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The effect of growing factors on the yield of seeds of ashwagandha (*Withania somnifera* (L.) Dun.) cultivated in Polish climatic conditions

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ABSTRACT

Ashwagandha (*Withania somnifera* (L.) Dun.), a subtropical medicinal plant of great value may be cultivated as an annual in a temperate climate zone. The aim of this study was to assess the possibility of obtaining seeds of ashwagandha capable of germinating from field plantation in Polish climatic conditions. The field seed yield depended to a great extent on the weather conditions. In 2000, which was a favorable year (warm and dry turn of September and October), it was even higher than the seed yield obtained in a greenhouse. The total number of seeds per m^2 and the percentage of seeds capable of germinating were significantly increased by mulching with black, plastic foil. However, the rising of plant density from 6 to 9 per m^2 had no significant effect on their seed yield.

INTRODUCTION

Ashwagandha (*Withania somnifera* (L.) Dun.) is a representative of the *Solanaceae* family, a self-pollinating plant which naturally occurs in subtropical areas. From time immemorial it has been used by folk medicine of African and Asian countries (especially India). Medicinal properties of the species are related to withanosides in roots, applied as an adaptogen (Russo et al. 2001), and withanolides in herb. The most important among withanolides is withaferin A. It shows immunosuppressive (Shohat et al. 1978), cytotoxic (Fuska et al. 1984), bacteriostatic and anti-inflammatory activity (Sethi et al. 1974).

Withania somnifera may be successfully cultivated as an annual plant in a temperate climate zone (Obidoska et al. 1999). The aim of this study was to assess the possibility of obtaining, in such conditions, high yield of seeds capable of germinating.

MATERIAL AND METHODS

The experiments were carried out in the experimental greenhouse and field of the Warsaw Agricultural University (WAU) in the years 1998 – 2000 (the weather conditions are characterised in Table 1).

Table 1. Weather conditions in the vegetation seasons of 1998 – 2000

Month	1998		1999		2000		Mean 1961 – 1990	
	Temp. [°C]	Precipitation [mm]	Temp. [°C]	Precipitation [mm]	Temp. [°C]	Precipitation [mm]	Temp. [°C]	Precipitation [mm]
V	15.7	50.6	13.1	47.8	15.8	43.8	13.7	58.1
VI	19.3	115.8	18.6	168.9	18.3	25.9	16.9	67.8
VII	19.3	77.4	21.1	35.8	17.2	128.2	18.1	66.5
VIII	17.9	62.2	18.4	38.5	18.6	54.3	17.6	65.7
IX	14.2	27.2	16.0	25.2	12.1	55.9	13.5	43.1
X	8.5	61.2	8.9	50.1	11.6	3.0	8.6	35.9
Mean/ Total	15.8	394.4	16.0	366.3	15.6	311.1	14.7	337.1

Plants of *Withania somnifera* (L.) Dun. were propagated generatively and the sowing material originated from WAU greenhouse plantation, initiated with the seeds granted by the Research Institute of Medicinal Plants – Poznań.

The field experiment was held in randomized complete block design with 4 replications. Young plants (10 weeks old) were transplanted from greenhouse to field conditions in May. The effect of two growing factors on the yield of seeds was assessed: mulching with black, plastic foil and plant density (6 or 9 plants per m^2). At the same time 1, 2, and 3 year old plants were cultivated in the greenhouse conditions, in 10 dm^3 pots with peat substrate. The yield of seeds was measured by their number per square meter of field plantation, and per plant in a greenhouse. The quality of yield was assessed by the percentage of seeds capable of germinating. In the previous, yet unpublished, experiments concerning ashwagandha it had been observed, that the germination capacity of seeds coming from ripe and half-ripe fruits oscillated around 90%, from over-ripe fruits decreased to 70%, and the seeds from green fruits did not germinate at all. Thus, in this experiment, the seeds originating from green fruits were classified as non-germinating and from half-ripe and ripe fruits as capable of germinating.

The number of seeds, calculated per one plant cultivated in the field conditions considered as optimum, i.e. mulched, and at the density of 6 plants per m^2, was compared to the number of seeds from 1, 2, and 3 year old plants cultivated in a greenhouse.

The data (means from 3 years) were subjected to the one or two way analysis of variance and the Tukey test with statistical significance set at $p = 0.05$.

RESULTS AND DISCUSSION

In the field plantation of *Withania somnifera,* in Polish climatic conditions, mulching with black, plastic foil significantly influenced the seed yield, but changing the plant density from 6 to 9 plants per m^2 had no effect on it (Fig. 1). In mulched fields, a higher number of seeds per m^2 was obtained, and the percentage of seeds capable of germinating significantly increased (Fig. 1, Table 2).

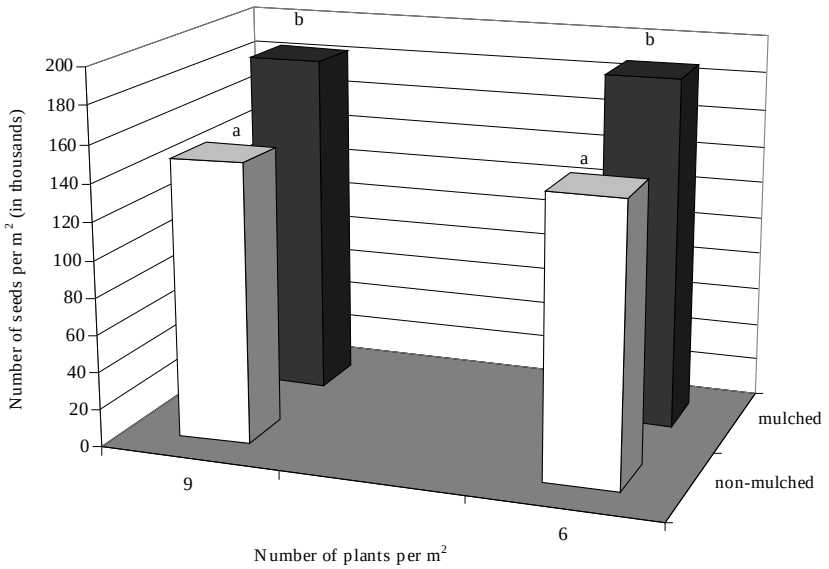

Figure 1. The effect of black, plastic mulch and plant density on total seed number in field plantation of *Withania somnifera* in Polish conditions (mean for 1998 – 2000)

Table 2. The effect of mulching on the percentage of seeds from green, half-ripe and ripe fruits in total seed number in field plantation of *Withania somnifera* at the density of 6 plants per m^2

Seeds from	Mulched field	Non-mulched field
Green fruits	30 a*	36 b
Half-ripe fruits	38 a	39 a
Ripe fruits	32 b	25 a

* Means within each row followed by the same letters do not differ significantly

The crop increase caused by mulching with black plastic foil was reported for the *Solanaceae* vegetables like tomato (Mohapatra et al. 1999), or pepper (Abdul-Baki et al. 1999). The acceleration of fruit ripening by mulching was also reported in pepper (Vos and Sumarni 1997), watermelon, squash (Ibarra-Jimenez and Flores-Velasquez 1997) and other crops.

A vital factor influencing field seed plantation of ashwagandha was the weather. The seed yield (Table 3) and its quality (Table 4) varied significantly for each of the three vegetation seasons. The year 1999 was the least effective one: the lowest number of seeds per square meter and the lowest percentage of seeds capable of germinating were noted. It should be pointed out though, that the percentage of seeds from ripe fruits in the yield obtained in 1999 did not differ

from those obtained in the best season – 2000 (27 and 28%, respectively), but the percentage of seeds from half-ripe and green fruits equalled 15% and 58% respectively, whereas in 2000, thanks to a very warm and dry weather in October, 65% and 7%.

Table 3. Total seed number obtained from *Withania somnifera* field plantation in 1998 – 2000

Year	1998	1999	2000
Seed number per m^2 (in thousands)	194 b*	109 a	198 b

* Note – see Table 2

Table 4. Percentage of seeds from green, half-ripe and ripe fruits in total seed number obtained in field plantation of *Withania somnifera* (1998 – 2000)

Seeds from	1998	1999	2000
Green fruits	50 b*	58 c	7 a
Half-ripe fruits	25 b	15 a	65 c
Ripe fruits	25 a	27 a	28 a

* Note – see Table 2

The comparison of seed number per plant in the field and in greenhouse conditions (Fig. 2) revealed, that higher total number of seeds was obtained from the field plants. It was probably due to the easier access of pollinating insects. The situation is similar to the one observed in self-pollinating tomatoes. Shaking by wind or bee vibrations help the release of pollen, limit the blossom drop, and in result, increase the crop of fruits**.** In a greenhouse, however, almost 100% of seeds achieved the germination capability. Taking into consideration the means of 3 vegetation seasons, it should be stated that the number of seeds capable of germinating, from 1-year-old field plant and 1 or even 2-year-old greenhouse plant, was similar. The significant difference appeared when it came to comparison of field plants with a greenhouse 3-year-old plantation (Fig. 2).

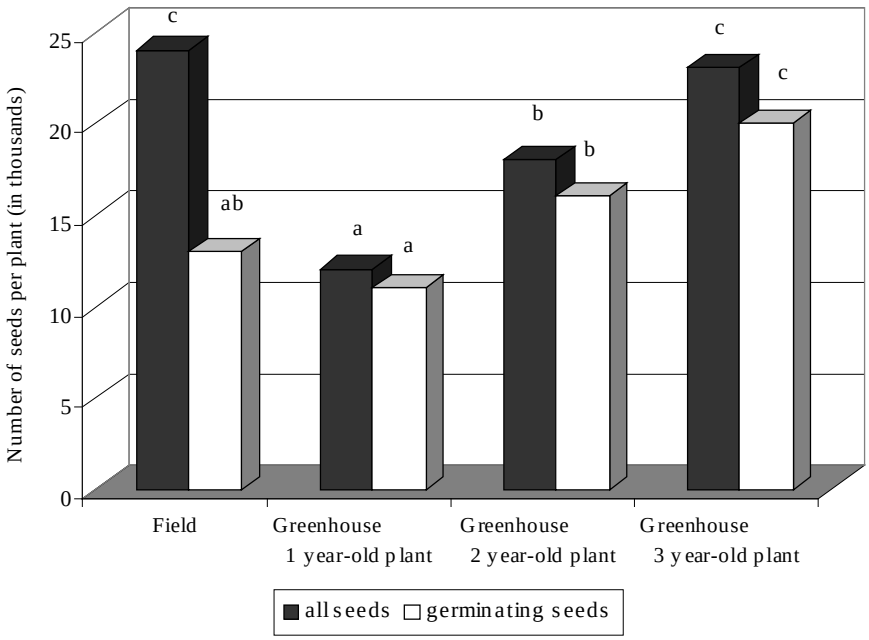

Figure 2. Total seed number and the number of seeds capable of germinating obtained from field and from 1-, 2-, and 3-year-old greenhouse plantations of *Withania somnifera* (mean for 1998 – 2000)

However it should be emphasised, that in the most advantageous weather conditions of vegetation season 2000, field plants yielded significantly better than even 3-year-old greenhouse ones (Table 5), whereas in the most disadvantageous season (1999), field yield of seeds capable of germinating achieved scarcely 50% of the one obtained in 1-year-old greenhouse plantation.

Table 5. Comparison of seed number per plant (in thousands) obtained from the field and greenhouse in the seasons unfavourable (1999) and favourable (2000) for field seed production

Year	Seed number	Field	Greenhouse 1-year-old plants	Greenhouse 2-year-old plants	Greenhouse 3-year-old plants
1999	Total	14.5 a*	13.9 a	21.5 b	24.4 b
	Capable of germinating	5.2 a	13.1 b	19.4 c	21.7 c
2000	Total	26.4 d	9.9 a	13.7 b	21.7 c
	Capable of germinating	22.6 c	9.8 a	11.7 a	17.7 b

* Note – see Table 2

CONCLUSIONS

1. In Polish climatic conditions the field yield of *Withania somnifera* seeds capable of germinating, was to a great extent dependent on weather; especially at the end of the vegetation season (September-October).
2. Black, plastic mulch significantly increased the seed yield obtained from field plantation and accelerated fruit ripening, rising the percentage of seeds capable of germinating in the yield.
3. Increasing plant density from 6 to 9 plants per square meter of field had no effect on seed yield, may thus be considered aimless.
4. The greenhouse plantation gave higher yield of seeds capable of germinating not earlier than in the 3rd year of cultivation, however in the season unfavourable for the field production, it got the advantage over it even in the 1st year.

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WPŁYW CZYNNIKÓW AGROTECHNICZNYCH NA PLON NASION *WITHANIA SOMNIFERA* (L.) DUN. UPRAWIANEJ W POLSKICH WARUNKACH KLIMATYCZNYCH

Streszczenie: *Withania somnifera,* subtropikalna roślina o dużej wartości leczniczej, może być uprawiana w klimacie umiarkowanym jako jednoroczna. Celem pracy było określenie możliwości pozyskiwania dobrej jakości materiału siewnego w uprawie polowej, w warunkach polskich. Plon nasion w dużym stopniu uzależniony jest od warunków atmosferycznych. W roku 2000, o korzystnym dla roślin przebiegu pogody (ciepły i suchy przełom września i października) plon nasion był nawet wyższy od plonu uzyskanego z roślin rosnących w szklarni. Ściółkowanie czarną folią istotnie podwyższyło liczbę nasion otrzymanych z m^2 oraz udział nasion zdolnych do kiełkowania. Nie obserwowano natomiast znaczącego wpływu zwiększenia zagęszczenia z 6 do 9 roślin na m^2 na plon nasion.

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