e da cor na emergência, crescimento e rendimento de tomates (*Solanum lycopersicum* L.)

RESUMO

O cultivo em recipientes ou vasos como uma forma viável alternativa de cultivo é popular em lares rurais, semi-urbanos e urbanos. Como medida para atingir a produção ótima de cultivos no cultivo em vasos, foi realizado um experimento sobre a influência do tipo e da cor do recipiente na emergência, crescimento e rendimento de tomates (*Solanum lycopersicum*) a na Fazenda de Ensino e Pesquisa do Departamento de Ciência e Tecnologia de Cultivos, Escola de Agricultura e Tecnologia Agrícola, Universidade Federal de Tecnologia, Owerri. Os tratamentos foram quatro tipos de recipientes (metal, madeira, argila e polietileno) e quatro cores de recipientes (preto, amarelo, verde e vermelho), em um experimento fatorial 2 x 4 dispostos em um delineamento inteiramente casualizado (CRD) com 3 repetições. Os dados foram coletados nos seguintes parâmetros: dias para emergência, dias para emergência de 50%, altura da planta em 3, 6 e WAP, número de folhas em 3, 6 e 9 WAP, número de ramos em 3, 6 e 9 WAP, dias para floração e número de frutos por planta. O tipo de recipiente mostrou diferenças significativas em todos os parâmetros avaliados, exceto para características de avaliação de germinação. A cor dos recipientes mostrou diferença significativa apenas nos parâmetros de rendimento. Especificamente, recipientes de cor preta feitos de madeira tiveram o melhor desempenho em todos os parâmetros avaliados, enquanto vasos de barro tiveram o menor desempenho. Recipientes de madeira preta podem suportar aumento apreciável na produção de tomate.

Palavras-chave: Atributos do vaso, Cultivo em vaso, Desempenho da cultura, Produção de tomate.

1. Introduction

The need to increase food production to fight hunger has led to the development of various ways and means to grow crops. In conventional agriculture, crops are cultivated in arable land or fields. Over the years, deviations from field cultivation of crops have emerged. Crops can be grown in soil-based and soilless liquid and solid media. These unconventional methods of growing crops were originally established to investigate how a crop or its environment could be manipulated to achieve growth advantages. However, over time researchers have found that these alternative methods are suitable for small- and medium-scale crop production. Indeed, these unconventional methods of growing crops have resulted in appreciable increases in the quality and quantity of crop production. In a comparative study, Treftz and Omaye (2015) demonstrated that some vegetable and fruit crops grown unconventionally presented better performance in fruit grip and the survival rate than those cultivated in the field.

One of the most important commercial vegetable crops cultivated worldwide is tomato, which has economic, nutritional and medicinal value. Moreover, tomato is a short-duration crop that can be grown year-round. Tomato fruit is red in colour, attractive and can be consumed in many ways – for example, raw in dishes such as salads and sauces and as a drink. Given that tomato is used in the preparation of many meals, growing tomatoes in containers is a common sight in urban and semi-urban areas.

There are two major unconventional methods of growing crops: container cropping (or pot farming) and hydroponics. Container cropping involves the use of containers (of various types, sizes, colours and shapes) filled with soil only, soil mixed with other materials or soilless materials to grow crops. It is the oldest and the most popular unconventional method of growing crops among farmers. Growing crops in containers is inexpensive, easy to set up and can be established at any time of the year. The containers used in crop farming are usually made of different materials and colours. It is reasonable to suspect that container attributes may have some impact on the emergence, growth and yield of crops. Consistently, there have been numerous studies on container cropping (Segaw et al., 2016; Gallegos et al., 2020; Kim et al., 2020; Kaudo et al., 2022; Junaedi et al., 2023; Onwubiko et al., 2023). The results have shown that container attributes such as the size and type have significant effects on seedling growth (Zine et al., 2016; Kishor, 2020; Abebe, 2021), root and shoot growth (Amoroso et al., 2010; Pooter et al., 2012; Bouzo and Favaro, 2015; Kim et al., 2021), plant growth and the crop yield (Srivastava et al., 2019; Lee et al., 2022; Sharma et al., 2022). Containers used to grow crops at home have different colours, which allow individuals to garden with containers of different colour for aesthetics (Bachman, 2022). There has been limited research on the effect of container colours on seedling and crop production (Markham et al., 2011; Sanchez-Aguilar et al., 2016; Witcher, et al., 2020; McBrayer et al., 2022). The available results have shown container colour has a significant effect on crop production. Unfortunately, none of these studies examined tomatoes. Hence, the present study examined the effect of container type and colour on the emergence, growth and yield of tomatoes. It also examined the effect of the interaction between container type and colour on the production of tomatoes.

2. Material and Methods

This study was conducted during the early cropping season of 2024 at the greenhouse of the Department of Crop Science and Technology, Federal University of Technology Owerri, Imo State, Nigeria. It is located between 70°00'E and 07°05'E and between 05°20'N and 05°25'N, at 55 m above sea level. The average relative daily temperature and humidity of the greenhouse was 33.5 °C and 80.1%, respectively.

The experiment used a 2 × 4 factorial completely randomised design (CRD) with 3 replications. Specifically, there were four container types – polyethylene, metal, wooden and clay – and four colours – black, green, yellow and red. The containers were cylindrical, had a volume of 4 liters, and had 10 perforations on the bottom. The media used was a mixture of garden soil and poultry manure (1:1, v/v). Two-thirds of the volume of each container was filled with the media. This study used Roma tomatoes, the seeds of which were obtained from the Germplasm Unit of the Department of Crop Science and Technology. Two seeds were planted in each container. A watering can was used to irrigate the plants two times a week. Standard agronomical and other phytosanitary practices were carried out every 2 weeks to remove weeds and to maintain a disease-free crop environment.

The following data were collected: the number of days to emergence; the number of days to 50% emergence; plant height at 3, 6 and 9 weeks after planting (WAP); the number of leaves at 3, 6 and 9 WAP; the number of branches at 3, 6 and 9 WAP; the number of days to flowering; and the number of fruits per plant. The data were subjected to analysis of variance (ANOVA). When significant, Fisher's least significant difference test was used to determine differences between the treatments. A p-value < 0.05 was considered to indicate a statistically significant difference. The GenStat statistical software (edition 22 version 1) was used for statistical analysis.

3. Results and Discussion

Table 1 presents the effect of the container type and colour on the number of days to emergence and 50% emergence. Overall, the container type and colour did not have a significant effect on the number of days to emergence or 50% emergence. Similarly, the container type and colour interaction was not significant for the number of days to emergence or 50% emergence. Overall, the number of days to emergence and 50% emergence was the same (approximately 7 days) for all the container types and colours used for the study. This result indicates that the container type and colour did not influence the rate and speed of emergence of tomato seedlings.

A previous study reported a similar result (Markham et al., 2011). However, another study reported that black trays, plastic pots, plastic bags and nonwoven fabric bags had a significant effect on seed emergence and other germination related parameters of *Palergonium graveolens* (Shagufta et al., 2023).

Table 2 shows the influence of container type and colour on number of branches at 3, 6 and 9 WAP. The container type had a significant difference on the number of branches at 3, 6 and 9 WAP. Wooden containers led to the highest mean number of branches at 3, 6 and 9 WAP, while clay containers resulted in the lowest mean number of branches. On the contrary, the container colour did not significantly affect the number of branches at 3, 6, and 9 WAP.

The container type and colour interaction had a significant effect on the number of branches only at 6 WAP. Overall, black wooden containers had the highest mean number of branches (12.67) while clay containers had the lowest mean number of branches (4.67). Table 3 shows the influence of the container type and colour on the number of leaves at 3, 6 and 9 WAP. Similarly to the number of branches, there was a significant difference in the number of leaves at 3, 6 and 9 WAP based on the container type.

The plants grown in wooden containers had the highest mean number of leaves, while the plants grown in clay containers had the lowest mean number of leaves. The container colour did not have a significant effect on the number of leaves. However, the container type and colour interaction was significant at 3 and 9 WAP.

Overall, plants grown in black wooden containers had the highest mean number of leaves – 24.00 at 3 WAP and 255.00 at 9 WAP – while plants grown in black clay containers had the lowest mean number of leaves – 14.00 at 3 WAP and 40.00 at 9 WAP.

Table 4 shows the effect of the influence of container type and colour on plant height at 3, 6, 9 WAP. Again, the container type had a significant effect. Plants grown in wooden containers had the highest mean, while plants grown in clay containers had the shortest mean height at 3, 6, 9 WAP. The container colour showed a significant difference at 6 WAP.

Table 1: The influence of the container type and colour on the number of days to emergence and 50% emergence

	Days to emergence					Days to 50% emergence				
	Black	Green	Red	Yellow	Mean	Black	Green	Red	Yellow	Mean
Clay	6.33	7.00	6.33	6.66	6.58	6.66	7.00	6.33	6.33	6.58
Metal	7.00	6.33	6.66	7.00	6.75	7.00	6.66	6.33	6.66	6.66
Polyethylene	7.00	6.66	7.00	6.66	6.83	6.33	6.66	6.66	7.00	6.66
Wood	6.66	6.66	6.66	7.00	6.75	6.66	6.66	7.00	7.00	6.75
Mean	6.75	6.66	6.66	6.83		6.66	6.75	6.58	6.75	
Type			$p < 0.05$					$p< 0.05$		
Colour			$p < 0.05$					$p< 0.05$		
Type × colour			$p < 0.05$					$p< 0.05$		

The data were analysed with one-way analysis of variance to determine whether the container type, container colour and container type × colour interaction were significant. None of them was significant ($p< 0.05$)

Table 2: The influence of the container type and colour on number of branches at 3, 6 and 9 weeks after planting (WAP)

	3 WAP					6 WAP					9 WAP				
	Black	Green	Red	Yellow	Mean	Black	Green	Red	Yellow	Mean	Black	Green	Red	Yellow	Mean
Clay	3.33	3.66	3.00	4.00	3.50	4.67	6.00	7.67	11.33	7.42	5.00	6.33	11.33	17.33	10.00
Metal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Polyethylene	3.66	3.66	4.33	4.00	3.91	9.67	8.67	8.67	10.67	9.42	17.33	15.67	19.00	17.00	17.25
Wood	4.33	4.66	3.66	3.66	4.08	12.67	12.00	10.67	10.67	11.50	23.67	21.33	19.67	18.00	20.67
Mean	2.83	3.00	2.75	2.91		6.75	6.67	6.75	8.17		11.50	10.83	12.50	13.08	
Type					0.46					1.27					4.31
Colour					ns					ns					ns
Type × colour					ns					2.55					ns

The data were analysed with one-way analysis of variance to determine whether the container type, container colour and container type × colour interaction were significant. ns indicates that there was not a significant difference. When the difference was significant, Fisher's least significant difference test was performed, and the t-critical value is presented.

At this time, plants grown in yellow containers had the highest mean height, while plants grown in black containers had the lowest mean height. The container type and colour interaction had a significant effect at 9 WAP. Plants grown in black wooden containers had the highest mean height (100.8 cm), while plants grown in black clay containers had the shortest mean height (30.30 cm).

Table 5 shows the influence of the container type and colour on the number of days to flowering and the number of fruits. For the number of days to flowering, the container colour had a significant effect. The plants grown in yellow containers had the lowest mean number of days to flowering, while the plants grown in the red containers had the longest mean number of days to flowering. The container type and colour interaction was not significant.

Regarding the number of fruits, the container type but not the colour had a significant effect. The plants grown in wooden and polyethylene containers showed the highest number of fruits per plant, while the plants grown in the clay containers had the lowest mean number of fruits.

The container type and colour interaction was not significant. Apparently, black wooden containers enhanced tomato fruit growth, similarly to how these containers enhanced the growth rate. Nutrient release for crop growth and development is influenced by temperature (Juan and Xiang-dong, 2024), and dark-coloured containers are good absorbers of heat and can keep the substrate (soil) warm. Hence, the black wooden containers had the best temperature that facilitated nutrient release.

On the other hand, the poor performance of tomato plants grown in clay pots may be associated with the water retention ability of the container. It is easy for clay pots to get waterlogged, especially when they are not properly perforated.

In this study, the growth rate of tomatoes was assessed based on the number of branches, the number of leaves and plant height. Only the container type had a significant influence on these parameters. Plants grown in wooden containers showed the best performance for these parameters at 3, 6 and 9 WAP. On the other hand, plants grown in clay containers showed the lowest values for these parameters at 3, 6, and 9 WAP.

The container colour only had a significant effect on plant height at 6 WAP. The container type and colour interaction had a significant effect on the number of branches at 6 WAP, the number of leaves at 3 and 9 WAP, and plant height at 9 WAP.

Table 3: The influence of the container type and colour on number of leaves at 3, 6 and 9 weeks after planting (WAP)

	3 WAP					6 WAP					9 WAP				
	Black	Green	Red	Yellow	Mean	Black	Green	Red	Yellow	Mean	Black	Green	Red	Yellow	Mean
Clay	14.00	13.67	16.00	18.33	15.50	13.30	37.70	44.30	77.30	43.2	40.00	59.70	98.00	188.70	96.60
Metal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Polyethylene	15.00	18.00	20.00	17.33	17.58	67.00	69.70	69.70	107.30	78.80	170.30	155.30	165.70	171.30	165.70
Wood	24.00	18.00	16.00	18.00	19.00	141.30	107.00	104.0	101.70	113.50	255.00	211.00	174.00	167.30	201.80
Mean	13.25	12.42	13.00	13.42		55.40	54.00	54.5	71.60		116.3	106.50	109.4	131.8	
Type				2.56					21.14					36.78	
Colour				ns					ns					ns	
Type × colour				5.12					ns					73.56	

The data were analysed with one-way analysis of variance to determine whether the container type, container colour and container type × colour interaction were significant. ns indicates that there was not a significant difference. When the difference was significant, Fisher's least significant difference test was performed, and the t-critical value is presented.

Table 4: The influence of the container type and colour on the plant height at 3, 6 and 9 weeks after planting (WAP)

	3 WAP					6 WAP					9 WAP				
	Black	Green	Red	Yellow	Mean	Black	Green	Red	Yellow	Mean	Black	Green	Red	Yellow	Mean
Clay	12.33	15.67	14.33	19.00	15.33	15.00	26.30	25.30	55.30	30.50	30.30	45.80	49.50	86.70	53.10
Metal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Polyethylene	16.33	20.67	19.33	18.33	18.67	43.30	48.20	44.00	51.50	46.80	83.60	81.50	81.10	89.90	84.00
Wood	25.00	19.33	21.00	20.00	21.33	45.30	64.30	55.50	52.00	54.30	100.8	91.00	99.10	82.70	93.40
Mean	13.42	13.92	13.67	14.33		25.90	34.70	31.20	39.70		53.70	54.60	57.40	64.80	
Type				3.09					9.19					9.98	
Colour				ns					9.16					ns	
Type × colour				ns					ns					19.66	

The data were analysed with one-way analysis of variance to determine whether the container type, container colour and container type × colour interaction were significant. ns indicates that there was not a significant difference. When the difference was significant, Fisher's least significant difference test was performed, and the t-critical value is presented.

Table 5: The influence of the container type and colour on the number of days to flowering and the number of fruit

	Number of days to flowering					Number of fruit				
	Black	Green	Red	Yellow	Mean	Black	Green	Red	Yellow	Mean
Clay	57.66	56.00	55.66	47.66	54.24	0.66	0.66	1.00	1.33	0.91
Metal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Poly	49.33	46.66	53.33	51.00	50.08	4.00	1.66	2.66	2.33	2.66
Wood	42.66	44.66	49.66	45.00	45.49	3.66	3.00	2.33	1.66	2.66
Mean	37.41	37.33	39.66	35.91		2.08	1.33	1.49	1.33	
Type					ns					1.00
Colour					4.84					ns
Type × colour					ns					ns

The data were analysed with one-way analysis of variance to determine whether the container type, container colour and container type × colour interaction were significant. ns indicates that there was not a significant difference. When the difference was significant, Fisher's least significant difference test was performed, and the t-critical value is presented.

The differences in the growth rate among the container types may be related to thermal conductivity (i.e., the rate at which each container typer gains and loses heat). Wooden containers regulate substrate temperature better than other container types because wood has natural insulating properties (Dieke, 2020), protecting plant roots from extreme temperature fluctuations. Further, wooden containers have better potential for air circulation. Microbes in the soil that carry out catabolic processes that release nutrients from organic matter depend on the oxygen in the soil for respiration. Plant growth therefore can be enhanced or hindered by the extent of soil aeration. In addition, soil aeration is essential for plant root respiration. Similar results have been reported in previous studies (Costa, 2020; McBrayer et al., 2022; Shagufta et al., 2023).

4. Conclusions

The container type and colour had a significant influence mostly on the growth of tomatoes. An appreciable increase in tomato production can be achieved by growing the plants in black wooden containers. Other container types, especially clay containers, did not enhance tomato production, so their use is not advised. Apparently, container type and colour is an important factor to be considered in tomato production.

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