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Content:	Use of stabilized sewage sludge in the deciduous ornamental shrub production

Abstract

The effect of the soil fertilization with sewage sludge at dosages corresponding to 0, 5, 10 and 20 tons ha⁻¹ on growth, physiological events and decorative quality of four species of ornamental shrubs: *Deutzia scabra* 'Codsall Pink', *Spiraea betulifolia*, *Forsythia intermedia* 'Nothorn Gold' and *Weigela rosea*, was evaluated. Fertilization with sewage sludge, before plant planting, increased quantity of N, P, K, Mg and organic substrate in soil. All of the used dosages of the sewage sludge, from 5 to 20 tons ha⁻¹, greatly increased growth, development, biomass, decorative quality, chlorophyll content and some enzyme activity in the evaluated ornamental shrubs, although for majority of these species dosages of 5-10 tons ha⁻¹ were most profitable. This indicates that the examined ornamental plants are very sensitive to the sewage sludge and they can be fertilized with them in nursery production.

Introduction

Sewage sludge is a very complex product containing residues or traces of the large number of chemicals used in society as a whole. Organic waste has been used as fertiliser by generations of farmers going back to ancient times, when more or less composted material from households and husbandry was used directly on the surrounding fields.

Agricultural use of sewage sludge has without doubt many beneficial aspects, as recycling of nutrients from human and animal waste generally is in line with sustainable development. It helps to increase crop production, maintain the organic pool in soils and to reduce the use of mineral fertilisers, which is a limited resource (P) or produced under large energy consumption (N).

Material and Methods

Experiments were carried out on four ornamental shrub species which are very popular in Poland and are recommended for planting in gardens and city parks:

- *Deutzia scabra* 'Codsall Pink'
- *Spiraea betulifolia*
- *Forsythia intermedia* 'Nothorn Gold'
- *Weigela rosea*

The woody cuttings were commercially rooted in multiflowerpots (3 cm in diameter and 6 cm in height) during winter and spring of 2007 in Experimental Field Station of the Research Institute of Pomology and Floriculture, Nowy Dwor. Than, they were planted in half of May, on plots fertilized with different dosages of stabilized sewage sludge, in the experimental field of Polish Academy of Sciences, Lodz.

Ten rooted cuttings of the each shrub species were planted in three repetitions on the randomly chosen plots of which soil were mixed before planting with stabilized sewage sludge at dosages corresponding to:

- 0 tons ha^{-1} sewage sludge (control)
- 5 tons ha^{-1} sewage sludge
- 10 tons ha^{-1} sewage sludge
- 20 tons ha^{-1} sewage sludge

Stabilized sewage sludge was produced by municipal wastewater treatment plant (GOŚ), Lodz. The fertilization level for the treatments was chosen on the basis of the previous author experience and EU regulations concerning fertilization with sewage sludge in farmland. The sewage sludge was mixed with soil down to 20 cm in depth and the composition of the such fertilized soil is presented in Table 1. The cuttings were watered directly after planting to the field and than shrubs were cultivated free of weeds during all vegetative season.

The composition of the soil fertilized with the sewage sludge was evaluated in May directly before plant planting. Nitrate (N) was evaluated using Kjeldahl method, phosphor (P) and potassium (K) by Egner-Rhiem method (PB-02, 15.07.2005), magnesium (Mg) with Schachtschabel method (PB-03, 15.07.2005) and pH in 1N KCL using potencjometric technique (PB-01, 15.07.2005).

The effect of the used sewage sludge dosages on shrubs development was evaluated in half of May, June, July and September 2007 by measuring in each plant:

- height from the ground level up to the upper vegetative bud,
- number of shoots which were longer than 3 cm, to see the branching,
- the total sum of length of shoots which were longer than 3 cm, to see the plant biomass,

and additionally:

- chlorophyll a+b content in leafs to indicate their color, in July,

- activity of acid (pH 6.0) and alkaline (pH 7.5) phosphatase in July, to indicate the metabolism in plants,
- observation of the fall down of leaves in November, to see the plant readiness to the entrance into winter dormancy,
- fresh and dry weight of plant in November, to indicate their biomass,
- moisture content of plants measured in November, to indicate their readiness to the entrance into winter dormancy,

Results and discussion

The obtained results show that fertilization with sewage sludge increased quantity of N, P, K, Mg and organic substrate in soil. The quantity of these components and pH increased when dosages were higher, with the exception of K where reversal effect was observed. (Table 1).

Table1. Composition of soil fertilized with stabilized sewage sludge using dosages of 5, 10 and 20 tons ha⁻¹

Dosages of sewage sludges (tons ha ⁻¹)	N % s.m.	Organic substrate %	pH KCl	P	K	Mg
				mg 100 g ⁻¹ soil		
0	0,19	4,22	5,73	10,7	9,26	9,38
5	0,35	7,95	6,32	39,4	39,8	14,3
10	0,37	9,05	6,49	52,3	25,6	14,5
20	0,49	12,3	6,75	70,4	17,0	15,4

Sewage sludge mixed with soil before ornamental plant planting positively influenced their growth, development and biomass during all vegetative season. Results indicate that all of the used dosages of the sewage sludge, from 5 to 20 tons ha⁻¹, increased growth of the evaluated ornamental shrubs: *Deutzia scabra* 'Codsall Pink', *Spiraea betulifolia*, *Forsythia intermedia* 'Nothorn Gold' and *Weigela rosea*. For majority of these species, the sewage sludge at dosages of 5-10 tons ha⁻¹ were most profitable why 20 tons ha⁻¹ were only slightly less effective in the growth improvement, although all the used amounts increased greatly height, number of shoots and biomass of plants, as to compare to control, in which soil was not fertilized (Fig. 1, 3, 5, 7, Table 2). This suggests that the elaborated ornamental plant species are very sensitive to the sewage sludge and the used dosages are optimal for their fertilization.

The increased dosages of sludge affected the higher content of chlorophyll a+b and the more intensive color of leafs (Fig. 2, 4, 6, 8), however this dependency did not influenced greatly the time of the leaf fall down in autumn. In *Forsythia* and *Weigela* plants, all leafs fell down at the same time, independently if the plants were not fertilized (control) or fertilized with the low or higher sludge dosages. Similar independencies were found in the shoot moisture content. They contained similar amount of water in November, independently of fertilization level. Leafs of *Deutzia* and *Spiraea* plants has been fallen also at the same time in spite of the shoot moisture content was slightly higher in November due to the fertilization with higher dosages of sludge (Table 2). These indicate that the used dosages of sludge did not delay the plant entrance into winter dormancy and the plants have the opportunity to be resistant to the winter frosts. The used dosages of sludge increased not only the plant height, branching and biomass, but also they improved greatly decorative quality of plants and their compactness.

Plants of *Deutzia scabra* grew slowly during first month after planting, probably due to the soil overgrowing by roots. After this, since half of June the growth was accelerated and it was the most intensive in the period from July to September. The highest number of shoots and their biomass was produced when soil was mixed, before plant planting, with sewage sludge at dosages of 5-10 tons ha⁻¹. The plants fertilized with sludge were higher, better branched, more compact and of better decorative quality than control. Treatment with dosages of 20 tons ha⁻¹ was also promising, although due to its less effectiveness and higher cost of fertilization it can be less recommended in the evaluated plant species production (Fig. 1, Photo 1). The used dosages of sludge did not affected time of leaf fall down, although the shoot moisture content in November was slightly increased by this fertilization (Table 2). This suggests that the plants enter into winter dormancy at the same time and their frost resistance should be similar, independently of the used sludge dosages. The soil fertilization with sludge increased also intensity of the shoot and leaf color. It was correlated with the higher chlorophyll a+b content. The chlorophyll content increased when amount of sludge was higher. The used fertilization did not affect activity of acid and alkaline phosphatase, independently of the used sludge dosages (Fig. 2).

Growth of *Spiraea betulifolia* plants was affected similarly by the used sludge dosages, as it was observed in the case of *Deutzia scabra*, however, due to the

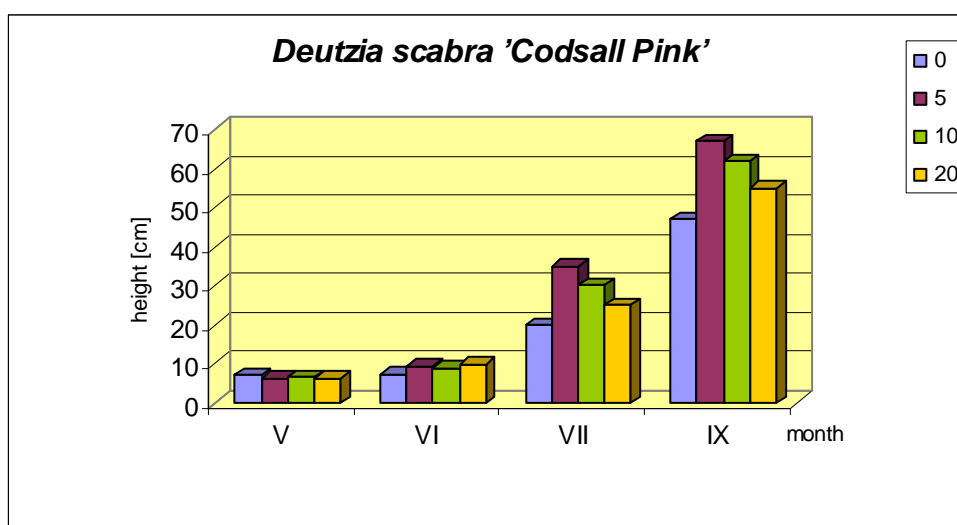
species character, plants of *S. betulifolia* produced slightly more shoots than *Deutzia* and the height of plants was lower. In *S. betulifolia*, the most profitable was the sludge fertilization at dosages of 10 tons ha⁻¹. Dosages of 5 tons ha⁻¹ were only slightly less effective. Dosages of 20 tons ha⁻¹ increased also the growth of plants but in less degree than 5 and 10 tons ha⁻¹. (Fig. 3, Photo 2). Plants were of good quality independently of fertilization. The highest chlorophyll a+b content in leafs and their more intensive color were observed after fertilization with sludge at all dosages and especially at 10 tons ha⁻¹. The activity of alkaline and acid phosphatase in plants fertilized with 5-10 tons ha⁻¹ of sludge was similar to control and it decreased when amount of this fertilizer was higher (Fig. 4).

The soil fertilization with sewage sludge accelerated growth of *Forsythia intermedia* 'Nothern Gold' plants. In opposite to the previously mentioned species sludge dosages of 5 and 10 tons ha⁻¹ increased similarly the number of shoots (branching), but for the height of plants and total sum of the shoot length (biomass), the most profitable was 5 tons ha⁻¹. Requisition of these plants for lower dosages of sludge could be connected with the lower branching and lower total biomass, which is of this species character (Fig. 5). The used dosages of sludge increased chlorophyll a+b content in leafs and the highest amount of it was found under influence of dosage of 10 tons ha⁻¹. Fertilization with sludge at dosage of 10 and 20 tons ha⁻¹ increased also activity of acid and alkaline phosphatase (Fig 6).

Plants of *Weigela rosea* were also sensitive to sludge fertilization, as the mentioned above species did. The most profitable for their height, branching and biomass was 10 tons ha⁻¹. The dosages of 5 and 20 tons ha⁻¹ were only slightly less profitable for the growth improvements. The chlorophyll a+b content and activity of acid and alkaline phosphatase increased proportionally to the sludge dosages.

The obtained results shows that plants of *Deutzia scabra* 'Codsall Pink', *Spiraea betulifolia*, *Forsythia intermedia* 'Nothern Gold' and *Weigela rosea* can be fertilized in nursery with stabilized sewage sludge at dosages of 5-10 tons ha⁻¹. Fertilization with dosages of 20 tons ha⁻¹ can be less useful due to the slightly lower effectiveness in the plant development improvements and higher cost of fertilization, although this dosages also affect positively the plant growth. The effects of the used dosages can be modified by the soil quality, but the obtained results suggest that the recommended here amounts of sewage sludge, produced by GOŚ in Lodz, can be

useful for majority of fields. The used dosages are rather small and they probably have the weak influence on the pollution of environment, where this production takes place. Fertilization with the used sewage sludge improves height, branching, biomass and quality of plants and thus this treatment can be used in production of these shrubs in nursery. The fertilization of deciduous ornamental shrubs in nursery with stabilized sludge do not pollute gardens or parks because the roots are free of soil when these plants are taken from nursery and then transported and planted in gardens or city parks. The obtained results of research show that fertilization of ornamental shrubs in nursery with sewage sludge can decrease or replace the use of synthetic fertilizers and thus it should be recommended in ornamental nursery production to avoid the pollution in environment.



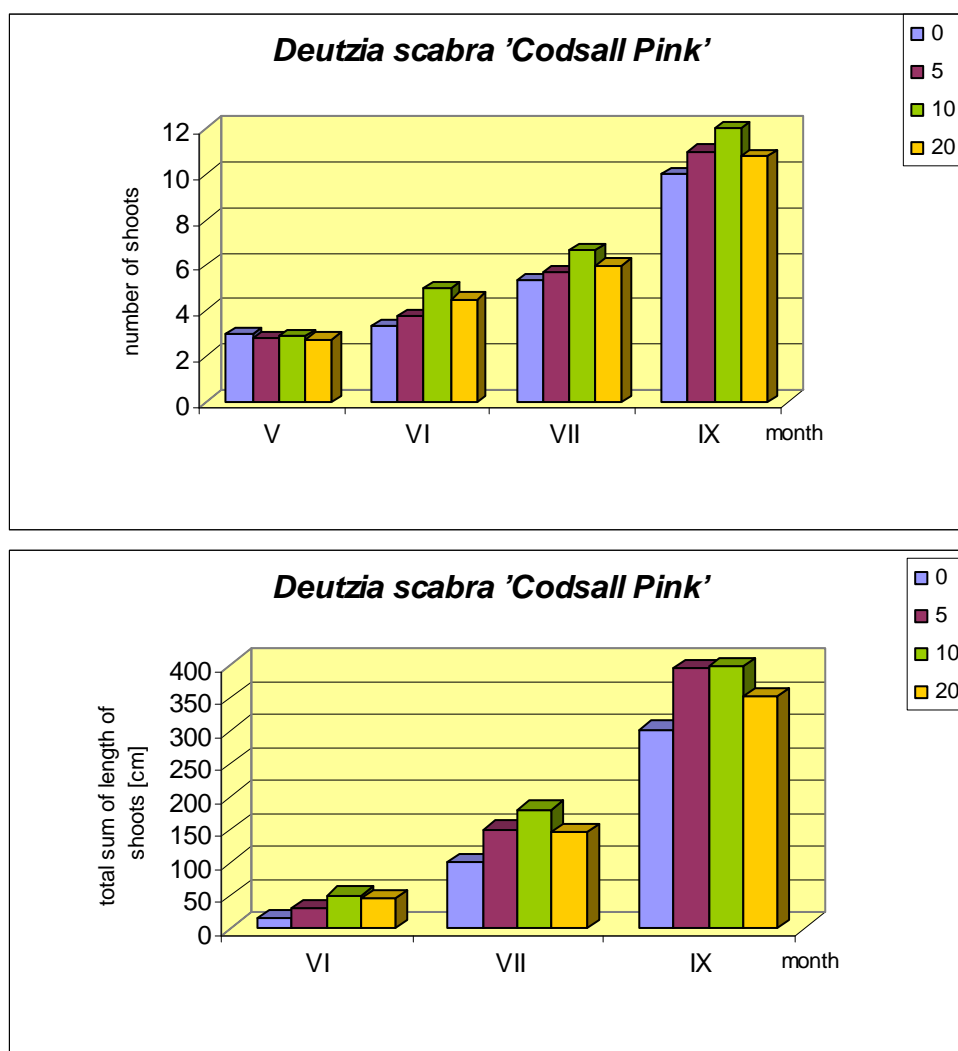
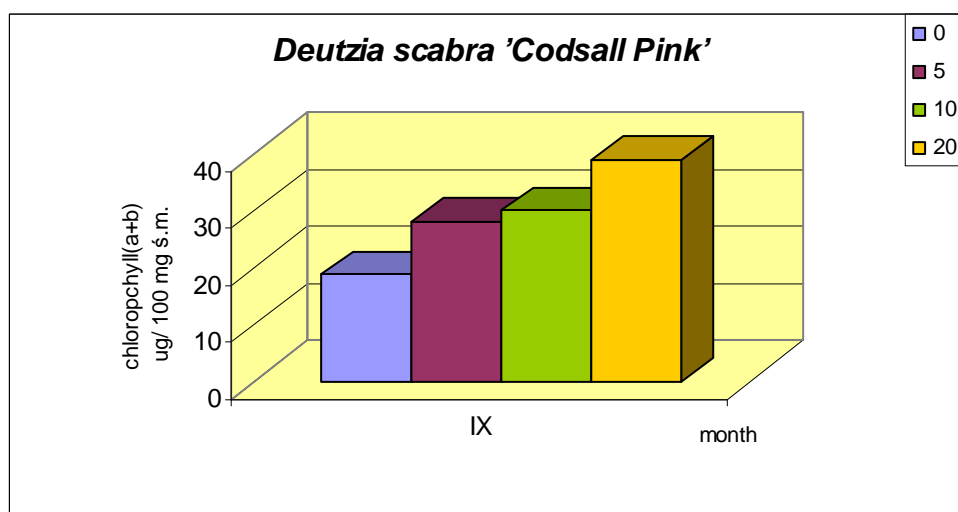


Fig. 1. Height, number of shoots and total sum of the shoot length of *Deutzia scabra* 'Codsall Pink' fertilized with dewatered and stabilized sewage sludge at dosages of 5, 10 and 20 tons ha⁻¹.



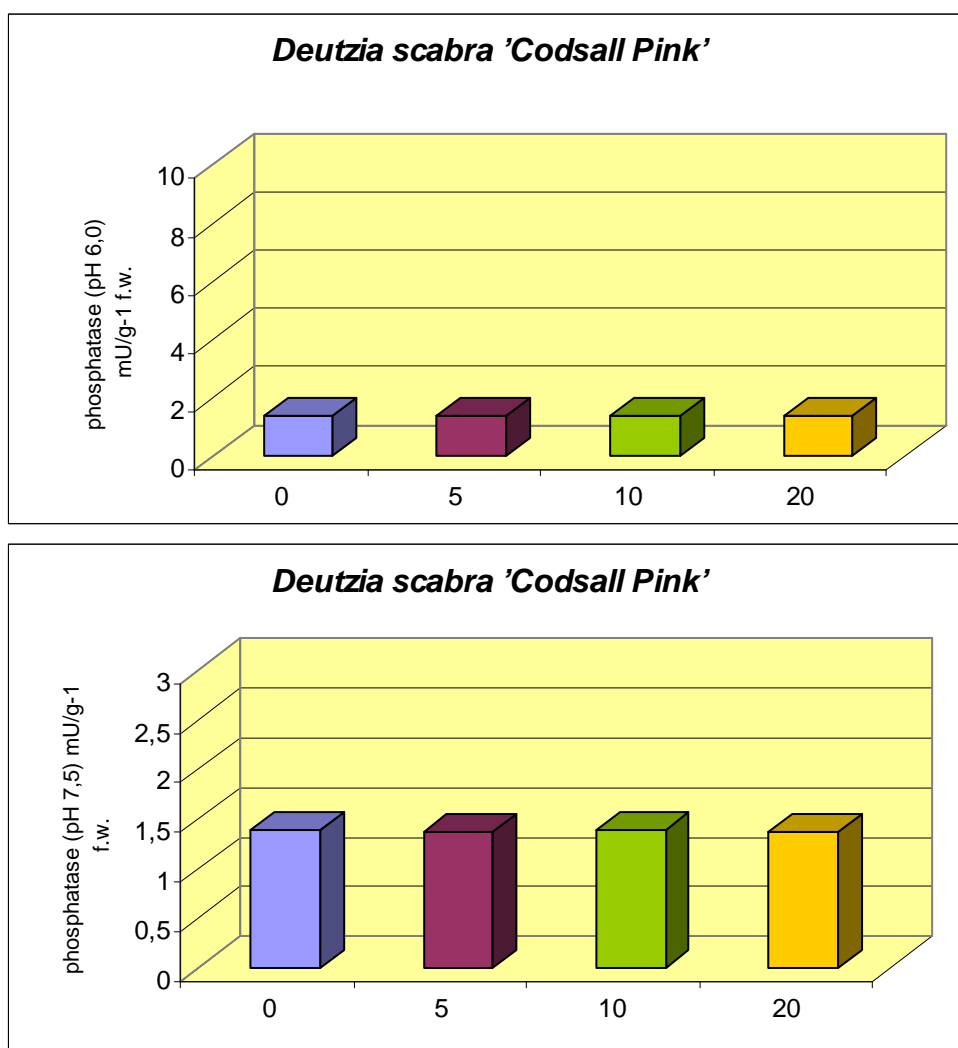


Fig. 2. Chlorophyll a+b content and activity of the acid and alkaline phosphatase in leafs of *Deutzia scabra* 'Codsall Pink' fertilized with dewatered and stabilized sewage sludge at dosages of 5,10 and 20 tons ha⁻¹.

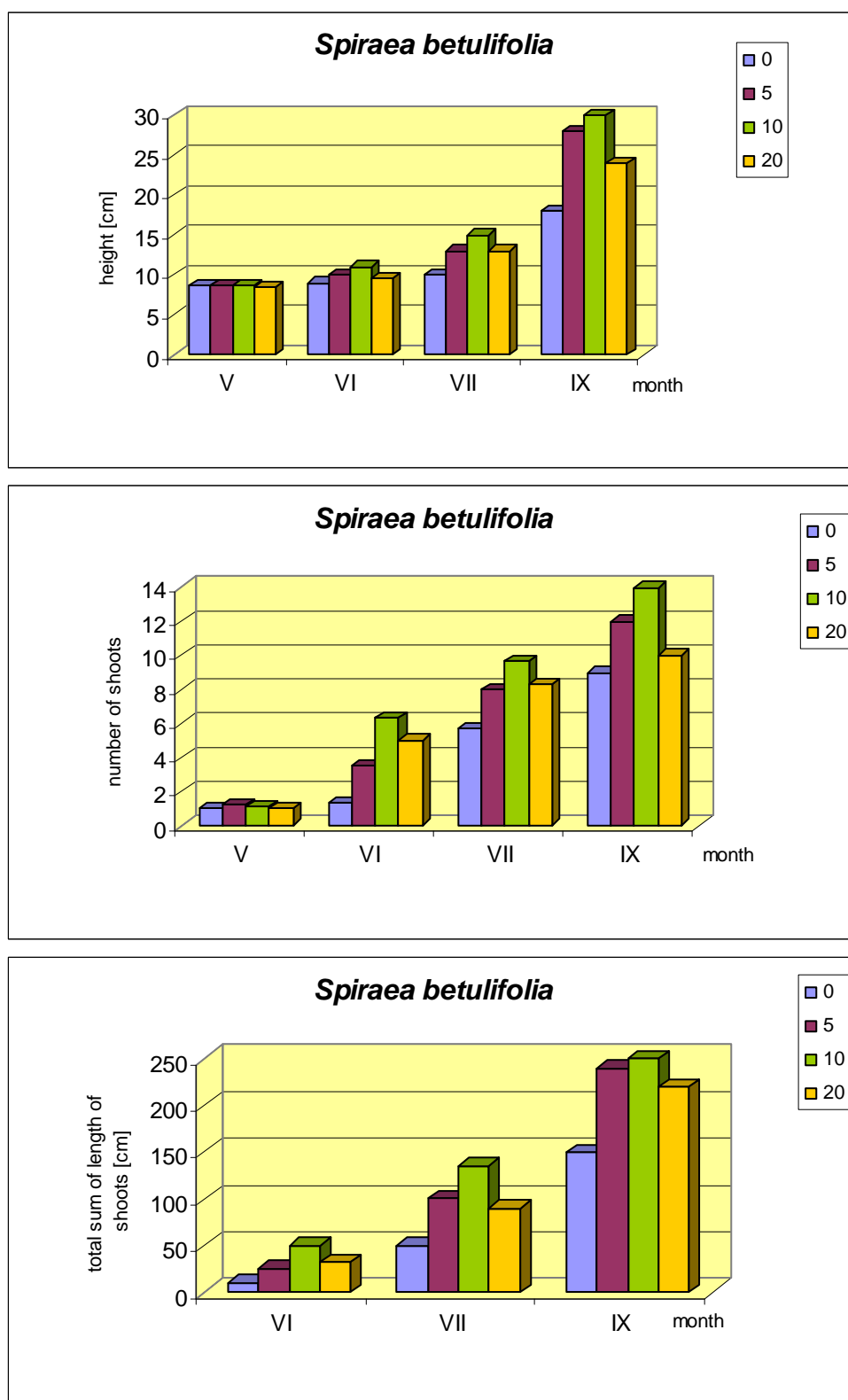


Fig. 3. Height, number of shoots and total sum of the shoot length of *Spiraea betulifolia* fertilized with dewatered and stabilized sewage sludge at dosages of 5, 10 and 20 tons ha⁻¹

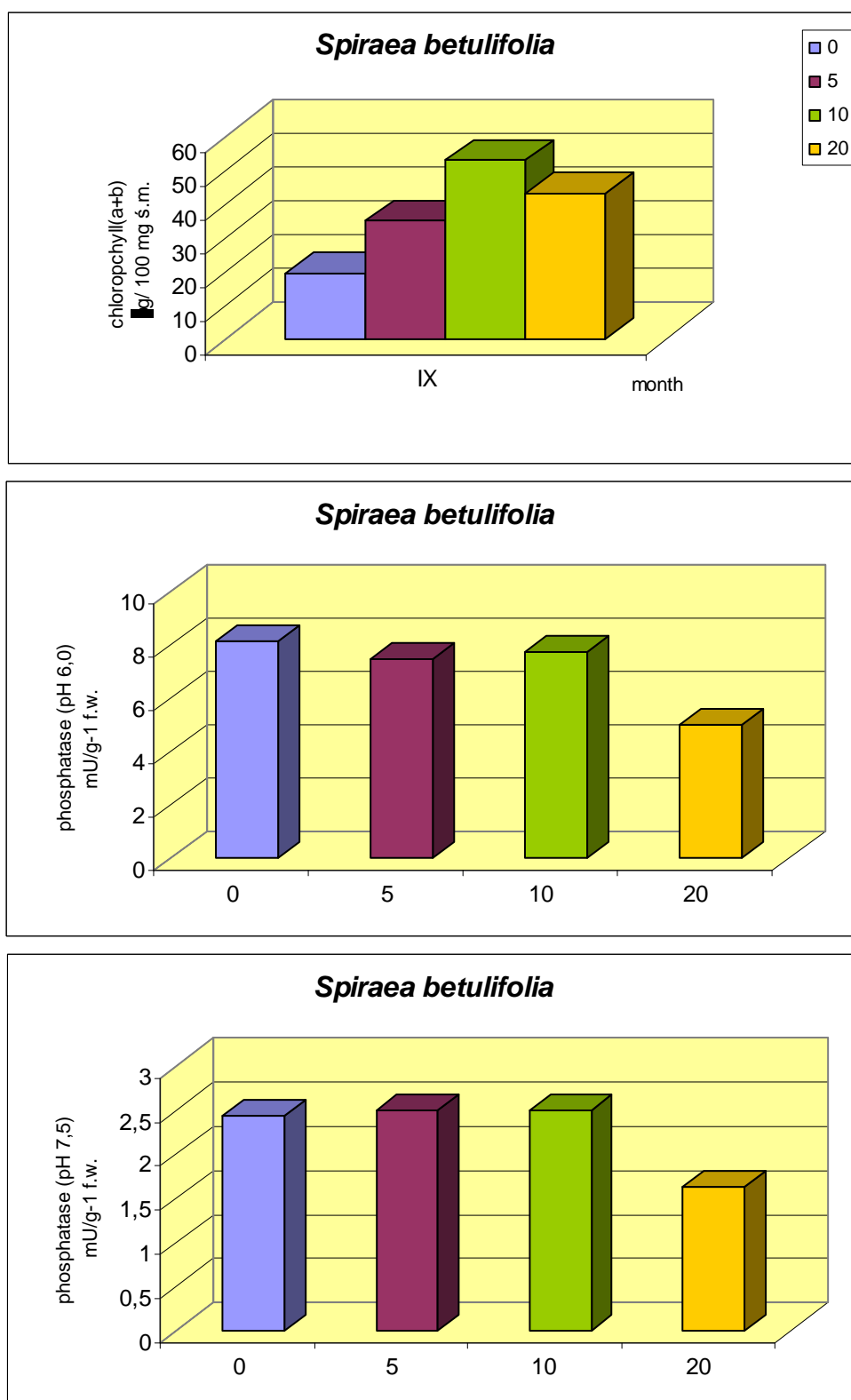


Fig. 4. Chlorophyll a+b content and activity of the acid and alkaline phosphatase in leafs of *Spiraea betulifolia* fertilized with dewatered and stabilized sewage sludge at dosages of 5, 10 and 20 tons ha⁻¹.

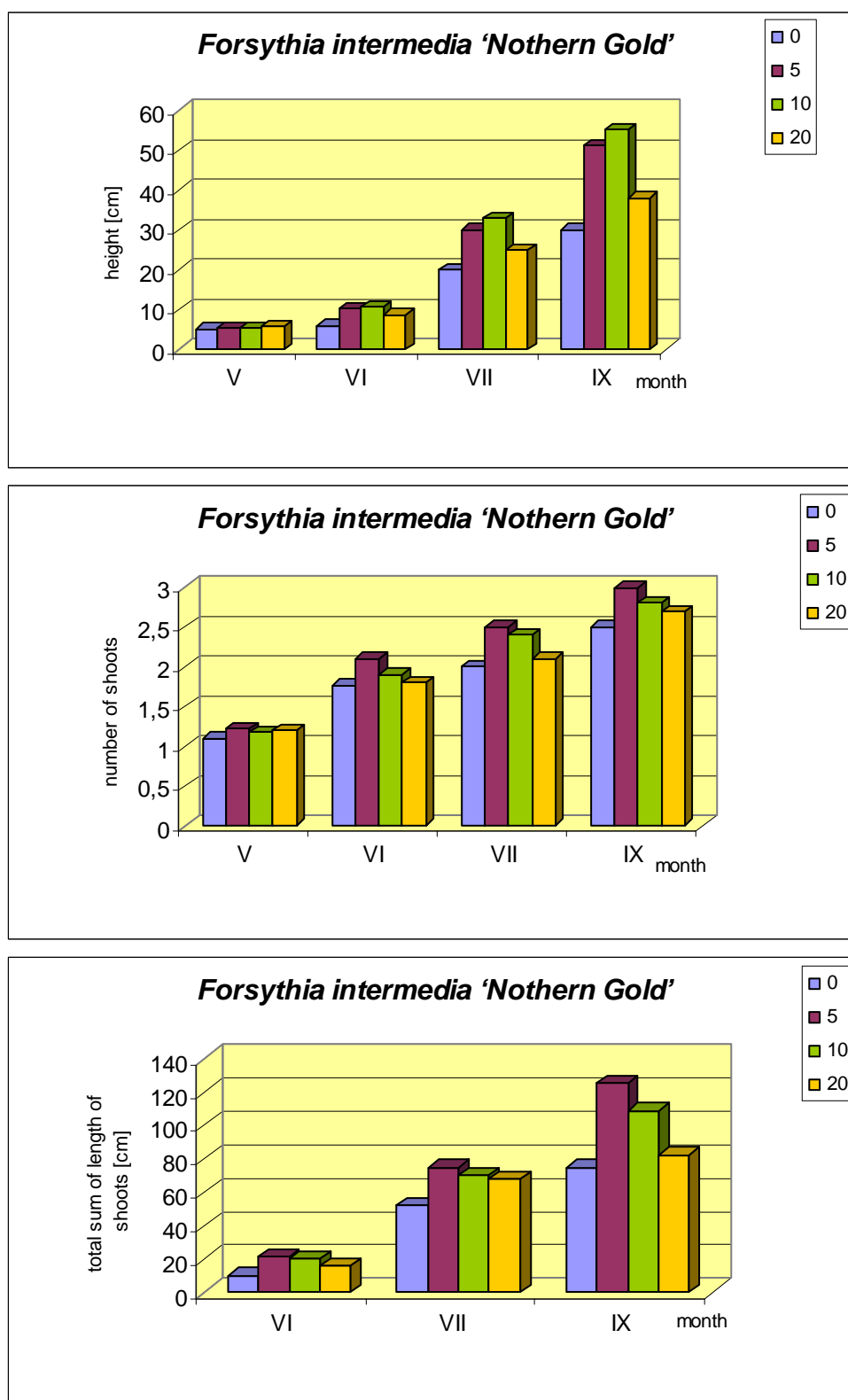


Fig. 5. Height, number of shoots and total sum of the shoot length of *Forsythia intermedia* 'Nothorn Gold' fertilized with dewatered and stabilized sewage sludge at dosages of 5, 10 and 20 tons ha⁻¹

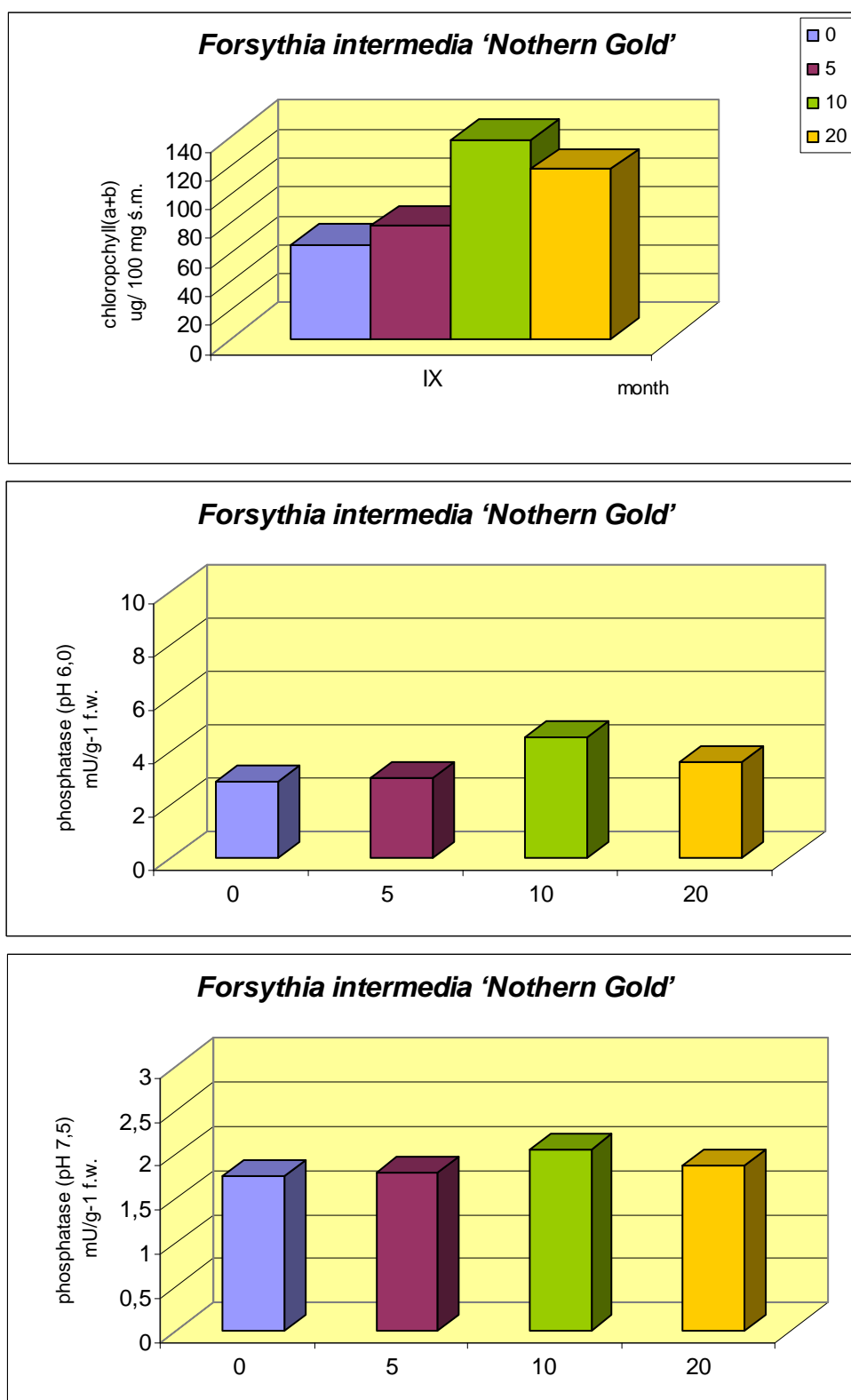


Fig. 6. Chlorophyll a+b content and activity of the acid and alkaline phosphatase in leafs of *Forsythia intermedia* 'Nothern Gold' fertilized with dewatered and stabilized sewage sludge at dosages of 5,10 and 20 tons ha⁻¹.

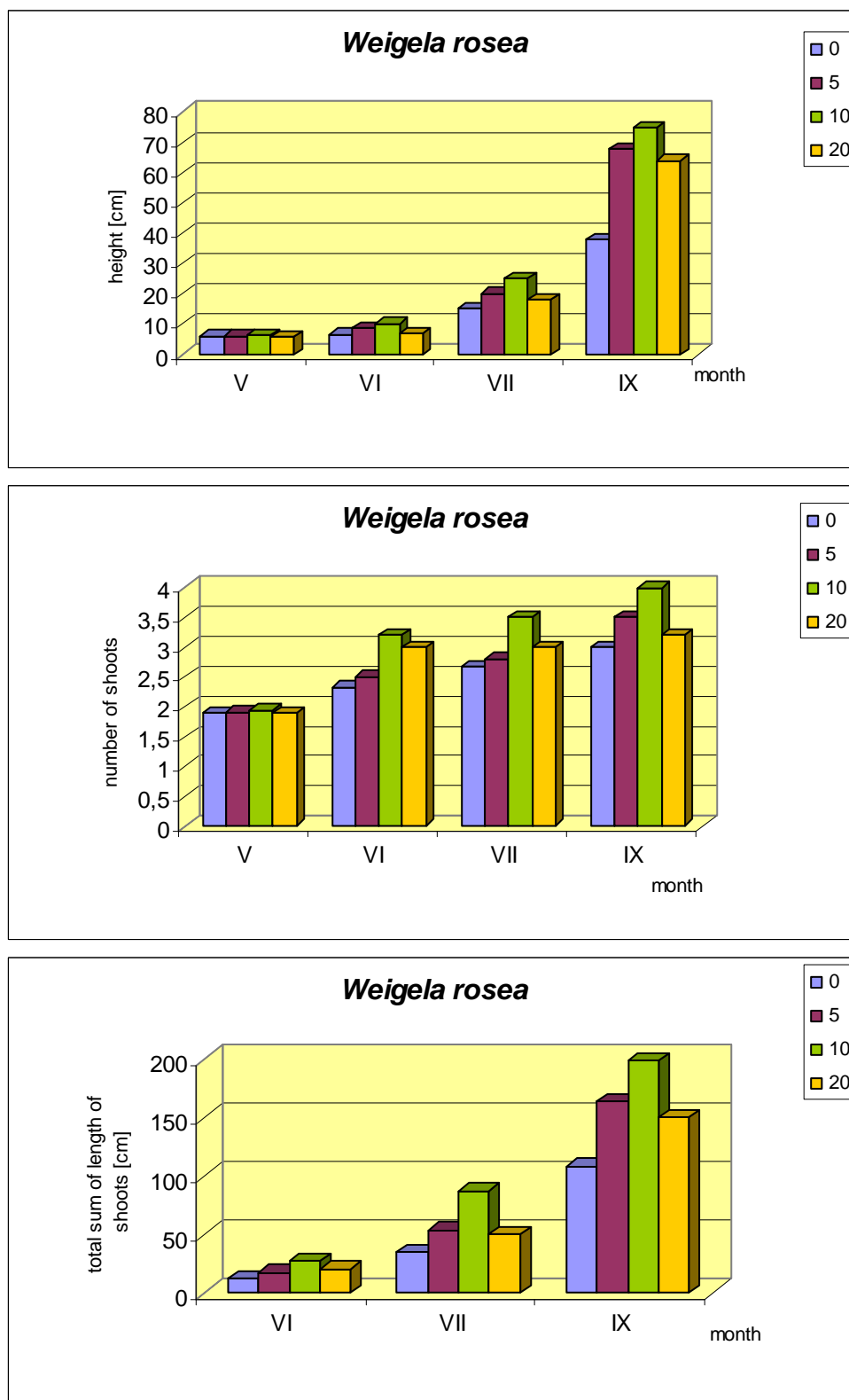


Fig. 7. Height, number of shoots and total sum of the shoot length of *Weigela rosea* fertilized with dewatered and stabilized sewage sludge at dosages of 5, 10 and 20 tons ha⁻¹

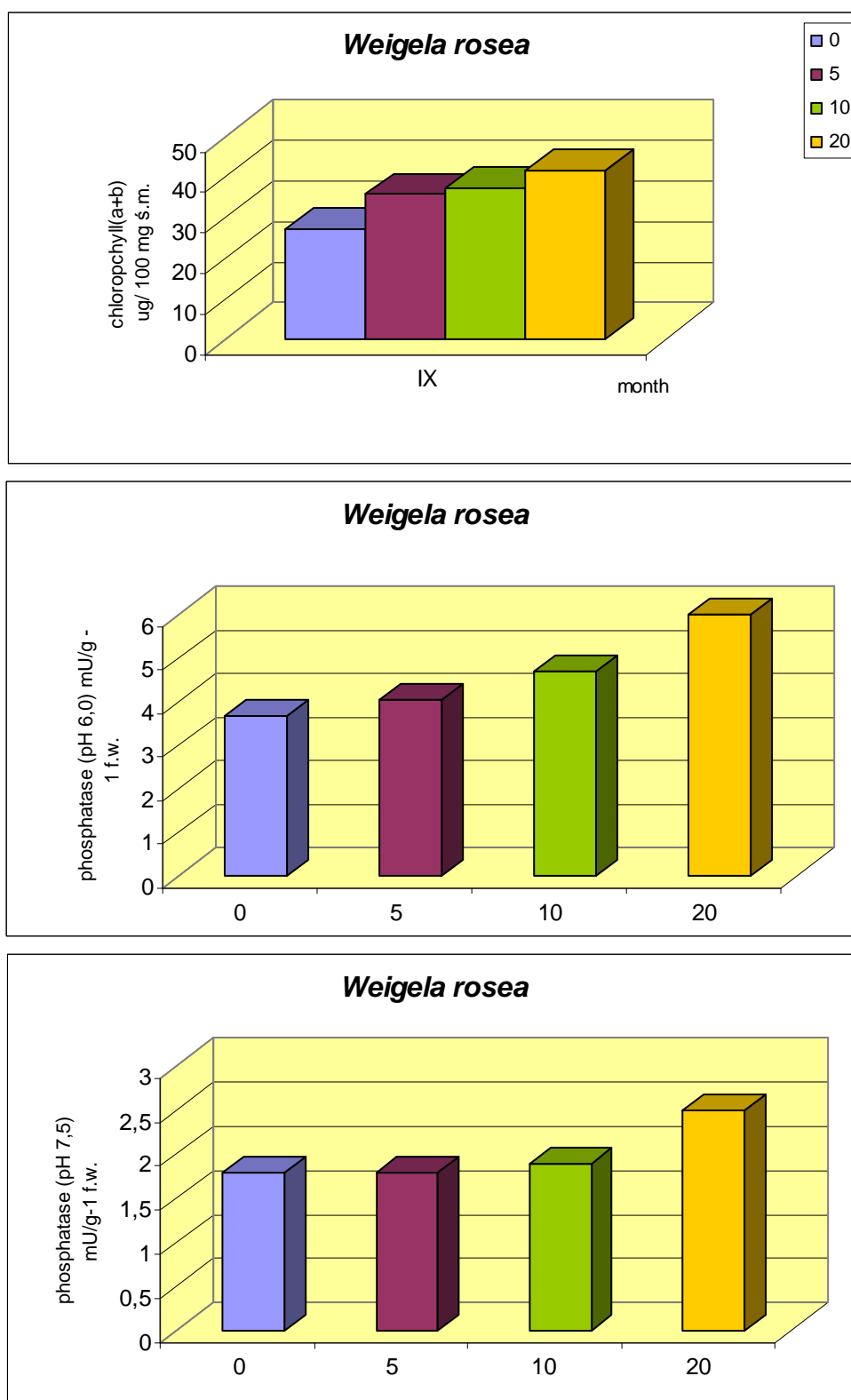


Fig. 8. Chlorophyll a+b content and activity of the acid and alkaline phosphatase in leafs of *Weigela rosea* fertilized with dewatered and stabilized sewage sludge at dosages of 5,10 and 20 tons ha⁻¹.

Table 2. Fresh and dry weight of one plant taken in November from the plots fertilized with sewage sludge at dosages of 5, 10 and 20 tons ha⁻¹.

Dosages of sewage sludges (tons ha ⁻¹)	Shrub species			
	<i>Weigela rosea</i>	<i>Spiraea betulifolia</i>	<i>Forsythia intermedia</i> 'Nothorn Gold'	<i>Deutzia scabra</i> 'Codsall Pink'
Fresh weight (g)				
0	46,2	20,1	18,2	77,9
5	55,0	25,4	25,6	90,7
10	54,7	25,9	23,6	91,2
20	50,5	21,6	21,9	88,0
Dry weight (g)				
0	19,3	8,1	6,6	30,6
5	24,9	10,8	9,2	35,9
10	25,5	11,1	8,5	36,3
20	22,5	9,2	7,4	34,8
Shoot moisture content (%)				
0	41,7	40,2	35,3	39,3
5	45,0	42,5	35,6	39,6
10	46,6	42,9	36,0	39,8
20	44,5	42,6	33,7	39,5

Ornamental shrub cultivated on plots fertilized with different dosages of sewage sludge

28. 05. 2007







13. 07. 2007









3. 09. 2007





