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INFLUENCE OF METHODS OF POST-HARVEST TREATMENT OF MAIZE HYBRID SEEDS ON THEIR QUALITY AND LONGEVITY

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The Laboratory of Storage and Standardization of Grain of the State Institution «Institute of Grain Crops of NAAS of Ukraine» has studied the effects of the methods and modes of post-harvest treatment of maize hybrid seeds on the seed quality and economical longevity during long-term storage.

The optimal methods and modes of separation of seeds intended for long-term storage were defined. The cleaning rate should be at least 80%, and fractions should be selected from this category by calibration on sieves with mesh diameters of 9, 8 and 7 mm. Gravimetric sorting increases the germinability and yield of hybrid seeds, and chemical treatment should be carried out immediately before sowing this crop. It was proven that, provided the optimized methods and modes of post-harvest and pre-sowing treatment, the maize hybrids could be stored for 3–4 years.

Key words: *maize hybrids, seeds, post-harvest treatment, quality, longevity*

Introduction. Post-harvest treatment of maize hybrids involves various technical and technological operations that significantly affect the seed quality of this crop. The quality is characterized by several parameters: seed germinability, growth power, size, damage degree, infections, pest infestation, etc. However, post-harvest treatment can still affect the economical longevity of seeds, ie the period during which they are suitable for sowing.

The main technical and technological operations of post-harvest treatment include drying, cleaning, sorting and calibration of seeds. Operations should also include pre-sowing or pre-sowing treatment of seeds, it dressing, incrustation, saturation of seeds with various stimulants and growth activators. Advance pre-sowing treatment includes pre-treatment, which is performed in advance, immediate pre-sowing is the treatment immediately before sowing.

Literature review and objective setting. In some studies, the effect of post-harvest treatment on the maize hybrid seed quality was investigated, in particular, the temperature-ventilation drying modes producing high-quality sowing seeds were defined [1–4]. The separation methods, by which the most sterling sowing fractions are selected from the total mass, were also established [5–7]. There are reports about exposures to various biologicals, trace elements and growth regulators, which are recommended for advance pre-sowing and immediate pre-sowing treatments of maize seed [8–10]. However, data on how the technical and technological procedures of post-harvest, advance pre-sowing and immediate pre-sowing treatments affect the seed longevity and quality after long-term storage are very limited. The suitability of seeds for long-term storage is determined by the time during which seeds remain conditioned, with laboratory germinability in compliance with State Standard of Ukraine DSTU 2240 [11].

In this regard, studies assessing the impact of major operations of post-harvest, advance pre-sowing and immediate pre-sowing treatment of maize hybrid seeds on the their economical longevity are of current interest. The absence of such studies results in packing seeds of different quality for long-term storage of high-quality without taking into account their capacity to be stored. After all, the need to create stocks of seeds (insurance funds) may arise in the maize seed production.

Our purpose was to evaluate the effects of the methods and modes of post-harvest treatment of maize hybrid seeds on their quality and economical longevity during long-term storage.

Materials and methods. The study was conducted in the Laboratory of Storage and Standardization of Grain of the State Institution «Institute of Grain Crops» of NAAS of Ukraine (SI IGC NAAS) in 2018–2021. Seeds were dried and separated by different methods in laboratory and industrial driers and separators for seed maize. Advance pre-sowing and immediate pre-sowing preparation was performed by treating seeds with dressers and growth regulators in doses recommended for maize. Seeds were stored in compliance with the instructions specified in State Standard of Ukraine DSTU 2240 and the recommendations accepted in maize seed production. The seed quality was evaluated by germinability, growth power, 100-seed weight, mechanical and thermal damage, as described in State Standard of Ukraine DSTU 4138 [12]. In addition, in the field, the seed germinability and yield were determined in accordance with field methods of experimentation on maize [13]. Maize hybrid cultivation techniques were in accordance with the recommendations developed for the Northern Steppe. The data were statistically processed and tested for significance [14]. Maize hybrids bred at the SI IGC NAAS were taken as test material.

Results and discussion. Of all post-harvest operations, drying can have the greatest impact on the condition and quality of seeds. In the experiments, we studied different methods of drying of maize cobs: natural drying (slow drying indoors), ventilation with big air volumes unheated air, thermal drying (with air heated to the maximum allowable temperature depending on the water content in seeds). The methods differed in drying speeds and effects on the seed quality. In particular, the drying speed was 0.08–0.10% per hour for natural drying, 0.18–0.23 % per hour for ventilation and 0.35–0.40 % per hour for thermal drying, with corresponding drying times.

The seed quality after different methods of drying and during storage varied. At the beginning of storage, the effects of the methods were almost identical: the laboratory germinability was 95–97% and the field germinability was 82-88%, without significant differences in the yield (Table 1). However, after 3-year storage, the effects of the methods differed: after natural drying, the laboratory and field germinabilities decreased by 2–5% and 6–10%, respectively; the yield decreased by 6–12 % compared to the thermal method. Reduction in the germinability and yield was especially sharp when seeds with a water content of 41.3% were dried under the natural conditions. The ventilation effect on the seed quality was intermediate when compared with the natural and thermal methods.

Table 1

Effects of the drying methods on the maize hybrid seed quality during long-term storage, 2018–2021

Drying method	Moisture content, %			Germinability, %				Yield (from dried seeds), t/ha	
				Laboratory		Field			
	Harvest	1	2	1	2	1	2	1	2
Control (natural)	41.0	13.6	15.7	95	90	80	66	6.53	6.02
	32.5	13.8	15.5	97	92	85	70	6.80	6.66
	20.3	13.5	15.0	97	93	84	71	6.90	6.83
Ventilation	41.0	13.5	14.1	95	92	85	70	6.80	6.64
	32.8	13.9	14.2	96	94	87	75	6.98	6.80
	20.5	13.4	14.5	97	93	84	72	6.84	6.70
Thermal	40.8	13.7	14.0	97	95	85	76	7.01	6.90
	32.4	13.8	14.0	98	96	88	80	7.12	7.10
	20.7	13.0	13.8	97	95	85	77	7.08	6.91
LSD							2.4		0.18

Note: control (natural drying); 1 – at the beginning of storage (2018); 2 – at the end of storage (2021)

The negative impact of too slow drying of maize cobs with high moisture content can be explained by special physiological and microbiological processes that are interrelated. It was shown that, upon slow drying, primary germination could start and subsequently come to halt, leading to a decrease in the germination power and germinability of seeds, especially in the field. In addition, the development of microflora, mainly of thermophilic microorganisms, is activated under warm and wet conditions, and the seed vigor and growth power decline because of waste products of these microorganisms. In contrast, optimally fast drying at maximum allowable temperatures causes no germination and thermally sterilizes seeds from pathogenic microorganisms, positively affecting on the storage duration and seed quality.

However, the question arises as to the choice of those optimal drying temperatures that positively affect the storage of maize hybrids. We experimentally selected modes, after which the seed quality is maintained for 3–4 years (Table 2). The modes depended on harvest moisture through a negative correlation, ie the higher moisture content is, the lower temperature should be and vice versa. Thus, seeds with a water content of 30–32% had the highest germinability after drying at 36–40ºC, and seeds with a water content of 20–22% required 40–44ºC. The yield trends were similar in hybrids and self-pollinated lines. An increasing in the temperature to 42–46ºC or to 46–50ºC reduced the laboratory germinability by 2–7%, the field germinability by 4–12% and the yield by 7.2–8.6% (in the hybrids) and 10.2–12.1% (in the lines).

The next, no less important operation of post-harvest treatment affecting the seed quality and storage duration is separation, which can be performed as cleaning, sorting and calibrating. The experiments demonstrated how the cleaning mode could affect the viability of seeds stored for a long time.

The results showed that the cleaning effect depended on division of seeds into separate categories: the main category, which is used for sowing, and waste, ie impurities (Table 3). At a ratio of 80/20 (main/waste), seeds with higher vigor and germinability are separated compared to a ratio of 85/15.

Table 2

Effects of the drying temperatures on the maize seed quality during their long-term storage, 2018–2021

Seeds	Harvest moisture, %	Mode/temperature (˚C)	Germinability, %		Yield (from dried seeds), t/ha
			Laboratory	Field	
DB Khotyn	30-32	Ventilation	95	80	6.01
		Thermal 36-40	94	86	6.25
		Thermal 42-46	92	82	5.80
	20-22	Ventilation	95	86	6.03
		Thermal 40-44	96	86	6.17
		Thermal 46-50	90	78	5.64
		LSD_{05}		2.7	0.12
LK 680 MVZS	30-32	Ventilation	90	69	2.64
		Thermal 36-40	93	75	2.98
		Thermal 42-46	85	63	2.62
	20-22	Ventilation	90	72	2.81
		Thermal 40-44	94	75	2.95
		Thermal 46-50	87	65	2.65
		LSD_{05}		2.9	0.21

After storage of such seeds, the laboratory and field germinabilities were higher by 3% and 8%, respectively, compared to seeds with a ratio of 85/15. The waste fraction consisted of substandard seeds; their laboratory germinability was 82–83% at the beginning of storage and 72–80% at the end of storage; the field germinability was 60–66% and 53–60%, respectively.

Thus, as early as at the first stage of separation (cleaning), one can select seeds of different quality and longevity by optimal ratio between the individual categories of seeds.

Table 3

Maize hybrid seed quality after cleaning and long-term storage, 2018–2021

Seeds	Seed characteristic		Seed vigor, %		Germinability, %			
					Laboratory		Field	
	Content, %	1000-seed weight, g	1	2	1	2	1	2
Prior to cleaning (control)	100	253	91	86	94	92	80	73
Main	80	268	95	91	98	95	87	83
	85	260	93	90	98	92	85	75
Waste	20	203	80	76	83	80	66	60
	15	195	78	70	82	72	60	53

The final operations of seed separation include calibration and gravimetric sorting; they also significantly influence the seed quality and long-term storage duration. Calibration was performed by sieving seeds on horizontal sieves with a mesh diameter of 9, 8, 7 and 6 mm, thus 4 fractions were obtained. Sorting was sieving each fraction on vibrating sieves and blowing out with air under pressure. That is, after calibration the fractions differed in the seed shapes and sizes, but after gravimetric sorting there were differences in the seed weight, specific gravity and windage between the fractions. These types of separation are especially important when it is necessary to select seed fractions of high quality and longevity.

In particular, after calibration, we different obtained the seed fractions quality of different quality: fractions 1–3 showed higher germinabilities and yield capacities, while these parameters were lower for fraction 4 (Table 4).

Table 4

Influence of the methods of separation and calibration of the sowing fractions of maize hybrid seeds on the seed quality during long-term storage, 2018–2021

Method	Fraction	Germinability, %			Yield (from dried seeds), t/ha
		Laboratory		Field	
		Standard method	Cold test		
Control (after cleaning)		92	81	76	6.60
Sieve calibration	1	94	81	80	6.73
	2	95	84	83	6.90
	3	94	85	81	6.77
	4	90	75	70	6.05
Gravimetric sorting	1	95	82	83	7.02
	2	96	87	85	7.09
	3	96	87	84	7.14
	4	92	80	75	6.50
LSD_{05}				2.7	0.36

The laboratory germinability decreased by 4-5% when measured by standard method and by 6–10% when measured by cold test; the field germinability decreased by 10–12%; the yield also decreased by 10.1–12.3%. After gravimetric sorting, the seed quality improved in all fractions, but mostly in fraction 4. Therefore, separation by gravimetric sorting is an effective and economically justified method, especially for seeds of fraction 4, in order to increase their field germinability, yield capacity and tolerance to long-term storage.

In modern technologies of storage of maize sowing material, chemical treatment of seeds is interpreted differently. Previously, it was performed in a stream with previous operations, so this approach was expected to guarantee stable storage, as it protected against storehouse pests and pathogens. However, recently, the technology of preparing maize seeds has become more flexible, as a number of factors have been taken into account, including economical ones, as sowing material may be unsold, subject to market situations.

Therefore, the effects of different methods of chemical treatment were studied: advance pre-sowing treatment when seeds were treated in advance and kept for a long time and immediate pre-sowing when untreated seeds were stored and treated 10 days before sowing. The results on the laboratory and field assessments of various methods of chemical treatment are summarized in Table 5. First of all, it was found that any treatment method increased the field germinability and grain yields of the maize hybrids. However, when treated seeds were stored longer than one year, the laboratory germinability, especially determined by cold test, reduced compared to untreated seeds (control). This is likely to indicate a toxic effect of a dresser on corcules, which was enhanced as the shelf life was extended. Therefore, immediate pre-sowing chemical treatment-dressing was the most effective, as the germinability and yield capacity of seeds were the highest in this variant. To protect untreated seeds against infestation by storehouse pests and infections, it is recommended to store them at low humidity, temperature, preferably packed in airtight containers [15].

Conclusions. The peculiarities of influence of post-harvest treatment on the maize hybrid seed quality and longevity have been established. The effects depended significantly on the methods and modes of drying, separation and chemical treatment of seeds.

Table 5

Effects of the chemical treatment methods on the maize hybrid seed quality during long-term storage, 2018–2021

Method	Storage time, years	Germinability, %			Yield (from dried seeds), t/ha
		Laboratory		Field	
		Standard method	Cold test		
Control (without dressing)	1	98	88	75	5.68
	2	97	85	72	5.70
	3	95	83	65	5.03
	4	92	80	60	4.90
Advance pre-sowing treatment	1	97	80	81	6.08
	2	94	77	80	5.90
	3	92	70	71	5.58
	4	85	64	66	5.03
Immediate pre-sowing treatment	1	98	88	85	6.64
	2	98	86	84	6.61
	3	94	83	80	6.30
	4	92	80	78	6.28
LSD_{05}				3.7	0.20

Thermal drying at optimal temperatures was the most effective method, namely 36–40ºC for 30–32% moisture and 40–44ºC for 20–22% moisture. Under such drying conditions, high viability of seeds was achieved after long-term storage.

The separation stage was influenced by cleaning, calibration and separation operations that can be used to select seeds most suitable for long-term storage. For this purpose, seeds are cleaned in the 80/20 mode (main/waste ratio). The main seeds are calibrated into 4 fractions, of which fractions 1–3 are packed for storage, and fraction 4 is additionally sorted on gravimetric separating sieves to improve its quality and longevity during storage.

Chemical treatment-dressing is mandatory for seeds that are stored for a long time. It is recommended to treat seeds immediately before sowing, thus the laboratory germinability is preserved, the field germinability is increased, and the yield capacity rises compared to seeds untreated or treated at the beginning of storage.

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ВПЛИВ СПОСОБІВ ПІСЛЯЗБИРАЛЬНОЇ ОБРОБКИ НАСІННЯ ГІБРИДІВ КУКУРУДЗИ НА ЙОГО ЯКІСТЬ І ДОВГОВІЧНІСТЬ

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Матеріали і методи. Наведено результати дослідження у яких виявлено вплив технологічних операцій та способів післязбиральної обробки на якість і довговічність насіння гібридів кукурудзи при їх зберіганні. Операції і способи включали сушіння вологих качанів до сухого стану, сепарування насіння в режимах його очищення, калібрування і гравітаційного сортування, а також хімічну обробку – допосівну і передпосівну.

Обговорення результатів. Виявлено, що новий спосіб сушіння залежить від збиральної вологості і швидкості випаровування вологи із качанів. За вологості в межах 20,3–41,0 % більш ефективним було сушіння за оптимальної температури і швидкої вологовіддачі, за якого унеможливлювалось проростання насіння, а також пригнічувалась будь-яка діяльність мікроорганізмів. Температурний режим сушіння за вологості 30–32 % мають бути в межах 36–40 ºС, а за вологості 20–22 % відповідно 40–44 ºС.

Встановлено оптимальні способи і режими сепарування, внаслідок яких зберігається висока схожість і врожайність насіння гібридів кукурудзи за їх тривалого зберігання. Для насіння, що спрямовується на тривале зберігання, повнота очищення має становити не менше ніж 80 %, а з нього слід відбирати за допомогою калібрування фракції, які виділяються на ситах з діаметром отворів 9, 8 і 7 мм. Гравітаційне сортування підвищує схожість і врожайність насіння гібридів, особливо того, що відносилось до найдрібнішої фракції (в наших дослідах слід із сепарувального сита з отворами діаметром 6-5,5 мм залежно від гібридів).

Хімічна обробка – протруєння насіння належить до обов‶язкової операції в технологіях зберігання і сівби гібридів кукурудзи. Виявлено, що хімічну обробку – протруєння необхідно здійснювати безпосередньо перед сівбою цієї культури, у разі зберігання насіння у необробленому стані.

Висновки. Доведено, що за оптимізації способів і режимів післязбиральної і передпосівної обробки тривалість зберігання гібридів кукурудзи може складати 3-4 роки, упродовж яких залишається кондиційною лабораторна схожість насіння, а також високою його польову та врожайність.

Ключові слова: *гібрид кукурудзи, насіння, післязбиральна обробка, якість, довговічність.*

ВЛИЯНИЕ СПОСОБОВ ПОСЛЕУБОРОЧНОЙ ОБРАБОТКЕ СЕМЯН ГИБРИДОВ КУКУРУЗЫ НА ИХ КАЧЕСТВО И ДОЛГОВЕЧНОСТЬ

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Цель исследования – установить влияние способов и режимов послеуборочной обработке семян гибридов кукурузы на показатели их качества и хозяйственную долговечность в условиях длительного хранения.

Материалы и методы. Послеуборочная обработка включала сушку влажных початков до сухого состояния, сепарирование в режимах очистки, калибрования на плоских горизонтальных ситах с ячеями диаметром 9, 8, 7, 6 мм, сортирование гравитационное на пневмосепараторах. Качество семян контролировали по показателям энергии прорастания, всхожести, силы роста, массы 1000 семян, травмирования, пораженности вредителями и болезнями.

Обсуждение результатов. Из разных способов сушки початков наиболее эффективной была термическая при температурах в зависимости от уборочной влажности семян. При влажности 30-32 % оптимальная температура составляла 36–40 ºС, при влажности 20–22 % – 40–44 ºС. Способы и режимы сепарирования значительным образом влияют на выход, качество и долговечность семян при длительном хранении. Очистку рекомендуется проводить в режиме выхода основной массы семян не более чем 80 %. При калибровании установлено, что семена первой-второй-третьей фракции отличаются высокой всхожестью, урожайностью и длительностью хранения, семена четвертой фракции подлежат дополнительному гравитационному сортированию. Выявлено значительное влияние химической обработки (протравливание) на качество и долговечность семян при

хранении. Обработку следует вести непосредственно перед севом, это сохраняет лабораторную схожесть, повышает полевую схожесть, а также урожайность сухого зерна.

Выводы. Для закладки семян гибридов кукурузы на длительное хранение необходимо учитывать их технологию послеуборочной обработке – сушку влажных початков, сепарирование семян, разнокачественность фракции, обязательную химическую предпосевную обработку – протравливание. При соблюдении оптимальных способов и режимов послеуборочной обработки качество и кондиционность семян гибридов кукурузы сохраняются в течение 3–4 лет.

Ключевые слова: *гибрид кукурузы, семена, послеуборочная обработка, качество, долговечность.*

INFLUENCE OF METHODS OF POST-HARVEST TREATMENT OF MAIZE HYBRID SEEDS ON THEIR QUALITY AND LONGEVITY

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The results on the effects of the technological operations and methods of post-harvest treatment on the maize hybrid seed quality and longevity are presented. The operations and methods included drying of wet cobs to dry consistency, separation of seeds in the cleaning, calibration and gravimetric sorting modes as well as chemical treatment (advance pre-sowing and immediate pre-sowing treatments).

The new drying method was found to depend on the harvest moisture and the speed of water evaporation from cobs. At moisture of 20.3–41.0%, drying at the optimum temperature and rapid water release were more effective, as this mode prevented seeds from germination and suppressed any activity of microorganisms. The drying temperature should be 36–40ºC at moisture of 30–32% and 40–44ºC at moisture of 20–22%.

The optimal methods and modes of separation, which ensured high germinability and yield of maize hybrid seeds after long-term storage, were defined. For seeds intended for long-term storage, the cleaning rate should be at least 80%, and fractions should be selected from this category by calibration on sieves with mesh diameters of 9, 8 and 7 mm. Gravimetric sorting increases the germinability and yield of hybrid seeds, especially of those that formed the smallest fraction (in our experiments, it came from the separation sieve with a mesh diameter of 6-5.5 mm depending on the hybrid).

Chemical treatment – seed dressing is a mandatory operation in the storage and sowing technologies for maize hybrids. It was found that chemical treatment – dressing should be carried out immediately before sowing this crop, and untreated seeds should be stored.

It was proven that, provided the optimized methods and modes of post-harvest and pre-sowing treatment, the maize hybrids could be stored for 3–4 years, with the laboratory and field germinabilities as well as yield of seeds remaining at high levels.

Key words: *maize hybrids, seeds, post-harvest treatment, quality, longevity.*