Scientific Papers. Series B, Horticulture. Vol. LXV, No. 1, 2021
Print ISSN 2285-5653, CD-ROM ISSN 2285-5661, Online ISSN 2286-1580, ISSN-L 2285-5653

URBAN AND PERI-URBAN VEGETABLE GARDENS COMPOSITION

Ana-Maria-Roxana HANGAN, Alexandru COJOCARU, Gabriel-Ciprian TELIBAN, Vasile VÎNTU, Vasile STOLERU

University of Agricultural Sciences and Veterinary Medicine of Iasi, Faculty of Horticulture, Departament of Legumiculture, 3 Mihail Sadoveanu Alley, 700490, Iasi, Romania

Corresponding author emails: roxanah@uaiasi.ro; vstoleru@uaiasi.ro

Abstract

The design of a small urban vegetable garden is very important because in this way the site area allocated to it will be used at maximum capacity to provide decor and sufficient production for family use. In this paper, we studied the way of designing an ornamental vegetable garden on raised beds with different heights and the appearance offered by them. The environment, the way of preparing the site and creating the raised beds will play an important role on the vegetable garden composition spectrum. According to the information gathered from preliminary research some visual results regarding the development of the plants will be evident from the first week of planting due to the different heights of the raised beds. Vegetable and medicinal plants such as curly kale, mangold, patisson, lavender, rosemary, basil and other ornamental species such as French marigold, silver ragwort, fountain grass, will offer the ornamental value. Most species had a good production and development in V1 (40 cm above ground level). Instead, mint and leeks had higher values in V3 (at ground level) and V2 (20 cm above ground level), respectively.

Key words: *urban garden, raised beds, vegetable garden, design.*

INTRODUCTION

Vegetables must occupy an important place in human food, due to the high content of nutrients and especially vitamins, whose lack or deficiency in nutrition can cause serious disorders in human metabolism (Hangan et al., 2018). The favourable effects of vegetable consumption are due to the high-water content, which leads to hydration of the body, as well as the high content of hydrocarbons, which is crucial in stimulating the activity of the muscular system (Valnet, 1982).

The technology cultivation of vegetable species allows their different associations for an intense, good and calculated use of the lands on which they are cultivated, allowing its use for a long period, by practicing vegetable crop rotation, whether it is a household garden or by a vegetable farm (Creasy, 1984; Liebman et al., 1993).

The biggest challenge for urban growers is the soil quality and in order to have a good soil quality and to lessen the exposure to soil contaminants is to plant in raised beds with an appropriate growing substrate (Megan et al., 2016). Another way to reduce contamination is taking into consideration companion planting and to use various plant species that can rapidly absorb soil contaminants or air particles (Hangan et al., 2020). The raised beds vegetable cultivation system in the urban and peri-urban area represents a valuable method in terms of contamination with various heavy metals or pesticides that can come from the soil by accumulation over time (Stoleru et al., 2015).

The gardens near houses in peri-urban and urban areas, represents a case in which consumers' preference is to associate various horticultural species with different functional roles: fruit trees, medicinal plants, fruit shrubs, vegetable species and vines (Rotaru et al., 2010).

In order to ensure the staggered production and for the most intensive use of the space, successive and intercalated cultures will be made, the latter increasing the ornamental potential of the design by adding complementary species by colour, shape and texture of the leaves or habitus.

Vegetable plants have many decorative features, starting from their size, to the colour and texture of leaves, flowers and fruits. The multitude of vegetable species currently cultivated includes species that decorate in spring by means of leaves forming vegetable

carpets, such as salad and spinach, in summer by flowers and habitus such as large beans and mangold (Kourik, 1986). Throughout the summer, all plants will provide decoration both in shape and colour. Shades of green-yellow leaves will be present in combination with yellow and red petiole of mangold plants. The green-grey leaves from leeks will contrast with the mangold leaves. Tomato fruits have a wide range of shapes and colours; from appearance to maturation, from an intense green to yellow, purple or cherry red, thus contributing to increasing the decorative effect that plants have (Mihai & Hoza, 2012).
The temperature differences existing at the beginning of 2020, respectively May, the time of establishment of the crop in the field, had a negative effect on the development of certain plants causing negative effects on their health and production. From an ornamental point of view, the plants returned to their desired shape and appearance in a relatively short time.
In this context, the aim of the study was to find out which hight of the raised beds offers the best results regarding the decoration offered by plants and the best results regarding the optimal production for family use.

MATERIALS AND METHODS

Experimental site
The research was carried out at University of Agricultural Science and Veterinary Medicine of Iași, Faculty of Horticulture, Romania, V. Adamachi farm during 2018-2020.
After a rigorous analysis of the ecological conditions offered by the area and according to the specific requirements of the plant species used the site was selected (Figure 1).
The existing soil in the experimental vegetable field is favourable for horticultural crops, showing good fertility due to the high content of organic matter (3.4-6.45%) (Stoleru et al., 2014; Munteanu et al., 2010). According to Teliban et al. (2021) and Cojocaru et al. (2019) the soil is an anthropic cambic chernozem with a pH of 7.2 and 31% clay.
Soil samples were taken to be analysed and to determine the nutritional elements in it. The Conrad probe was used to determine the pH. All measurements and samples taken were from a depth of 20 cm.

Figure 1. The plot intended for study within the experimental field of the Faculty of Horticulture, Iași (original)

The soil tests performed to the site were completed by WD-XRF S8 TIGER Sequential Spectrometer. The following values resulted for the macro and microelements and are embodied in Tables 1 and 2.

Table 1. Concentration of macroelements

	Substrate	Soil
N	0.39%	0.28%
P_2O_5	0.24%	0.32%
K_2O	2.05%	0.21%
CaO	3.12%	0.41%
MgO	0.60%	0.27%

Table 2. Concentration of microelements

	Substrate	Soil
MnO	0.10%	0.02%
Fe_2O_3	0.36%	0.74%
Na_2O	0.58%	0.39%
Zn	118 PPM	127 PPM
Cu	39 PPM	43 PPM
Mo	6 PPM	7 PPM
Cd	0 PPM	1.2 PPM
Pb	96 PPM	74 PPM
Ni	35 PPM	16 PPM
Cr	80 PPM	11 PPM
Co	8 PPM	0 PPM

The experimental farm is located at 47°10’43”N and 27°37’14”E and is part of a temperate-continental climate, pronounced in the hilly area and more moderate in the plateau area. It is characterized by differentiations of the climatological elements both in time and space. The average annual temperature is 9.6°C and with a total average rainfall of 521 mm per year (Hamburdă et al., 2016).

During the experimental year, in the vegetation period, the average temperature was 19.56°C, the precipitation was 369.01 mm and the relative air humidity was 62.55% (Table 3) (Centrul Meteorologic Regional Moldova, Iaşi, 2020).

Table 3. Meteorological conditions during April-October 2020

Month	Average air temp. (^{0}C)	Max. air temp. (^{0}C)	Min. air. Temp. (^{0}C)	Relative humidity (%)	Total duration of sunlight	Total amount of precipitation (mm)
April	11.1	26.9	-5.9	42.0	279.8	1.6
May	24.4	30.1	3.5	67.0	178.2	130.5
June	21.3	33.4	6.1	71.0	235.7	99.0
July	22.92	26.99	18.49	61.39	280.4	27.49
August	23.63	27.87	18.12	54.09	289.6	8.8
September	19.54	23.86	14.47	59.89	264.1	26.24
October	14.09	16.98	10.79	82.54	129.5	75.38

Biological material and experimental design

The biological material used is composed of seeds, seedlings and cuttings. Crops are established by sowing directly into the field (patisson, beans, carrot) and by planting seedling (kale, leek, celery, celeriac, mangold, sweet pepper, cucumber, tomatoes, eggplant, peppermint, basil, oregano, parsley, sage, thyme, onion, silver ragwort, French marigolds) and cuttings (aster, lavender, Chinese fountain grass, decorative sage, lamb's ear and rosemary).

The seeds and cuttings were purchased from various physical and online specialty stores and nurseries. The seedlings were made in the greenhouse nursery of the vegetable growing department within the University of Agricultural Sciences and Veterinary Medicine Iaşi. The crop management practices applied during the vegetation period were those recommended by the special literature and according to the plant species (Munteanu et al., 2010; Stoleru et al., 2012; Sima, 2017).

The plot intended for research has an area of 190 m^2 and is divided into three experimental variants of equal size and shape (Figure 2) as follows:

V1 - raised beds with a height of 40 cm above ground level;

V2 - raised beds with a height of 20 cm above ground level;

V3 - beds at the ground level.

The cultivation technology applied is the basic one, regarding the optimal management of the vegetation factors for the selected species, in order to obtain healthy plants, with nutritional value and with a pleasant aesthetic aspect.

Crop rotation was taken into account for better pests and disease management according to ecological agriculture principles (Figure 3).

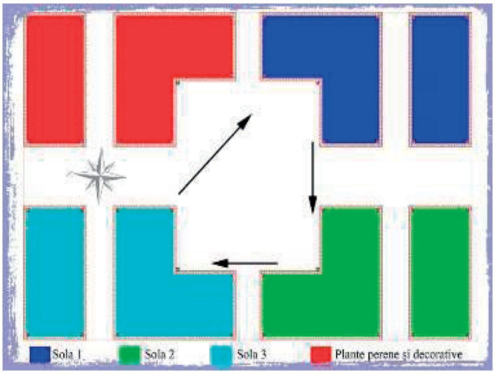

Figure 3. Crop rotation scheme (original)

Each experimental variant consists of the same plant species used in the same quantity and planted using the same design in order to evaluate which experimental variant offers the best results for crop yield and ornamental effect offered by intercropping method.

Figure 2. Representation of experimental variants (original)

The landscaping was done by basic levelling of the land. Subsequently, the site was divided into three equal parts and was marked according to the design. For the V1 and V2 variants (Figure 4), fir wood frames were built for raised beds with heights of 40 cm and 20 cm above ground level and were treated with water-based wood primer for long protection. The V3 variant was delimited with a plastic border at ground level.

Figure 4. Raised beds construction stages (original)

The substrate used in V1 and V2 is the existing soil in the experimental field improved with leaf compost and manure. Peat and Orgevit were incorporated in all three variants.

After the establishment of the raised beds, the basic soil works were carried out in order to prepare the germination and planting bed: deep soil mobilization, soil shredding and soil modelling.

The last stage of preparation of the culture substrate is represented by the installation of the irrigation system. It consists of Arctic automatic irrigation station, solenoid valve, main pipe with a diameter of 0.5 cm, taps, watering hose with built-in drippers every 20 cm and other necessary elements (elbows, connecting hose, connectors, plug end, clamps for fixing). In Figure 5 is represented the different stages of crop establishment and the functional irrigation system.

After the establishment of the raised beds, the preparation of the culture substrate and the installation of the irrigation system, the crop was established as follows.

On 29th of April 2020, the silver ragwort crops, leek, celeriac, celery, kale and purple cauliflower were established.

On 30th of April 2020, the crops of red cabbage, sweet pepper, cucumber, patisson, carrot, tomato, mint, basil, oregano and parsley were established.

On 11th of May 2020, the cultures of sage, eggplant, thyme, white onion, beans, aster, lavender, Chinese fountain grass, decorative sage, lamb's ear and rosemary were established.

The care works applied were the general and special ones depending on the species and according to the special literature.

Figure 5. Different stages of crop establishment (original)

Statistical analysis
The statistical evaluation of the data was carried out by one-way ANOVA using a SPSS ver. 21 Tukey tests were performed in order to estimate the significant difference of vegetable production between the tree experimental variants. Differences between groups were considered statistically significant when $p<0.05$.

RESULTS AND DISCUSSIONS

Results regarding the ornamental effect
The design of a small urban vegetable garden is very important because in this way the site area allocated to it will be used at maximum capacity to provide decor and enough production for family use. Its purpose is to combine the utilitarian function with the aesthetic one (Hangan et al., 2018). In this garden aromatic plants and vegetable plants are combined with flowering plants to enhance the aesthetic effect. Also, for aesthetic reasons, ornamental varieties of utilitarian plants are used (e.g.: decorative sage, mangold).
Gardens for culinary purposes look better designed in a free style, but can be organized according to a mixed or geometric scheme as the style adopted in the present study. According to Sima (2017) in order to create an ornamental vegetable garden some factors must be taken into account: contrasting hights, habitus, flowers, fruits, colours and other visual effects.
In this research, the ornamental value of the whole design is offered mainly by the colour of the leaves, petiole, flowers and flower clusters, as can be seen in Figure 6. The eye is drawn primarily by the bright orange colour of the French marigold flowers.

Figure 6. V1 overview (original)

The colour and shape of these plants is balanced in compositions by associating them with plants in cold shades - silver ragwort or lamb's ear - and by using in the background medium-sized plants (carrots, celery, basil) and creeping plants (patisson) and climbing plants (beans).
Opposed to these compositions are the plants with cold shades, having a medium size and voluminous shape. The scenery in this area is mainly offered by the shape and colour of the leaves. Kale cabbage provides the background for decorative sage flowers while mangold is used as a light green background for the leeks. Also, the mangold offers small accents of red and yellow from the petiole (Figure 7).

Figure 7. Colour detail - mangold and leek (original)

The perennial species provide the desired decoration mainly by the shape and colour of the leaves, as seen in Figure 8. Depending on the season, they also provide decoration through flowers. The colour contrast is balanced. Purple flowers offered by Russian sage and lamb's ear, in contrast to the red-pink flowers offered by the gaura. Even the Chinese fountain grass provides decoration through the floral spikes towards the end of summer.

Figure 8. Detail of the decoration offered by the leaves of the lamb's ear and the gaura (original)

With the onset of the cold season, the garden design continues to be ornamental due to kale, mangold, leek and perennial species. At low temperatures, the species of mangold and kale cabbage intensify the colour of their leaves, thus having a very high visual impact as it can be seen in Figure 9.

Figure 9. Detail on plant colouring in November (original)

The evolution of the plants is observed in Figure 10. The four images were taken at four different months to highlight how plants develop and how various their colours can be during different seasons.

Figure 10. Experimental variants in May, June, August and November (original)

Results regarding the yield

Due to temperature fluctuations from the beginning of May 2020, certain species have been affected, resulting in low yields for tomato, cucumber and carrot species. Two preventive treatments were performed based on copper and sulphur in accordance with the principles of organic farming (Stoleru et al., 2014).

Despite these temperature fluctuations, yield differences can be observed between the three variants, thus the V1 (40 cm above ground level) has the best results in terms of yield. The results of V2 (20 cm above the ground) and V3 (at ground level) vary depending on the species.

The total production values per plants from the three experimental variants are represented in Table 4.

According to the statistical analysis of the yield, both of the tomato varieties (Tigerella and Black Cherry) have no significant differences between the three variants. For both cultivars of tomatoes, the lowest yield was obtained on beds made at 20 cm above ground level. The best results of tomato were obtained on the V1 at 40 cm beds.

Sweet pepper obtained the best results in V1 compared with others version significant for $p \leq 0.05$.

The best result of onions can be obtained on raised beds with a hight at 40 cm (1,235.01 g) compared with V2 (608.66 g).

Leek has better results in both of the raised beds variants with a close production of 4,115.00 g and 4,190.00 g compared to the V3.

The different hights and substrate used in the three variants influenced the celery yield significantly. The production varied from 1,640.00 g in V1 to 1,029.00 g in V3.

On the other hand, celeriac obtained the best results at ground level compared with the other to variants significant for $p \leq 0.05$.

The best results from the entire compositions were obtained by mangold in V1 with 13,097.00 g production and with a relevant difference from the other two variants.

Table 4. Results regarding the yield of vegetable species included in composition (g)

Common name / cultivar	Total weight (g)		
	V1	V2	V3
Tomato cv. Tigerella	805.00 ± 116.00 ns	616.00 ± 93.92 ns	680.00 ± 92.17 ns
Tomato cv. Black Cherry	645.00 ± 151.32 ns	470.00 ± 45.48 ns	530.00 ± 77.37 ns
Sweet pepper cv. Barbara	1,846.42 ± 218.83 a	1,066.46 ± 90.78 b	702.00 ± 141.05 b
Onion cv. Di Parma	1,235.01 ± 259.49 a	608.66 ± 59.73 b	879.59 ± 89.71 ab
Leek cv. Blue de Solaise	4,115.00 ± 135.98 a	4,190.00 ± 44.34 a	2,920.00 ± 36.47 b
Celery cv. Gigante Dorato 2	1,640.00 ± 5.68 a	1,323.00 ± 10.58 b	1,029.00 ± 16.33 c
Celeriac cv. Giant Prague	1,715.00 ± 49.47 b	1,560.00 ± 30.09 b	3,960.00 ± 570.67 a
Mangold cv. Chard Bright Lights	13,097.00 ± 1,996.94 a	6,226.00 ± 843.89 b	5,679.00 ± 1,332.28 b
Carrot cv. Cosmic Purple	505.00 ± 48.87 a	265.00 ± 38.69 b	310.00 ± 36.75 b
Carrot cv. Royal Chantenay	3,130.00 ± 266.55 a	2,040.00 ± 409.89 b	2,475.00 ± 520.03 ab
Kale cv. Kadet	4,620.00 ± 453.89 a	2,050.00 ± 209.22 c	3,061.00 ± 101.15 b
Kale cv. Nero di Toscana	2,326.00 ± 24.61 a	1,570.00 ± 19.61 c	1,997.00 ± 6.92 b
Kale cv. Scarlet	2,608.00 ± 20.86 a	961.00 ± 15.26 c	1,104.00 ± 31.85 b
Cucumber cv. Ekol	2,784.00 ± 53.7 a	1,386.00 ± 199.73 b	1,174.00 ± 179 b
Peppermint cv. Cinderella	935.00 ± 126.73 b	670.00 ± 157.18 b	1,340.00 ± 129.67 a
Oregano cv. Kreta	565.00 ± 82.48 ns	478.00 ± 56.66 ns	449.00 ± 38.24 ns
Parsley cv. Triple Moss Curled	2,569.00 ± 516.19 ns	2,163.00 ± 454.48 ns	2,069.00 ± 203.26 ns
Thyme cv. Di Provenza	846.00 ± 86.35 a	739.00 ± 24.42 a	576.00 ± 6.09 b

Legend: cv. - cultivar; V1 - raised beds on 40 cm; V2 - raised beds on 20 cm; V3 - beds on the ground level; ns - nonsignificant; the lowercase letters represent the results of the Tukey test for $p \leq 0.05$ (a - the highest value and c - the lowest value). The test was calculated on line.

Carrot cv. Cosmic Purple obtained the best results in V1 compared with others version significant for $p \leq 0.05$.

Due to the very well-loosened and nutrient-rich substrate, the carrot cv. Royal Chantenay has good result in V1 compared to V2 and V3.

Kale cv. Kadet has significant differences in all three variants with highest production in V1 with a total of 4,620.00 g.

Kale cv. Nero di Toscana has lower production compared to cv. Kadet but despite this it has significant differences in all variants.

Kale cv. Scarlet has the lowest production compared to the other too cultivars but it has significant differences in all three variants with a maximum production in V1.

Cucumber obtained the best results in V1 compared with others version significant for $p \leq 0.05$.

Despite the well-loosened and nutrient-rich substrate in V1 and V2, peppermint has better results in V3 compared to other two version significant for $p \leq 0.05$.

Both oregano and parsley have nonsignificant results in all three variants but with high production in V1 with 565.00 g and 2,569.00 g, respectively.

Thyme has the highest values in V1 and V2 with 846.00 g and 739.00 g, respectively.

CONCLUSIONS

In the development process, the climatic conditions of the area, the type and shape of the land, the ecological requirements of the plants, the way of their association and succession, the decorative elements and the possibility to decorate for a longer period of time were taken into account.

In addition to the manure and compost, crop rotation and crop residue management are also key tools for improving soil fertility and food quality.The ornamental value of the whole design is offered mainly by the colour of the leaves, petiole, flowers and flower clusters. Other plants, such as fountain grass, decorate during the whole year through their shape and colour from green during spring and summer to yellow in autumn.

Overall, there are important yield differences between the three versions, thus the V1 version (40 cm bed) has the best results in terms of yield. The results of yield from V2 (20 cm above the ground) and V3 (at ground level) versions vary according on the species.

Most species had a good production and development in V1. Instead, peppermint and leeks had higher values in V3 and V2, respectively.

Overall, the most productive plant species are the ones for leaf consumption like mangold and kale, especially in V1.

REFERENCES

Cojocaru, A., Munteanu, N., Brîndușa, A.P., Stan, T., Teliban, G.C., Vîntu, C., Stoleru, V. (2019). Biochemical and Production of Rhubarb Under Growing Technological Factors. *Revista de Chimie 2019*. 70(6):2000-2003.

Creasy, R. (1984). *The Complete Book of Edible Landscaping.* Random House Value Pub.

Hamburdă, S.B., Teliban, G.C., Munteanu, N., Stoleru, V. (2016). Effect of Intercropping System on the Quality and Quantity of Runner Bean (*Phaseolus coccineus* L.). *Not Bot Horti Agrobo*, 2016, 44(2):613-618.

Hangan, A.M.R., Cojocaru, A., Teliban, G.C., Amișculesei, P., Stoleru, V. (2020). Preliminary study regarding the use of medicinal and decorative plants in the concept of peri-urban gardens with role on environmental protection. *Scientific Papers. Series B, Horticulture,* Vol. LXIV, No. 2, 2020, Bucharest.

Hangan, A.M.R., Gache, M., Teliban, G.C., Stoleru, V. (2018). Preliminary studies regarding the use of vegetable species in the concept of urban gardens. *Lucrări Ştiinţifice Seria Horticultură*, 61(1) / 2018, USAMV Iași.

Kourik, R. (1986). *Designing and maintaining your edible landscape naturally.* Metamorphic Press.

Liebman, M., Dyck, E. (1993). Crop rotation and intercropping strategies for weed management. *Ecol Appl,* 3:92–122.

Megan, M.G., Timothy, W.L., Laurie, E.D. (2016). Agroecological and social characteristics of New York city community gardens: contributions to urban food security, ecosystem services, and environmental education. *Urban Ecosystem (2016),* 19:763–794.

Mihai, C., Hoza, G. (2012). Researches regarding the productive and ornamental characteristics of vegetable growing in utilitarian gardens. *Scientific Papers, Series B, Horticulture*, Vol. LVI.

Munteanu, N., Bireescu, L., Bulgariu, D., Hura, C., Stoian, L., Stoleru, V. (2010). *Monografia producţiei legumicole ecologice din nord-estul României: posibilităţi şi riscuri.* Editura Arhip Art, Iaşi.

Rotaru, L., Filipov, F., Mustea, M., Stoleru, V. (2010). Influence of some "Terroir Viticole" Factors on Quantity and Quality of Grapes. *Notulae Botanicae Horti Agrobotanici*, 38(1):176-18 .

Sima, R. (2017). *Legumicultură ornamentală*, Editura AcademicPres, Cluj-Napoca.

Stoleru, V., Munteanu, N., Hura, C. (2015). Organophosphorus pesticide residues in soil and vegetable, through different growing systems. *Environmental Engineering and Management Journal,* 14(6): 1465-1473.

Stoleru, V., Munteanu, N., Sellitto, M.V. (2014). *New Approach of Organic Vegetable Systems.* Aracne Publising House.

Stoleru, V., Munteanu, N., Stoleru, C.M., Rotaru, L. (2012). Cultivar Selection and Pest Control Techniques on Organic White Cabbage Yield. *Notulae Botanicae Horti Agrobotanici*. 40(2) Pages: 190-196.

Teliban, G.C, Burducea, M., Zheljazkov, V.D., Dincheva, I., Badjakov, I., Munteanu, N., Mihalache, G., Cojocaru, A., Popa, L.D., Stoleru, V. (2021). The Effect of Myco-Biocontrol Based Formulates on Yield, Physiology and Secondary Products of Organically Grown Basil. *Agriculture 2021*, 11, 180.

Valnet, J. (1982). *Practice of Aromatherapy: Holistic Health and the Essential Oils of Flowers and Herbs.* Inner Traditions.

***Centrul Meteorologic Regional Moldova Iaşi, 2018-2020 - Date meteorologice, Iași county.