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Study On Particular Methods In The Capsulation Of The Sugar Beet Seeds And Its Influence On Their Productivity

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Abstract Global agricultural development focuses more on productivity growth than on rational use of resources and food security. According to the practice of recent years, for the profitable cultivation of sugar beets with minimal costs and without manual labor and to form the density of plants, it is necessary to have seeds with 90-95% germination rates, more than 90% of monogermity, as well asat least 90% of uniformity.

Keywords: sugar beet, processing, seeds capsulation, seeds, sugar content, productivity, sugar collection

Introduction

According to the generally accepted concept of food security, a country is considered prosperous if at least 80% of the main types of products are produced within thecountry [1,2]. However, the transition of Kazakhstan commodity producers to new methods of economic management threw the country back in the positions of the food security. In Kazakhstan, the issue of providing the population with locally produced sugar has become acute. It acquired even greater attention against the backdrop of the COVID-19 pandemic [3]. Closed borders and restrictions on the import of a number of food items, including sugar pose new important tasks for the Government and agricultural producers.

The Republic of Kazakhstan occupies an insignificant share in the world production of sugar beet (0.3% in terms of sowing area, 0.2% in production). The first place in the sugar beet sowingin the world is taken by Russia (19.5%), followed by Ukraine (11.7%) [4]. In terms of production, due to the high yield (761 c/ha), the first place is occupied by France (14%), followed by the USA (13.7%), and the third place takes Russia (12.4%). In the production of granulated sugar per capita, France (65.2 kg), Belarus (67.1 kg), Russia (43 kg), Germany (41.7 kg), Turkey (36.9 kg) have higher than average indicators. China has the lowest sugar consumption per capita (6.0 kg), which is associated with the specifics of the population's nutrition and the structure of the state economy. The increase in the total consumption of sugar in the world over the past 45-50 years indicates an increase in its importance for providing the world's population with food. As a strategic food commodity, sugar is receiving intense scrutiny from government regulators in developed countries.

Every year the country buys abroad sugar beet seeds in the amount of 700-850 million tenge, so, the imported sugar beet seeds make up to 92%. The share of produced seeds in Kazakhstan is 8% respectively. Therefore, we can say that the Kazakhstan seed production lost its positions in the country [5]. The restrictions prevent the successfulaccomplishing of the task set by the President of the Republic of Kazakhstan in the framework of measures for import substitution of sugar beet hybrids.

Sugar beet in our country is the main raw material for sugar production. The level of sugar beet production directly affects the food security of the country. Scientists of the Kazakh Scientific Research Institute of Agriculture and Crop Production have created 15 hybrids of sugar beet, 8 from them are competitive hybrids, which are approved for production in the Republic of Kazakhstan. Kazakh farmers buy encapsulated seeds of foreign sugar beet hybrids, and the level of confidence in Kazakh seeds is very low. This is because in our country there was no unified technology for coating and encapsulating sugar beet seeds using water-soluble film-formers, protective and stimulating substances, which did not allow settingthe sowing conditions in accordance with modern requirements of international standards (defuzzing, grading, disinfection).

There are new treatments for seeds before sowing, which are described in newarticles, for example pelleting, encapsulation, coating, pilling, encrusting, dragee-making[6-10].

Thanks to the pelleting and encapsulation process, the seeds acquire the ideal pea shape for modern precision planters. In addition, dragee form performs protective and stimulating functions in the early stages of plant development.

It is well known that the most important link in the cultivation of any agricultural crop is the preparation of seed material on an industrial basis, especially for sugar beet, which is affected by various types of root rot: fusarium, red, brown, tail, phoma, sclerotinous, white, as well as vascular bud necrosis [11].

High yields of high-quality root crops are unthinkable without well-prepared seeds of the best zoned varieties and hybrids. Sugar beet seedlings and young plants are very susceptible to diseases and pests. In order to protect seedlings from harmful organisms and increase germination, seeds are treated with protective and stimulating drugs. The active substance of the treatment differentiates from the shell into the soil and a protective zone is formed around the seed, which is a barrier for phytopathogens and harmful insects [12].

As a result of many years of observations, S.Yu. Kuznetsov, N.A. Surkov, S.I. Smurov [13-14] came to the conclusion that in the conditions of early spring with dry and windy weather, the top layer of the soil dries up, which prevents the emergence of early and even seedlings of sugar beet. Due to the lack of moisture, the emerged beet plants cannot develop intensively. The protection of seedlings from pests (beet flea and weevils)plays an important role in such difficult weather conditions, and therefore, in order to prevent damage by fungi (causative agents of the root-borer) the seeds must be treated with insecticidal substances based on Fludioxonil, Imidacloprid, Tebuconazole and other chemical compounds which have a systemic intra-plant effect upon contact and retain their activity until the development phase of sugar beet (phase with 4 leaves in a plant) [12, 13].

According to the studies, the most effective technology today is coating with film-forming compounds. With this method of treatment, pesticides are applied to the surface of the seeds in film-forming compositions that fix the drugs for an unlimited time. The advantage of this method is that it excludes the shedding of protective and stimulating substances from the surface of the seeds during handling and transport operations, long-term storage, sowing and adverse weather. This method also helps to avoid mixing seeds, reduce the release of harmful substances into the environment, significantly improve the working conditions of the personnel, viability and germination readiness of seeds [14, 15, 16].

The use of encapsulated seeds is one of the promising directions in the development of sowing technology not only for sugar beet, but also for other row crops. The capsule has a diameter of 20 to 30 mm and, unlike dragees, contains much more nutrients, stimulating and protective substances. In connection with a sharp increase in the particle size of the seed, it is required to determine the type of the seeding machine and its design parameters [17].

In this regard, the authors of the article have developed methods for encapsulating sugar beet seeds of Kazakhselected hybrids in combination with various treatment agents. The practical significance of this work lies in the introduction of Kazakh sugar beet seeds into production practice, contributing to the formation of Kazakh sugar beet seed industry, the provision of beet-growing farms with local and inexpensive seeds, the stable functioning and development of the Kazakh hybrid seed market and a decrease in the share of imported seeds.

Among the methods for assessing the sowing qualities of seeds, the most significant indicators are germination readiness, laboratory and field germination. Germination readiness and laboratory germination are determined under conditions close to ideal, that is to say in thermostats. Germination readiness characterizes the evenness of seed germination.Field germination rate largely depends on it. If the germination readiness is low, then the field germination also decreases [18, 19, 20]. Field germination is understood as the number of seeds that sprouted in the field. The methods of influence on seeds duringpre-sowing and pre-seeding treatment are divided into physical, biological, microbiological, chemical ones and their combinations [21]. Pre-sowing treatment with biological substances in order to protect seeds from pests and diseases, as well as to stimulate germination, is highly effective and eliminates environmental pollution [22,23,24].

The Ministry of Agriculture of the Republic of Kazakhstan has developed a Concept for the implementation of a sectoral program for the development of sugar production in Kazakhstan for 2018-2027[25]. Its main objectives are:

-increasing the share of beet sugar in local consumption from 10% to 75% by 2027;

-development of local seed production;

-providing farmers with modern methods for growing sugar beets in the framework of trainings;

-expansion of the certified producers' network;

- development of selectionforlocal varieties and hybrids.

Materials and methods

Experimental studies were carried out in laboratory and field conditions in accordance with current standards and existing methods.

The study on the seed encapsulation with various types of treatment agents and its influence on the productivity of sugar beet was carried out at the Kazakh Scientific Research Institute of Agriculture and Crop Production. Field experiments were laid according to the method of field experiment [26]. The placement of the plots wassequential.

The agricultural technology of sugar beet had a generally accepted character. The predecessor was winter wheat. The main soil for cultivation was autumn plowing, plowed to a depth of 27-30 cm. Before sowing the seed plants, cultivation with harrowing was carried out. Further, chemical treatment with Dual Gold herbicide was made at a dose of 2.0 l/ha. One treatment with B-58 against beet flea and leaf lice. Seeding rate was 1.7 seed units. Seeding was carried out on April 23. The seeding depth throughout the entire plot was 3.0-4.0 cm.

The hybrid NZ (normal-sugar hybrid Aisholpan) was sown during the experimentwith 6 treatment options, using substancesMaxim and Prestige in different ratios.

Field experiments were carried out in the foothill-steppe zone of the South-East of Kazakhstan. The climate is extremely continental. According to the long-term data of the meteorological station, the average annual air temperature is + 8.3 C^0, its minimum is -40 C^0 and its maximum is +42 C^0. The sum of positive temperatures for the period of active vegetation(April-September), according to our average long-term data, reaches 3429 C^0, which is quite enough for the formation of optimal yields of the sugar beet seed plants.

The soil cover of the experimental plot is represented by foothill light-brown soils. They are formed on forest loamy soils and have a pronounced fertile profile. A characteristic feature of light-brown soils is their high carbonate content. In terms of mechanical composition, it belongs to medium-loamy. The content of coarse dust is 40-45%, physical clay is about 40%, and silt particles decrease according to the profile from 13.82 to 8.62%. The soils of the site are characterized by deep groundwater occurrence, as well as low mineralization, which excludes the possibility of soil salinization as a result of irrigation. The humus content in the plow-layer is 2.44%, which amountsharply decreases. There is a high content of carbonates (CO_2), its amount is increasing from 25% in the 0-22cm layer to 4.7% in the 40-68cm layer. Due to the high carbonate content, the reaction of the soilis slightly alkaline pH-7, -7.5. The absorption capacity does not exceed 15 mg/eq. In the composition of the absorbed bases, the main part is Ca (11.65-13.12mg/eq), the amount of absorbed Mg is not high (1.97 - 2.62 mg/eq). In the arable layer, the total nitrogen is 0.15%, phosphorus - 0.21%, and their number in the upper layers is higher than in the lower ones (in the 40-68 cm layer their content is 0.06 and 0.191%, respectively).

The purpose of the research is to assess the effect of various options for seed treatment on the productivity of sugar beet.

Experiments on pre-sowing seed treatment were carried out on the seeds of the Kazakh hybrid Aisholpan, which has been approved for use in production in the Republic of Kazakhstan since 2016. This hybrid is competitive, differs in size and seed alignment and fits well into the seed production system. Agricultural techniques for cultivating sugar beet seed plants are common in the South-East of Kazakhstan.

Aisholpan hybrid is a single-seeded hybrid on a sterile basis. The growing season is 165-170 days. The maximum yield is 750-800 c/ha, sugar content is 16.5-17.7%. The hybrid is characterized by increased sugar content and a relatively high disease tolerance. It issuitable for mechanized harvesting.

When studying the main issues posed for development, the following seed production technologies were carried out:

- Treatment (dressing) is a technological process of seed processing with aqueous suspensions of protective and stimulating substances in order to protect sprouts and young plants against pests and diseases.

- Grading of dried, but not treated with insecticides, dragees was carried out on a grating separator of the grading machine. During the grading process, the seeds are divided into three fractions using grates. Seeds of a smaller size of the sowing fraction amounted to 10-20% and they were re-dressed. During the calibration process, 1-2% of seeds of a larger sowing fraction were separated.Such seeds, after removing the shell, were also subjected to repeated dressing. For further processing, dressed seeds with sizes of 3.5-4.5 mm and 4.5-5.5 mm were accepted.

- Incrustationis a uniform finely dispersed treatment of the seed surface with a mixture of components, in which protective and stimulating substances are reliably fixed (insecticides, fungicides, growth stimulants, micronutrients).

- Pelleting is an application of inert organic and mineral substances to seeds in order to obtain a uniform spherical shape of each seed, to ensure the most accurate placement of seeds in rows and to reduce the seeding rate by 2-3 times.

- Encapsulation is a covering of seeds with a polymer shell with various micro-additives. This method allows the use of seed dressers, growth regulators and other physiologically active compounds in one system together with the polymer.

For pre-sowing treatment of sugar beet seeds, a water-soluble film-forming polymer was used - carboxymethyl cellulose (CMC), Gellan, Maxim and Prestige dressing solutions.

Laboratory experiments

The composition of the dragee mixtures was selected from the components used for the coating of sugar beet seeds. The composition of the coating includesclay pellets, bentonite clay, wood flour in different proportions (% by weight). Sodium carboxymethyl cellulose was used as an adhesive. As dressing solutions, we chose Maxim and Gellan. The consumption rate of each substance, as well as the consumption of the working fluid, is determined by the Directory of pesticidesapproved for use in the territory of the Republic of Kazakhstan. Quantitative deposition of substance on seeds (percentage of substance applied to seeds) is the amount of substance that was actually applied to seeds during treatment.

At each stage, a laboratory analysis of seeds was carried out, like accounting for the germination readiness of sugar beet seeds on the 4th day, determination of germinationon the 14th day (adopted by the International Rules for the Analysis of Seeds, GOST 20797-87), and germination of seeds at a constant temperature20±2 C^{0}.

Results

The main stage of pre-sowing seed treatment is seed defuzzing, which improves the flowability of the seeds and the uniformity of seeding for sowing with precision seeders. Due to the defuzzing of seeds, their germination readiness increases, since the parenchymal tissue of the pericarp is removed, which is an inhibitor of seed germination, a carrier of various diseases and a substrate for the development of microorganisms. We have carried out studies on the influence of the thickness of the pericarp on the mass of 1000 seeds, the germination readiness, germination, the dynamics of theleaves and roots growth. Undefuzzed sugar beet seeds had low germination readiness (56%) and laboratory germination (76%). As the thickness of the pericarp decreases, when the shell is removed by defuzzing, these indicators increase. So, when the parenchymal membrane was removed by 50%, the germination readiness and seed germination increased by 14.0 and 9.0%, respectively. Deeper defuzzing results in higher seeding rates. Germination readiness reached 75.0%, and laboratory germination - 90.0%. However, complete removal of the amniotic membrane reduces germination readiness and seed germination. This can be explained by the fact that when the membrane is completely removed, the seed is deprived of the natural supply of the necessary moisture through the tubules. The most important condition for defuzzing seeds is the removal of rough, loose parts of the seed without injuring it.

The sowing qualities of the treated seeds are shown in Figure 1. As can be seen from the figure, in many variants the encapsulation of seeds led to an increase in germination readiness and stimulation of their germination. The most effective were the concentrations of CMC (1%), Gellan (0.5%), Maxim (5%) 1:4 and CMC (1%), Gellan (0.5%), Prestige (5%) 1:1.

The high field germination of sugar beet seeds, especially when sown at the final density, largely determines the quality and yield of root crops. Field germination depends on the quality of the seeds and the correct preparation of the seedbed.

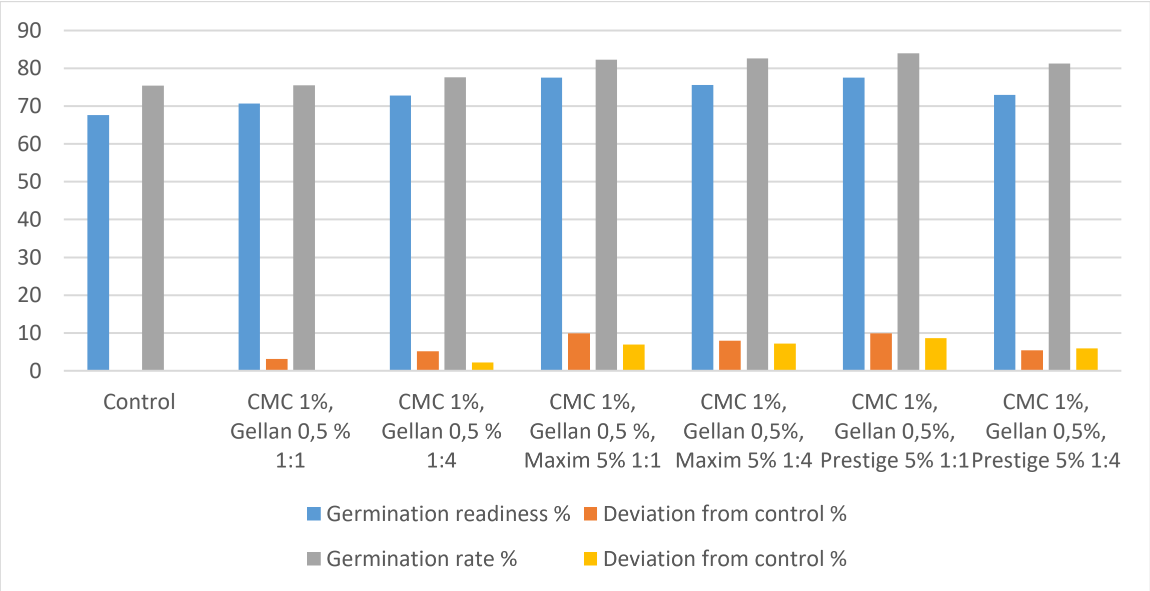

Figure 1. Influence of polymers with different concentration of disinfectants on the germination readiness and rate of encapsulated sugar beet seeds (2020)

Analyzing the data in Table 2, we can conclude that the use of Maxim and Prestige seed dressings in all variants contributes to an increase in field germination and density of planting before closing of crop, in comparison with control variant.

Table 2. Field germination and planting density of sugar beet hybrid, depending on the dressing variants

Dressing variants	Field germination (%) andplanting density (thplants/ha)				Planting density beforeclosing of crop, th plants/ha
	after 5 days	after 7 days	after 10 days	after 15 days	
Control	10.0/15.0	25.5/38.2	45.1/67.6	55.4/83.3	87.6
CMC 1%, Gellan 0,5% 1:1	9.5/14.2	25.1/37.6	44.9/67.3	55.2/83.2	85.8
CMC 1%, Gellan 0,5% 1:4	10.1/15.1	26.2/39.3	46.8/70.2	57.0/85.5	85.7
CMC1%, Gellan 0,5%, Maxim 5% 1:1	11.2/16.8	27.4/41.1	50.1/75.1	62.3/88.0	88.1
CMC 1%, Gellan 0,5%, Maxim 5% 1:4	11.0/16.5	27.2/40.8	49.9/74.8	61.5/87.9	88.8
CMC 1%, Gellan 0,5%, Prestige 5% 1:1	11.6/17.4	28.7/43.0	52.3/78.4	64.0/90.0	90.2
CMC 1%, Gellan 0,5%, Prestige 5% 1:4	10.9/16.3	27.1/40.6	48.7/73.0	60.2/87.5	87.9

* Note: field germination is in the numerator and planting density is in the denominator

The data in Table 3 indicate that the highest planting density for harvesting was observed in the variant CMC1%, Gellan 0.5%, Prestige 5% 1:1 - 90.2 th plants/ha. For the rest of the variants, the difference in planting density was within the experimental error. The smallest planting density was observedin variants CMC1%, Gellan0.5% 1:1 - 85.8 th plants/ha and CMC 1%, Gellan 0.5% 1:4 - 85.7 th plant/ha.

The best indicator of the planting density before harvesting was observedin the variant CMC1%, Gellan 0.5%, Prestige 5% 1:1 - 87.8 th plants/ha and the smallest indicator was in the variant CMC 1%, Gellan 0.5% 1:1 - 83,2 th plants/ha.

Comparing the average values of various dressing options, we can conclude that the options for seed treatment with Maxim and Prestige have an advantage over the variantswith CMC1%, Gellan 0.5% 1:1, CMC1%, Gellan 0.5% 1:4. So, with CMC 1%, Gellan 0.5% 1:1 the difference was 2.2 th plants/ha, with CMC 1%, Gellan 0.5% 1:4 the difference was 2.0 th plants/ha.

The highest yield of crops was observed in the variant CMC1%, Gellan 0.5%, Prestige 5% 1:1 - 59.0 t/ha. The lowest yield (46.4 t/ha) was observed in the variant CMC1%, Gellan 0.5% 1:4.

Table 3. Influence of various variantsof encapsulation on the density of the planting for harvesting and the yield of crops

Variants	Planting densityfor harvesting, th plants/ha	Crop yield, c/ha	Saccharinity, %	Sugar gathering, c/ha
Control	84.5	486.9	14.2	69.14
CMC1%, Gellan 0,5% 1:1	83.2	475.2	13.75	65.34
CMC 1%, Gellan 0,5% 1:4	83.4	464.1	14.0	64.97
CMC 1%, Gellan 0,5%, Maxim 5% 1:1	85.4	505.1	15.75	79.55
CMC 1%, Gellan 0,5%, Maxim 5% 1:4	86.3	532.2	14.75	78.5
CMC 1%, Gellan 0,5%, Prestige 5% 1:1	87.8	590.1	15.9	93.82
CMC 1%, Gellan 0,5%, Prestige 5% 1:4	85.2	548.4	14.3	78.42

Comparing the indicators of the yield during the studies, we can conclude that the variants for dressing with Prestige have the highest yield, which exceed the variant with Maximin terms of yield by an average of 4.3-5.8 t/ha. Thus, the variants with CMC1%, Gellan 0.5%, Maxim 5% 1:1 and CMC1%, Gellan 0.5%, Prestige 5% 1:1 provide an increase in sugar content compared to other encapsulation variants.

Pre-sowing encapsulation of sugar beet seeds helped to:

-increase the sowing quality of seeds by 15-20%;

- stimulate the physiological and biochemical processes of plant growth and development;

- reduce the consumption of seeds during precise seeding, thereby exclude the thinning of seedlings and reduce labor costs.

Discussion

In general, the cultivation of sugar beet in the conditions of the Almaty region is economically profitable, while seed dressing with Prestige helps to effectively protect sugar beets from soil-dwelling pests, helping to make a uniform arrangement of plants in a row, providing an optimal plant density for harvesting.

Conclusion

In this article, we described the study of particular methods for encapsulating sugar beet seeds and the effect on their productivity. The main stage of pre-sowing seed treatment is defuzzing of the seeds, which improves the flowability of seeds and the uniformity of seeding with precision seeders. Due to the defuzzing of seeds, their germination rate and readiness increase, since the parenchymal tissue of the pericarp is removed, which is an inhibitor of seed germination, a carrier of various diseases and a substrate for the development of microorganisms. We have carried out studies on the influence of the pericarp's thickness on the weight of 1000 seeds, the germination readiness, germination rate, the dynamics of the leaves and roots growth. Treatment with Prestige substance had greater affect then the treatment with Maxim in terms of yield by an average of 4.3-5.8 t/ha. Thus, the variants with CMC1%, Gellan 0.5%, Maxim 5% 1:1 and CMC1%, Gellan 0.5%, Prestige 5% 1:1 provided an increase in sugar content compared to other encapsulation variants. Pre-sowing encapsulation of sugar beet seeds made it possible to increase the seeding quality of seeds by 15-20%, stimulate physiological and biochemical processes of plant growth and development, to reduce the consumption of seeds during precise seeding, thereby eliminating seedling thinning and reducing labor costs.

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