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# Evaluation of quantity and quality of common pine seeds (*Pinus sylvestris* L.) obtained in two-stage seed extraction process under laboratory conditions

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**Abstract:** *Evaluation of quantity and quality of common pine seeds* (*Pinus sylvestris* L.) *obtained in two-stage seed extraction process under laboratory conditions.* The cone drying process is interrupted with inter-stage soaking for 5, 15 and 30 minutes. Application of soaking causes at the second stage an increase in water content of cones, that during break close partially the scales previously open; during repeated drying they obtain the open state at the second stage quicker than at the first stage. No phase of partial drying (usually recommended in practice) at the beginning of second stage was applied; it could cause the reduced seed vitality. The investigations showed that seeds of Forest Inspectorate Bytów were not damaged due to moistening and neglecting of partial drying phase, when lower temperature is applied; it was confirmed in verifying investigations of seeds obtained in the single-stage process.

*Key words*: seeds, vitality, energy, germination capacity, seed extraction.

## INTRODUCTION

In Polish forests two kinds of regeneration have been carried on: natural regeneration and artificial regeneration. The natural regeneration makes 9% only, the artificial regeneration makes the rest. Proper execution of artificial regeneration calls for appropriate preparation of the site and seed material or the forest plants; it should be of good quality and vital. In Poland more than half of artificial regenerations are executed with the use of coniferous seeds and forest plants. Obtaining of seeds is performed in objects called the kilns, where the cones are subjected to thermal and thermal-mechanical processing in order to release seeds from the cones. The seed extraction process is long-lasting and energy-consuming. Since many years it has been carried on according to unchangeable principles worked out by Tyszkiewicz [1949]; in spite of introduction of modern machines and equipment, the time needed to obtain the seed material is invariable. The seed extraction problem has been dealt with by Staszkiewicz, Tomanek, Drahal [after Białobok 1993], Bogdanow [1966], Załęski [1995] and the others; they tried to shorten seed extraction time by increasing temperature, decreasing air humidity, changing pressure or segregation of cones; however, in spite of many investigations no significant changes in seed extraction time were introduced without deterioration of seed vitality. The seeds are live organisms that are sensitive to increased temperature and variable moisture content.

At present, the seed extraction in kilns is usually carried out in a one-stage continuous process [Więsik and Aniszewska

2011]; it consists in gradual increasing air temperature inside the cabinet with simultaneous decreasing humidity. The authors of this paper propose a two-stage process application in pine seed extraction [Aniszewska 2009], which consists in alternate moistening and drying of cones that are partially open. This process can shorten the time and can increase effectiveness of common pine seed extraction. However, there is a risk of damage to the seeds in cones, especially if the increased temperature is applied at the beginning of subsequent drying stage after moistening.

The paper presents results of investigations on vitality of seeds (germination capacity and energy) extracted from the cones in two stages with application of various duration of the first stage and moistening time as well as variable conditions of temperature and moisture content at the first and second stages.

## MATERIAL AND METHODS

The investigated common pine cones were obtained in 2011 from silvicultural seed stands (GDN) in Forest Inspectorate Bytów. From the seed batch transported to Department of Agricultural and Forest Machinery there were selected 60 cones of different size.

Prior to seed extraction, the cones were measured and weighed. Their length (h) and thickness (d) were measured with the use of a slide caliper (0.1 mm), their initial mass ($m_o$) and subsequent mass ($m_x$) measurements were executed with the use of a laboratory scales WPS 600C of accuracy 0.01 g. After initial measurements the investigated material was divided into two groups, each of three batches. The cone seeds were extracted in two stages: the first group cones during 5 hours, the second group cones during 7 hours.

Upon completion of the first stage, the individual cones of batches were soaked in water of temperature 30°C during 5, 15, 30 minutes, then they were taken off water, dried and left for 12 hours.

At the beginning of second stage, the cones were weighed again and placed in a laboratory dryer for further seed extraction. The second stage was completed after 7 hours.

Changes in mass and seed number of particular cones were determined every two hours and then every hour during process.

Temperature in the dryer amounted to 35°C during first two hours of the first stage, then during subsequent hours to 50°C. At second stage the lower temperature was neglected and it was adjusted to 50°C.

In order to determine the dry mass ($m_s$), the cones were additionally dried in the dryer at temperature 105 ±2°C.

Upon completion of two-stage process, the open scales (reclinated off stem) and closed scales were counted in each cone in order to determine the cone opening state (k), as a ratio of open scales number ($n_o$) to total number of all scales on the cone ($n_w$). The percent of seeds obtained in the process as analyzed also.

Vitality of seeds poured out from the cones during second process stage was evaluated in germination test in Jakobsen germination apparatus, by counting the number of seeds germinated for some length of time. The germination energy

was determined after 7 days, the germination capacity after 21 days [Załęski 1995].

Quality of seeds obtained in the second process stage was additionally compared with seeds obtained in the single-stage process.

## RESULTS OF INVESTIGATIONS

### Basic size parameters of cones

There were 60 cones in the investigated set. Their basic size parameters are presented in Table 1. It was found that cones of the I group (first three batches) had insignificantly higher average length and thickness when compared to cones of the II group, while the latter ones (three subsequent batches) had insignificantly higher average initial mass; it was proved by statistics. As a result of statistical calculations, no differences between average size parameters were found; therefore, both sets can be regarded as one in the analysis of size parameters.

TABLE 1. Results of measurements on basic parameters of cones

| Group | Value | Length h | Thickness d | Initial mass $m_0$ |
|---|---|---|---|---|
| | | mm | mm | g |
| I | Mean | **41.60** | **21.30** | **6.47** |
| | Stand. dev. | 6.40 | 2.50 | 2.16 |
| | Min. | 30.30 | 16.30 | 3.13 |
| | Max. | 55.70 | 27.50 | 12.42 |
| II | Mean | **40.10** | **20.80** | **6.52** |
| | Stand. dev. | 5.50 | 2.90 | 2.28 |
| | Min. | 31.10 | 15.30 | 2.88 |
| | Max. | 50.70 | 25.90 | 11.38 |

Considering dependence between the cone length (h) and thickness (d) it was found that an increase in cone thickness by 1 mm caused an increase in the length by about 1.8 mm:

$$h = 1.787\ d + 0.329;$$

$$R = 0.811 > R_{tab} = 0.250 \qquad (1)$$

According to investigations of Staszkiewicz [1968] the cone length increment amounts to 1.7 mm.

### Duration and conditions of two-stage seed extraction process

The maximal time of seed extraction during two-stage process for the cones of I group amounted to 24.5 h, while of the second group 26.5 h; the effective cone seed extraction in the dryer lasted 12 and 14 h, respectively. The rest of time was taken by moistening, consisted in three variants of cone soaking and the break.

Figure 1 presents changes in temperature and moisture content inside the chamber during process. Average temperature at the first stage amounted initially to 34°C, then to 49°C, at the second stage it was equal to about 51°C.

The initial air humidity inside the chamber amounted to 33%, and after two hours it dropped to 14%. At the second stage it was stabilized at the level of about 12%.

### Number of scales and degree of cone opening

The total number of all scales in the common pine cones amounted to 52 (from 32 to 76 pcs), including 20 scales of medium opening. The highest number of open scales (about 25 pcs) was found in cones dried for 7 h at the first stage and soaked

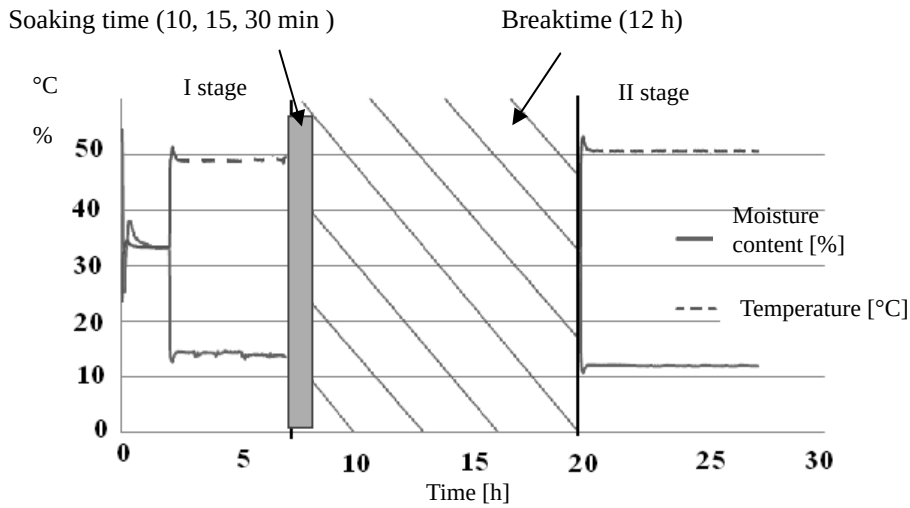


FIGURE 1. Changes in dry thermometer temperature and moisture content inside drying chamber, with marked soaking time and break for cones of II group

for 5 minutes (II.5), the least number (about 17 pcs.) in the scales subjected to seed extraction for 5 h at the first stage and moistened for 30 minutes (I.30).

In Table 2 there are presented the mean, maximal, minimal, and standard deviation values of: open scales ($n_o$), all scales ($n_w$) and degree of opening (k) for 6 batches.

One can find that not all scales were open (index k value). In the investigated batches this index amounted on the average to 0.39 (from 0.34 to 0.46), while the highest value was found for cones of batch II.5.

Considering the cone batches as one set, there was determined a dependence between the number of all scales ($n_w$) and the cone thickness (d):

$$n_w = 20.3\ d + 9.21$$

$$R = 0.552 > R_{tab} = 0.250 \qquad (2)$$

It was found that an increase in the cone thickness by 1 mm caused an increase in the number of all scales by about 2 pcs.

## Number and quality of obtained seeds

During two-stage seed extraction, from the open cones were fallen vital and not vital seeds. At the first stage there were obtained in total 152 vital seeds during 5-hour seed extraction and 326 seeds during 7-hour process (Tab. 3); the first stage prolongation from 5 to 7 hours enabled to obtain about 200 vital seeds more.

At the second stage, after soaking there were obtained on the average 110 seeds each from the cones of I group and about 90 seeds each from the cones of II group. During the entire process the highest number of seeds were obtained from the batch I.5., and the least number from II.30.

It was found that average seed number per cone amounted to 19 and 25 from I and II batch, respectively. Comparison

TABLE 2. Number of scales and degree of cone opening

| Batch | Value | Scales | | Degree of opening k | Batch | Value | Scales | | Degree of opening k |
|---|---|---|---|---|---|---|---|---|---|
| | | open no | all nw | | | | open no | all nw | |
| | | pcs | | – | | | pcs | | – |
| I.5 | Mean | **19.7** | **46.9** | **0.41** | II.5 | Mean | **24.7** | **52.4** | **0.46** |
| | Min. | 9 | 32 | 0.25 | | Min. | 8 | 38 | 0.21 |
| | Max. | 33 | 62 | 0.60 | | Max. | 39 | 67 | 0.58 |
| | Stand. dev. | 8.68 | 10.397 | 0.121 | | Stand. dev. | 9.967 | 10.178 | 0.134 |
| I.15 | Mean | **19.2** | **50.3** | **0.38** | II.15 | Mean | **19.8** | **51.6** | **0.38** |
| | Min. | 0 | 39 | 0.00 | | Min. | 12 | 35 | 0.27 |
| | Max. | 37 | 57 | 0.67 | | Max. | 30 | 67 | 0.50 |
| | Stand. dev. | 11.774 | 5.187 | 0.231 | | Stand. dev. | 6.408 | 10.024 | 0.083 |
| I.30 | Mean | **16.5** | **49.8** | **0.36** | II.30 | Mean | **20.4** | **60.1** | **0.34** |
| | Min. | 1 | 32 | 0.01 | | Min. | 0 | 54 | 0.00 |
| | Max. | 27 | 76 | 0.56 | | Max. | 35 | 69 | 0.59 |
| | Stand. dev. | 6.737 | 13.122 | 0.162 | | Stand. dev. | 13.057 | 4.654 | 0.218 |

TABLE 3. Number of seeds obtained from two groups of cones during two-stage seed extraction process

| Group | I stage seeds | | II stage seeds | | Seeds extracted from cones at 105°C | Number of open cones | Average seed number per cone obtained in process |
|---|---|---|---|---|---|---|---|
| | pcs | | | | | | |
| | vital | not vital | vital | not vital | × | × | × |
| I | 152 | 16 | 334 | 19 | 63 | 28 | 18.6 |
| II | 326 | 22 | 273 | 44 | 59 | 27 | 24.6 |

between these values and the number of open scales enabled to find that not all scales contained two seeds.

During two-stage seed extraction process there were obtained in total 1186 seeds, more seeds from II group.

Number of obtained seeds was in sufficient for the planned seed vitality investigations; according to recommendations four repetitions by 100 seeds each should be executed. Therefore, seed extraction from 150 cones was additionally carried out according to assumed methodology.

Percentage of vital and not vital pine seeds obtained during seed extraction from cones of I and II groups is presented in Figure 2.

Considering the results it was found that percentage of obtained seeds increased with time. At the first stage of

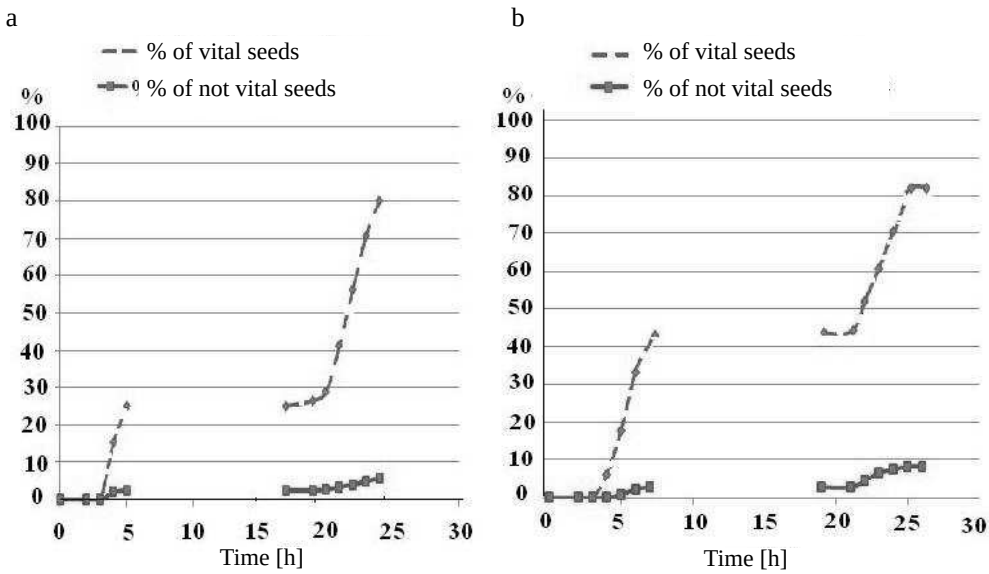


FIGURE 2. Percentage of vital and not vital pine seeds obtained during two-stage seed extraction from cones: a – I group, b – II group

seed extraction process, from the cones of I group about 26% of vital seeds were obtained and about 3% of not vital seeds, whole at the second stage 57% and 3%, respectively. From the cones of II group, at the first and second stage there were obtained about 45% and 38% of vital seeds and 3% and 6% of not vital seeds. In the analysis there were neglected cones, which did not yield the seeds during process. In the first group 2 cones did not open, in the second group 3 cones. They were characterized by smaller size (length 31 mm, thickness 16 mm).

Table 4 presents results of seed vitality determination: the germination energy and capacity.

During seed extraction process not all seeds were extracted from the investigated batches. After additional drying of cones at 105°C (Tab. 3), from the first group about 11% of seeds fell out, from the second group about 8%. The obtained seeds lost their vitality because of too high temperature inside the dryer chamber.

It was found (Tab. 4), that the highest germination energy and capacity had the seeds of cone group I, that were soaked for 5 minutes (germination energy 72, germination capacity 82) and of cone group II soaked for 30 minutes (germination energy 75, germination capacity 85). The least germination energy and capacity were found for the seeds extracted from cones of I and II groups, that were previously soaked for 15 minutes.

The investigations showed that seeds obtained in two-stage extraction process can be included to III vitality class, except for batch I.5 of the seeds included to II quality class. Because of the obtained low seed vitality class (III) there were carried out verifying investigations to evaluate the seeds obtained in single--stage process. After seed extraction

Table 4. Quality of seeds obtained after two-stage extraction process

| Batch | Germin. energy [%] | Class | Germin. capacity [%] | Class | Batch | Germin. energy [%] | Class | Germin. capacity [%] | Class |
|---|---|---|---|---|---|---|---|---|---|
| I.5 | 88 | | 94 | | II.5 | 70 | | 76 | |
| | 65 | | 77 | | | 71 | | 79 | |
| | 62 | | 74 | | | 66 | | 73 | |
| | 72 | | 82 | | | 69 | | 76 | |
| Mean | 72 | II | 82 | II | Mean | 69 | III | 76 | III |
| I.15 | 61 | | 70 | | II.15 | 58 | | 66 | |
| | 72 | | 81 | | | 61 | | 69 | |
| | 60 | | 68 | | | 58 | | 66 | |
| | 64 | | 73 | | | 59 | | 67 | |
| Mean | 64 | III | 73 | III | Mean | 59 | III | 67 | – |
| I.30 | 69 | | 80 | | II.30 | 77 | | 87 | |
| | 75 | | 82 | | | 70 | | 82 | |
| | 59 | | 62 | | | 78 | | 85 | |
| | 68 | | 75 | | | 75 | | 85 | |
| Mean | 68 | III | 75 | III | Mean | 75 | III | 85 | II |

from the cones and their sowing on germination apparatus bench, they were also included in III vitality class (Tab. 5). Therefore, it is evident that carried out two-stage seed extraction process, without additional drying phase at the second stage, caused no deterioration in seed quality.

TABLE 5. Quality of seeds obtained in single--stage extraction process (in percent)

| Control sample | | | | |
|---|---|---|---|---|
| Batch | Germination energy [%] | | Germination capacity [%] | |
| No moistening | 73 | | 78 | |
| | 64 | | 70 | |
| | 69 | | 78 | |
| | 65 | | 72 | |
| Mean | 68 | III | 75 | III |

## SUMMARY AND CONCLUSIONS

- In the two investigated groups of common pine cones that originated from Forest Inspectorate Bytów, no significant differences between the average values of basic size parameters were found.
- The maximal time of two-stage seed extraction process with moistening amounted to 24.5 h for I group of cones, 26.5 h for II group of cones, while the effective extraction time was equal to 12 and 14 hours, respectively.
- The temperature and moisture content conditions in the seed extraction chamber during drying process (temperature 50°C, moisture content 12%) assure good quality of the obtained seeds.

- The analysis showed that percent amount of seeds increased with time. Less open scales were found on the cones of I group, than on the cones of II group. On the average, less seeds were also obtained from these batches.
- The seeds obtained in two-stage extraction process can be included to III quality class; this was confirmed in verifying germination test carried out for seeds extracted in single-stage process. It is evident that moistening of pine cones and drying under assumed conditions of temperature and moisture content caused no deterioration in seed quality.

## REFERENCES

ANISZEWSKA M. 2009: Analiza dwuetapowego łuszczenia ze zraszaniem wodą szyszek sosny zwyczajnej *Pinus sylvestris* L. Leśne Prace Badawcze 70 (4): 329–338.

BIAŁOBOK S. et al. 1993: Biologia sosny zwyczajnej. Instytut Dendrologii Polskiej Akademii Nauk w Kórniku, 622.

BOGDANOW B.P. 1966: O suszkie szyszek w wakuomie. Lesnoje chozjajstwo 3: 57–60.

PETRENKO Y. 2012: Ocena jakości nasion sosny zwyczajnej pozyskanych w procesie dwuetapowego łuszczenia szyszek. Praca inżynierska w Katedrze Maszyn Rolniczych i Leśnych, 63.

STASZKIEWICZ J. 1968: Badania nad sosną zwyczajną z Europy południowo-wschodniej i Kaukazu oraz jej stosunkiem do sosny z innych obszarów Europy, oparte na zmienności morfologicznej szyszek. Fragmenta Floristica et Geobotanica XIV/3: 253–315.

TYSZKIEWICZ S. 1949: Wyłuszczanie nasion leśnych. Państwowe Wydawnictwo Rolnicze i Leśne, Warszawa.

WIĘSIK J., ANISZEWSKA M. 2011: Urządzenia techniczne w produkcji leśnej. Tom 1. Urządzenia do hodowli i ochrony lasu. SGGW, Warszawa, 380.

ZAŁĘSKI A. 1995: Nasiennictwo leśnych drzew i krzewów iglastych. Wydawnictwo Świat, Warszawa, 178.

**Streszczenie:** *Ocena ilości i jakości nasion sosny zwyczajnej* (*Pinus sylvestris* L.) *pozyskanych w procesie dwuetapowego łuszczenia szyszek w warunkach laboratoryjnych.* W artykule opisano żywotność nasion pozyskanych po przeprowadzeniu dwuetapowego łuszczenia szyszek sosny zwyczajnej. Badane szyszki podzielono na dwie grupy, które łuszczono w pierwszym etapie 5 lub 7 godzin, po tym moczono 5, 15 i 30 minut, pozostawiono na 12 godzin i poddano kolejnemu suszeniu przez 7 godzin. Pozyskane w drugim etapie nasiona wysiano na kiełkowniku Jakobsena oraz ceniono ich energię i zdolność kiełkowania. Po 21-dniowej ocenie nasiona zaliczono do trzeciej klasy żywotności. Wynik – III klasa jakości nasion przyczynił się do wykonania próby kontrolnej, polegającej na ocenie nasion pozyskanych w procesie jednoetapowym. Wynik oceny nasion był taki sam. Ostatecznie stwierdzono, że nasiona pozyskane w procesie dwuetapowym nie uległy uszkodzeniu w wyniku nawilżania i braku fazy podsuszania w drugim etapie.

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