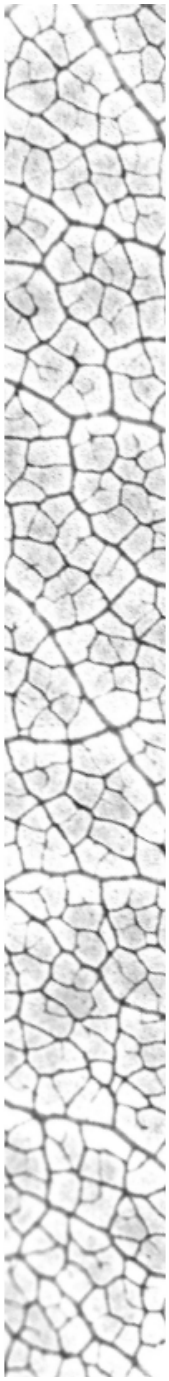

EurAsian Journal of BioSciences
Eurasia J Biosci 12, 72-77 (2018)

Formation of the seed layer from the organomineral mixture during the Seed pelleting of coniferous tree species

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Abstract
The seed pelleting is one of the most perspective way of the presowing processing of seeds. It covers seeds with a shell of organomineral materials, polymer binders and target additives and helps to smooth their surface, provide seedlings in the early phases of development with the necessary elements of mineral nutrition, protecting them from pests and diseases. At present, this technique is used in agriculture for seeding small seeds. The studies presented in this article are aimed at optimizing the technological process of seed pelleting of coniferous tree species, namely, Scots pine (*Pinus silvestris* L.) and Korean pine cedar (*Pinus koraiensis* Siebold et Zucc.). Experimental studies were performed using an electromechanical seed drazhirator. The organomineral mixture was used in a ratio of 0.48 kg per 1 kg of seeds. At the end of the process, the bonding strength of the filler to the seeds was determined. The dynamics of formation of the layer thickness was determined on the cross sections of the treated seeds using an optical microscope. As a result, the dependence of the thickness of the layer on the time and repetition of the seed pelleting was established. The article presents diagrams of experimental information with its subsequent equalization by a theoretical law having a high agreement on a given time interval. The thickness of the first layer formed around the seeds of Scotch pine was 0,3 mm - 0,4 mm and Korean pine cedar - 0,5 - 0,7 mm. The seeder does not destroy this shell. When increasing the coating layer for 1 stage, the optimum thickness is reached within 7-8 minutes. When it is planned to increase the thickness of the layer, the draining process is expediently divided into 2 stages. The time of pelleting at stage 1 is 2 minutes, on the second - 6 minutes. When the thickness of the limiting layer is reached and the pelleting is continued, it is possible to reduce time.

Keywords: seed pelleting, covering (pelleting) layer, seeds, Scotch pine, Korean pine cedar

Ostroshenko VYu, Akimov RYu, Gamaeva SV, Inshakov SV, Ostroshenko VV, Ostroshenko LYu, Zamyshlyaev SV (2018) Formation of the seed layer from the organomineral mixture during the Seed pelleting of coniferous tree species. Eurasia J Biosci 12: 72-77.

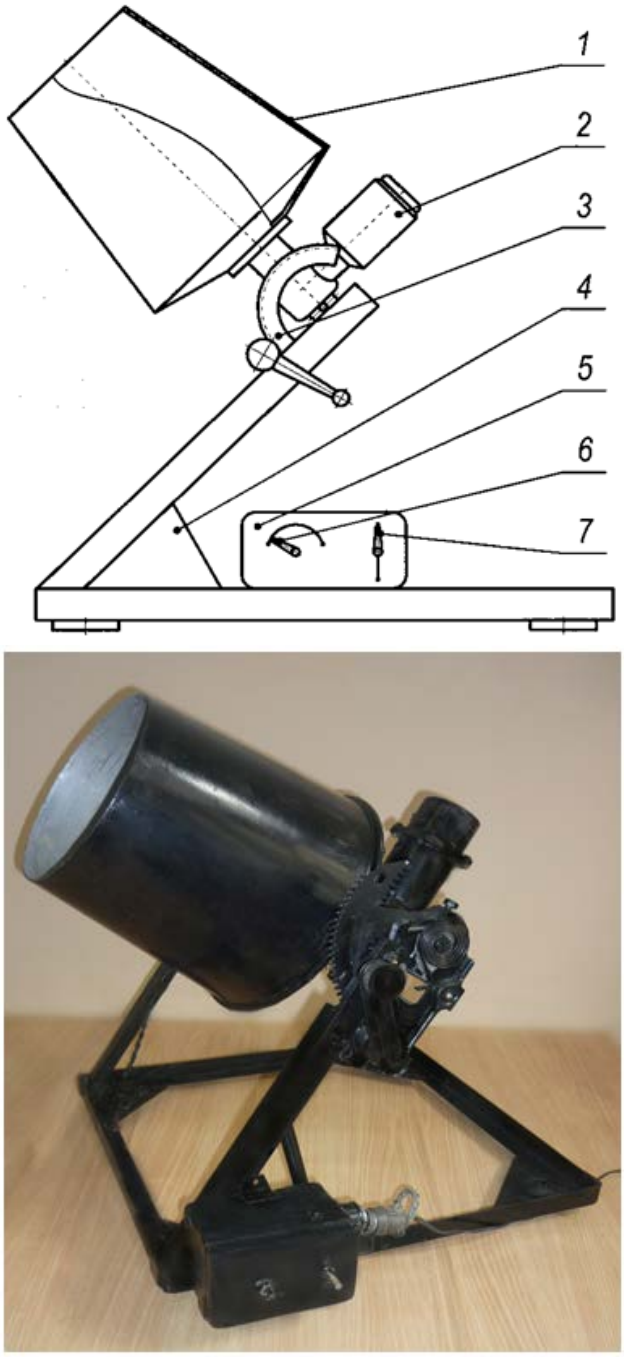
INTRODUCTION

In recent decades, in the forestry of Russia and abroad, experimental work has been activated to grow planting material using growth stimulators (regulators) during reforestation. Preseeding seed treatment is of great positive importance. Seed pelleting is one of the persperctive methods of such processing. It is a coating of seeds in a shell of organomineral materials, polymer binders and targeted additives, which leads to the smoothing of their surface, providing sprouts in the early phases of development with the necessary elements of mineral nutrition, protecting them from pests and diseases (Akimov et al. 2011, Akimov and Ostroshenko 2016, Ostashevskiy et al. 1997, Zamyshlyaev et al. 2017, Kopytkov 2013, Maslakov et al. 1985, Mukhin 1971, Usov et al. 2015, Brockwell 1962).

As a result of the seed pelleting, granules (pellets) are formed in diameter, depending on the size of the seeds, suitable for storage, transportation and spot-sowing. At the time of germination of the seed in the soil, the layer of the granule dissolves (decomposes), providing the sprout with nutrients and protecting it from aggressive soil flora (Maslakov et al. 1985, Mukhin 1971).

Processing seeds of forest species and crops have obtained the most widespread technology of pelleting (Zamyshlyaev et al. 2017, Kopytkov 2013, Maslakov et al. 1985, Mukhin 1971, Devi and Selvaraj 1995,

Received: February 2018
Accepted: May 2018
Printed: July 2018



1 - a drum;
2 - drive motor-reducer;
3 - mechanism for changing the angle of inclination of the drum axis;
4 - frame;
5 - the electric control system;
6 - the regulator of frequency of the drum rotation;
7 - the switch of direction of the drum rotation.

Fig. 1. Scheme and photo of the experimental drazhirator

Moënne-Loccoz et al. 1999, Srimathi et al. 2013, Min Ryu et al. 2006, Rudolf 1950, Taylor et al. 1998, Taylor et al. 2001, Fraser and Adams 1980, Yadav et al. 2000]. At present, this effective method of presowing seed preparation is used on an industrial scale in Russia's agriculture in the sowing of small-seed crops (vegetable, sugar beet, cotton) (Maslakov et al. 1985, Mukhin 1971).

In the forestry of Russia, the employees of LenNIILKh (St. Petersburg) (Maslakov et al. 1985) started the first experiments on the pelting and sowing of small seeds of coniferous tree species (Pinus sylvestris, Ayaan spruce) in the 1980s. In the Far East, the efficiency of seed pelleting is studied by foresters of the Primorskaya State Academy of Agriculture and the "GTS" – a branch of Federal Scientific Center of the East Asia Terrestrial Biodiversity. Possibilities of mechanized coating of seeds of Korean cider pine (*Pinus koraiensis* Siebold et Zucc.), Scots pine (*Pinus silvestris* L.) and Amur larch (*Larix amurensis)* are studied. In addition, the components of the coating mixture have been developed (Akimov et al. 2011, Akimov and Ostroshenko 2016). Adhesive has a huge role. It is the filler and the main component and provides the formation of a dragee and nutrient layer on the seeds. Now, the possibility of improving the technological process of seed pelleting is being studied.

The purpose of the research is to analyze the conditions for the formation of a seed layer from a coating mixture when treating seeds of Scotch pine (*Pinus silvestris* L.) and Korean pine cedar (*Pinus koraiensis* Siebold et Zucc.). It is necessary to solve the following tasks to achieve the goal:

1. To carry out the pelleting of seeds of Scotch pine and Korean pine cedar with the help of a mechanical device;
2. To determine the dependence of the layer thickness on the time and repetition of the pelleting.

MATERIALS AND METHODS

Seed pelleting was carried out at the Forestry Department and in the laboratory of the Primorskaya State Academy of Agriculture using an electromechanical drazhirator (**Fig. 1**).

The experienced drazhirator is made based on the motor-reducer MU-100 AGU with the power of 120 W, with the speed of its rotation - 150-300 rpm. The angle of inclination of the tank axis is 40° ± 5°, the volume of the drazhirator tank is 8 l.

The seeds for 40-60 minutes were treated with $KMnO_4$ solution before pelleting. Then seeds were placed in a solution of the growth stimulator Epin-Extra with a concentration of 0.5 ml / 2 l of water for 30 minutes.

The technological process of seed pelleting includes six methods: weighing and filling seeds in a drazhirator; addition to the seeds of the binder (PVA glue); mixing seeds with glue; addition of filler (wood ash); grinding of the lumps of the coating mixture; completion of the pelleting process - extraction of granules from the working capacity of the drazhirator. The most laborious and responsible, in terms of the quality of the work

(a)

(b)

Fig. 2. Pelleted seeds: a) Scots pine, b) Korean cedar pine

performed, is the mixing of seeds with glue. The execution of this method determines the level of execution of the entire technological operation (Akimov and Ostroshenko 2016, Usov et al. 2015, Brockwell 1962). Identification of the amount of adhesive for the production process was produced by the search way. Seeds were mixed with the coating mixture at the rate of 250 g of seeds, 60 g of adhesive (PVA adhesive) and 60 g of wood ash, the production of which in the conditions of high forest cover of the Far Eastern region is not connected with difficulties (Akimov et al. 2011, Akimov and Ostroshenko 2016, Brockwell 1962).

The seed pelleting was carried out by the method of layering the covering mixture with periodic moistening of the seeds. The production rate for the eight-hour shift was 11.4 kg of pelleted seeds. Pelleted seeds were dried for 4-6 hours at room temperature (**Fig. 2**).

At the end of drying, the strength of the adherence of the filler to the seeds was determined. Putting the pelleted seeds in water, the time of the beginning of decomposition of the coating layer was revealed.

The dynamics of formation of the thickness of the layer was determined on the cross sections of the treated seeds. The thickness of the coating weight was measured using an optical microscope with a digital

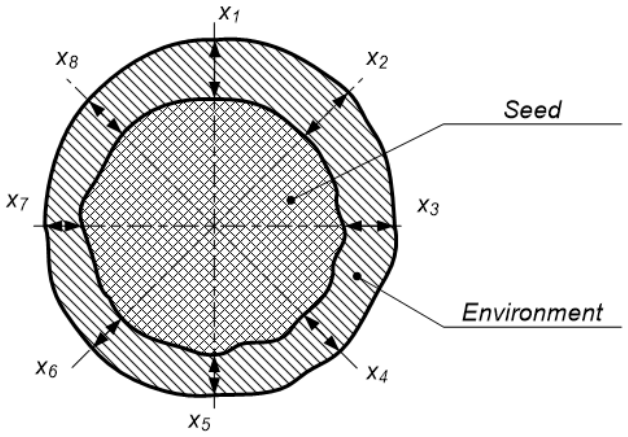


Fig. 3. Scheme for determining the average thickness of the layer

Fig. 4. Thickness of the layer of Scots pine seed (Pinus silvestris L.) at the first stage of pelletizing (time - 7 minutes)

eyepiece and a binocular magnifier. In this case, the plane of the seed cut from the conditional center was divided into eight equiangular sectors, and thickness values X1 X2 ... X8 along the lines coinciding with the sides of the corners of the mentioned sectors were determined (**Fig. 3**).

Subsequently, the average thickness of the layer of each seed was determined as the arithmetic mean of the measured values by the formula:

$$\bar{x} = \frac{1}{8}\sum_{i=8}^{i=8} x_i \qquad (1)$$

The pelleted seeds were sown on garden bed. Non-pelleted seeds were used for control. Seeds were sown in four replicates; 100 units were sown in each replication. The soil germination was determined.

RESULTS

At the end of the pelleting, the maximum thickness of the first layer (shell) formed around the seeds of Scots pine was observed with a pelletizing time of 7-8 minutes and amounted to 0,3 mm - 0,4 mm (**Fig. 4**). The thickness of the first layer of Korean cedar pine was 0.5 - 0.7 mm (**Fig. 5**). The seeding machine does not destroy this shell. The average diameter of the pelleted seeds was: for Scots pine - 3,2-3,8 mm, for Korean cedar pine - 12-14 mm.

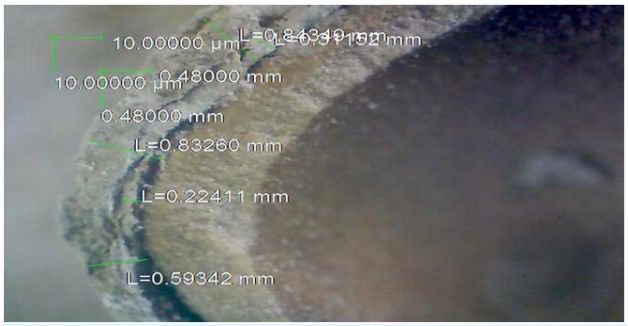


Fig. 5. Thickness of the layer of Korean cedar pine (*Pinus koraiensis* Siebold et Zucc.) at the first stage of pelletizing (time - 8 minutes)

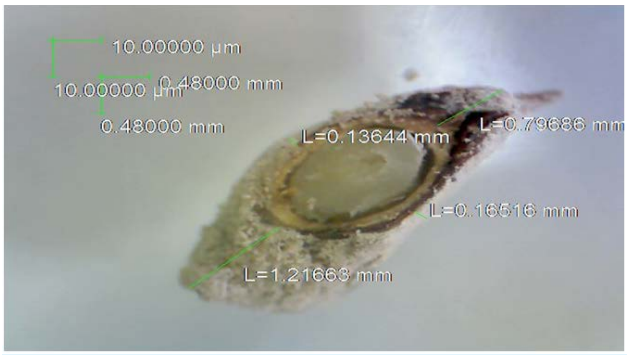


Fig. 6. Thickness of the layer of Scots pine seed (*Pinus silvestris* L.) at the second stage of pelletizing (time - 2 + 6 min.)

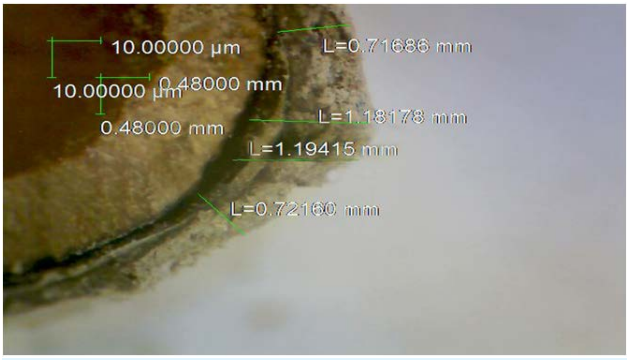
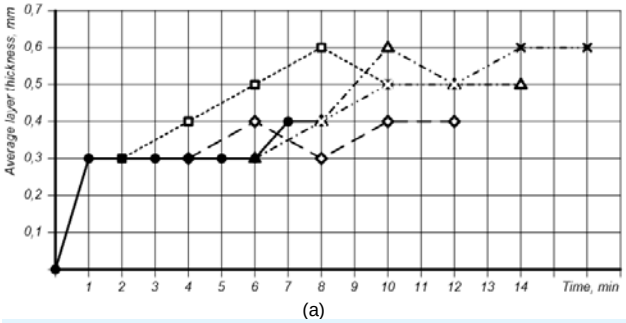


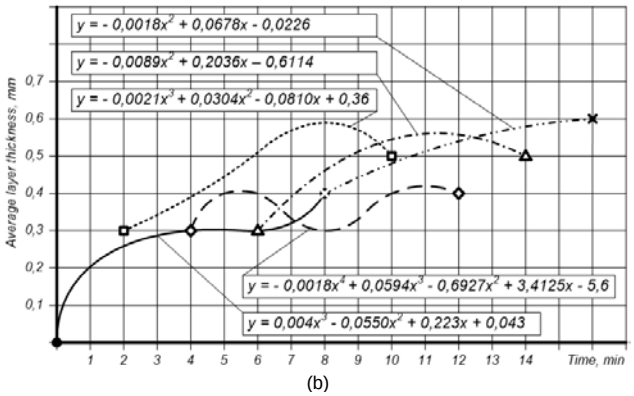
Fig. 7. Thickness of the layer of Korean cedar pine seed (*Pinus koraiensis* Siebold et Zucc.) at the second stage of pelletizing (time - 2 + 6 min.)



(a)

Fig. 8. The dynamics of layer building on seeds of Scots pine (a – an experimental information)

At the second stage of seed pelleting, a higher thickness of the layer of Scots pine seeds was 0.6 mm



(b)

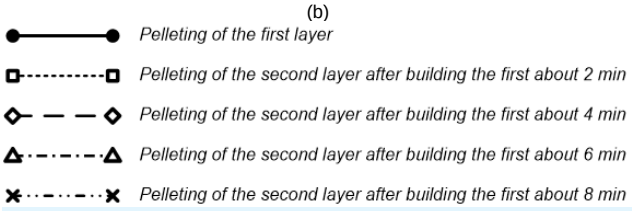
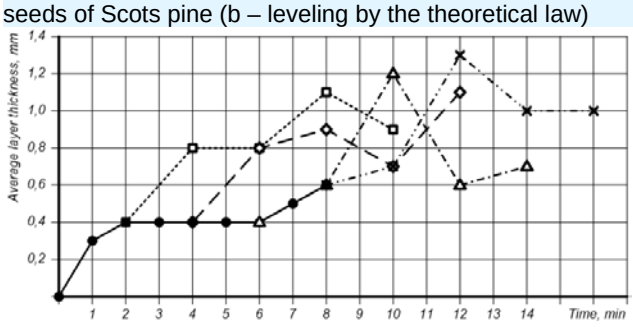


Fig. 8 (continued). The dynamics of layer building on seeds of Scots pine (b – leveling by the theoretical law)



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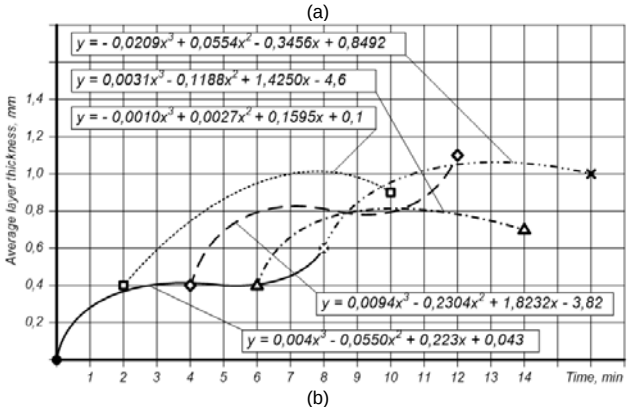

(b)

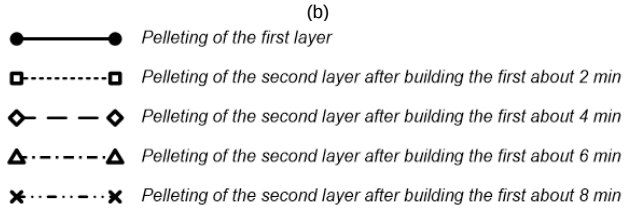

Fig. 9. The dynamics of layer building on seeds of Korean pine (a – an experimental information; b – leveling by the theoretical law)

(**Figs. 6**, **8**). It was observed with the duration of pelletizing for 2 + 6 - 8 + 6 minutes. Higher thickness of the layer of Korean cedar pine seeds was 1.1-1.3 mm with a seed pelletizing time of 2+6-8+4 minutes (**Figs. 7**, **9**).

The pelleeted seeds placed in water were characterized by a high degree of strength on first day of the experiment. In the following days, the seeds swelled and a decrease in the strength of the attachment of the layer to the seed was noted.

CONCLUSIONS

The developed electromechanical drazhirator allows to carry out seed pelleting of coniferous seed of small (pine - *Pinus* L., larch - *Larix* Mill.) and large (Korean cedar pine - (*Pinus koraiensis* Siebold et Zucc.) sizes.

The pelleting mixture is tightly attached to the seeds, providing seedlings with nutrients. Further studies on the effectiveness of growing planting material from drained seeds are necessary. Optimal layer on seeds of Scots pine and Korean pine is achieved in 1 stage, with the build-up time of 7-8 minutes. If it is intended to build up a larger layer, it would be more appropriate to break up the coating process into 2 stages. So, the pelleted seeds must be unloaded, dried and begin to pellet again. The time for pelleting at 1 stage is 2 minutes, on the second stage is 6 minutes. It should be noted that when the thickness of the limiting layer is reached, it is possible to reduce the layer with further pelleting.

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