

Yield of a herb (*Datura innoxia* Mill.) and content of alkaloids depending on development stage of harvested plants

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S u m m a r y

The experiments were carried out in 2004–2006 in the Department of Vegetable and Medicinal Plants, Agricultural University in Lublin. The aim of presented work was to evaluate a development stage in which should the *Datura innoxia* plants be harvested to obtain herb with high content of alkaloids per area unit. Plants were harvested: 1 – in a stage of vegetative growth, 2 – in the beginning of flowering, 3 – in the beginning of fructification. The effects of weather conditions on air-dry herb yield (17.0–23.2 kg·100 m⁻²) and content of tropane alkaloids (0.166–0.224%) was stated. Significantly lower mean herb yield was obtained from plants harvested in vegetative growth stage. Significant relationship between tropane alkaloids content and development stage of plants was not stated. Quantity of tropane alkaloids obtained in cultivation of *Datura innoxia* (22.32–55.57 g·100 m⁻²) depended more on high value of air-dry herb yield per area unit (12.9–28.5 kg·100 m⁻²) than on content of these active substances in material (0.150–0.236%).

Key words: *Datura innoxia*, plant development stage, air-dry herb yield, tropane alkaloids content

Thorn-apple (*Datura innoxia* Mill.) is a medicinal plant belonging to *Solanaceae* family. It contains tropane alkaloids, which play an important role in medicine, acting specifically on autonomic nervous system. Herb of the thorn-apple is used in many preparations applied in medical care [1-3]. Numerous works proved the content of alkaloids to be unstable [2, 4-6]. There are constant changes of quantity and quality of tropane alkaloids in plants of *Datura innoxia* as they are influenced by many agrotechnical factors. The most important are: the cultivation method, fertilization, weather conditions (especially low temperature and a long-life rain-falls) as well as development stage of plants at the harvesting time [4, 7-13].

The aim of present work was to estimate if there is a correlation between growth phase of *Datura innoxia* plants and content of tropane alkaloids in herb obtained from the area unit.

MATERIALS AND METHODS

The agrotechnical experiment was conducted in 2004–2006 on the experimental field of Department of Vegetable Crops and Medicinal Plants in Felin. Laboratory analyses were done in the Department Laboratory. Weather conditions characteristics (air temperature and rainfalls) are presented on the basis of results obtained from the Agrometeorological Observatory of the Agricultural University in Lublin.

The experimental objects of the research were *Datura innoxia* plants of 'Indianka' cultivar. Plants were cultivated in a loess soil made from loess-like formation on chalky marl with organic matter content of 1.6%. Fertilization and care treatments were carried out according to principles for this plant [9, 10]. Plants were cultivated from seeds sowed directly in the field in the 3rd decade of April. The spacing used was 0.6 x 0.6 m with 3 seeds per point. In the phase of first leaves plants were thinned out and one plant per point was left. The experiment was established according to single classification in four replications (with 12 plants per replication), the area of replication plot was 4.32 m².

Datura innoxia plants were harvested in 3 stages of development: at vegetative growth stage (time of harvest: 2004 – 1st decade of July, 2005 – 2nd decade of July, 2006 – 3rd decade of July); - at the beginning of flowering (time of harvest: 2004 – 2nd decade of July, 2005 – 1st decade of August, 2006 – 1st decade of August); - at the beginning of fructification (time of harvest: 2004 – 3rd decade of July, 2005 – 2nd decade of August, 2006 – 2nd decade of August). The beginning of flowering and fructification was assumed as a day, in which at least three plants per replication had flowers in full flowering or growing fruits on first branches. Each plant was harvested separately. Fresh weight was defined right after harvest and then, after drying in a professional dryer, air-dry weight was estimated according to the Polish Norm requirements [14]. The content of alkaloids in *Datura innoxiae* material was marked with drop-weight method for *Belladonnae folium* according to Polish Farmacopoea VI [15] as a sum of tropane alkaloids in recalculation on hyoscyamine. Taking into consideration content of these alkaloids in an air-dry weight of herb as well as yield of air-dried herb (kg · 100 m⁻²) obtained from *Datura* plants harvested in different development stages the quantity of tropane alkaloids was estimated (g · 100 m⁻²).

The results of the experiments were statistically evaluated using the analysis of variance. The significance of differences was proved on the basis of Tukey t-test at 5% level of significance. Changeability of the air-dry herb yield of thor-apple and content of tropane alkaloids were showed with coefficient variation (%) of these parameters.

RESULTS AND DISCUSSION

In the years 2004–2006 the average yield of air-dry herb obtained from plants of *Datura innoxia* was $19.1 \text{ kg} \cdot 100 \text{ m}^{-2}$ (Table 1). A large differentiation in this yield was stated depending on the year. Significantly higher yield was obtained in 2005 (mean $23.3 \text{ kg} \cdot 100 \text{ m}^{-2}$) in comparison to 2004 (mean $17.0 \text{ kg} \cdot 100 \text{ m}^{-2}$) and 2006 (mean $17.3 \text{ kg} \cdot 100 \text{ m}^{-2}$). With the use of analyses of variance the significant dependence of air-dry herb yield and development stage of harvested plants was stated. Regardless of the year, the highest statistically yield was obtained from older plants – harvested in the beginning of April ($21.8 \text{ kg} \cdot 100 \text{ m}^{-2}$) and during fructification ($20.4 \text{ kg} \cdot 100 \text{ m}^{-2}$) with reference to yield from younger plants, which were harvested in vegetative growth stage ($15.2 \text{ kg} \cdot 100 \text{ m}^{-2}$). The highest and statistically significant effect of harvested plants on yield was observed in 2005. The yield of air-dry herb obtained from plants in the beginning of flowering and fructification was 28.5 and $28.1 \text{ kg} \cdot 100 \text{ m}^{-2}$, respectively, while yield obtained from plants in vegetative growth stage was significantly smaller – $12.9 \text{ kg} \cdot 100 \text{ m}^{-2}$. Also in 2004 higher yield of air-dry herb was obtained from flowering ($17.2 \text{ kg} \cdot 100 \text{ m}^{-2}$) and fructifying plants ($20.0 \text{ kg} \cdot 100 \text{ m}^{-2}$) than from plants in vegetative stage ($13.8 \text{ kg} \cdot 100 \text{ m}^{-2}$), although these differences were not statistically significant. In 2006 no relationship between yield of *Datura innoxia* herb and stage of harvested plants development was observed. Higher yield was obtained from plants in vegetative stage ($19.0 \text{ kg} \cdot 100 \text{ m}^{-2}$) and in the beginning of flowering ($19.6 \text{ kg} \cdot 100 \text{ m}^{-2}$) than from those in fructification ($13.2 \text{ kg} \cdot 100 \text{ m}^{-2}$). In 2004–2006 an unlike weather conditions were observed during vegetation of *Datura innoxia* (Fig. 1). Definitely, weather conditions in 2006 were beneficial for plants' growth and development. Average monthly twenty-four-hour temperatures in May and June were slightly higher than average year-round values, while the average temperature of July was by 3.9°C higher than average long-term temperature (17.9°C). This month was also drought – sum of rainfalls was only 6.8 mm (long-term sum for July: 78.2 mm). Undoubtedly, such conditions made an effect on taking shape of *Datura* plants yield, especially in those harvested in the beginning of fructification. In 2004–2005 average monthly twenty-four-hour air temperatures in May, June and July were lower than in hot 2006, while the arrangement and sum of rainfalls were more favourable for *Datura innoxia* growth and biomass formation.

In the early works on *Datura innoxia* yielding [7, 11-13, 16, 17] it was stated that yielding of this plant is very unstable in our climate conditions. It depends on weather, especially air temperature and sum of rainfalls during cultivation period. In presented work yield of air-dry herb depending on years and development stage ranged from 1.2 to $28.5 \text{ kg} \cdot 100 \text{ m}^{-2}$. The coefficient of its variation in 2004–2006 was 46.5% . Results obtained in the research also prove instability of *Datura innoxia* yield of in our climate.

Table 1.

Yield of air-dry herb and content of tropane alkaloids depending on harvested plants development stage.

development stage	yield of air-dry herb (kg · 100 m ²)				tropane alkaloids content (%)				tropane alkaloids amount (g · 100 m ²)			
	2004	2005	2006	mean	2004	2005	2006	mean	2004	2005	2006	mean
vegetative stage	13.8	12.9	19.0	15.2	0.187	0.173	0.236	0.199	25.81	22.32	44.84	30.99
beginning of flowering	17.2	28.5	19.6	21.8	0.160	0.195	0.236	0.197	27.52	55.57	46.25	43.11
beginning of fructification	20.0	28.1	13.2	20.4	0.150	0.196	0.200	0.182	30.00	55.07	26.40	37.16
Mean	17.0	23.2	17.3	19.1	0.166	0.188	0.224	0.192	27.78	44.32	39.16	37.09
variation coefficient (%)	46.5				17.8							
NIR _{0.05} years (a)	3.42				0.0271							
development stage (b)	3.42				ns.							
interaction (a ^b b)	7.85				0.0646							

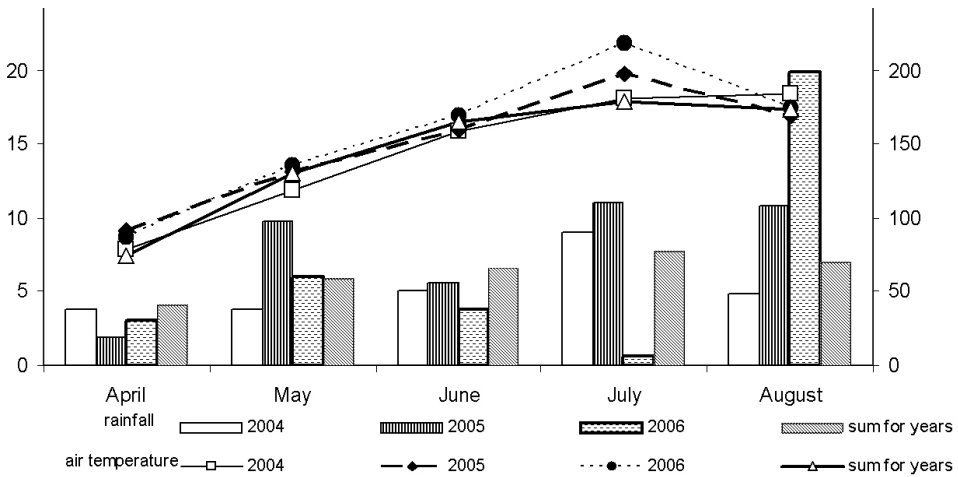


Fig. 1. Average monthly air temperatures and sums of rainfalls in 2004 to 2006 in thorn-apple period of vegetation compared to yearly average values.

In 2004–2006 mean content of tropane alkaloids in *Datura innoxia* herb was 0.192%. Significantly higher content of these biologically active substances was in herb cultivated in hot 2006 (mean 0.224%) than in 2004 (mean 0.166%) and 2005 (mean 0.188%). The thermal conditions for cultivation of warm-liked plants in 2006 were very favorable. As it was showed in earlier works, they have a big and advantageous effect on accumulation of tropane alkaloids in *Datura innoxia* plants [4-6, 11, 13, 17]. In the papers mentioned a significant dependence of tropane alkaloids content in *Datura innoxia* plants and development stage of harvested plants was not showed. However, more alkaloids were observed in plants harvested in vegetative stage (0.199%) and in the beginning of flowering (0.197%) than during fructification (0.182%). Other papers concerning this subject prove that younger plants accumulate more alkaloids while in older plants a higher content of

these substances is identified in top parts [5-7]. Herb of *Datura innoxia* harvested in 2004–2006 had less alkaloids than 0.250% so that obtained material did not meet the standard requirements [3, 14].

Taking into consideration yield of air-dry herb and content of tropane alkaloids, authors counted the amount of alkaloids obtained from 100 m². The highest quantity was observed in 2005 (44.32 g · 100 m²) in comparison to 2004 (27.78 g · 100 m²) and 2006 (39.16 g · 100 m²). On this ground it can be concluded that quantity of tropane alkaloids of *Datura innoxia* obtained from the area unit depends mainly on yield value of air-dry herb and than on alkaloids content in herb. These parameters are in a close relationship with the development stage of harvested plants and weather conditions during cultivation.

CONCLUSIONS

1. The effect of thermal and humidity conditions in 2004–2006 on air-dry herb of *Datura innoxia* yield and a content of tropane alkaloids in herb was proved.
2. The relationship between air-dry herb yield of *Datura innoxia* and development stage of harvested plants was stated. Significantly lower mean herb yield was obtained from plants harvested during vegetative growth stage.
3. A significant relationship between tropane alkaloids content and development stage of plants was not observed.
4. Quantity of tropane alkaloids in cultivation of *Datura innoxia* depended mostly on value of air-dry herb yield from an area unit, than on a content of these active substances in herb.

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PLON ZIELA BIELUNIA INDIAŃSKIEGO (*DATURA INNOXIA* MILL.) ORAZ ZAWARTOŚĆ ALKALOIDÓW W ZALEŻNOŚCI OD FAZY ROZWOJOWEJ ZBIERANYCH ROŚLIN

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Streszczenie

Badania przeprowadzono w latach 2004–2006 w Katedrze Warzywnictwa i Roślin Leczniczych AR w Lublinie. Celem niniejszej pracy było stwierdzenie, w jakiej fazie rozwojowej należy zbierać rośliny bieleń indiańskiego, by uzyskać ziele o dużej ilości alkaloidów z jednostki powierzchni. Zbiory przeprowadzono: 1 – w fazie wzrostu wegetatywnego, 2 – na początku kwitnienia, 3 – na początku owocowania. Stwierdzono wpływ warunków pogodowych na plon powietrznie suchego ziele (17,0–23,2 kg·100 m⁻²) oraz na zawartość alkaloidów tropanowych (0,166–0,224%) w tym ziele. Istotnie mniejszy średni plon ziele otrzymano z roślin zbieranych w okresie wzrostu wegetatywnego. Nie stwierdzono statystycznie istotnej zależności zawartości alkaloidów tropanowych od fazy rozwojowej roślin. Ilość alkaloidów tropanowych (22,32–55,57 g · 100 m⁻²) uzyskanych z uprawy bieleń indiańskiego zależała w dużym stopniu od wielkości plonu powietrznie suchego ziele zebranego z jednostki powierzchni (12,9–28,5 kg·100 m⁻²), zaś w następnej kolejności od zawartości tych substancji czynnych w surowcu (0,150–0,236%).

Słowa kluczowe: bieleń indiański, faza rozwojowa roślin, plon powietrznie suchego ziele, zawartość alkaloidów tropanowych