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# Assessment of adaptive attributes of varieties and numbers of hop plant

**Shtanko I.**
*Institute of agriculture of Polissia of NAAS, Kyivske shose, 131, Zhytomyr, 10007, Ukraine; e-mail: shtanko_hop@meta.ua*

**The purpose**. To assess parameters of productivity, autoadaptivity of new genotypes and the registered varieties (standards) of hop plant of different selection parentage and selection on its basis of the most valuable ones for selection and production of genotypes. **Methods.** Field — for determination of attributes of plants of varieties and numbers by procedures of selection probes with hop plant of IAP and by procedures of UPOV; mathematical-statistical — for detection of parameters of ecological pliability and stability, reliability of experiences; system analysis and generalization. **Results.** They used method based on test of genotypes in long-term probe at different ecological conditions (year) on indexes of regression coefficient (ecological pliability), on variation of stability of an attribute (aberration from a regression line) and on generalized ball assessment of practical significance. Average productivity in experiment made 1,88 t/hectare, and top productivity demonstrated selection numbers 7031 (2,29 t/hectare), 6007 (2,23 t/hectare), A-265 (2,10 t/hectare). Productivity at the level of 2,0 t/hectare was registered for numbers 7042, 5970a and 7007. That very genotypes had positive indexes of genotypic effect of development of an attribute. Numbers with greater regression coefficient ($b_i$>1,0) were determined: A-265, 6007, 7009, 7042, and 7043. Slavianka and 7007 were characterized by average level of ecological pliability ($b_i$ 1). Alto, Promin, Gaidamatskyi, 5970a, 6034, 7031 poorly react to change of conditions of growing and have smaller ecological pliability ($b_i$<1,0). As to stability of productivity (standard deviation from regression Si2 is close to null) were fixed the following varieties: Alto, Slavianka, Promin, Gaidamatskyi, and numbers: 5970a, 6034, 7031 which had average and low ecological pliability. Variation of stability of probed attribute ($S_i^2$ 0,12-0,94) is more significant for numbers A-265, 6007, 7009, 7042, 7043 with high level of ecological pliability. **Conclusions.** Genotypes 6007, A-265, 7042 are the best ones for growing in zone of Polissia according to generalized assessment of practical significance.

***Key words:*** *selection of hop plant, takeoff, genotype, productivity, pliability, autoadaptivity, stability.*

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**Introduction.** A hop growing is important industry of agricultural production, the products of that have an enormous amount of applications, beginning from brewing and ending a cosmetology. In Ukraine the bulk of hop-gardens is territorial concentrated in the Polesye and Forest-steppe (north) zones that is distinguished by the terms of the sufficient moistening and have favourable ground-climatic terms. But global and regional changes of climate, with the all greater amount of unfavorable for a production weather factors, in particular, high temperatures and protracted droughty periods do not assist stability of the productivity and do growing of hop more risky. One of decision factors of receipt of high, stable and quality harvests of hop there is a plant-breeding sort [1–3].

A selection of hop is a difficult, labour intensive process that requires realization of tedious plant-breeding work both with the plants of woman and sex of men, and his duration 10-15 [4–7]. Due to a considerable heterozygosity, the plants of hop do not keep stability genome at reproduction through seed. Every new genotype is unique from the point of view of his genetic composition, that is why for reproduction of hop use the methods of cloning (vegetative reproduction). Every sign of new form, that is got during hybridization, varies within the limits of combination and norm of reaction of the display of basic signs of hop in the certain region of growing. The plant of hop is very sensible to duration of light day and

local terms and, as a result, the varieties not always adjusted to the terms outside a country, where they were created. Change of signs of the productivity and quality in variable conditions is ponderable. By the main factors of environment, that determine the productivity and quality of cones of hop there is a temperature, water and nutritives. As a region of Polesye has certain changes of weather terms, then presently there is a selection of varieties actual tasks to the selection with an increase firmness to the abiotic factors that reduce the productivity and worsen quality of products [4].

A harvest and quality of products in an eventual variant are a system effect, that comes forward as a result of co-operation in the process of height, development, formation of macrosystem with the dynamics of change of environment of existence. An adaptivity shows the reaction of the biological system on the change of environment by alteration of chain of morphogenic effects, that ends with forming of concrete sign of plant. Thus, the genetic effect of adaptive reaction on limits or surplus of factors of environment is taken to adjusting of chains of metabolic and morphogenic processes and can be expressed in co-operation of foods of genes on the different levels of biological organization of plant [8]. Therefore at the estimation of the productivity of plants of hop in the variable terms of environment it is important to know and character of reaction of separate genotypes (varieties or numbers) on their oscillation, and determination of parameters of adaptivity and stability of genotype during realization of level of development of productive signs is an important task on the stage of his plant-breeding study and of high quality estimation of fitness to distribution. **Aim of researches.** The aim of our researches was to conduct the evaluation of parameters of the productivity, ecological adaptivity of new genotypes and registered varieties (standards) of hop of different plant-breeding origin and selection on his basis of most valuable for a selection and production of genotypes. **Materials and methods of researches.** In researches 4 varieties of hop, added to the State register of sorts of plants in Ukraine, were used: Alta – early; Slavyanka – middle ripeness; Promin – middle ripeness; Haidamatskii – late and 9 genotypes (numbers) of hop, got from the difficult crossing for the use of varieties of home and foreign selection and masculine and woman genotypes of different plant-breeding origin, from what 6 – middle ripeness, 2 – middling–late and 1 late.

Study is undertaken a during 2010–2014 in the department of selection and innovative technologies of hop of Institute of agriculture of Polesye NAAS in the conditions of competitive test of sorts. Gobbing of experience areas conducted during 2009 on the plantation equipped by a trellis by 221 one-year nursery transplants grown from cuttings. Chart of researches – randomized, every area of varieties or number is formed from 10 plants with the area of feed of 3м х 1м, the repeated is fourfold. All supervisions and accounts on experience areas were executed in accordance with methodologies generally accepted for the estimation of plants of hop [9,10] but in obedience to a national standard a 2027–2009 "Selection of hop. Methods of tests. Technical requirements" [11].

On the basis of data of long-term study 9 numbers in comparing to 4 standard sorts of hop determined the statistical indexes of dispersion of the productivity on every year and on the whole for period of researches on methodology expounded B.A. Dospekhov (1985) [12] but set the effect of genotype $E_i$ (a difference of middle index of quantitative sign is on the set of genotypes to the corresponding value of concrete genotype) and parameters of ecological plasticity $b_i$ coefficient of regression) and stability $S_i^2$ by standard deviation from the line of regression), that expected on methodology of S.A. Eberhart, W.A. Russel (1966) [13].

**Results and discussions.**

The years of realization of researches differed after the hydrothermal mode, that allowed to estimate the adaptivity of the investigated sorts and numbers of hop to the climatic terms of Polesye, what during the last decades acquire more droughty character with the protracted periods without precipitations and with increase temperatures of air (1,5–2,0°С accordingly long-term norm). It is fixed for period of researches, that in 2011 a provision of moisture of plants of hop (during May-August) was critically subzero - only 7 percents from a norm. For 2010, 2012 and 2013 also characteristic was an insufficient provision of moisture - during a vegetation 82–85 percents of precipitations fell out from a norm. And in

2014 the most moist period is marked during a vegetation (107 percents are from the norm of precipitations). For forming of harvest of hop in the point of researches a temperature condition was folded also unfavorably, in particular, in throughout the year of supervisions the increase of temperature of air is marked on the whole for period of vegetation on 10–20 persents of from a long-term norm. Especially critical periods with high temperatures and shortage of moisture were marked in June-July, when plants passed the phases of flowering and forming of cones.

For determination of ecological plasticity and stability conducted the mathematically-statistical analysis of parameters of the productivity of genotypes and registered varieties (standards) of hop of different plant-breeding origin on results the competitive study of varieties in the conditions of point of researches (Zhytomyr) during 2010–2014 (table 1).

2013, 2014 had the best terms for a height and development of plants. It confirms the positive value of index of index of terms of year ($E_{j2013}$=0,15, $E_{j2014}$=0,14) but the high middle productivity of sorts and numbers is in these years – 2,03, 2,02 t/ha. 2011 and 2012 appeared less friendly to the vegetation of hop ($E_{j2011}$=0,02, $E_{j2012}$=0,05), the less productivity was accordingly fixed at the investigated selection of genotypes. And by the most unfavorable year it was set 2010, when the negative value of index of terms of year took place ($E_{j2010}$=–0,36) but the most subzero middle index of the productivity (1,52 t/ha).

Table 1. The productivity of sorts and numbers of hop is in 2010–2014
in the conditions of competitive study of sorts ISGP

| № | Sort, number | Harvest of dry hop, t/ha | | | | | | Effect of genotype of sort, number | |
|---|---|---|---|---|---|---|---|---|---|
| | | 2010 | 2011 | 2012 | 2013 | 2014 | AV on a sort, number, $\overline{Xi}$ | $E_i$ | Grade |
| 1 | Alta | 1,19 | 1,17 | 1,15 | 1,52 | 1,43 | 1,29 | -0,59 | 3 |
| 2 | Slovianka | 1,39 | 1,84 | 1,83 | 1,65 | 1,79 | 1,70 | -0,18 | 2 |
| 3 | Promin | 1,44 | 1,67 | 1,77 | 1,71 | 1,69 | 1,66 | -0,23 | 2 |
| 4 | Haidamatskii | 1,48 | 1,83 | 1,68 | 1,79 | 1,64 | 1,68 | -0,20 | 2 |
| 5 | A–265 | 1,49 | 2,34 | 2,09 | 2,32 | 2,28 | 2,10 | 0,22 | 2 |
| 6 | 5970a | 1,80 | 2,33 | 1,99 | 1,92 | 2,06 | 2,02 | 0,14 | 2 |
| 7 | 6007 | 1,78 | 2,09 | 2,28 | 2,50 | 2,51 | 2,23 | 0,35 | 1 |
| 8 | 6034 | 1,65 | 2,16 | 1,87 | 1,89 | 1,81 | 1,88 | -0,01 | 2 |
| 9 | 7007 | 1,61 | 1,82 | 2,35 | 1,89 | 2,33 | 2,00 | 0,12 | 2 |
| 10 | 7009 | 1,20 | 1,98 | 1,88 | 2,48 | 2,30 | 1,97 | 0,09 | 2 |
| 11 | 7031 | 2,18 | 2,04 | 2,23 | 2,55 | 2,47 | 2,29 | 0,41 | 1 |
| 12 | 7042 | 1,52 | 2,03 | 2,19 | 2,24 | 2,19 | 2,03 | 0,15 | 2 |
| 13 | 7043 | 1,03 | 1,41 | 1,75 | 1,97 | 1,79 | 1,59 | -0,29 | 3 |
| AV for a year, $\overline{Xj}$ | | 1,52 | 1,90 | 1,93 | 2,03 | 2,02 | 1,88 | - | - |
| $LSD_{05}$ | | 0,31 | 0,23 | 0,22 | 0,30 | 0,31 | 0,24 | - | - |
| Index of terms of year, $E_j$ | | -0,36 | 0,02 | 0,05 | 0,15 | 0,14 | - | - | - |

Middle productivity on the whole for period of researches a posteriori presented 1,88 т/ha, and the greatest productivity was shown by plant-breeding numbers 7031 (2,29 t/ha), 6007 (2,23 t/ha), A–265 (2,10 t/ha). High productivity at the level of 2,0 t/ha it is marked for numbers 7042, 5970a and 7007, that

prevailed the indexes of standard sorts and mean value a posteriori. The positive indexes of effect of genotype of numbers showed the forms marked already with the greatest (accordingly – 0,41, 0,35, 0,22 t/ha) and high (accordingly – 0,15, 0,14, 0,12 t/ha) productivity.

The estimation of parameters of ecological plasticity and stability for the investigated genotypes is expounded in a table 2.

Table 2. Parameters of ecological adaptivity of sorts and numbers of hop

| № | Sort, number | Middle productivity, $\overline{Xi}$, t/ha | Coefficient of plasticity | | Variation of stability, $S_i^2$ | Sum of grade |
|---|---|---|---|---|---|---|
| | | | $b_i$ | Grade | | |
| 1 | Alta | 1,29 | 0,46 | 3 | 0,01 | 6 |
| 2 | Slovianka | 1,70 | 0,71 | 2 | 0,02 | 4 |
| 3 | Promin | 1,66 | 0,54 | 3 | 0 | 5 |
| 4 | Haidamatskii | 1,68 | 0,48 | 3 | 0,01 | 5 |
| 5 | A–265 | 2,10 | 1,60 | 1 | 0,26 | 3 |
| 6 | 5970a | 2,02 | 0,41 | 3 | 0,02 | 5 |
| 7 | 6007 | 2,23 | 1,37 | 1 | 0,14 | 2 |
| 8 | 6034 | 1,88 | 0,44 | 3 | 0,02 | 5 |
| 9 | 7007 | 2,00 | 1,03 | 2 | 0,18 | 4 |
| 10 | 7009 | 1,97 | 2,25 | 1 | 0,94 | 3 |
| 11 | 7031 | 2,29 | 0,54 | 3 | 0,03 | 4 |
| 12 | 7042 | 2,03 | 1,39 | 1 | 0,13 | 3 |
| 13 | 7043 | 1,59 | 1,65 | 1 | 0,31 | 4 |

The coefficient of regression ($b_i$) characterizes the reaction of sort or number on the change of terms of environment and gives an opportunity to forecast the change of the investigated sign, in this case to the productivity of plants of hop, within the limits of changes of actual terms of experience. The greater size of coefficient of regression specifies on the best norm of reaction of genotype at the change of terms of growing, that is the result of co-operation of macrosystem (plants) with the dynamics of change of environment. On methodology of estimation of parameters of ecological plasticity and stability [7] co-operating of every sort or number with the terms of environment is divided by two parts: linear component of regression ($b_i$) and nonlinear component that is determined by standard deviation from the line of regression ($S_i^2$). Variation of stability of the investigated sign shows as far as reliably a sort or plant-breeding number in the series of experiments answers plasticity as evaluated by the coefficient of regression *bi*. In our researches certainly, that to the genotypes of intensive type with an increase reaction on the improvement of terms of growing numbers belong with the greatest coefficient of regression. Plant-breeding numbers got in this category A–265, 6007, 7009, 7042 end 7043. Standard sort Slavianka and number 7007 are characterized by the middle level of ecological plasticity ($bi \approx 1$). Sorts of Alta, Promin, Haydamatskii and numbers of 5970a, 6034, 7031 with the subzero coefficient of regression poorly react on the change of terms of growing and have more subzero ecological plasticity among the investigated genotypes. High stability of the productivity was distinguish genotypes with the indexes of $S_i^2$ near to the zero (sorts – Alta, Slovianka, Promin, Haydamatskii, numbers – 5970a, 6034, 7031), id est genotypes are with subzero and middle ecological plasticity. And for numbers with the high

level of ecological plasticity characteristic is more meaningful varying of stability of the investigated sign. The results of estimations of results of analysis of variance testify that most sorts and numbers have a reliable linear review on oscillation of ecological terms, as $F_{regr.}>F_{05teor.}$. The productivity changes in accordance with the changes of terms of height and development of plants (to the index of terms of *Ej*), but there are differences after the degree of reaction of genotypes. The estimation of practical meaningfulness of separate genotypes it is impossible to do, leaning only against the value of effects of genotype ($E_i$) or on the estimations of reaction of numbers on the terms of environment (*bi)*. In relation to confidence intervals $\gamma_{Ei..-E..}$ end $\gamma_{bi-b..}$ for sorts and numbers of experiments conducted distribution after grades. Confidence limits $\gamma$ expected for the parameter of $E_i$, coming from the parameter of $LSD_{05}$ for experience on the whole (Table 1): $\gamma_{Ei..-E.}=\pm LSD_{05}=\pm 0,24$, for a parameter *bi*: $\gamma_{bi-b}=1\pm t_{05}S_b=1\pm 0,38$. After the effect of genotype grade unit gave to the numbers in that $E_i>0,24$, id est to the numbers that have an effect, for certain prevailing middle effect for the selection of the investigated sorts; grade two - to the numbers in that $-0,24< E_i >0,24$ and three – to the numbers in that: $-0,24<E_i$. After the degree of expression of review, id est after plasticity for understanding of effect of genotype, units gave a grade to the numbers from $bi>1,38$, two – from $0,62\leq bi\leq 1,38$ and three – from $bi<0,62$. Sumy of grades gave possibility to get the index of estimation of practical meaningfulness of numbers. A number 6007, that has a minimum sum of grades (reliable exceeding after the productivity – 2,23 t/ha), high ecological plasticity (of $b_i=1,37$) and small deviation from the line of regression (0,14), is certain in research the most valuable number. Among genotypes that collected a sum 3 points most valuable there are numbers of A–265 and 7042 (high productivity, plasticity and insignificant varying of sign), and here a number 7009, at the high productivity (1,97 t/ha) and the greatest coefficient of ecological plasticity (2,25), was distinguished by the very considerable varying of stability of sign (0,94). Also, deserve attention of numbers 7007 and 7031, that have a general point of estimation 4, but after the productivity and plasticity are let in on the ground above standard sorts.

**Conclusions**

For the increase of effectiveness of selection on adaptive signs the method of their estimation is used at sorts and numbers of hop, based on probation of genotypes in long-term research at the different terms of environment (to the year) on the indexes of coefficient of regression (ecological plasticity) that testifies to the corresponding norm of reaction, after varying of stability of sign (deviation is from the line of regression) and by generalized estimation of practical meaningfulness of the investigated genotypes.

By conducted estimation to the genotypes of intensive type with an increase reaction on the improvement of terms of growing numbers belong with the greater coefficient of regression ($b_i>1,0$) : A-265, 6007, 7009, 7042 and a 7043. Slavianka and 7007 characterized by the middle level of ecological plasticity ($b_i\approx 1$). Alta, Promin, Haidamatskii, 5970a, 6034, 7031 poorly react on the change of terms of growing and have more subzero ecological plasticity ($b_i<1,0$). After stability of the productivity (quadratic deviation from regression of Si2 is near to the zero) sorts are certain: Alta, Slavianka, Promin, Haidamatskii; numbers: 5970a, 6034, 7031, that have middle and subzero ecological plasticity. For the numbers of A–265, 6007, 7009, 7042, 7043 with the high level of ecological plasticity characteristic is more meaningful varying of stability of the investigated sign ($S_i^2$ 0,12-0,94).

By generalized estimation of practical meaningfulness most adjusted to the changes of terms of growing in the zone of Polesye it follows to count genotypes 6007, A- 265, 7042.

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