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Comparing industrial grain and seed for sowing of corn in the conditions of Uzbekistan

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Abstract. It is necessary to harvest the matured crop of corn at low cost and on time to produce qualitative seed. Therefore, research was conducted about the determination of the maturing period of the corn in the period of waxy maturity of the corncob and physical-mechanical properties of the corn were studied too, for comparing industrial grain and corn for seeding. It was defined that during the experiment the corn may be harvested in its waxy matured period, namely 10-16 days earlier than maturing completely for producing industrial grain in Uzbekistan. However, this harvesting method can not be used to produce corn for seeding. If the corn-crop is harvested earlier for producing industrial grain, there might be an opportunity to do next agronomic and mechanized operations such as ploughing or providing the field with organic fertilizers before snowy days. However, for producing corn-seed, of course, the completely ripening period of the corn-grain should be waited. Studying the physical-mechanical properties of the corn is important to determine the parameters of the corn-harvester and thresher machines for harvesting seed-corn.

1. Introduction
Corn is grown as one of the main plants in many countries at present time. The main reason is that corn is an important forage plant for development of livestock and poultry-ranch [1-7]. Also, another reason is that the products are produced by the corn for use in the food industry, medicine, and technical purposes. Those products are pop-corns, canned-foods, starch, crystallized sugar, alcohol, and other products [8-10].

The motherland of corn is the country of North America. It is known that, the conclusive evidence of archaeological and botanical scientists' observations grew corn grown as a cultural plant in the southwestern part of the United States of America 3013 years ago. Wild corn existed in the "Tehuacn" Valley of southern Mexico 7013 years ago, and corn growing began for cultural purposes in this region 4613 years ago. Corn is produced at more than 500 million tons at present day all over the world, and the United States is the leader as a corn-growing country, with more than 40 percent of the world's production. Most of its crop is grown in the Midwestern region known as the Corn Belt, which

comprises Ohio, Indiana, Illinois, Iowa, Missouri, Kansas, and Nebraska. The other leading corn-growing nations are China, Brazil, Mexico, Russia, Italy, India, and other countries [11]. In

Uzbekistan, corn is grown only on the main corn area, but after harvesting wheat crops [12], corn with other crops is seeded on the wheat field as a second crop in Uzbekistan [13] and after wheat harvesting, only early-maturing and middle-maturing corn sorts are seeded. The early-maturing corn is ripened between 70-75 days and the middle-maturing corn is ripened between 90-95 days in our Republic.

If we consider it, instead of wheat growing in an empty area, this indicator will increase to 300000 hectares. One of the biggest tasks is growing corn for seed. It is required to harvest the ripped crops without loss and qualitatively. In particular, if this work is performed with the help of mechanization methods and technical instruments, we will achieve decrease in serious labor and material expenses.

Nowadays, a complex of harvesting machines and earlier-harvesting technology are being produced for harvesting seed-corn in Uzbekistan. Research is being conducted into the creation of the corn-harvester machine and corn-thresher machine. For determination of the parameters and modes of operation of the worker-elements of the created machines, it is necessary to know the maturing period of the crop and its physical-mechanical properties [14,15]. Therefore, we determined the maturing period of the crop and the physical-mechanical properties of the corn for harvesting corn-seed.

2. Materials and methods

According to experience of world researchers, the harvesting methods, which are in grain form or in pod-corn form, are used to harvest corn for industrial grain [16-26].

The combine-harvesters for cropping the corn for grain reap the corn stalks. The corncobs are picked from their stalks and they are threshed by the combine-thresher. The grain is separated. This method is very thrifty, but for this method, the corn has to be ripened completely. Its moisture should be between 22-26 per cent [3].

In Uzbekistan, this method is used in very few areas, because the stalk of the corn is used as coarse hay for cattle animals. The vegetation period is long (120 days) and the corn that is seeded after wheat as a repeatedly crop can not dry well. Furthermore, only the grain part of the corn is harvested by this method, and the stalk part of the corn is strewed on the surface of the field as humus (organic fertilizer). Moreover, this causes not to be harvested the forage that is used as coarse hay for cattle animals.

Nowadays, some new harvesting methods are being researched to settle these defects of the above-mentioned methods [3,18]. However, in Uzbekistan, these harvesting methods can not be used because the cost of energy is too high and the machines that are used for doing these operations are very expensive.

The corn is harvested as a formed corncob in two forms, namely, husks are peeled from their pod-corns or without peeling the husks. This method is done with the help of corn harvester machines or combines. At first, the stalks of the corn are reaped, pod-corn is stripped and stalks are cut. The silo is unloaded onto transport that is moving on the side of the combine. In addition, corn-cobs are peeled from their husks or they are unloaded without being peeled onto a trailer that is joined to the transport. This method is much better than others in Uzbekistan because the grain of the corn and its stalks are harvested and the pod-corn might be harvested when its moisture is 35-40 per cent.

Therefore, the research was performed on earlier harvesting of the corn crop in pod-corn form. At first, we studied the maturing period of the corn crop for producing industrial grain. Then the results were analyzed to determine the physical-mechanical properties of corncobs and stalks to compare corn grain for seeding. The research was observed by sorts of corn that are most grown in Uzbekistan, namely Uzbekistan-100 and Qorasuv-350 ABM sorts.

3. Results and Discussions

The results showed that the study of the maturing dynamics of grain of the sort Uzbekisatn-100 from 4 September to 1 October (figure 1), the moisture of the grain changed from 68.6 per cent to 17.0 per cent during that period. The milk period of the grain went on until 2 September, and it consisted of 12 days. The paste period, namely decreasing the moisture from 56.2 per cent to 39.0 per cent, continued from 10 September to 16 September, and it lasted 7 days. The waxy ripening period of the grain, namely the decreasing of the moisture from 40 per cent, started on 15 September. On 28 September, it reached 18.2 per cent and ripened completely. So, at that time, the waxy ripening period of the corn consisted of 14-16 days.

As if this situation, it was defined as an early maturing sort of corn which is named Qorasuv-350 AMB too. However, the waxy ripening period of this sort, namely the decreasing interval of the moisture from 40 per cent to 20 per cent, was observed from 11 September to 23 September and that period was organized for 11-12 days. It is seen that by experiments, the ripening period of the corn from waxy ripening until completely ripening is 14-16 days for late-ripening corn and 10-12 days for early-ripening corn.

During the experiments, the changing of the drying dynamics was defined of the pod-corns that were harvested in different periods and dried in shade and in sun light. The results of the experiment showed that (figure 2), the moisture of the sort Uzbekistan-100 of corn was 40.8 per cent on 15 September, namely it was harvested in the waxy ripening period, and dried from 15 September to 11 October, the mass of the corncob decreased from 316 grams to 187 grams. The mass of the dried corncobs decreased sharply from 316 grams to 207 grams from 15 September to 27 September. It decreased from 207 grams to 190 grams from 27 September to 3 October. When it was observed from 3 October to 11 October, it decreased to 187 grams, almost did not change.

As if this experiment was not enough, another one was performed with sort of corn which is named Qorasuv-350 AMB. So, the moisture of this sort was about 40 per cent on 11 September. This sort of corn was harvested on 11 September because it had already ripened into a waxy form and the change of the mass was observed by 11 October.
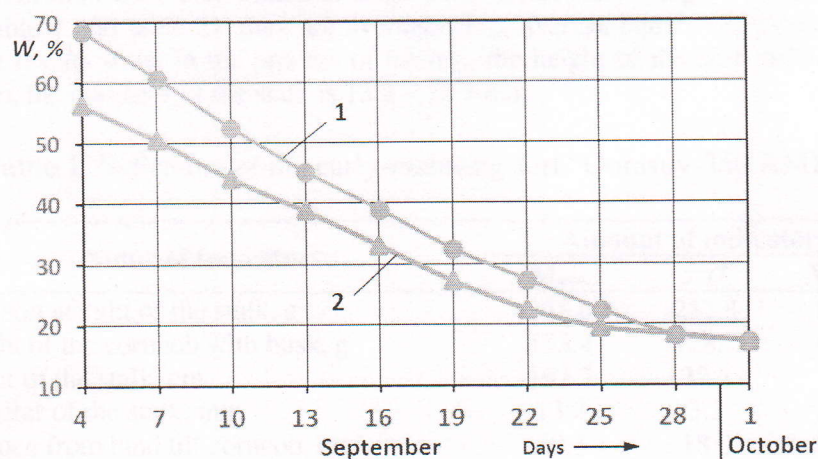

Figure 1. The ripening dynamics of the ear of corn. 1 - the sort of Uzbekistan-100; 2 - the sort of Qorasuv–350 AMB, W – Moisture of the grain.

On 11 September, the average mass of the corncob was 247 grams. It decreased sharply to 154 grams by 1 October. Between October 1-5, it decreased from 154 to 149 grams, from 5 October to 9 October it decreased insignificantly to 146 grams, then did not change, just remained constant.

The result of the experiment shows that the late-ripening corn that is harvested in its waxy ripened period dries for 18-20 days. When early-ripening corn is dried in natural condition, it is dried for

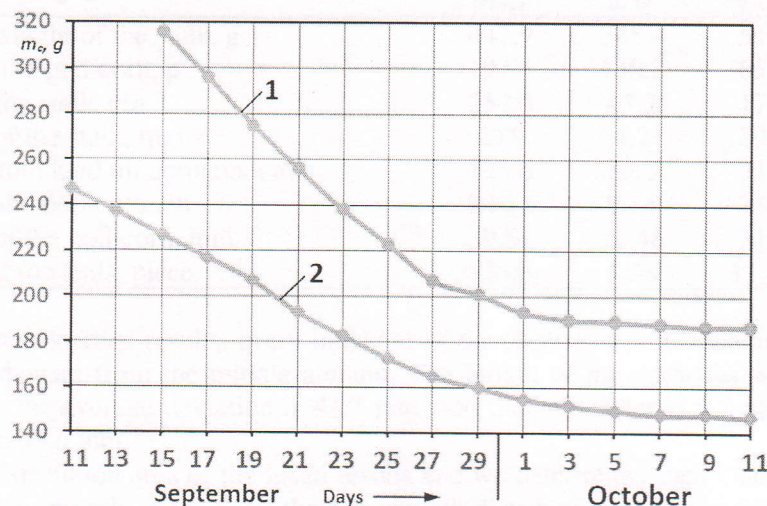14-15 days and moisture decreases by 18 percent. It can be ready for threshing and use in industrial aim.

Figure 2. The line graph shows the change of the corn mass that was harvested day by day. It was dried in a shaded place and the sun shone. 1-the sort of Uzbekistan-100; 2-the sort of Qorasuv–350 AMB

This change is in good agreement with the results of K. Astanakulov's research on wheat [27].

After defining the maturing period of the crop, we studied the physical and mechanical properties of the corn. The experiments were tested by early-maturing sorts "Qorasuv-350 AMB" and "Uzbekistan-100", late-maturing hybrid sorts of corn. These sorts are grown mostly in our Republic. The size-mass indicators were determined of those sorts before harvesting the crop. These indicators are shown in (table 1 and table 2); they are average-$M_{ave.}$, average-square deviation- and coefficient variation-V. The results show in the process of harvest, the height of the corn stalk is an average of 192.7 – 257.0 cm, the diameter of the stalk is 13.2 – 20.9 mm.

Table 1. Indicators of the early-maturing sort "Qorasuv-350 AMB"

Name of indicators	Amount of indicators		
	$M_{ave.}$	$\pm\sigma$	V, %
Common weight of the stalk, g	378.6	252.4	57.2
Weight of the corncob with husk, g	153.4	128.2	49.8
Height of the stalk, cm	192.7	37.3	19.3
Diameter of the stalk, mm	13.2	3.2	34.7
Distance from land till corncob, cm	80.3	18.0	22.4
Length of the pod-corn, cm	18.3	5.7	31.2
Diameter of the pod-corn, mm	38.9	6.0	15.4
Quantity of the leafs, piece	9.1	1.3	14.7

The position of the corncobs from land is at 80.3-123.6 cm height and this indicator is necessary to determine the height of the corncob picker-apparatus of the corn-harvester.

The pod-corns are harvested by the help corn-harvester machine and threshed, separated by the help corn-thresher machine. For substantiation of the parameters of the corn-thresher machine, the size-mass indicators were learned from the corncob and those indicators are shown in (table 3).

Table 2. Indicators of the late-maturing sort "Uzbekistan-100"

Name of indicators	Amount of indicators		
	$M_{ave.}$	$\pm \sigma$	V, %
Common weight of the stalk, g	447.9	245.4	51.2
Weight of the pod-corn, g	197.5	130.2	65.9
Height of the stalk, cm	257.0	43.2	17.1
Diameter of the stalk, mm	20.9	4.2	20.2
Distance from land till corncob, cm	123.6	39.3	31.8
Length of the pod-corn cm	24.32	9.34	38.4
Diameter of the pod-corn, mm	39.81	12.46	31.3
Quantity of the leafs, piece	13.06	1.48	11.37

It is known that, from learned results, every indicator of the corncob has its own amount and self-character. They also deviate from the middle amount. The length of the corncobs with husks is an average of 262.5 mm, the average deviation is 44.7 mm, and their diameter is 5.2 mm deviated and they are organized into 38.6 mm.

We analyzed the distribution area of the taken results and we determined their characterizations of the spread distance were smooth. We can see the non-smooth distribution of the amounts by weight of corncob, its grain and of the piths. These indicators are average amounts of 122.1 g, 99.3 g and 22.8 g. Their variation surfaces are 42.1 % on corncobs and their pith. The grain weight is 44.7 %. The result showed that the deviation of the amount is serious one from the other.

Table 3. Size-mass indicators of the corncobs

Name of the indicators	Amount of the indicators		
	$M_{ave.}$	$\pm \sigma$	V, %
Length of the corncobs with together husks, mm	262.5	44.7	17.0
Diameter of the corncobs with together husks, mm	38.6	5.2	13.6
Weight of the corncobs with together husks, g	130.6	51.2	38.9
Quantity of the husks, pieces	6.2	1.9	30.7
Weight of the husks, g	8.5	3.3	38.9
Length of the husks, mm	216.5	35.8	16.5
Weight of the corncob, g	122.1	51.4	42.1
Length of the corncob, mm	208.7	42.7	20.5
Diameter of the corncob, mm	37.6	4.5	12.1
Weight grain of the corncob, g	99.3	44.4	44.7
Weight of the pith, g	22.8	9.6	42.1
Diameter of the pith, g	24.2	3.1	13.0

There are husks of the corncobs average-amount 6.2 pieces and the weight of the husks is 8.5 g. Their deviation from the average-amount is equal to the amount of the husk 1.9 pieces and the weight of the husks 3.3 g. The husks are situated near 120° at an angle and those husks wrap around 4-5 times the compact thickness of the corncob.

After peeling the husks of the corncobs, their length is an average of 208.7 mm, their diameter is 37.6 mm, and their average-square deviation is equal to length of 42.7 mm, at diameter of 4.5 mm.

The length is 20.5 per cent; the diameter is 12.1 per cent. The corncob with husk consists of husks 6.5-7.0 percent, grains 76 per cent, and piths 17 per cent.

The weight of the grains of the corncobs was 99.3 g, their deviation from the average was 44.4 g. One of the main indicators is the weight and diameter of the pith. They are shown in table 3. They

equal the diameter of the pith at 24.2 mm, their weight is 22.8 g and the deviation from average-amount of the indicators equals the diameter of the pith at 3.1 mm, their weight is 9.6 g.

They are being consideredby definite results. The main weight of the husk-corncobs is grains, 75.8 per cent, piths 17.7 percent, and husks, 6.5 per cent. The diameter of the pith is smaller at 13.4 mm than on peeled corncobs and corncobs with husks at 14.4 mm. The main sizes of the grain are length, width, and thickness. These indicators were learned by experiment.

It is known that by experiment, the main size of the grain is length and it changes from 8.4 mm to 10.5 mm. More than 80 per cent of the grains are from 9 mm to 10 mm. The middle length is 9.73 mm, their middle-square deviation is 0.50 mm (table 4). The size of the width grain is near to its size length. It equals 8.34 mm, their middle-square deviation is 0.67 mm, and their variation surface is 8.05 percent.

The smaller size of the corn grains is its thickness. It is equal to an average of 5.16 mm, middle-square deviation of 0.46 mm, and variation coefficient of 9.02 percent. It is seen from the results that the grain length is more than 1.39 mm than the grain width. This difference is more than 4.57 mm than the grain thickness.

Table 4. Sizes of the corn grain

Sizes of the grain	$M_{ave.}$	$\pm \sigma$	V, %
Length, mm	9.73	0.50	5.14
Width, mm	8.34	0.67	8.05
Thickness, mm	5.16	0.46	9.02

The husk-corncobs are moved around the worker-surface across and down of the corn-thresher machine. The corncobs are rubbed with worker-surfaces. Therefore, we must learn their friction coefficient. It is known that from experiments (table 5), there is a difference between the friction angle of the husk, pith and grain.

Table 5. Rubbing angle of the component corncobs

Sample	Movement way	Friction angle		
		M_{mid}	$\pm \sigma$	V, %
Husk	across	23.2	3.3	14.3
	down	22.7	4.2	18.6
Pith	across	13.2	4.0	30.5
	down	19.3	1.5	8.0
Grain	-	21.8	3.5	16.4

Across and down friction angle of the husk near one another it equals 23.2° and 22.7°. In addition, across and down friction angle of the pith equals 13.2° and 19.3°. It was determined that there is a difference one from another 1.5 times. The friction angle of the grain was average of 21.8°. Its middle-square deviation 3.5° variation degree was 16.4 percent. The analyzing of the taken results showed that the pith has leased to friction angle in the learned samples and it is between 13-19°. This indicator for husk is 22-23° and for grain, it is 21-22°. We may say this. We will pay attention to these results next for research work and we will use this information.

After observing experiments about the determination of ripening period and physical-mechanical properties of industrial grain, we decided to compare the above-mentioned experimental results with those of producing seed-corn. According to some agronomic researchers' observations, there is a special determination method for harvesting corn-crop for producing seed-corn figure 3 [25-27].
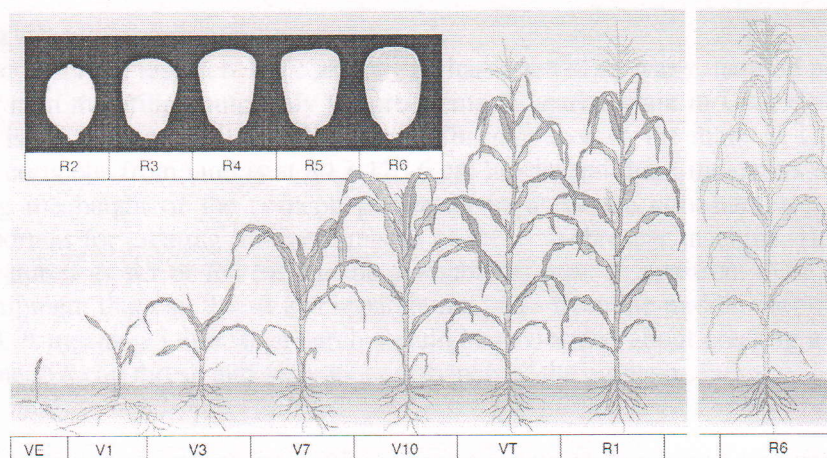
Figure 3. Corn-seed development.

During their research, they defined that matured corn-seed can be known by its color. When corn-seed matures, its color becomes dark-yellow and completely full, as shown in figure 3 R6 position. When we observed the ripening period of the corn for producing industrial corn-grain, it was defined by comparison that most of the grain on the ear became like the R5 position of figure 3 while being harvested. It means that corn-grain which is harvested for industrial purposes is not available for sowing as a seed.

Other researchers' teams determined that, after harvesting pod-corn, corn-seeds should be further sorted in order to have good quality. Some processes should be followed to achieve it. First of all, select cobs of equal size with thick husks, then remove rotten cobs and the cobs which are not completely covered with husk. The next step is to remove the cobs with too big and too small kernels (seeds). Remove the kernels from the top and bottom parts of a cob to select uniform kernels as seed. Removed cobs or kernels (grain) should be used for food consumption, but not for seed. Figure 4 [26]
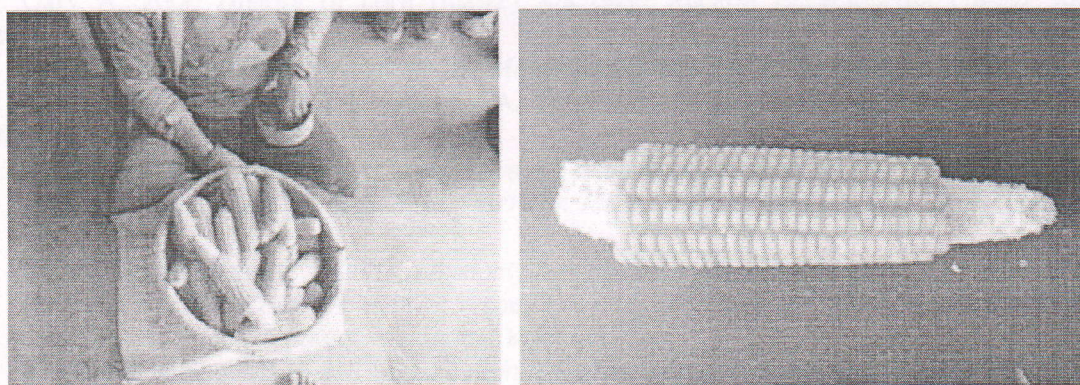

Figure 4. Selecting qualitative seed.

According to the above-mentioned observations, even full matured grains as shown in R6 position of fig. 2 can not be sowed as the seed if they are located on the top and bottom part of the cob. Therefore, many farmers in Uzbekistan and some foreign countries sow corn-seed in R5 and R6 positions [18-23]. It influences the decrease in the quality of seed and the deterioration of crop productivity. In addition, there is no mechanized method or machine to harvest and select the exact middle part of the seeds of the cob. This situation demands new research into the condition of Uzbekistan.

4. Conclusion

According to observed research, the corn may be harvested in its waxy matured period, namely 10-16 days earlier than maturing completely for producing industrial grain in Uzbekistan. The height of the corn stalk is an average of 192.7-257.0 cm. The diameter of the stalk is 13.2-20.9 mm. The position of the corncobs from land is at 80.3-123.6 cm height and these indicators are very necessary for determining the height of the corncob picker-apparatus of the corn-harvester. The size of the corncob is important for creating the mechanisms of the corn-thresher machine. However, industrial grain that is matured as R5 or R6 can not be available to sow. In addition, there is no agricultural machine or equipment that can thresh and separate the grain from the middle part of the corn cob for sowing as seed. It means, additional research should be performed about creating a new type of corn thresher machine that can thresh and separate exactly part of the corncob.

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