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Comprehensive assessment of productivity interrelations and indicators of quality of millet seeds

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Abstract

The aim of the study was to determine optimal conditions for harvesting millet seeds in Right-Bank Forest-Steppe of Ukraine that would provide maximum yield of high-quality seeds. Implementation of this goal was done by determining and analyzing of multifactor relationships of forming high-yielding seed sowing of millet, by optimizing ways of its mowing and threshing and conditions that would ensure improvement of sowing qualities and yielding properties of seeds using the method of correlation pleiades. The two-factor field experiment involved the following grading factors: A (seed ripeness degree in panicle) 25–30%, 45–50, 65–70 (control) and 85–90% of seeds reached the full maturity phase; B (duration of softening rolls) direct harvesting and in three, six (control) and nine days after mowing. The sowing quality of seeds formed on mother plants was tested in laboratory conditions in autumn of the harvest year and sowing next year (the first seed progeny) with threshing by occurrence of 65–70% of seed maturity in panicle. As a result of the research it was found: 1. Between yield of maternal plants and millet plants of the first seed offspring there is a direct correlation of medium strength. 2. Between yield of maternal plants and laboratory and technological indicators of seed quality there are strong correlations that are associated with it through the integrated quality indicator of seed material and millet output. 3. The integrated quality indicator and separately each of the studied laboratory parameters of seed material quality on high level influence the formation of grain yield of plants of the first seed offspring.

***Key words*:** Millet, variety, seeds, maternal plants, the first seed progeny, mowing way, threshing period, sign-indicator, correlation pleiad.

Introduction

Quality of seed material is predetermined by genetic potential of a variety, development conditions of maternal plants and, especially, environmental conditions in which a new organism is developing. These provisions need to consider that the study of biological objects is associated with polyfactorial relationships with the environment, each other, and features within the same species causing significant difficulties in studying this issue. Existing methods of analysis of polyfactorial links are significantly associated with intuition and subjective interpretations due to lack of reliable objective criteria. However, the correlation pleiades method differs from them by objective possibility of separating essential connections from non-essential ones, objective placing of attributes on the degree of their significance and the possibility to define the structure of interconnections within any complex of attributes [5, 11].

In practice of millet cultivation a direct harvesting as well as a separated way of gathering its harvest became widespread. Depending on the soil-climate and varietal characteristics some scientists prefer each of them. Usually direct harvesting is most often used for full maturity of 50–60% of seeds and in cases where plant height is less than 45 cm, or at thinned density and low sloping panicle [9]. Other scientists [6] point to its shortcomings – direct threshing of not fully ripe seeds can cause a significant reduction in its sowing qualities. To avoid this phenomenon they suggest using biphasic threshing – for the first time at lower speeds of the threshing machine, only the ripe and most significant seeds are threshed (up to 60% of the total weight of the crop), and the rest are threshed 5–6 days after drying and used for food or feed purposes [1, 2]. However, Efanov [4] and Kajuna[8] suggest that harvesting methods do not have a significant impact both on the level of grain yield or millet seeds and sowing qualities. Summarizing results of studies in scientific literature, the study of impact of mowing and threshing timing on sowing qualities and yield properties of millet seeds has a schematic and single character. In conditions of unstable humidity of Right-Bank Forest-Steppe of Ukraine, this question has not been studied to this day. This is the relevance and novelty of the chosen direction of research.

The aim of the study was to determine optimal conditions for harvesting millet seeds in Right-Bank Forest-Steppe of Ukraine which will provide maximum yield of high-quality seeds. Achieving this goal was done by solving such problems to define and analyze polyfactorial relationships of forming highly productive sowing of millet seeds by optimizing ways of its mowing and threshing as well as conditions that will ensure improvement of sowing qualities and yielding properties of seeds.

Material and Methods

Research was carried out during 2011–2015 in field crop rotation in the Department of Crop Production at Uman NUH. The two-factor field experiment to study effects of harvesting peculiarities of maternal plants on sowing qualities and yield properties of millet seeds (2011–2014) involved the following grading factors: *A (seed ripeness degree in panicle)* 25–30%, 45–50, 65–70 (*control*) and 85–90% of seeds reached the full maturity phase; *B (duration of softening rolls)* direct harvesting and in three, six (*control*) and nine days after mowing. Cutting height of rolls was 12–15 cm. For sowing, intermediate millet variety Zolotyste was used.

Sowing quality of seeds formed on mother plants was tested in laboratory conditions in autumn of the harvest year and sowing next year (the first seed progeny) with threshing by occurrence of 65–70% of seed maturity in panicle (2012–2015).

The millet predecessor in both generations was winter wheat. Phosphate and potash fertilizers were used during autumn tillage, nitrogen ones during first spring cultivation by general rule $N_{60}P_{60}K_{60}$. The sowing term was the second decade of May, sowing method was usual line. There were four repetitions, placing of variants was consistent.

The research area is characterized by unstable moisture. The comprehensive assessment of moisture and temperature conditions during years of the research was done by the hydrothermal coefficient (HTC). G.T. Selianynova shows that millet growing season in 2012 was characterized as medium dry season (HTC = 0.6) and in 2011, 2013, 2014 and 2015 they were excessive wet (HTC = 2.0) and sufficient wet ones (HTC = 1.0–1.5), respectively. In this case, usually at the time of the full maturity there is a hot weather and only in some years (2011) a significant amount of rain during this period caused a partial ear necking of crops and trouble to the harvest.

For comparison of vitality and viability indicators we proposed *the generalized indicator of seed quality,* which is the average percentage among a certain group of indicators (energy (%), rate (*days*) and simultaneity of seed germination (*plants day^{-1}*), its growth power (%) and laboratory similarity (%))[7] .

To have correlation pleiad, the degree of influence of growing conditions was determined on the formation of sowing qualities and yield properties of millet seed and the relationship of yield level of plants of the first offspring with a number of agronomic characteristics of seeds from maternal plants: **A** energy of seed germination (%); **B** speed of seed germination (days); **C** simultaneity of seed germination (plant day^{-1}); **D** power of seed growth (%); **E** laboratory seed germination (%); **F** generalized indicator of seed quality (%); **G** weight of 1000 seeds (g); **H** test value(gl^{-1});**I** uniformity of seeds (%); **J** seed hoodness (%); **K** millet yield (t ha^{-1}); **L** protein content in seeds (%); **M** fat content in seeds (%); $\mathbf{Y_1}$ yield of maternal plants (t ha^{-1}); $\mathbf{Y_2}$ yield of plants of the first seed offspring (t ha^{-1}). To have pleiades correlation links at the level of r > 0.5 are involved [3, 5, 10].

Results and Discussion

The results of the research show that mowing terms and duration of biomass binning in windrows had a different effect on the yield of millet seed (Table 1).Thus, the use of the recommended mowing period contributed to obtaining the highest yield of seeds by the separate method of harvesting when ripeness of seeds in the panicle reached 65–70%, according to the average for thrashing variants 3.85 t ha^{-1}. Early mowing terms were followed by significant shortfalls of seed yielding, when the number of ripe seeds in the panicle was only 25–30 and 45–50%. It was lower by 0.44 and 0.24 t ha^{-1} at $LSD_{05\,(A)}$ = 0.11–0.15 t ha^{-1}, respectively. Delay in mowing of millet crops before the time when the number of ripe seeds in the panicle increased to 85–90%, proved unsuccessful in this regard. Under these conditions, yielding was followed by significant losses (0.56 t ha^{-1}) due to ripe seed shedding.

Direct seed threshing was much better at this degree of seed ripeness. The yield was 3.55–4.21 t ha^{-1} during the years of research. Early terms of direct threshing caused a substantial shortfall (0.69–2.28 t ha^{-1}) of seed yield. The worst variant of the direct threshing was when there was the full ripeness of only 25–30% seeds in the panicle. It was the lowest yield during all the years of research, at the level of 1.16–1.82 t ha^{-1}. Although, ripe seeds were characterized by a large particle size and heaviness, their direct threshing in this period was greatly complicated by the raised humidity of harvesting biomass of millet seed crops. It caused significant crop losses. Further postponement of terms of direct threshing before 45–50 and 65–70% of ripe millet seed in the panicle significantly improved the quality and contributed to a significant increase in yield – by 0.42 and 1.60 t ha^{-1}.

Binning in windrows turned out positive for high productivity.

Table 1. Effect of features of harvesting millet seeds on its yielding properties in generations t ha^{-1}.

Duration of binning windrow (*factor B*)	Seed sowing (2011–2014)	The first seed generation (2012–2015)
The degree of ripeness of seeds in the panicle (*Factor A*) – 25–30%		
Direct threshing	1.59	2.18
Three days	3.33	3.22
Six days	3.63	3.84
Nine days	3.27	3.93
The degree of ripeness of seeds in the panicle (*Factor A*) – 45–50%		
Direct threshing	2.01	3.24
Three days	3.57	3.71
Six days	3.78	3.65
Nine days	3.48	3.44
The degree of ripeness of seeds in the panicle (*Factor A*) – 65–70% (*control*)		
Direct threshing	3.19	3.28
Three days	3.95	4.14
Six days	3.96	4.08
Nine days	3.65	3.55
The degree of ripeness of seeds in the panicle (*Factor A*) – 85–90%		
Direct threshing	3.87	2.67
Three days	3.73	2.53
Six days	3.41	2.36
Nine days	2.74	2.00
$LSD_{05\,(A)}$	*0.11–0.15*	*0.11–0.15*
$LSD_{05\,(B)}$	*0.11–0.15*	*0.11–0.15*
$LSD_{05\,(AB)}$	*0.22–0.30*	*0.21–0.29*

Thus, when mowing of millet crops by 25–30% of seed maturity in the panicle, binning in windrows during three and six days significantly improved the quality of threshing through drying of leafy mass. In addition, due to the ability of filled though unripe millet seeds to ripen in windrows, the productivity significantly increased by 2.04–0.30 t ha^{-1} reaching the level of 3.33–3.63 t ha^{-1} ($LSD_{05\,(B)}$ = 0.11–0.15 t ha^{-1}). However, further delay in terms of threshing for three days more has caused crop losses (0.30 t ha^{-1}) because of shatter losses of the most weighty and ripe seeds. A similar tendency was observed during all the years of research. However, if there are 25–30 and 45–50% of ripe seeds in the panicle, binning in windrows for at least six days is the most effective. At the same time, at 65–70% of ripeness, the efficiency of this agricultural measure for three and six days was equivalent (the difference was 0.01 t ha^{-1}), while at 85–90% of ripeness it was not appropriate (every three days seed losses increased because of shedding by 4, 11 and 21%).

Test *in vitro* on modification changes influenced by the studied characteristics of harvesting seed crops and weather conditions of the cultivation year allowed determining some regularity on developing sowing qualities of millet seeds (Table 2).

Thus, the application of a separate harvesting method when there were 65–70% of seed ripeness in the panicle and duration of binning in windrows for three to six days contributed to the formation of the highest quality millet seeds. Accordingly, in terms of laboratory germination, seeds grown by the combination of features of harvesting corresponded to the category of elite ones and had the highest level of this indicator, respectively 96.8 and 96.3%; the highest were germinating energy (93.2 and 92.7%), rate of germination (1.92 and 1.94 days), simultaneity of germination (24.9 and 24.7 seeds/day) and power of growth (97.8 and 97.0%). The calculated integrated seed quality score confirmed that the highest quality millet seed material is formed by these parameters of harvesting – 100 and 99.3% or the first and second places in the overall assessment of sowing qualities of harvested seeds. In addition, the received data and analysis indicate that the seed material is formed first (25–30% of ripe seeds) on the top of the panicle due to better flow of macronutrients to it characterized by high sowing qualities. However, for the development of high-quality seeds under these conditions the application of a separate threshing with windrow binning at least six to nine days turned proved to be necessary. So, germinating energy and laboratory germination of seeds grown in these areas was 90.7–90.8 and 96.3% by the integrated quality score of 97.5 and 97.9% (the third and fourth places).

Binning of windrows was efficient during next harvest period when the ripeness of seeds in the panicle increased to 45–50%. However, in this case, for developing the highest level of quality indicators its duration within three to six day was sufficient and the integrated quality score was 96.6 and 96.1% or the fifth and sixth places, respectively.

The application of the direct threshing of windrows at the slightest degree of seed ripeness in the panicle (25–30%) was the least appropriate for millet cultivation in seed plantings. By the level of laboratory germination the harvested seed material did not meet the category of the original material (87.3%). In addition, in the technology of growing millet crops, the dead-ripe stage at the time of 85–90% of seed ripeness in the panicle was quite unacceptable. By the integrated quality score, the seed material harvested by both direct and separate threshing was of the least quality. Checked variants by the integrated quality score took the lowest places and were characterized by major losses during harvest, comparing with the best areas.

The analysis of data on yielding of the next generation (the first seed generation) indicates that the studied peculiarities of seed harvesting caused a significant affining quality of yield properties (see Table 1).

Thus, on average during the years of studies developing the highest yield of millet crops of the first seed generation has provided the duration of the growing season when a separate method of collecting was used having 65–70% of seed ripeness in the panicle, respectively 4.14–3.55 t ha^{-1}. Under the terms of premature separate threshing of seed crops (25–30% and 45–50 of ripe seeds in the panicle) this indicator has decreased on average by 0.26 and 0.32 t ha^{-1} ($LSD_{05\,(AB)}$ = 0.21–0.29 t ha^{-1}). However, the biggest shortfall of harvesting of the first seed generation was obtained in areas where seed crops

Table 2. Sowing seed qualities depending on the characteristics of harvesting of seed crops (2011–2014).

Duration of windrow binning (*Factor B*)	Germinating energy, %	Rate of germination, days	Simultaneity of germination, seed day^{-1}	Power of growth, %	Laboratory germination, %	Integrated seed quality score, %	Place
Seed ripeness degree in panicle (*factor A*) – 25–30%							
Direct harvesting	83.7	2.38	19.8	86.5	87.3	85.8	13
Three days	85.7	2.18	22.3	89.7	91.8	91.3	9
Six days	90.7	2.02	24.3	95.8	96.3	97.5	4
Nine days	90.8	2.00	24.5	95.8	96.3	97.9	3
Seed ripeness degree in panicle (*factor A*) – 45–50%							
Direct harvesting	85.7	2.21	18.8	88.5	91.2	87.8	12
Three days	91.2	2.04	23.5	95.5	95.3	96.6	5
Six days	91.2	2.06	23.2	95.3	95.3	96.1	6
Nine days	84.2	2.11	22.4	92.7	93.8	92.6	8
Seed ripeness degree in panicle (*factor A*) – 65–70% (контроль)							
Direct harvesting	86.7	2.23	22.6	88.8	90.8	90.9	10
Three days	93.2	1.92	24.9	97.8	96.8	100.0	1
Six days	92.7	1.94	24.7	97.0	96.3	99.3	2
Nine days	86.3	2.09	22.8	95.2	95.8	94.5	7
Seed ripeness degree in panicle (*factor A*) – 85–90%							
Direct harvesting	86.2	2.27	20.3	88.7	89.2	88.2	11
Three days	95.8	2.30	18.0	86.8	88.5	85.6	14
Six days	84.7	2.36	17.7	86.3	87.8	84.5	15
Nine days	83.8	2.39	17.3	84.5	85.5	82.9	16

were mowed with a significant delay (85–90% of ripe seeds in the panicle), respectively 2.67–2.00 t ha^{-1} or by 1.40–2.08 t ha^{-1} and significantly less than the most optimal terms of threshing (65–70% and three days of binning in windrows).

With the time postponement of terms of a separate threshing from 25–30% of ripe seeds in the panicle to 45–50 and 65–75% the effective duration of binning gradually decreased from nine to six and three days, respectively, contributing to the significant increase in harvest of the first seed generation. When there is a dead-ripe stage on the roots of ripe seeds (85–90%), the application of this agricultural measure is not useful, followed only by deterioration of yielding properties of gathered seeds and substantial losses of millet grain yield in next generation.

Evaluating the effectiveness of direct seed threshing, it was found that using it at 45–50 and 65–70% degree of ripeness was statistically equivalent. Thus, the level of yield of the first seed generation in these areas was respectively 3.24 and 3.28 t ha^{-1} or by 0.36 and 0.64 t ha^{-1} significantly less comparing with variants of the separate threshing when mowing in the same terms. However, the application of this agricultural method in very early (25–30%) and late (85–90%) terms of harvesting seed crops caused a significant shortage of grain of the first seed generation, by the level of 1.06–1.10 and 0.56–0.61 t ha^{-1}.

According to the results of four-year research, correlation pleiad was built (Fig.1) from data which showed that yield of maternal plants ($\mathbf{Y_1}$) is directly linked with that of plants of the first seed offspring ($\mathbf{Y_2}$) (r = 0.51 ± 0.04).

In addition, between yield ($\mathbf{Y_1}$) and integrated indicator of seed material quality (**F**), there is correlation of medium strength *(r =* 0.55 ± 0.03). On high direct level, this depended on energy of seed germination (**A**) – r = 0.89 ± 0.00, power of seed growth (**D**) – r = 0.88 ± 0.00, simultaneity of seed germination (**C**) – r = 0.87 ± 0.00 and laboratory seed germination (**E**) – r = 0.87 ± 0.00, with a speed of seed germination (**B**) had a strong inverse relationship – r = 0.88 ± 0.00. In turn all our submitted quality indicators of seed material in research laboratory have close direct inverse correlations with each other (**A**, **C**, **D**, **E**) and with the speed of seed germination (**B**) at the level of r = 0.80...0.85 ± 0.00 and r =-0.88 ± 0.00.

In addition with the exception of simultaneity of seed germination (**C**), all other laboratory parameters of millet seed material quality at average close level correlated with yield of maternal plants: in accordance with energy of seed germination (**A**) and laboratory similarity (**E**) – r = 0.53...0.55 ± 0.03; with power of seed growth (**D**) – r = 0.85 ± 0.00 and reversed – with the speed of seed germination (**B**) – r =-0.56 ± 0.02. Simultaneity of seed germination (**C**) also depended on the level of yield of maternal plants but strength of this connection did not meet conditions of construction of this pleiad (r <0.5) therefore this indicator was expelled from the corresponding group in the link 'yield of maternal plants – integrated quality indicator – laboratory indicators of seed material quality'.

In contrast to the link where the sign-indicator is yield of maternal plants ($\mathbf{Y_1}$), in the link with the second sign-indicator yield of plants of the first seed offspring ($\mathbf{Y_2}$) all of the studied parameters of seed material quality had a direct impact on its formation.

Thus, yield of millet grain grown from seeds formed by different terms of mowing and threshing ($\mathbf{Y_2}$), as right at the close level depended on the integrated quality indicator (**F**) – r = 0.87 ± 0.00 and separately closely correlated with indicators (**A**, **C**, **D**, **E**) and with the speed of seed germination (**B**) inversely – respectively r = 0.82...0.85 ± 0.00 and r =-0.88 ± 0.00. Analysis of multiple correlations between the studied parameters of technological and grinding grain quality allowed building the correct geometric shape (star) which indicates their complex interaction. Thus, between protein content in grain (**L**), uniformity of grain (**I**) and its heaviness (**H** and **G**) medium and close relations were set – respectively at the level of r = 0.54...0.81 ± 0.03. In turn, the concentration of fat in grain (**M**) at the average level is inversely correlated with other technological and cereal qualities (**G**, **H**, **I**, **L**) and indirectly may demonstrate that increasing amount of fat in grain indicates reduction of caryopsides size, their heaviness and uniformity. This group of quality indicators of grain did not have direct connection with agronomic characteristics like yield and cereals output – between them, there is the intermediate link "seed hoodness (**J**) – fat content (**M**)". Inverse nature of relationships within that link *(r* =-0.59 ± 0.02 and 0.87 ± 0.00) indicates that an increase in the number of flower glumas (**J**) that not only is the technological quality of grain deteriorating (**G**, **H**, **I**, **L**), but also weight yield of cereals is reduced (**K**).

Analysis of the other link "yield – millet output – technological indicators of quality", where the sign-indicator is yield of plants of the first seed offspring ($\mathbf{Y_2}$), indicates that the level of the last ones may indirectly indicate yielding properties of seed material ($\mathbf{Y_1}$) and ability to predict future yields. Thus, between yield of

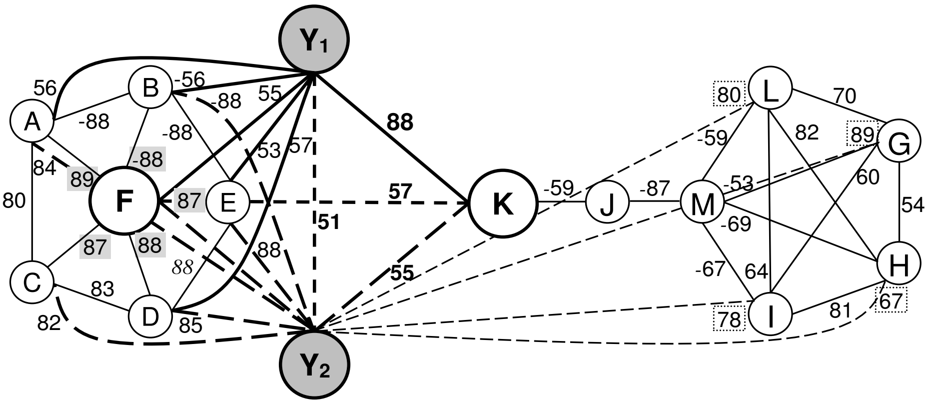

Figure 1. Correlation pleiad of dependencies of sowing qualities and yield properties of millet seeds formed under the influence of harvest characteristics, the average for 2011–2015. *Note. Numbers in the figure – the value of correlation coefficients after the decimal point.*

plants of the first seed offspring (**Y_2**) and millet output from yield of maternal plants (**K**), its important parameters (**G** and **H**), uniformity (**I**) of grain and its protein content (**L**), close multiple correlation relationships are determined – respectively r = 0.67...0.89 ± 0.01.

Thus, although the relationship between crop yield of the first seed offspring (**Y_2**) and grain hoodness (**J**) in constructing this pleiad is not acknowledged $(r < 0.5)$, its inverse nature $(r = -0.41)$ may indirectly indicate deterioration of yielding properties of seed material with a decrease of filling caryopsides.

Conclusions

1. Obtaining the highest yield of seeds of maternal plants by a separate harvesting method promotes the use of the term of mowing when its degree of ripeness in the panicle reached 65–70%, respectively, on average comparing with threshing variants of 3.85 t ha^{-1}. Early mowing terms (25–30 and 45–50% of ripeness) and their delay (85–90% of ripeness) are followed by significant shortfalls of seed yield, respectively 0.44, 0.24 and 0.56 t ha^{-1}.
2. When there is a dead–ripe stage on the roots (85–90%), the direct threshing of maternal plants is the most optimal – the yield was 3.55–4.21 t ha^{-1} during the years of research. Early direct threshing terms cause a significant shortfall of seed yield (0.69–2.28 t ha^{-1}) and they were the largest at full ripeness of only 25–30% of seeds in the panicle.
3. Developing the highest yield of millet crops of the first seed generation provides the duration of vegetation of maternal plants when the separate gathering is at 65–70% degree of seed ripeness in the panicle, respectively 4.14–3.55 t ha^{-1}. In case of early terms of the direct threshing, the level of yield significantly decreases by 0.26 and 0.32 t ha^{-1} and with the delay of terms it increases by 1.40–2.08 t ha^{-1}.
4. With the time postponement of terms of a separate threshing from 25–30% to 45–50 and 65–75% of ripe seeds in the panicle the effective duration of binning gradually decreases from nine to six and three days, respectively, contributing to the significant increase in harvest of the first seed generation. When there is a dead-ripe stage on the roots of ripe seeds (85–90%), the application of this agricultural measure is not useful.
5. Between yield of maternal plants and millet plants of the first seed offspring, there is a direct correlation of medium strength. Between yield of maternal plants and laboratory and technological indicators of seed quality, there are strong correlations that are associated with it through the integrated quality indicator of seed material and millet output. The integrated quality indicator and separately each of the studied laboratory parameters of seed material quality on high level influence the formation of grain yield of plants of the first seed offspring.

References

[1]Gbabo, A., Gana, I. M., and Amoto, M. S. 2013. Design, fabrication and testing of a millet thresher. Net Journal of Agricultural Science **1**(4):100–106.

[2]Andrianova, L. O. 2012. Methods of crop care and harvesting of millet in the Middle Urals region. Perm, 20 p.

[3]Borovikov, V. P. 2003. Statistica. The art of data analysis on the computer: for professionals. Sankt-Peterburg, 688 p.

[4]Efanov, A. I. 2000. Influence of different ways of harvesting peas, buckwheat and millet on grain yield, sowing qualities and fruitful properties of seeds in the conditions of south-western part of CBSR. Belgorodskajà gosudarstvennajà selskohozjàistvennajà akademijà. Belgorod, 26 p.

[5]Kempton, R.A. and Fox, P.N. 1997. Statistical Methods for Plant Variety Evaluation. Chapman and Hall, Great Britain, 188 p.

[6]Korenev, G. V. 1975. Yielding quality of millet seeds harvested in different phases of maturity. Nauchnye trudy Voronezhskogo SHI **71**:49–53.

[7]Poltoretskyi, S. P. 2015. Agrobiological bases of forming high-quality seeds of millet in the conditions of Right-Bank Forest-Steppe of Ukraine. Kyiv, 40 p.

[8]Kajuna, S.T.A.R. 2001. Millet: Post-harvest Operations. INPho (The Information Network on Post-harvest Operations), Post-harvest Compendium, Sokone University of Agriculture (SUA), AGSI/FAO, pp. 2–49.

[9]Solovev, A. V. 2008. Selection of the optimal timing and methods of harvesting of millet and buckwheat. Sbornik Vestnik RGAZU **4**(9):70–72.

[10] Statistical Papers 1997. Statistische Hefte. January pp. 27–28.

[11]Terentev, P.V. 1960. Further development of the method of correlation pleiades. Leningrad, pp. 27-36.