Biological bases of crop insurance with state support

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Abstract. Crop insurance is an important financial instrument for the stable and successful functioning of crop production, realized by reducing risks. The purpose of the study is to substantiate the need to take into account the individual varieties characteristics when insuring agricultural crops with state support. In this case, it is necessary to solve the following tasks: - to formulate the agricultural crops individual varieties biological characteristics; - to classify all emergencies according to the impact type on plants; - to substantiate (using the example of spring barley) the need to correct the existing approach when concluding crop insurance contracts with state support. When formulating insurance rules, it is necessary to use the capabilities of immunity genetics, which allows it to be rationally and purposefully applied in breeding programs to achieve resistance to abiotic and biotic compensated and non-compensated factors. As can be seen from the presented calculation, it cannot be said that the presence of a variety in the State Register of Breeding Achievements is a prerequisite for its successful cultivation. Therefore, it is necessary for each agricultural crop to identify a number of features, the presence of which makes this variety resistant to the totality of the given microregion all factors.

1. Introduction

Crop insurance is an important financial instrument for the stable and successful functioning of crop production, realized by reducing risks [1-4]. The insurance tools use allows to redistribute risk over time and reduce its impact on the results of an agricultural enterprise in unfavorable periods. This helps to maintain its financial stability. Risk insurance also provides conditions for the technological development of agro-industrial production [5-7].
The realization of the under-harvesting risk is manifested in a decrease in the yield of cultivated crops due to unfavorable abiotic factors (weather conditions) or biotic factors (the spread of diseases and plant pests). At the same time, the yield of each agricultural crop depends on the region climatic conditions, the characteristics of its soil cover, the soil type and properties, the cultivation technologies use, an important element of which is the highly productive varieties use with varying degrees of resistance or immunity in the cultivation process [8-10].

2. Methodology
The study analyzed long-term data on the spring barley yield in the central natural-economic zone of the Samara region. The Volga Region Research Institute of Breeding and Seed Production, within the framework of the Bioresource Collection, grows the agricultural crops seeds of various varieties and lines to be used for breeding purposes. Cultivating them in conditions when only the variety potential influences the differences in their yield makes it possible to assess their value in insurance terms.

Based on the data obtained, all studied varieties were divided into three groups.

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3. Discussion and results
The ability of crops to withstand adverse effects (development of diseases, damage by pests or abiotic natural factors) can be expressed in the immunity form, or in the form of a resistance mechanism that reduces the negative impact of abiotic and biotic conditions [11-16].

Crops can have innate or induced immunity. Innate immunity is genetically determined and is inherited, acquired immunity arises under the impact of external influences during the agricultural crops cultivation (the use of fertilizers, growth stimulants, etc.), is not inherited. Knowledge of the immunity genetic basis makes it possible to rationally and purposefully use it in breeding programs when creating resistant varieties [17-21].

The cultivation of resistant and immune varieties allows regulating the pests number within populations and between populations in agrocenoses. It increases the yield and quality of cultivated crops, reduces the cost of taking measures to combat pests, and further improves the ecological situation in general. Plant resistance to unfavorable abiotic factors causing stress is based on the ability to adapt to changing environmental conditions - adaptation. With the unfavorable conditions slow development, plants successfully compensate for their onset by hardening, the endurance formation. For the conditions of the Middle Volga region forest-steppe zone, important adaptive properties to cultivation conditions are: for winter crops - winter hardiness, drought resistance, withstanding temperature drops in autumn, late spring frosts, long-term stay under high snow cover; for spring crops - heat resistance and drought resistance, resistance to dry winds [22-24].

The legal framework for agricultural insurance is established by Federal Law No. 260-FZ and the Rules for Insurance of Agricultural Crops and Plantings of Perennial Plantations with State Support [25-30]. Clause 4.2 of the Insurance Rules contains a criteria list for the insured event occurrence, which can be classified as: - factors of long-term effect, which in the future (with the development of plants) can be compensated; - uncompensated factors (mudflow, fire, etc.), the occurrence of which leads to the plants instant death (Figure 1).

The first group of factors leads to death only with prolonged exposure; therefore, an increase in the varieties resistance to this effect can be achieved through selection.

The cultivated crops stability can be due to the complex action of various factors: anatomical and morphological features (habit, cuticle thickness, structure and location of stomata, wax coating, etc.), the content of organic acids, phytocides, proteins and their decay products, hypersensitivity reactions,
the formation of phytoalexins, phagocytosis. At the same time, it is under a much more complex genetic control than economically valuable traits, such as the quantity and quality of products, ripening period, etc. [31-36]

As a result of the compensated factors influence, the agricultural crops physiological activity and their normal functioning are disrupted. The longer this impact, the more resources the plant spends on the restoration of vital activity, the greater the yield loss [37-41].

![Diagram of events leading to the death of crops](image)

Figure 1. Classification of events leading to the death of crops.

Uncompensated factors can also be partially regulated genetically by cultivating modern resistant varieties or breeding for resistance to them.

At present, in the Russian Federation, the possibility of insuring agricultural crops with state support is limited exclusively to varieties recommended for cultivation in this region in accordance with the State Register of Breeding Achievements Permitted for Use. Volume 1. Plant Varieties (as of March 12, 2020). This formal approach reduces the possibility of using new, more efficient varieties. Let's consider this statement using the example of spring barley. In the Samara region, on the basis of the Volga Research Institute of Breeding and Seed Production named after P.N. Konstantinov is supported by the "Bioresource collection", the main function of which is to maintain a stock of agricultural crops various varieties seeds, which are subsequently used as a source material for breeding work. The varieties are sown in one field, in several repetitions, using the same technology. In other words, the yield of such crops is mainly influenced only by the variety characteristics, its adaptability to the given microregion.
conditions (soil, climate, a set of diseases and pests). The analyzed data were obtained for the period 2007-2016 (table 1) [42-49].

Table 1. Deviations in the spring barley yield for the varieties selected groups.

| Group                           | 2007  | 2009  | 2010  | 2011  | 2012  | 2013  | 2014  | 2015  | 2016  |
|---------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| Recommended varieties group     | -1.6  | -4.3  | 2.2   | 5.3   | 0.8   | 1.1   | 2.6   | 4.4   | 0.6   |
| Non-recommended varieties of group 1 | 3.6   | 3.9   | -0.3  | 2.0   | 1.1   | 0.8   | 2.3   | 1.0   | -0.6  |
| Non-recommended varieties of group 2 | -2.0  | -1.3  | -2.1  | -8.3  | -2.2  | -2.2  | -5.6  | -6.1  | -     |

In accordance with the data obtained, all varieties and lines were grouped by yield into three equal groups. The first group included varieties recommended for cultivation in region 7 (Middle Volga). These include the varieties: Agate, Anna, Nutans 553, Priazovsky 9, Bezenchuksky 2, Vityaz, Orlan, Yastreb. The total deviation of their yield from the average for 9 years was 11.3 cwt/ha. In figure 2 shows that the fluctuations in yield over the years are much greater than in the second group.

The second group included varieties that are not recommended by the state register, but showed the final positive deviations from the average yield for the study period. These varieties are classified by us in the non-recommended varieties of group 1: K9267 local, Zemlyak, Orenburgsky 15, Orenburgsky 16, Orenburgsky 17, Spomin, Zernogradsky 244, Belogorodets. The total deviation for 9 years was 13.6 cwt/ha, which is higher than that of the recommended varieties.

The third group included varieties and lines that were not recommended for cultivation, which showed a negative deviation from the average yield. These are non-recommended varieties of group 2, which included: K9277, K9278, MK47, Zernogradsky 584, Zernogradsky 813, K665, Chakinsky 221. In this variant, the total deviation for the period was -29.9 cwt/ha compared to the average yield of the varieties entire set.

4. Conclusions
Agricultural insurance is an important segment of property risk insurance in the Russian Federation. At the same time, insurance in the field of crop production is more common both in our country and abroad.
The location of an arable land significant part in Russia in the risky farming zone pushes agricultural producers to an agricultural insurance programs widespread use. When concluding crop insurance contracts with state support, the peculiarities associated with the climatic, soil, and biological characteristics of the regions must be taken into account. When formulating insurance rules, it is necessary to use the capabilities of immunity genetics, which allows it to be rationally and purposefully applied in breeding programs to achieve resistance to abiotic and biotic compensated and non-compensated factors. As can be seen from the presented calculation, it cannot be said that the variety presence in the State Register of Breeding Achievements is a prerequisite for its successful cultivation. Therefore, it is necessary for each agricultural crop to identify the features number, the presence of which makes this variety resistant to the totality of all factors of the given microregion.

References
[1] Ray D K, Gerber J S, Macdonald G K and West P C 2015 *Nature Communications* 6 6989
[2] Lobell D B, Schlenker W and Costa-Roberts J 2011 *Science* 333(6042) 616-20
[3] Roberts M J, Schlenker W and Eyer J 2013 *American Journal of Agricultural Economics* 95(2) 236-43
[4] Hiebert C W, Moscou M J, Hewitt T, Steuernagel B, Hernández-Pinzón I, Green P, Pujol V, et al. 2020 *Nature Communications* 11(1) 1123 doi: 10.1038/s41467-020-14937-2
[5] Wulft B B H and Moscou M J 2014 *Frontiers in Plant Science* 5(DEC) 692 doi: 10.3389/fpls.2014.00692
[6] Zhichkin K, Nosov V, Zhichkina L, Shelnov Yu and Aydinov H 2020 E3S Web of Conference 164 06019 doi: 10.1051/e3sconf /202016406019
[7] Andersen E J, Ali S, Byamukama E, Yen Y and Nepal M P 2018 *Genes* 9(7) 339 doi: 10.3390/genes9070339
[8] Kutschera U and Hossfeld U 2012 *Journal of Applied Botany and Food Quality* 85(1) 1-5
[9] Dangl J L, Horvath D M and Staskawicz B J 2013 *Science* 341(6147) 746-51 doi: 10.1126/science.1236011
[10] Marino D, Peeters N and Rivas S 2012 *Plant Physiology* 160(1) 15-27 doi: 10.1104/pp.112.199281
[11] Vleeshouwers V G A A and Oliver R P 2014 *Molecular Plant-Microbe Interactions* 27(3) 196-206 doi: 10.1094/MPMI-10-13-0313-IA
[12] Lo Presti L, Lanver D, Schweizer G, Tanaka S, Liang L, Tollot M, Zuccaro A, et al. 2015 *Annual Review of Plant Biology* 66 513-45 doi: 10.1146/annurev-arplant-043014-114623
[13] Andersen E J, Ali S, Neil Reese R, Yen Y, Neupane S and Nepal M P 2016 *Evolutionary Bioinformatics* 12 99-108 doi: 10.4137/EBO.S38085
[14] Kumar D 2020 *Plant Archives* 20(1) 1169-74
[15] War A R, Paulraj M G, Ahmad T, Bhueroo A A, Hussain B, Ignacimuthu S and Sharma H C 2012 *Plant Signaling and Behavior* 7(10) doi: 10.4161/psb.21663
[16] Jamiołkowska A 2020 *Agronomy* 10(2) agronomy10020173 doi: 10.3390/agronomy10020173
[17] Li P, Lu Y-J, Chen H and Day B 2020 *Critical Reviews in Plant Sciences* 39(1) 72-100 doi: 10.1080/07352689.2020.1757829
[18] Gaquerel E and Stitz M 2017 *Molecular Plant* 10(4) 537-9 doi: 10.1016/j.molp.2017.02.006
[19] Huot B, Yao J, Montgomery B L and He S Y 2014 *Molecular Plant* 7(8) 1267-87 doi: 10.1093/mp/ssu049
[20] Leary A Y, Savage Z, Tumtas Y and Bozkurt T O 2019 *Current Opinion in Plant Biology* 52 46-53 doi: 10.1016/j.copbi.2019.07.002
[21] Owens B 2019 *Nature* 575(7784) 55-6 doi: 10.1038/d41586-019-03640-y
[22] Sato K, Kadota Y and Shirasu K 2019 *Frontiers in Plant Science* 10 1165 doi: 10.3389/fpls.2019.01165
[23] Gheysen G and Mitchum M G 2011 *Current Opinion in Plant Biology* 14(4) 415-21 doi: 10.1016/j.pbi.2011.03.012
[24] Nobori T and Tsuda K 2019 Current Opinion in Plant Biology 50 58-66 doi: 10.1016/j.pbi.2019.02.003
[25] Zhao S and Yue C 2020 Agricultural Economics (United Kingdom) 51(3) 359-72 doi: 10.1111/agec.12559
[26] Belasco E, Galinato S, Marsh T, Miles C and Wallace R 2013 Agricultural and Resource Economics Review 42(3) 403-18 doi: 10.1017/S1068280500004445
[27] Du X, Hennessy D A and Feng H 2014 American Journal of Agricultural Economics 96(1) 232-52 doi: 10.1093/ajae/aat057
[28] Glauber J W 2013 American Journal of Agricultural Economics 95(2) 482-8 doi: 10.1093/ajae/aas091
[29] Ho S-T, Ifti J E, Rickard B J and Turvey C G 2018 Agricultural and Resource Economics Review 47(3) 452-76 doi: 10.1017/age.2017.29
[30] Picazo-Tadeo A J and Wall A 2011 Agricultural Economics 42(4) 451-64 doi: 10.1111/j.1574-0862.2011.00537.x
[31] Roe B E 2015 Applied Economic Perspectives and Policy 37(4) 553-74 doi: 10.1093/aep/ppv022
[32] Yu J and Sumner D A 2018 Agricultural Economics (United Kingdom) 49(4) 533-45 doi: 10.1111/agec.12434
[33] Zhichkin K, Nosov V, Zhichkina L, Grigoryeva O, Kondak V and Lysova T 2020 IOP Conference Series: Earth and Environmental Science 433 012004 doi: 10.1088/1755-1315/433/1/012004
[34] Bulut H 2020 Agricultural Finance Review 80(4) 507-27 doi: 10.1108/AFR-08-2019-0090
[35] Bulut H 2017 Journal of Agricultural and Resource Economics 42(3) 406-26
[36] Verezubova T A, Zhichkin K A, Mukhitbekova A M, Penkin A A and Zhichkina L N 2020 BIO Web of Conferences 17 00003 doi: 10.1051/bioconf/20201700003
[37] Senapati A K 2020 Heliyon 6(3) e03503 doi: 10.1016/j.heliyon.2020.e03503
[38] Kim Y, Yu J and Pendell D L 2020 European Review of Agricultural Economics 47(1) 324-47 doi: 10.1093/erae/jbz035
[39] Nosov V V, Kotar O K, Kosheleva M M, Alaikina L N and Novikova N A 2014 Ecology, Environment and Conservation 20(4) 1857-63
[40] Nosov V V 2020 Proceedings of the 33rd International Business Information Management Association Conference, IBIMA 2019: Education Excellence and Innovation Management through Vision, 2019 7594-600
[41] Bellemare M F and Novak L 2017 American Journal of Agricultural Economics 99(2) 357-78 doi: 10.1093/aje/aaw053
[42] Zhichkin K, Nosov V, Zhichkina L, Zhenzhebir V and Sagina O 2020 IOP Conference Series: Earth and Environmental Science 421 022066 doi: 10.1088/1755-1315/421/2/022066
[43] Bjerne B, Trifkovic N 2018 European Review of Agricultural Economics 45(3) 397-431 doi: 10.1093/erae/jbx037
[44] Zhichkin K, Nosov V, Zhichkina L, Zhenzhebir V and Rubtsova S 2020 E3S Web of Conferences 175 13008 https://doi.org/10.1051/e3sconf/202017513008
[45] Clarke D J 2016 American Economic Journal: Microeconomics 8(1) 283-306 doi: 10.1257/mic.20140103
[46] Zhichkin K A, Nosov V V, Andreev V I, Kotar O K and Zhichkina L N A. 2019 IOP Conference Series: Earth and Environmental Science 341 012005 doi:10.1088/1755-1315/341/1/012005
[47] Cornaggia J 2013 Journal of Financial Economics 109(2) 419-40 doi: 10.1016/j.jfineco.2013.03.004
[48] Firsova A, Balash O and Nosov V 2014 Springer Proceedings in Complexity 299-304 doi: 10.1007/978-94-007-7362-2_39
[49] Tekueva M T, Burkov A V, Nosov V V, Novoselova S A and Nayanov A V 2016 Research Journal of Pharmaceutical, Biological and Chemical Sciences 7(6) 1634-8