International Journal of Agricultural Technology 2023 Vol. 19(2):669-676
Available online http://www.ijat-aatsea.com
ISSN 2630-0192 (Online)

Efficiency and productivity of selected vegetables as influenced by various production system for household sustainability amidst pandemic crisis

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Silverio, B. G. S., Gonzaga, N. R., Gonzaga, A. B., Pabellon, J. M. L. and Cimagala, K. C. (2023). Efficiency and productivity of selected vegetables as influenced by various production system for household sustainability amidst pandemic crisis. International Journal of Agricultural Technology 19(2):669-676.

Abstract Results showed that majority of test crops favorably grew under container setup. Okra (40.09kg), eggplant (43.18kg) and bitter gourd (22.07kg) which produced the highest yield/100m and more efficient utilizing the container set-up with return of expenses (ROE) significantly higher relative to the conventional practice. For squash (21.81kg), a significantly higher yield and ROE was obtained using square-foot system. The long bean showed no significant difference among the production systems utilized though container gardening exhibited the highest yield and ROE among treatments. Implementation of these innovative technologies for backyard production could potentially address challenges of food sustainability for every households aside from its intangible benefits of providing agri-leisure and aesthetics values particularly for vulnerable individuals confined in homes due to restrictions. Its productivity and economic viability amid spatial limitations made it more suitable and therefore recommended for households and other stakeholders to implement in their gardens.

Keywords: Horticulture, Vegetable production system, Container gardening, Vertical gardening, Square-foot gardening, Food sustainability

Introduction

The world need to respond to the challenges in global food systems due to the Covid-19 pandemic. This crisis highlights the vulnerabilities of the current systems, particularly distorting the food supply chain and agricultural trade. Since then, the world has been working on the challenge of the ‘new normal’ facing the agriculture sector today. The post-pandemic era had created both social and physical challenges that directly affects the health and well-being of

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the community. Pandemic protocols prohibit anyone to roam around for no reason that is why home activities such as gardening is highly recommended for families staying at their houses (Matias and Dominski, 2020). The food production system promotes and consists of different home gardening options that also provides alternative food supply among these families. However, there is a glaring gap when it comes to the perceived sustainability: greater yields per area compared to conventional agriculture, improved resource use and decreased detrimental environmental effects (Lal, 2020). It is imperative for this generation to rethink and restructure its ways and practices in a way that would suffice the pressing need of the current situation.

There are a lot of food production systems that were practiced among household from the different regions of the world. Among these stems are vertical, square foot and container gardening. This production system had risen to the forefront of many households nowadays. Moreover, these technologies are perceived be manageable enough for ordinary household (Lal, 2020).

Container gardening or pot gardening/farming is the practice of growing plants, including edible plants, exclusively in containers instead of planting them in the ground. A container in gardening is a small, enclosed and usually portable object used for displaying live flowers or plants. It may take the form of a pot, box, tub, basket, tin, barrel or hanging basket (Deveza and Holmer, 2002). Square foot gardening is the practice of dividing the growing area into small square sections, typically 1 foot on a side, hence the name. The aim is to assist the planning and creating of a small but intensively planted vegetable garden. The phrase "square foot gardening" was popularized by Mel Bartholomew in a 1981 Rodale Press book and subsequent PBS television series. Bartholomew, a retired engineer, devised a raised 4 by 4 feet (1.2 m × 1.2 m) square beds with a grid. Each of these 4 by 4 square beds was then divided into sixteen one-foot squares, the grid. Each square was planted with a different crop species based on a formulation of either one, four, nine or sixteen plants per square depending on the plant's overall size. To encourage a variety of different crops in succession, and to discourage pests, each square was used for a different kind of plant (crop rotation) within the growing season (Bartholomew, 2013). Vertical gardening is a method of growing plants in an upright form by making use of stakes, cages, bamboo and other vertical supports. The purpose of an intensively grown garden is to harvest the most produce possible from a given space. It was found out that this practice is best suited for plants that require maximum sunlight such as fruit and also several vegetables. Plants grown in a vertical garden are less accessible to diseases and pests, and crop harvesting and cultivation is easier. Vertical gardening provides adequate aeration to the plants, and also increases the beauty of the garden.

Moreover, the system provides aesthetic value among its gardeners which adds appreciation among its practitioners (Utami and Jayadi, 2011).

Nevertheless, an initiative of implementing various alternative measures that challenge current food systems and improve household sustainability is time-sensitive and necessary leading to a search for sustainable methods of production systems. Innovative technologies such as vertical gardening, container gardening, and square-foot gardening have been put into a retrospect with the consideration of this method's perceived sustainability compared to conventional backyard gardening, improved resource use, decreased detrimental environmental effects, and other intangible qualities e.g. aesthetic value, agri-leisure and bonding activities for household members among others.

Moreover, the identification and establishment of viable production systems would provide an avenue for local households to follow as a model farm to replicate as their tool for survival and sustainability. The study aggressively promotes an adaptive mindset that significantly helps attain household food security in localities. Further, this serves as a necessary strategy to encourage families who were affected by the worldwide crisis, to produce adequate, accessible, and affordable food for their table.

In line with household food sustainability, a popular Filipino vegetable dish called 'pinakbet' has been a staple of many rural communities in the country. The dish consists of vegetables namely: okra (*Abelmoschus esculentus*), eggplant (*Solanum melongena*), squash (*Cucurbita maxima*), bitter gourd (*Momordica charantia*), and yard long bean (*Vigna unguiculata*), respectively. These vegetables are known to be easily grown and thrive in many households in the countryside of many provinces which makes these vegetables a logical choice in the conduct of a study aimed to provide food in our homes.

The results of the study provided significant information and ideas to vegetable home growers, urban gardeners, students, researchers, and extensionists about different food production systems relative to producing better food productivity even in a limited area. Moreover, the study gives opportunities to individuals who are planning to engage in gardening amidst the pandemic by maximizing food productivity from limited spaces at home while providing attractions in the environment.

The study was conducted under Claveria conditions to assess the response of the aforementioned vegetables towards various production systems in terms of productivity, and economic efficiency and to validate such innovative management method in comparison with the conventional practice. Specifically, the study aimed to evaluate the productivity of the test crop, and assess efficiency through its return of expenses (ROE), respectively.

Materials and methods

Location of the study

The study was conducted at the Research Station of University of Science and Technology of Southern Philippines (USTP) (SE 8º36.667‘n124º52.964’E) and 590 m above sea level, Claveria, Misamis Oriental from January to September 2021. Specifically, it was established at the PANDEMIC Farm which stands for ‘Productive Agriculture for National Development through Entrepreneurial Mindset and Innovative Culture’, with the aim to address food security for households amidst the crisis brought upon by the pandemic.

Treatments and experimental design

The study was laid-out in a Randomized Complete Block Design (RCBD) with three replications for each vegetable test crops (okra, eggplant, squash, bitter gourd and long bean) having the four production system as treatments. The treatments consisted of the following: container gardening, square-foot gardening, vertical gardening and the conventional practice as the control. Each treatment was 3m x 3m with equal to 9 square meter. The space extended in the experimental area that gave convenience in farm activities such as watering, harvesting, applying fertilizer, placing labels on individual plots, gathering data, and many other activities related to the study.

Production system set-up

Conventional set-up followed the usual home-based practice of planting directly from soil with minimal management applied with the synthetic fertilizer. Container gardening was made with the use of homogenous containers filled with a growing media composed of garden Soil (GS), Carbonized Rice Hull (CRH), Coco peat (CCP), and Chicken Dung (CD), respectively. The mixture were prepared at the ratio of 1 GS: 1CRH: 1 CCP: 0.5 CD. Square foot gardening was established with the use of wooden boxes with the use of bamboo shoots that serves as the division for the square foot measurement filled with the aforementioned growing media mixture. The vertical gardening were established with the use of a fabricated arc trellis made from steel that was just tall enough for the ease of harvest which also utilized the same growing media formulation.

Data gathering

The yield per plot were recorded by weighing the harvest per replication per treatment per plot with each plant and converted to yield in kilograms per 100 m2 by using this formula:

$$\text{Yield } (100\ m^2/ha) = \frac{\text{Plot yield (kg)}}{\text{Plot area } (m^2)} \times 100\ (m^2)$$

Return on Expenses (ROE) were calculated in each vegetable per treatment based on the costs incurred (fertilizers, materials and labor) and the market price of harvested fresh produce using this formula:

$$\frac{Net\ Income}{Total\ Expenses} = Return\ on\ Expenses\ (ROE)$$

Statistical Analysis

The obtained data was subjected to analysis of variance (ANOVA) to determine the level of significance using ASSISTAT (version 7.0 beta). The Tukey's Test or Honest Significant Differences (HSD) was used to compare the significant differences among treatment means.

Results

Study showed that most vegetables grown under the container gardening practice got the highest weight of produce of 40.09, 21.59 and 22.07 kg for okra, eggplant and bitter gourd respectively (Table 1 and 2). On the other hand, square-foot gardening enhanced the squash reported higher yield (21.81 kg) when cultivated under square-foot gardening set-up.

Table 1. Yield and return of expenses (ROE) of okra and eggplant as influenced by various production systems in Claveria, Misamis Oriental, Northern Mindanao, Philippines

Production System	Okra		Eggplant	
	Yield (kg/100 m^2)	ROE (Php)	Yield (kg/100 m^2)	ROE (Php)
Conventional Practice	18.85b	0.55b	29.40b	0.64ab
Container Gardening	40.09a	1.67a	43.18a	1.01a
Square-foot Gardening	28.00ab	0.75b	31.93b	0.40bc
Vertical Gardening	24.74b	0.55b	25.85b	0.11c
F-test	**	*	**	**
C.V. (%)	7.31	5.07	4.79	4.10

** Significant at a level of 1% of probability (p < .01)
* Significant at a level of 5% of probability (.01 =< p < .05)
ns = Not significant (p>= .05)

On the return of expenses, results showed that container gardening, among production system employed, had resulted to the highest ROE of these test crops namely, okra (1.67), eggplant (1.01) and bitter gourd (0.81 kg), respectively. Meanwhile, squash (1.55) production for square-foot gardening had resulted to the highest ROE (Table 1 and 2).

Table 2. Yield and return of expenses of squash, bitter gourd and yard long bean subjected to different production systems in Claveria, Misamis Oriental, Philippines

Production System	**Squash**		**Bitter Gourd**		**Yard Long Bean**	
	Yield ($kg/100\ m^2$)	**ROE (Php)**	**Yield ($kg/100\ m^2$)**	**ROE (Php)**	**Yield ($kg/100\ m^2$)**	**ROE (Php)**
Conventional Practice	62.70c	0.10b	5.16b	0.57b	73.44	0.61
Container Gardening	147.10b	0.78b	22.07a	0.81a	91.32	0.96
Square-foot Gardening	218.10a	1.55a	17.86a	0.42.a	79.30	0.64
Vertical Gardening	122.70bc	0.48b	15.73a	0.26a	61.55	0.27
F-test	**	**	**	**	ns	ns
C.V. (%)	8.44	4.76	7.91	12.75	7.00	5.59

** Significant at a level of 1% of probability ($p < .01$)
 * Significant at a level of 5% of probability ($.01 =< p < .05$)
ns = Not significant ($p >= .05$)

Discussion

The aforementioned results on increased yield through container gardening affirms the study of Masabni and Cotner (2009) that a common vegetable crop could produce well even with limited space when planted in containers and this production system suggests better management practices hence could possibly improve vegetable production (Kumawat *et al.,* 2019). In addition, several studies reported that container-grown okra crop were healthily sustained as compared to conventional practice (Islam *et al.,* 2012) and found that conventional practices of trellising in bitter gourd have a negative effect on its performance (Ashraf *et al.,* 2018).

Moreover, the economic efficiency of utilizing containers does help in better economic returns due to the fertilizer-savvy qualities of containers for vegetable production (Abdimutalip *et al.,* 2019). Studies on urban rooftop gardening utilizing containers do provide significant results in its financial aspect and are reported to be viable for city dwellers (Sajjaduzzaman *et al.,* 2005).

Aside from the integration of specialized growing media, the additional expenses incurred through the use of planter containers and boxes as well as long-lasting designed trellises with 10-year computed life span made innovated production systems more efficient compared to traditional household gardening. These innovative systems offer significant value and potential on their economic viability as a result of modified and space-intensive gardening method (Niemiera, 2018).

Aside from the productivity and economic viability, it is noteworthy to mention the intangible qualities this production system could bring to household whom are restricted in their individual homes. First, is the opportunity of agri-leisure activities, defined as a garden model operation that offers visitors and household an experience of rural life in the comfort of their own backyard (Tsai, 2009). Agri-leisure offers a lot of nostalgia for individuals who missed rural outdoors. Additionally, the visual aesthetics offered by these set-up does also trigger visual stimulus creating a stress-relieving feeling for those that experienced being around these production systems (Sun *et al.*, 2018). In seeking extra physical activities, having home gardens does offer enough of activities to help keep mental and physical well-being of the household especially for the older adults (Corley *et al.*, 2021). These and the results of similar studies give weight on how important it is for families and the community as a whole to this home gardens available in their backyards (Montefrio, 2020). Moreover, the stress-mitigation aspect of having home gardens does also contribute to the over-all wellness of a household family (Erickson, 2012). Other benefits include: garden mobility, optimum space utilization, environmental-friendly practices, availability of fresh produce, and high nutrient contenting vegetables.

Innovative technologies for backyard production significantly address the current challenges, particularly for individuals confined in homes due to restrictions. Its productivity and economic viability amid spatial limitations make it more suitable and recommendable for households and other stakeholders to implement in their gardens. Moreover, it also offers intangible benefits such as visual aesthetics, fitness through extra physical activity, stress mitigation, and an opportunity for agri-leisure activities as extra added values to establishing these production systems. Further, verification for the viability of the production of other crops/vegetables is also highly recommend.

Acknowledgements

The authors highly appreciate the support of USTP-Claveria community in the success of this research endeavor. Further, a grateful appreciation of all individuals involved in the project, especially for those who had exerted time and effort to complete this report amidst the challenge of the pandemic.

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(Received: 20 June 2022, accepted: 28 February 2023)