Important physical and mechanical properties of the mung bean seed for harvesting and cleaning process

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Abstract. Known physical and mechanical properties of the mung bean and its seed is important for harvesting and cleaning. Experiments for determining were performed according to defined methods by sorts of mash bean "Turon", "Durdona", "Kakhrabo" and "Radost" that are being grown in large amount in present days and during the experiments the fraction content of the mash bean seed as well other impurities in its content also length, width and thickness of the seed were defined. There are pure seed between 85-86 % in content of seed mixtures, about 2 % broken and free seeds as well between 12-14 % other impurities. The seed of mash bean sort "Durdona" is the biggest among other sorts, its average grain length is 6.29 mm, width is 4.25 mm and thickness is 3.96 mm. "Turon" and "Kakhrabo" sorts' seeds have average sizes, their average seed lengths are 5.85 mm and 5.58 mm, their widths are 4.25 and 4.16 mm also their thicknesses are 3.68 mm and 3.96 mm respectively. According to size, the smallest grains belong to "Radost" sort, their sizes were defined at 4.58 mm, 3.46 mm and 3.60 mm respectively. According to researches, it was defined that there are other impurities around 11.1-11.4 per cent, free and broken seeds about 1.9-3.4 per cent in the content of mash bean that harvested by cereal harvester combine and they should be separated before using consumption or sending to sell, as well it is expedient to separate to fractions according to dimension of seed.

1. Introduction
Mash bean (Phaseolus aureus Piper.) and according to last classification "Vigna radiate" (L Wilzek) is one year grass-similar plant, it was grown as cultural plant in farm 5-6 thousand years ago. Its homeland is southern-western Asia.

Because of advantages of the mash bean as above mentioned, growing volume of mash bean is increasing year from year along the world. According to information of Food and Agriculture Organization (FAO) every year 5.3 million tons mash bean is produced along the world [1].

Also, in our country during the last recent years the volume of mash-bean producing and exporting has been increasing (figure 1). Uzbekistan is a leader among Central Asian countries according to mash-
bean producing and annual consumption of population. For harvesting crops two times in a year, as well
getting additional income by sowing repetition plant and improving soil productivity mash-bean is being
grown in main areas of the harvested fields of autumn cereal plants.

![Graph of area and gross crop of the growing mash-bean in Uzbekistan](image1)

Ripened crops are harvested with two phase method by the help of cereal combines and different
thresher devices (figure 2).

![Figure 2](image2)

Figure 1. Area and gross crop of the growing mash-bean in Uzbekistan.

According to measure of "Bazis" for storing the seeds in storages, seeds should be primary cleaned
and their moisture should be declined till 14-15 per cent [2, 3]. Moisture in grain mixture content
increases mainly according to share of moisture of the other impurities, namely bits of stalk, leaf, non-
ripened and crushed seeds as well small compounds. Besides of these, sorbent (sucking the moisture
itself) property is at high level, therefore threshed mash-bean should be separated quickly from other
compounds especially compounds which have much moisture [4].

The method of mash bean seed cleaning and the substantiation of the parameters and operating modes
of machines depend directly on the condition of the processed material, namely the morphological
composition of the seed mixture to be cleaned and the physical and mechanical properties of the seed [5-17]. Therefore, experiments were conducted to study the morphological composition and size of the pulverized mash bean seed mixture using cereal harvesters and various thresher devices.

2. Research method
The experiments were performed on samples taken from a mixture of mash-bean seed threshed by using the Case-2166 and Claas Dominator-130 combines in accordance with existing standard guidelines.

Grains are characterized by dimensions such as length, width and thickness. Grain length \( l \) is its largest longitudinal dimension, width \( b \) is the average transverse dimension, and thickness \( \delta \) is the smallest transverse dimension (figure 3, a).

Experiments to determine the size of mash bean seed were carried out according to the methods established in the varieties of "Turon", "Durdona", "Qakhrabo" and "Radost", which are currently grown by farmers and peasant farms. In this case, the length, width and thickness of the seed were measured using a modern digital caliper (figure 3, b).

![Figure 3. Sizes of mash bean seed and measuring process. a) sizes of seed; b) measuring process of the mash bean by the modern digital caliper.](image)

The determined values were processed by mathematical statistical methods and their minimum \( (X_{\text{min}}) \), average \( (H_{\text{ave}}) \) and maximum \( (X_{\text{max}}) \), values, standard deviation \( (\pm \sigma) \), coefficient of variation \( (V) \) were determined [18].

3. Results and discussion
Initially, the components of the seed mixture were separated into separate fractions. According to this, it was found that the mixture of mash bean seed consists of components such as whole seed, crushed, loose and broken grain, mineral compounds (lumps, stones), stalk fragments, fine mixtures and weed seeds (figure 4).

![Figure 4. Morphological content of the mash bean seed mixture. 1 – mash bean seed, 2 – crushed, loose and broken seed, 3 – mineral mixtures, 4 – mineral compounds, 5 – fine mixtures, 6 – weed seeds.](image)

The mass of each component of the seed mixture was measured, the values were mathematically and statistically processed, and their share in the composition of the mixture was determined (table 1).
When studying the share of components in the seed mixture, the content of crushed seed in the cereal combine "Case-2166" was 86.7 % pure grain, crushed, loose and broken grains 1.9 %, mineral compounds 1.0 %, stalk fragments 1.8 %, fine impurities 7.8%, weed seeds 0.8%. Pure seeds contain 85.5% in mash bean seed compound that harvested by Claas "Dominator-130" cereal harvester combine, 3.4% of crushed, loose and broken seeds, 1.1% of mineral mixtures, 1.7% of stalk fragments, 7.4% of fine mixtures, weed seeds were observed to be around 0.9%.

Table 1. Morphological content of the mash bean mixture that threshed by combine harvesters “Case-2166” and “Clαаs Dominator-130”.

| Name of the Components | $X$, g | $\pm \sigma$, g | $V$, % | Per cent |
|------------------------|--------|------------------|--------|----------|
| Clean seed             | 867.4  | 3.64             | 0.42   | 86.7     |
| Crushed, loose and broken seed | 18.7 | 0.63 | 3.4 | 1.9 |
| Mineral mixtures       | 9.8    | 0.76             | 7.8    | 1.0      |
| Stalk fragments        | 17.6   | 0.59             | 3.4    | 1.8      |
| Fine mixtures          | 78.2   | 0.71             | 0.91   | 7.8      |
| Weed seeds             | 8.3    | 0.66             | 7.9    | 0.8      |

| Name of the Components | $X$, g | $\pm \sigma$, g | $V$, % | Per cent |
|------------------------|--------|------------------|--------|----------|
| Clean seed             | 854.7  | 2.79             | 3.3    | 85.5     |
| Crushed, loose and broken seed | 34.2 | 0.49 | 1.4 | 3.4 |
| Mineral mixtures       | 10.6   | 0.89             | 8.4    | 1.1      |
| Stalk fragments        | 16.7   | 1.28             | 7.7    | 1.7      |
| Fine mixtures          | 74.1   | 0.57             | 0.8    | 7.4      |
| Weed seeds             | 9.7    | 0.84             | 8.7    | 0.9      |

According to the results obtained in the experiment, the size of the mash bean seed varies depending on the sorts. According to size the seed of "Durdona" sort of the mash bean is the biggest, average seed length is 6.29 mm, width is 4.25 mm and thickness is 3.96 mm. These results were observed during the experiment (table 2).

Table 2. Size indicators of the mash bean seed.

| Mash bean sorts | Indicators and their amounts | $X_{max}$ | $X_{min}$ | $X_{ave}$ | $\pm \sigma$ | $V$, % |
|-----------------|-----------------------------|----------|----------|----------|-------------|--------|
| Length          |                             |          |          |          |             |        |
| Turon           |                            | 7.39     | 4.26     | 5.85     | 0.54        | 9.77   |
| Durdona         |                            | 7.42     | 5.16     | 6.29     | 0.58        | 10.77  |
| Qakhrabo        |                            | 6.48     | 4.33     | 5.58     | 0.47        | 8.42   |
| Radost          |                            | 5.52     | 3.64     | 4.58     | 0.38        | 8.39   |
| Width           |                             |          |          |          |             |        |
| Turon           |                            | 4.63     | 3.47     | 4.05     | 0.21        | 5.99   |
| Durdona         |                            | 4.87     | 3.62     | 4.25     | 0.33        | 8.04   |
| Qakhrabo        |                            | 4.90     | 3.27     | 4.16     | 0.30        | 7.10   |
| Radost          |                            | 3.96     | 2.96     | 3.46     | 0.21        | 5.98   |
| Thickness       |                             |          |          |          |             |        |
| Turon           |                            | 4.27     | 3.09     | 3.68     | 0.27        | 7.39   |
| Durdona         |                            | 4.98     | 3.30     | 3.96     | 0.34        | 8.56   |
| Qakhrabo        |                            | 4.84     | 3.31     | 3.99     | 0.29        | 7.29   |
| Radost          |                            | 4.19     | 3.01     | 3.60     | 0.25        | 7.29   |
"Turon" and "Qakhrabo" sort mash bean seeds are of medium size, with an average seed length of 5.85 mm, 5.58 mm, width 4.25 mm, 4.16 mm and a thickness of 3.68 mm and 3.96 mm respectively. The smallest seeds belonged to the "Radost" sort and were found to be 4.58 mm, 3.46 mm and 3.60 mm, respectively.

According to the results obtained in the experiments, in the purification of mash bean seed, the seed mixture contains 85-86% of pure seed, around 2% of broken and empty seed and 12-14% of other impurities. The variation in the amount of fine impurities in the weed mixture is close to 1%, while the variation in the amount of crushed, loose and broken grains and stalk fragments is moderate, the variation in mineral compounds and weed seeds is around 8% and high. When designing a mash-bean seed cleaning machine, its working surface should be selected depending on the amount of other impurities in the mash-bean seed and their variation. It is also advisable to take the width of the seeds as the main dimension when cleaning the mash bean seed into fractions. In this case, the size of the sieve holes should be the size that separates the mash bean seeds into 2 fractions in width, namely up to 3 mm wide and grains larger than 3 mm.

4. Conclusion

According to researches, it was defined that there are other impurities around 11.1-11.4 per cent, free and broken seeds about 1.9-3.4 per cent in the content of mash bean that harvested by cereal harvester combine and they should be separated before using consumption or sending to sell, as well it is expedient to separate to fractions according to dimension of seed.

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