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Short Communications

Optimal use of areas in perennial vegetable crops during first year of growing

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Abstract. *This paper tries to illustrate how intercropping increases the overall output of a cropping system and achieving much larger yields than sole crops by using environmental resources more fully over time or more efficiently in space. The research was conducted to establish the opportunity for optimal use of the growing area in perennial vegetables crops (Asparagus officinalis L., Rheum rhabarbarum L., Cynara cardunculus var. Scolymus, Levisticum officinale) by an intercropping system with annual vegetables (Brassica rapa subsp. Chinensis, Eruca sativa) in open field. The experiment was carried out in 2018 year in Vegetable Crops Research Institute (VCRI) Maritsa, Plovdiv, Bulgaria. Crops were grown under schemes: asparagus - 200+60/50 cm; artichoke - 200+60/90 cm; rhubarb - 200+60/90 cm; lovage - 200+60/50 cm; pak choi - 55+45+45+55/20 cm and 55+30+30+30+55/20 cm; rocket - 55+45+45+55/15 cm and 55+30+30+30+55/15 cm. As a result it was determined that the use of annual crops increases efficiency of the areas in perennial vegetables during the first year of growing. Annual vegetables pak choi and rocket grown under scheme 55 + 30 + 30 + 30 + 55/20cm and 55 + 30 + 30 + 30 + 55/15cm, respectively, are suitable for an intercropping system.*

Keywords: mixed growing, asparagus, rhubarb, lovage, artichoke, pak choi, rocket

Introduction

Perennial vegetable crops have larger plant habitus and need a bigger area than most annual crops in open field. This necessitates their cultivation by a specific technology of growing, especially for asparagus (Jones et al., 2008; Relf and McDaniel, 2015), rhubarb (Burt, 2000) and artichoke (Smith et al., 2008; Bratsch, 2014). Space between plant rows is increased and there is more space of soil for cultivation. As a result, significant space remains in the first year of planting, which requires frequent treatments of the soil to maintain it in good condition and to destroy weeds. This problem in the interline spacing is successfully solved by the use of small tractors with certain parameters. In the first year of growing perennial plants are still with small size and this allows to grow other vegetable crops in the same place. Intercropping has been used in practice for a long time, but it is mainly applied to annual crops, combining vegetables with cereals (Ijoyah, 2012); sweet potato with maize (Amede and Nigatu, 2001), radish with amaranths (Brintha and Seran, 2009), vegetables – maize (Dimitrios et al., 2010), potato - maize (Ifenkwe et al., 1989), pepper with bushitao (Jeyakumaran and Seran, 2007), melon with maize (Wuhua, 1985), but poorly applied to perennial plants with other crops.

The selection of an appropriate intercropping system for each case is quite complex as the success of the intercropping systems depends much on the interactions between the component species, the available management practices and the environmental conditions (Lithourgidis et al., 2011).

The purpose of the investigation was to establish the opportunity to optimize areas of growing by intercropping perennial and annual vegetable crops in open field.

Material and methods

The investigation was carried out in 2018 year at Maritsa VCRI, Plovdiv with perennial crops: asparagus (variety *Argenteul*l, Poland), artichoke (variety *Violet de provence*, Poland), rhubarb (variety *Victoria*, Italy), lovage (*Elsbetha*, EnzaZaden, Nederlands), and annual crops: pak choi (Italy) and rocket (Italy) in open field.

Seedlings from perennial plants were grown in trays with 32 cells; filled with peat and perlite 1:1 vol./vol., under conditions of unheated greenhouse. The seed were sown on 31/03, and the seedlings were planted in the field on 30/05. Before planting, soil was prepared by plowing at a depth of 20-25 cm and the soil surface were treated with a milling machine. Plants were planted under schemes, presented in Table 1.

The choice of a scheme for growing asparagus, artichoke, rhubarb and lovage with a distance between rows of 2.00m is based on the use of a small tractor for cultivation. This allows planting other crops when perennial plants are still not so much high in the first year of cultivation.

Depending on the climatic conditions of Bulgaria and the time of planting the perennial crops, it is advantageous to grow them together with crops suitable for late production. In the country for late production in open fields are used vegetables: tomatoes, green beans, cucumbers and zucchini. These vegetables are unsuitable because of the following disadvantages: regular soil treatment and fertilization; effective plant protection against diseases and pests; soil compaction due to frequent harvesting, mainly for cucumbers and zucchini. Crops from *Brassicaceae* (cabbage, kohlrabi, cauliflower and broccoli) are also not good choices for cultivation because

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of the following reasons: it is necessary to grow seedlings that require additional care resources, with duration of one month; require regular care - soil treatment, fertilizing and plant protection; vegetation ends almost at the same time as those of the perennial crops and later removal from the field.

For these reasons, for this experiment pak choi and rocket were selected as suitable crops for intercropping. They are characterized by short vegetation, about 30-40 days, and have a number of advantages: direct seed sowing in the field; do not need many nutrients and no additional fertilization is required; they are resistant to *Peronospora parasitica* and have no common diseases with other plants; they haven't common pests. They are attacked by cabbage fleas (*Phyllotreta* spp.), which do not harm asparagus, artichokes, rhubarb and lovage); early removal from the areas and allow time to make soil treatment, fertilization and prepare the perennial plants for winter; there is a possibility for a second sowing.

Annual plants (pak choi and rocket) were grown by direct sowing of seeds in the field. That was at the end of June, and harvesting was a month later, at the beginning of July. Sowing schemes are presented in Table 2.

Irrigation of plants was carried out by a dripping system with an irrigation rate of 40 L/m^2, and maintaining an optimal humidity in soil about 75-80%. Irrigation was performed selectively according to the needs of the plant species and climatic conditions during the vegetation period.

The experiment with the annual plants was set in three replicates, with a plot length of 2.50 m. From one replicate 15 plants were measured. The examined indicators were: number of leaves and fresh weight of the plant, g.

The experimental data were elaborated by ANOVA.

Table 1. Scheme of growing perennial plants

No	Vegetable crop	Scheme of growing
1.	Asparagus	200+60/50 cm
2.	Artichoke	200+60/90 cm
3.	Rhubarb	200+60/90 cm
4.	Lovage	200+60/50 cm

Table 2. Scheme of growing the annual plants

No	Vegetable crop	Scheme of growing
1.	Pak Choi	3 rows - 55+45+45+55/20 cm 4 rows - 55+30+30+30+55/20 cm
2.	Rocket	3 rows - 55+45+45+55/15 cm 4 rows - 55+30+30+30+55/15 cm

Results and discussion

The experiment with two planting schemes on 3 and 4 rows gives an opportunity to assess which is better for intercropping (Table 3). The biometric data of the production show that growing on 4 rows is more effective. The fresh mass, on average, for one plant is 98.88g and it has about 16 leaves.

Table 3. Biometric measurements of annual crops

Scheme of growing	Indicators of plants	
	Fresh weight of plant, g	Number of leaves
Pak choi		
55+45+45+55/20 cm	27.71^b	10.63^b
55+30+30+30+55/20 cm	98.88^a	16.41^a
Rocket		
55+45+45+55/15 cm	13.18^b	9.31^{ns}
55+30+30+30+55/15 cm	16.89^a	10.03^{ns}

*Values in rows followed by different letters are significantly different at P<0.05;
Duncan's Multiple Range Test

These indicators are lower in three-row cultivation where the fresh mass weight is 27.71g and the number of leaves is 11, respectively. The differences are statistically proven (P<0.05). The same trend is observed in the rocket, which responds better to 4-line cultivation. The difference in fresh mass, which is 16.89g and 13.18g, respectively, is proven. Plants form the approximately same number of leaves regardless of the scheme of growing.

The scheme of cultivation has a significant impact on the productivity of pak choi (Figure 1). Decrease of plant spacing results in the increase of yield per unit area. The quantity of yield is from 7.8kg to 3.4kg, in four-row cultivation and in three-row cultivation, respectively. The increase of yield is due to the increased number of plants per unit area. The same trend was also observed in an experiment by Hill (1990), which confirms the results obtained in this study.

Plant density has influence on biomass and leaf marketable yields of rocket (Figure 2). The same trend is observed as in the previous crop. The increase in yield is due to the increased number of plants per unit area. Yield increases from 0.290kg to 0.480kg of 10m^2, respectively, in three-row and four-row cultivation. The smaller plant habitus allows growing a larger number of plants. That was established in research by Taherlou and Dursun (2019).

Intercropping, the agricultural practice of cultivating two or more crops in the same space at the same time, is an old and commonly used cropping practice which aims to match efficiently crop demands to the available growth resources and labour. The most common advantage of intercropping is to increase productivity per unit area (Willey et al., 1983; Lithourgidis et al., 2011).

This agronomic method has been used as a means of sustainable agriculture, reducing use of herbicides, and has great potential for reducing pests and diseases while preserving the quality of production (Theunissen, 1997).

Conclusion

The publication provides opportunity to compact the areas in crops of perennial crops during the first year of their

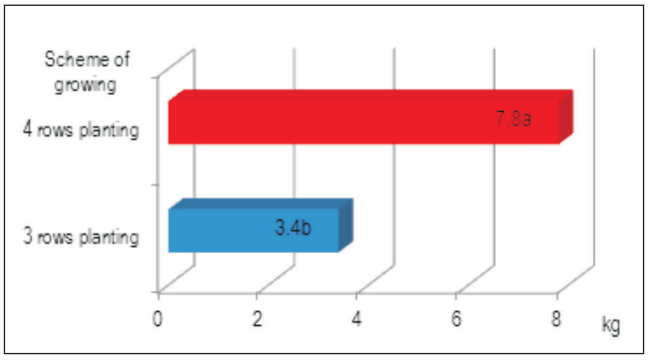

Figure 1. Yield from pak choi, kg/10 m^2

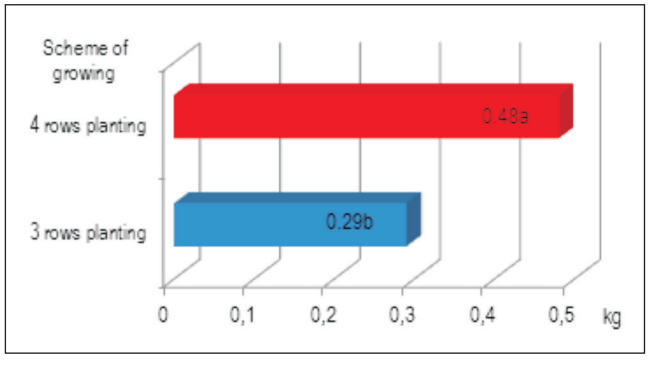

Figure 2. Yield from rocket, kg/10m^2

planting when they are still in an underdeveloped habitus and do not produce yield. This allows the cultivation of intermediate annual crops. They do not affect their growth due to short vegetation. Appropriate vegetable crops are pak choi and rocket. In the comparative study of two cultivation schemes, it was found that for pak choi the appropriate scheme was 55 + 30 + 30 + 30 + 55/20 cm, and for rocket 55 + 30 + 30 + 30 + 55/15 cm.

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