Physico-mechanical properties of seed pile of fodder crops

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Abstract. The purpose of the study is to study and analyze the physical and mechanical properties of the seed pile of fodder crops. The results of determining the physico-mechanical properties of the seed pile of fodder crops obtained in the combing clover plants with a comb of the combing drum of the harvesting machine are presented. The basic principles and methods of classical mechanics, mathematical analysis, and statistics were used in this study. It was found that the stiffness of the stems of the seed pile at a humidity of 40-60% is in the range of 0.07-0.008 N / m2. At the same time, with a moisture content of 35-65%, its bulk mass is 80-185 kg/ m3, respectively. The minimum value of the angle of the natural slope of the clover seed pile is 48o, and its maximum value reaches up to 90o; the value of the static friction coefficient at a humidity of 40-60% is within 0.98-1.02, and the value of the dynamic friction coefficient is within 0.5-0.7. The pile's temperature is directly proportional to the storage time; during self-heating, the appearance of the pile gradually changes depending on the storage time and temperature duration.

1 Introduction

Seed production is the most important factor in the development of agriculture in Uzbekistan. The production of seeds of high-yielding varieties is very important for obtaining a high yield and improving the quality of agricultural products [1-15]. A seed heap is a material obtained in the process of combing clover plants with a comb of combing drum of the harvesting machine. When combing, the comb tears off the inflorescences from the stems, which contain up to 40% (by weight) in a pile. Unlike other harvesting technologies, this method obtains a more concentrated heap of seeds. When harvesting clover for seeds, the inflorescences come off together with fragments of stems, the length of which can range from 5 to 65 cm [1-6]. The composition of the heap varies widely depending on the conditions of maturation and contamination of crops, the degree of flatness of plant stems, and other factors. The relative humidity of the heap and its components depends on the ripeness of crops, weather conditions, and time of day [16-37].

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2 Materials and Methods

The basic principles and methods of classical mechanics, mathematical analysis, and statistics were used in this study. There are no generalized mathematical models for determining the physico-mechanical properties of the seed pile of fodder crops obtained by the method of sifting plants for seeds [1-6]. Determination of the properties of the pile is carried out experimentally.

During the study period, the moisture content of the pile was determined before each experiment by drying according to a known technique, and the percentage ratio was calculated according to the formula [1, 2]

$$W = \frac{G_1 - G_2}{G_1} \cdot 100\%$$

where G_1 is the weight of the sample taken before drying, g; G_2 is the weight of the sample taken after drying, g.

The limits of changes in the content of the main components of the heap and their humidity are given in Table.1. The number of whole stems depends mainly on the state of the stem of the plants; the greater the flatness of the plants, the more tangled the stems are fed into the comb chamber, and the more the number of whole stems goes into the pile. This happens because a significant part of the stems during harvesting of a decayed plant does not fall between the fingers of the comb of the combing drum but is only pulled out and absorbed from the comb chamber together with the seed inflorescences.

Table 1. Composition and humidity of the pile

Name of components	Mass fraction, %	Relative humidity, %
Inflorescences	31	up to 50
Stems and leaves	55	up to 76
Free seeds	4	up to 35
Weeds	10	up to 80

In addition, the number of stems in a pile is also influenced by the humidity of the stem. In a pile with higher humidity, the number of long stem particles is less than in a dry one. This is because a wet plant has less effort to detach the inflorescences from the stem. The maximum separation force of the inflorescences from the stem does not exceed 20 N, and its minimum value is 1.4 N. According to the research results, V.G.Kovalev [6] notes that at a humidity of 45-50% of the stems, the force required to detach the inflorescences is in the range of 1.40-19.52 N with an average value of 10.46 N. With an increase in the humidity of the stem by 20-25%, the effort required to tear off the inflorescences decreases by 15-20%.

3 Results and Discussions

Stiffness properties of a pile of clover. The results of experiments to determine the stiffness characteristics are shown in Fig.1.

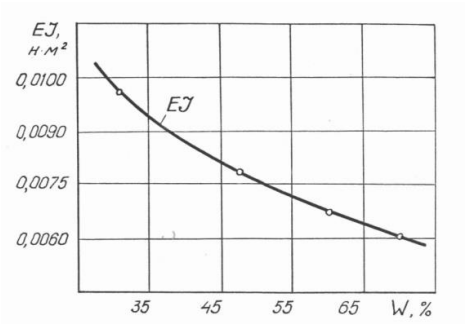

Fig. 1. The dependence on the stiffness of the stems of pile on their humidity

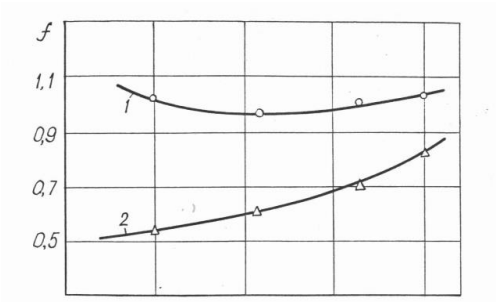

Fig. 2. Dependence of static (1) and dynamic (2) coefficients of friction of a pile of clover on their humidity

Based on the analysis of the dependence of the stiffness of the stem on its humidity, shown in Fig.1, it can be concluded that with a decrease in humidity from 70 to 30%, the stiffness of the stem increases from 0.006 N m^2 to 0.01 N m^2, and with a humidity of 30-40%, the intensity of the change in the indicator increases. On average, the stiffness value for calculations can be assumed to be equal to 0.07-0.008 N / m2, which corresponds to the humidity of the stems of 40-60%.

Fractional properties of the heap components. The results of experiments to determine the static and dynamic coefficients of friction are shown in Fig.3. Analysis of the data obtained shows that the value of the static friction coefficient practically does not depend on the humidity within its range of 30-70%, and therefore, for practical calculations at a humidity of 40-60%, it is possible to take an f value equal to 0.98-1.02. The value of the dynamic coefficient of friction with an increase in humidity from 35 to 60% increases from 0.5 to 0.7, and the intensity of its change increases with increasing humidity. For practical calculations, when the humidity of the pile during the drying period is 50-55%, the value of the dynamic coefficient of friction can be equal to 0.63-0.67.

Determination of the bulk mass and the angle of the natural slope of the pile. Like many other materials, the bulk mass of a pile of clover depends on humidity, composition, and the presence of gaps between the particles of the material. Figure 4 shows the pile's bulk mass's dependence on its humidity. The graph shows that with an increase in the humidity of the pile from 35 to 65%, its volume mass increases, respectively, from 80 to 185 kg/ m3. As can be seen from Fig.4, the smallest bulk mass has a pile with a humidity of 35% and a content of 50-60% of stems and their particles. When calculating the volume mass of the raw pile, 180 kg / m^3 can be taken.

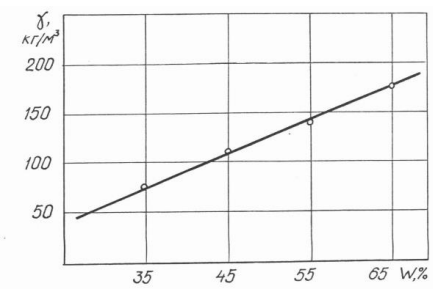

Fig. 3. Dependence of the bulk mass γ of the heap on the humidity W

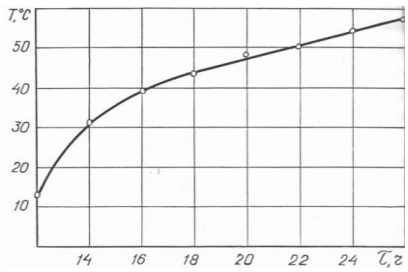

Fig. 4. Dependence of the self-heating capacity of the seed pile on the storage time before drying

One of the indicators of the mobility of the heap particles is the angle of the natural slope. Depending on the composition and humidity of the pile, the angle of the natural slope varies widely – from 48 to 90°. So, for example, a heap consisting of some inflorescence according to V. Maltri [4], has a natural slope angle of 48.3-50.5º.

A pile containing even a significant number of stems and their particles retains a vertical wall with a height of sometimes more than 1.0 m. This phenomenon can be observed when opening the sides of a tractor trailer filled with a pile. Thus, the minimum value of the angle of the natural slope of the clover seed pile should be 48o, and the maximum value of this angle reaches up to 90º [7-9].

Study of self-heating of the pile during storage before drying. In a heap, even with relatively low humidity, the self-heating process goes very quickly. This process is especially intense in a heap with high humidity. The results of studies of self-heating of the pile depending on the time of day are shown in Fig.5. From the graph, it can be seen that the increase in the temperature of the pile for the first day, that is, for 24 hours, can be considered directly proportional to the time. So, in 24 hours, the temperature of the heap rose by 38º – from 12 to 50º; on average, it increased by 1.5º per hour. In the process of self-heating, the appearance of the pile gradually changed depending on the duration of storage time and temperature. Inflorescences and seeds acquired a dark color, mold, and odor appeared.

4 Conclusions

1. It was found that the stiffness of the stems of the seed pile at a humidity of 40-60% is in the range of 0.07-0.008 N / m2. While at a relative humidity of 35-65, heap% of its body weight equals 80-185 kg/m3.

2. The minimum value of the angle of repose of seed lots of the same 48o clover, and its maximum value reaches 90°, the value of the coefficient of static friction is slightly dependent on humidity. The humidity is 40-60%, its value is in the range of 0.98-1.02 times, and the value of the dynamic coefficient of friction in the range of 0.5-0.7.

3. The pile's temperature is directly proportional to the time; in the process of self-heating, the appearance of the pile gradually changes depending on the storage time and temperature duration.

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