# VARIABILITY, HERITABILITY AND INTERRELATIONSHIPS IN THE MORE IMPORTANT PROPERTIES OF HOP CONNECTED WITH THE MECHANIZATION OF HARVESTING AND PROCESSING

*Marian Milczak*

## INTRODUCTION

The adaptation of varieties to mechanized harvesting is an important direction in contemporary breeding of all plants, and also of hop. Exceptional delicacy of the harvested raw material (cones) and the short period of its technological ripeness create the necessity of including in the process of selection the properties that did not play a greater role in hand harvesting. An ideal for combined harvester harvesting variety of hop should be characterized by a weak binding of cone to sprout, high elasticity of cover leaves, and by spherical cones of mean size. Before the process of methodical breeding will succeed in obtaining forms of the optimum level of all these peoperties simultaneously, we should collet information about the variability range in a population for each of them separately. It is also necessary to get to know their interrelations with other properties of economic significance and to determine the interaction between a genotype and the environment.

The aim of the present work was the evaluation of the variability and interrelations of some physical and economic properties in a mixed population of hop.

## MATERIAL AND METHODOLOGY

The experimental material was constituted by 90 plants of hop of cross-breeding origin (cv. Northern Brewer × Polish variety) in the 3rd-4th year of crop yielding. The plants were cultivated on soil derived from loess, at the distances 3 × 1.5 m. From the numerous investigated properties in the paper are included only those that are connected with either the mechanization of harvesting or are of significance for the brewing industry.

Samples for measurements were takne in the period of technological ripness of cones. The force of cone to sprout binding and the thickness and length of petiole were determined on the basis of 40 measurements from a plant; biometric measurements of dry cones were made in 10 repetitions.

The equipment used: the force of cone to sprout binding was determined with the application of an electromagnetic micropicker [1] content of $\alpha$ acids was determined conductometrically.

Results from the period 1974-1975 were worked out statistically, calculating for the whole population the following parameters: a) arithmetical means, b) coefficients of variability, c) coefficient of linear correlation between the years, d) coefficients of regression between years (repetitiveness coefficients), e) linear coefficients between all the properties within each year. The calculations were made by the Institute of Numerical Methods of Agricultural Academy in Lublin.

## PRESENTATION OF RESULTS

The presented in Table 1 values of the basic statistical parameters describe the level of the properties, their variability and repetitiveness in the years. From the breeder's point of view particular attention is drawn to three properties: the force of cone to sprout binding, the content of $\alpha$ acids, and the participation of torus in the weight of cone. The common property of these features is the relatively low interaction of genotype with the environment, the expression of which are the highest, within the group of investigated properties, coefficients of correlation (0.42-0.50) and regression (0.43-0.55) between the years. This increases considerably — in relation to other properties — the probability of adequante choice of desired genotypes, already after a single testing of the population. Without any greater risk of making a mistake we can assume that the calculated coefficients of regression determine the upper limit for the heritability coefficients ($b_{xy} \approx h^2$). At such a degree of heritage determination of properties the obtaining of a significant breeding advance as a result of selection should not pose greater difficulties.

The degree of interdependence between the investigated properties is presented by the correlation coefficients compiled in Table 2. All the values $r$ exceeding 0.207 are to be considered as significant, with the orror margin of 0.05. From the presented results attracts attention the relatively high correlation between the force necessary to pluck a cone and the thickness of petiole (0.829 in 1974 and 0.369 in 1975). Since, however, this last property shows low heritability ($h^2 = 0.214$) it cannot serve as a sure marker at the indirect evaluation the susceptibility of

Table 1

Mean value $\bar{x}$, variability $W$ and interdependence $r_{xy}$ and $b_{xy}$ of some properties of singles of hop from the 1971—1775 harvest

| Property | Property number | Measurement unit | Mean value $\bar{x}$ in the years | | Variability index $W$ in the years | | Correlation indeks $r_{xy}$ | Regression index $b_{xy}$ |
|---|---|---|---|---|---|---|---|---|
| | | | 1974 | 1975 | 1974 | 1975 | | |
| Force necessary to pluck a cone | 1 | N | 3.03 | 3.00 | 17.7 | 24.0 | 0.416 | 0.553 |
| Thickness of stem (fresh cones) | 2 | mm | 0.89 | 0.84 | 10.1 | 10.5 | 0.218 | 0.214 |
| Length of stem (fresh cones) | 3 | mm | 22.5 | 19.6 | 22.1 | 20.7 | 0.370 | 0.300 |
| Weight of 100 cones (dry) | 4 | g | 14.6 | 17.4 | 19.3 | 24.8 | 0.260 | 0.399 |
| Participation of torus in the weight of cone (dry) | 5 | % | 10.6 | 13.0 | 16.1 | 16.2 | 0.424 | 0.525 |
| Copmactness index of cone (dry) | 6 | conventional | 5.85 | 4.62 | 11.9 | 14.5 | 0.243 | 0.229 |
| Weight of fresh cones from one stalk | 7 | kg | 0.92 | 1.23 | 53.8 | 42.8 | 0.052 | 0.055 |
| Content of acids | 8 | % | 6.04 | 4.74 | 33.0 | 35.8 | 0.505 | 0.430 |

* x = property value in singles from 1974 (independent variable at the $b_{xy}$ index).
$y$ = property value in singles from 1975 (dependent variable at the $b_{xy}$ index).

Table 2

Correlation indexes in 1974 and 1975

| Property numbec* | Property number* | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| 1 | — | 0.829 | 0.241 | 0.206 | —0.014 | —0.300 | —0.276 | 0.180 |
| 2 | 0.369 | — | 0.301 | 0.285 | 0.019 | —0.349 | —0.303 | 0.145 |
| 3 | 0.346 | 0.005 | — | 0.270 | 0.235 | —0.319 | —0.005 | 0.092 |
| 4 | 0.366 | 0.275 | 0.321 | — | —0.164 | —0.470 | —0.114 | 0.147 |
| 5 | 0.278 | —0.159 | 0.185 | —0.230 | — | —0.252 | 0.140 | 0.064 |
| 6 | —0.428 | 0.185 | —0.386 | —0.278 | —0.425 | — | 0.063 | —0.170 |
| 7 | 0.101 | —0.016 | 0.089 | 0.288 | —0.060 | —0.135 | — | 0.144 |
| 8 | 0.205 | 0.175 | —0.002 | 0.492 | —0.125 | —0.130 | 0.314 | — |

$r_{xy}$ in 1974

$r_{xy}$ in 1975

* According to the sequance enumerated in Table 1.

cones to plucking. The properties characterized by the highest heritability (vide Nos 1, 5 and 8 in Table 1) were not correlated to each other ($r_{xy}$ negligible or diverse in the years). This phenomenon is very favourable for the breeding of new varieties. At a proper choice of the parent components there should occur in $F_2$ phenotypes of optimum level of each of the properties in question.

The economic value of a variety is to a considerable degree determined by its crop yielding potential. This property (No 7 in Table 1) in the investigated population was characterized by very high phenotypic variability ($W$ = 43-53%), the lowest heritability ($h^2$ = 0.06) and a lack of unequivocal correlation with the other investigated properties.

## DISCUSSION

The model of a variety well adapted for mechanized harvesting comprises many properties. According to Skládal (1974) none of the eighteen varieties investigated by him corresponded to the ideal model: the closest to the theoretical standard was the Yakima variety. One of the properties of considerable significance for the discussed direction of breeding is the susceptibility of cones to plucking. The reports of Zaorski [4] and Panas [2] point to considerable differentiation of varieties in respect of this property (2.6-5.3 N).

In the investigations of Szot and Milczak [1] the range of this property in 25 singles of hop varied from 1.6 to 4.2 N. This range was confirmed also in the present work, on much more numerous material (90 singles), and the mean value was in the range 2.5-3.5 N. The property

in question does not show correlations with other properties of economic significance (crop yield, technological value), which greatly facilitates the programming of breeding of ideal models of varieties, which are awaited both by the producer of raw material, and by the brewery industry.

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*M. Milczak*

## ZMIENNOŚĆ, ODZIEDZICZALNOŚĆ I WSPÓŁZALEŻNOŚĆ WAŻNIEJSZYCH WŁAŚCIWOŚCI CHMIELU WIĄŻĄCYCH SIĘ Z MECHANIZACJĄ ZBIORU I PRZETWÓRSTWEM

### Streszczenie

Znajomość zakresu zmienności cech ważnych gospodarczo oraz istotnych dla mechanizacji, ułatwia hodowcom wyprodukowanie odmian dostosowanych do współczesnych wymogów technologii uprawy i zbioru. W literaturze polskiej brak jest badań nad zmiennością i odziedziczalnością cech ilościowych w populacjach mieszańcowych chmielu. Wstępne prace na ten temat podjęto w Instytucie Hodowli Roślin w 1974 roku. Materiał eksperymentalny stanowiło pokolenie pierwsze ($F_1$) kombinacji krzyżówkowej: cv. Northern Brewer × ♂ krajowy. Badania prowadzono na 3—4 letnich roślinach (90 osobników żeńskich). Z licznych badanych cech uwzględniono w opracowaniu tylko te, które wiążą się bądź to z mechanizacją zbioru, bądź też są istotne dla przemysłu piwowarskiego. Były to cechy następujące: 1) siła statyczna niezbędna do oderwania szyszki od pędu, 2) grubość szypułki, 3) masa 100 szyszek, 4) wskaźnik zbitości szyszki, 5) udział osadki w masie szyszki, 6) masa zielonych szyszek z 1 pędu rośliny, 7) zawartość kwasów w suchej masie szyszek.

Zmienność fenotypowa wymienionych cech była w badanej populacji zbliżona do rozkładu normalnego. Na podstawie 2 letnich wyników wyselekcjonowano pojedynki odznaczające się dużą podatnością szyszek na zrywanie, a przy tym plenne i o dobrej jakości surowca.

*М. Мильчак*

# ИЗМЕНЧИВОСТЬ, НАСЛЕДУЕМОСТЬ И ВЗАИМОЗАВИСИМОСТЬ ВАЖНЕЙШИХ КАЧЕСТВ ХМЕЛЯ, СВЯЗАННЫХ С МЕХАНИЗАЦИЕЙ СБОРА И ПЕРЕРАБОТКОЙ

Резюме

Зная пределы изменчивости качеств, важных в хозяйственном отношении и существенных для механизации, растениеводы легче выводят сорта, приспособленные к современным требованиям технологии выращивания и сбора.

В польской литературе отсутствуют исследования изменчивости инаследуемости количественных свойств в гибридных популяциях хмеля. Предварительные работы по этой теме были предприняты в Институте растениеводства в 1974 г. Опытным материалом являлось первое поколение ($F_1$) комбинации при скрещивании: cv. Northern Brewer × ♂ отечественный. Исследования велись на 3-4-летних растениях (90 женских особей). Из многих исследуемых качеств в настоящей учтены лишь те, которые связаны либо с механизацией сбора, либо являются существенными для пивоваренной промышленности. Это были следующие качества: 1) статическая сила, необходимая для отрыва шишки от побега, 2) толщина ножки, 3) масса 100 шишек, 4) показатель плотности шишки, 5) удел стержня в массе шишки, 6) масса зеленых шишек с 1 побега растения, 7) содержание $\alpha$-кислот в сухой массе шишек.

Фенотипическая изменчивость упомянутых свойств была в иследуемой популяции близка к нормальному распределению. На основании 2-летних результатов были отобраны единичные экземпляры, отличающиеся повышенном срываемостью шишек, а притом уропжайные и с хорошим качеством сырья.

Address of the author

Doc. Dr Marian Milczak,
Institute of Plant Breeding and Seed Science, Agricultural Academy,
ul. Akademicka 15, 20-033 Lublin, Poland