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INFLUENCE OF GROWING CONDITIONS ON THE FORMATION OF TECHNOLOGICAL PROPERTIES OF GRAIN OF MILLET VARIETIES

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The results of studies on the influence of various terms and methods of sowing on yield and technological quality of grains of millet varieties Slobozhanske and Lana under the conditions of unstable moistening of Right-Bank Forest-Steppe.

Keywords: *variety, sowing term, method of sowing, yield, technological grain quality.*

Despite the fact that in global agriculture the use of millet grain covers only 2%, but for the population of many countries it is an important food crop. Thus, according to FAO, as of 2012 [1], about 87% of millet grain is used for food and feed purposes, and for Asian and African countries share of food grain (millet) is more than 95% of yield.

An intermediate product obtained during shelling of millet grain is polished millet, and cereal production – millet fodder “muchel”, feed granulation, grain mixture from primary grain processing and husks [2]. Millet is highly caloric and nutritional, it is well-boiled and well-absorbed by the human body. It is used for cooking porridges, soups, tortillas, salads, in the confectionery industry. Millet dishes are recommended for children, the elderly, and for lack of gluten in millet flour, pastry made from it is useful for people suffering from diseases of the intestinal tract [3 – 5].

According to a number of researchers [6, 7] the technological quality of grain and millet groats is characterized by high groats yield (75 – 80%), low hull content (15 – 17%) and high protein content (12 – 13%). Groats color should be yellow or bright yellow, which is determined by the content of carotenoids in the kernel. Modern varieties have a mass of 1000 grains at the level of 8 – 9 g, high uniformity (85 – 90%), a spherical shape and good properties.

Also millet grain is used for feeding livestock and poultry. Forage millet varieties are sown for hay, silage and green fodder. Its straw is used for making vitamin-grass flour, granules, briquettes [2, 8].

In addition, in recent years, with the aggravation of the global energy crisis, an interest of biofuels producers in it increases, because millet grain can be used in the production of ethanol [9].

However, despite these valuable properties and importance, amounts of millet seeds production and its low quality require improvement of elements of technologies concerning specific soil and climatic conditions of the area of cultivation. ***The topicality*** of the chosen direction of research lies in it.

The purpose of the research was to improve the technology of growing high-quality seeds of millet by optimizing the terms and methods of sowing, which will increase productivity and improve the technological quality of grain of different

varieties in the conditions of unstable moistening of southern part of Right-Bank Forest-Steppe.

Despite considerable antiquity and a large number of experiments on optimizing the terms and methods of sowing millet, researches concerning the combined influence of these factors on crop quality and seeds yielding properties of different varieties of this crop are of schematic and single character, but in terms of unstable wetting of southern part of Right-Bank Forest-Steppe they were not conducted.

Research Methods. Field researches performed during 2009 – 2011 on the experimental field of educational and scientific-industrial complex of Uman National University of Horticulture, situated in the Man'kivka natural and agricultural region of Middle Dnipro-Bug district of Forest-Steppe Right-Bank province of Ukraine.

In order to establish the optimal terms and methods of sowing of maternal plants of millet seed sowings in the experimental field of Uman National University of Horticulture three factor field experiment was laid (Table), which provided the study of the mutual influence of varietal characteristics (factor A), term (factor B) and method of sowing (factor C) on sowing qualities and harvest properties of millet seed. The results of these studies were analyzed previously [10].

The experiment was conducted according to methods of field researches [11 – 13]. Preceding crop of millet – is winter wheat. Phosphate and potash fertilizers were applied during autumn tillage, nitrogen – during the first spring cultivation in norm of $N_{60}P_{60}K_{60}$. Such varieties of millet were seeded – Slobozhanske (middle ripened, variety *aureum*) and Lana (middle ripened, variety *flavum*). Sowing terms – from the first decade of May to the first decade of June, control – the second term (the middle of the second decade of May). Methods of sowing – common linear and wide linear with row spacing – 15 and 45 cm and sowing norms – 3.5 and 2.0 million pcs. similar seeds per ha, respectively. In wide linear sowings two loosening were carried out: first – in phase of 2 – 3 leaves to a depth of 4 – 5 cm; the second – in the phase of tillering at a depth of 6 – 8 cm. Accounting area – 50 m². Repetitions – four, placement of variants is consistent. Harvesting was carried out by two-phase method – mowing in rolls followed by threshing in 4 – 6 days (combine 'Sampo-130'), weighing seeds and recalculating to standard moisture and weediness. Yield was controlled by trial sheaves of 1 m^2 in each repetition.

Soil of research fields – podzolized heavy loamy black soil on loess with humus content of 3.5%, low nitrogen supply alkaline hydrolyzed compounds (103 mg/kg of soil – by Kornfeld method), the average content of mobile compounds of phosphorus and high content – potassium (respectively 88 and 132 mg/kg – by Chirikov method), high saturation level with bases (95%), medium acidic reaction of soil solution (pH_{KCl} – 6.2) and low hydrolytic acidity (2.26 resin/kg of soil).

Accounting, analysis and observations were conducted according to conventional methods [11 – 19].

Conditions of researches have the character of unstable humectation. Thus, if the amount of rainfalls in 2009 and 2011 compared with average perennial data

(633 mm) had a moisture deficit – respectively 110 and 40 mm, 2010 was characterized by its excess of 124 mm. Thus, the distribution of rainfall by time was characterized by significant non-uniformity and significant deviations from average perennial value during all years of researches. For example, in April 2009, not a single millimeter of rain fell (average perennial quantity of 48 mm), and in July 2011, on the contrary, the excess was almost double – 151 mm (standard 87 mm). The most favorable weather conditions for the growth and development of millet sowings were observed in 2010. So, from the time of sowing in all periods, sowings were provided with sufficient amount of moisture, which in combination with a favorable temperature conditions at the level of 15,7 – 20,0 °C allowed us to obtain full and aligned sprouts. In contradistinction to this, the temperature regime during the sowing of the first period (the middle of the first decade of May) in 2009 and 2011 was characterized by a certain decrease (in 1,9 and 2,8 ° C) and fourth (middle of the first decade of June) – by increase (1,3 and 3,7 ° C) of this indicator, which had a negative impact on seed field germination and completeness of sprouts in both varieties of millet. However, it also should be noted that during the millet vegetation actually for years of investigations a significant excess of average perennial temperature of regime was observed, which sometimes reached 4 – 5 ° C and more. However, this warming trend in the conditions of region is observed during the last decade. Although millet belongs to the drought-resistant and heat-resistant crops, but such negative phenomena had a significant influence on the formation of structure and yield level of sowings.

Research Results. It is known that soil and climatic conditions and features of farming equipment have a significant influence on crop yield and its quality. According to our previous researches [20], and also according to other researchers [21], by means of selecting predecessors, fertilization system, soil tillage, features of sowing and harvesting, it is possible to affect the processes of formation of sowing qualities and yielding properties of seed and food grain quality of grouts crops.

By the results of conducted researches we have found that investigated terms and methods of sowing and weather conditions of research years carried significant influence on the formation of technological properties of grain of millet varieties Slobozhanske and Lana (Table). Thus, to the formation of the highest level of mass indices 1000 and grain nature contributed early (first) and recommended for the research area, second terms (the first and second decades of May) – respectively 7.75 – 8.06 g and 730 – 745 g/l (variety Slobozhanske) and 8.21 – 8.38 and 755 – 772 g/l (variety Lana).

It also should be noted that in both varieties to the formation of the most ponderous grain contributed ordinary row sowing compared to wide-row. In variety Slobozhanske the advantage by weight 1000 and grain nature was 0.27 g and 7 g/l, and in variety Lana 0.20 g and 10 g/l, respectively.

It was found that, although, the coefficient of variation of these indicators was negligible – respectively at the level of 1.8 – 2.4% (1000 grain weight) and 1.4 – 1.6% (grain nature), but in both cases we have found that the transfer in time of sowing terms from early to late, had a negative impact on the level of these indicators. Thus, on average for years of research in both varieties compared with

the control (second term) of weight decrease of 1000 seeds during sowing in the third decade of May and first decade of June was at the level of 0.06 – 0.29 g. Although depending on the varietal characteristics significant differences were not observed, but variety Lana had some advantage, which weight is 1000 and grains nature by years of research were the highest – respectively 8.22 g and 755 g/l or in 5 and 4% higher compared with the variety Slobozhanske.

On grain uniformity depend yield and commodity quality of groats. Thus, during the production of grout, grain larger in size is ground and forms muchel and smaller remains unhulled. Uniformity of grain depends on the varietal characteristics. However, even on one plant seeds with significant variation of its size are formed. Thus, within a panicle, the largest in size grain is formed in its upper part on the tops of branches, but closer to the central axis and in the bottom, seeds are much smaller. In terms of our researches, the analysis of data of millet grain uniformity allowed to establish that the level of this indicator depended both on its varietal characteristics and on growth conditions (see Table).

Ponderosity, uniformity and hull content of grain depending on the term and method of sowing millet varieties, 2009 – 2011

Research variant			Indices of technological qualities of grain			
Variety (*A*)	Way of sowing (*C*)	Sowing term (*B*)	Weight 1000, *g*	Nature, *g/l*	Uniformity, *%*	Hull content, *%*
Slobozhanske	Common linear	first	8,05	738	86,8	15,5
		second*	8,06	745	85,2	16,4
		third	7,96	720	84,8	17,2
		fourth	7,77	717	88,3	17,6
	Wide-row	first	7,75	732	83,6	15,9
		second*	7,80	730	84,6	16,5
		third	7,68	715	86,5	17,4
		fourth	7,52	714	82,5	18,0
$\bar{x}$			*7,82*	*726*	85,3	*16,8*
S			*0,19*	*11,4*	*1,87*	*0,87*
$S_{\bar{x}}$			*0,07*	*4,04*	*0,66*	*0,31*
V, %			*2,4*	*1,6*	*2,1*	*5,2*
Lana	Common linear	first	8,38	766	91,8	14,9
		second*	8,35	772	89,2	15,4
		third	8,29	756	90,2	15,7
		fourth	8,26	749	90,7	16,1
	Wide-row	first	8,24	755	88,0	14,2
		second*	8,21	761	88,0	14,8
		third	8,10	745	91,3	15,9
		fourth	7,94	740	86,3	16,6
$\bar{x}$			*8,22*	*755*	89,4	*15,3*
S			*0,14*	*10,5*	*1,90*	*0,89*
$S_{\bar{x}}$			*0,05*	*3,70*	*0,67*	*0,32*
V, %			*1,8*	*1,4*	*2,2*	*5,9*

Note * – control.

Depending on the varietal characteristics variety Lana had some advantage which uniformity of grain averaged 89.4% or in 4% higher compared with the variety Slobozhanske. It should be noted that with little diversity of data (V = 2,1 and 2,2%), with normal linear sowing its transfer to the early spring (first) and summer (fourth) terms had a positive effect on the level of the index of technological quality of grain in both varieties – 86.8 and 88.3% (variety Slobozhanske) and 91.8 and 90.7% (variety Lana) or in 1.7 – 3.5 and 0.5 – 2.7% higher compared with other terms under this method of sowing.

During wide-row sowing an advantage by uniformity in both varieties had sowing in the third decade of May (the third term). Thus, the transfer of sowing term to the next decade from recommended in the growing area second term (control) on average over the years of researches contributed to the formation of grain uniformity 86.5% (variety Slobozhanske) and 91.3% (variety Lana), or in 1.9 – 4.0 and 3.3 – 5.0% higher compared with other terms using such method of sowing.

A characteristic feature of millet grain is the presence of flower pellicles that cover the kernel. Actually they determine the hull content of grain. Hull content is connected with grain size and its ponderosity. Ponderous grain has lower percentage of pellicle compared to punny. For different varieties depending on growing conditions, it can vary from 13 to 21% [3].

Based on the results of our researches, a direct effect of studied technology elements for the formation of hull content level was observed (see Table). Thus, on average, over the research years grain grown during late spring and summer terms (third and fourth) was characterized by the highest hull content – in variety Slobozhanske at the level of 17.2 – 18.0% and 15.7 variety Lana – 15,7 – 16,6%, compared to 15.5 – 16.5 and 14.2 – 14.8% for other sowing terms. The coefficient of variation of the obtained data was at a level of 5.2 – 5.9%. It was found that the transfer of sowing to the early spring term (early May) with its both technological methods improved the quality of millet grain reducing the proportion of pellicles by 3 8 – 13.3% (variety Slobozhanske) and 3.8 – 16.9% (variety Lana). On average by sowing terms in variety Slobozhanske lower hull content had grain grown by common linear method (16.7%), and in variety Lana – wide-row (15.3%), compared with 17.0 and 15.5% in the corresponding variants of sowing methods.

The main indicator of technological properties of millet grain is yield of millet. No significant differences in the formation of this indicator level, depending on the varietal properties and character of terms and methods of sowing for years of researches were observed. As a trend worth noting the positive impact of using, the recommended for growing area, second sowing term (second decade of May) to increase the percentage of grain yield. Thus in both varieties using wide-row method of sowing showed, some (by 0.4 – 1.5 percentage points) decrease of this indicator level compared to the variants of common linear sowing (Fig.).

However, analysis of the indices of overall millet yield from millet grain harvest helped to reveal more clear advantages among the studied variants of terms and methods of sowing in both varieties of millet. Thus, the level of this index depended on ponderosity, uniformity and hull content of grain. However, first of

all, influence on its level had the overall productivity of a particular variety. Thus between millet grain yield and common millet yield from it, on average for the years of researches we have established a close correlation at the level of r = 0,86 – 0,89.

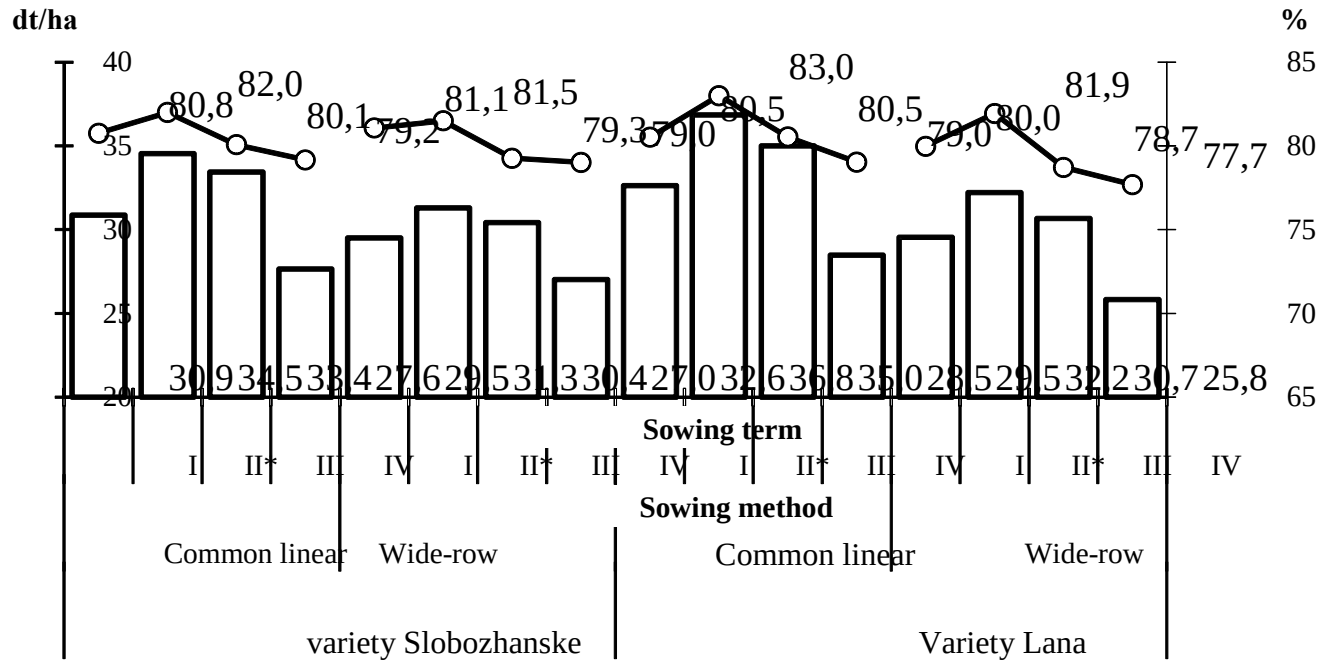

Fig. Millet yield (%, dt/ha) depending on the term and method of sowing of millet varieties, 2009 – 2011

* – control, / / / – millet yield, dt/ha /// – millet yield, %

Analysis of the influence of varietal characteristics on average in the experiment allowed to set significantly higher yield of millet in variety Lana – respectively 31.4 dt/ha or by 0.8 dt/ha higher compared with the variety Slobozhanske at NIR_{05} (A) = 0.6 dt/ha, with a share of factor influence of 14%.

Depending on sowing term in both varieties, significant advantage by weight yield of wheat per unit of area had the second and third (second and third decade of May) – at the level of 30.4 – 34.5 (variety Slobozhanske) and 30.7 – 36.8 dt/ha (variety Lana) or by 1.8 – 6.9 and 2.4 – 8.4 dt/ha higher compared to other variants of mineral nutrition at NIR_{05} (B) = 1.1 dt/ha with a share of factor influence of 32%.

Selection of the method of sowing also carried significant impact on the millet harvest in both varieties. Thus, the increase of this index in the usual linear method of sowing was 2.1 (variety Slobozhanske) and 3.7 dt/ha (variety Lana) at NIR_{05} (C) = 1.6 dt/ha with influence share 37%.

Thus, on the basis of conducted analysis of features of the technological

properties formation of grain of the studied millet varieties, we can draw the following **conclusions**.

1. Weather conditions of the year and varietal features and choice of term and method of sowing influenced the formation of grain ponderosity, uniformity and hull content and millet yield.

2. Combination of conventional linear seeding with early (first) and recommended for research areas the second term (the first and second decades of May) contributed to formation of the largest wight of 1000 and the nature of grain – respectively, 8,05-8,06 g, and 738 – 745 g/l (variety Slobozhanske) and 8,35 – 8,38 and 766 – 772 g/l (variety Lana).

3. According to the uniformity of the grain a significant advantage had variety Lana, which index on average was by 4% higher. Combination of early spring (first) or summer (fourth) term with the usual linear method of sowing contributed to decrease of the difference between the weight of grain from different parts of the panicle and improvement of its uniformity. During wide-row sowing an advantage by uniformity in both varieties had sowing in the third decade of May (the third term).

4. The use of late spring and summer terms (third and fourth) contributed to increase in hull content – respectively in the variety Slobozhanske this index was at the level of 17.2 – 18.0% and in variety Lana 15.7 – 16.6% compared with 15.5 – 16.5 and 14.2 – 14.8% during other sowing terms. On average by sowing terms in variety Slobozhanske lower hull content had grain grown by usual linear method (16.7%), and in variety Lana – by wide-row (15.3%), compared with 17.0 and 15.5% in the corresponding variants of sowing methods.

5. Yield of millet per unit of area depended on the overall productivity of sowings, and on improvement of the technological properties of grain. The largest in both varieties it was during the use of the second and third sowing terms by the usual linear method – 34.5 and 33.4 dt/ha (variety Slobozhanske) and 36.8 and 35.0 dt/ha (variety Lana).

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