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# UTILIZATION OF SUNFLOWER YIELD POTENTIAL IN RELATION TO STAND STRUCTURE AND GROWING CONDITIONS

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SUMMARY

The results of the trials carried out in the ČSFR for several years show that the yield potential of hybrids is under average growing conditions realized to 40–50%. The best growers reach the realization up to 70%.

The maximum utilization represents 95% of the corresponding achene yield of 4.5 t/ha. By breeding for increase of the stand yield potential the achene yield up to 6.3 t/ha can be reached i.e., 3 t/ha of oil. This represents an increase of the present yield potential, of 140%.

The optimum stand density varies according to the locality, soil texture, type of hybrid and sometimes according to the level of nutrition and management from 50 000 to 75 000 individuals per hectare, at the medium optimum 60–65 000 and yield per area (yield potential) up to 5.5 t/ha in experimental fields and 4.5 t/ha in production fields.

Higher stand productivity is connected with the increase of individuals per area. However, plants toleranting increase of density have to posses progressive traits.

**Key words: sunflower, yield potential, stand structure, growing conditions**

## INTRODUCTION

This study is focused on reason of uncomplete utilization of sunflower yield potential and aims at ascertaining its possible pre–conditions by determination of optimum stand density.

Estimates of the proportions of individual reasons and pre–conditions are based on the postulation that the yield potential of present hybrids represents 100% and its depression is caused by negative factors. For instance:

- decrease caused by disease in favourable years for sunflower growing even uder preservation of all principles of the growing technology leads to yield depression up 90%
- decrease caused by harvest losses even under preservation of all technological requirements to 85%
- decrease caused by neglecting technological requirements to 40%.

On the other hand but backwards:

- increase due to organizational measures can save the genetic yield potential and stabilize it at 55%
- increase due to correctly applied technological measures to 85%
- increase due to important harvest mechanization to 90%
- increase due to breeding for disease resistance to 95%
- increase due to breeding for improved plant yield potential to 105%
- increase due to breeding for improved stand yield potential to 140%

Limits of estimates vary between 40% and 14% which represents the range from 1–8 t/ha to 6–3 t/ha, which we consider as biologically realistic for sunflower productivity.

## MATERIAL AND METHODS

Optimum stand density for present genotypes was determined by analyses of several polyfactorial trials where stand density was one the factors studied.

A three-year trial was carried out at 4 locations with three cultivars at three planting rates representing 50 000, 67 000 and 83 000 individuals per hectar.

Varietal population VNIMK 6540, medium early hybrid Romsum 52 and early hybrid Romsum 90 were included in the trial. Presently, the productivity of these hybrids is not considered as very high. However, they were registered in the ČSFR when the trial was established. This choice has no substantial influence on the result of the study.

For determination of two basic parameters, i.e., optimum stand density and maximum achene yield corresponding to it, the following procedure was applied: initial relation is the equation

$$\ln y = \ln a + bx$$

- where y represents yield per plant
- x stand density

optimum density is derived from the relation

$$x_{opt} = -\frac{1}{b}$$

maximum yield from the relation

$$y_{max} = x_{opt}\frac{a}{e}$$

where "a, b" are regressive coefficients of linear regression between stand density and yield per plant, "e" is the Euler number.

In the described trials, the values "a, b" and hence also "x" opt. and "Y" max. are most exactly determined for the third trial where regression is calculated from 23 data, in the two trials the calculation is useful only for relative comparison of the variants involved.

## RESULTS AND DISCUSSION

Determination of optimum stand density was based on utilization of progressive plant traits in raising the yield potential. Raising yield potential of the stand by increasing its density requires a plant of a new type, that can keep the present high physiological capacity leading to undiminished achene production per plant even at a less robust morphological habit.

Such a plant that endures stand density increase to 85 000 individuals per hectare at the yield of 74 grams of achenes per plant will have increased yield potential by additional 35% and will achieve yield at the limit 6.3 t/ha, hence 3 t of good quality oil per hectare.

Traits that can affect sunflower yield potential increase must enable a higher stand density and limit conditions that favor the development of diseases in more dense stands.

High stand density requires decrease of plant height from the present 140–160 cm to approximately 120 cm. With regards to the fact that the plant height of hybrids is more

or less uniform in the whole stand, we cannot count with its vertical stratification and utilization of the space in storeys. Lower plants can be organized closer in the row than till now, i.e., the distance between achenes can be diminished from the present 22 cm up to 16 or 17 cm, which is a condition for an increase of stand density to 85 000 individuals per hectare.

A trait suitable for the increase of stand density is also the so-called "erectoid habit". The plant of this phenotype has leaf petioles inserted under a more acute angle. The plant perimeter is slightly smaller, so that the plant has a "poplar" appearance. Number and size of single leaves can remain undiminished. However, with regards to a higher mutual coverage of the leaves the total active photosyntetic leaf area of the plant is obviously somewhat lower. This needs not affect the yield too much in the negative direction because the normally formed leaf area in sunflower is somewhat oversized with regards to the achene yield achieved.

Narrow plant favourable for the increase of stand density can be also obtained by shortening petioles, the extreme case being leaves without petioles. This trait of complete lack of petioles does not occur within the framework of variability of the cultivated Helianthus annuus species, however, it can be created by transformation from some wild species of sunflower.

Shortening or even a complete petiole reduction limits considerably the leaf phototropism of sunflower.

Phototropic leaves show by about 10% higher utilization of the solar energy than stationary leaves. However, it has to be again noted, that the productivity of sunflower leaf area is usually higher than corresponds to the head sink area and capacity of the vascular bundles leading products of assimilation to the head. Smaller plants with short and erect petioles offer predisposition for the desired stand density increase to 85 000 individuals. The new habit must preserve the present level of physiological plant traits, i.e., completely functional sink area of the head with diameter 18 cm, size and efficiency of the root system and also undiminished capacity of the vascular bundles. Only the total active leaf area can be diminished but its area unit efficiency, sufficient for the desired achene yield per plant (i.e., 75 g), has to be preserved.

Besides traits enabling immediately a higher stand density, the new type of the plant also has to possess traits limiting the development of head diseases in the more dense stands.

Those are particularly traits of the head as such. It is necessary to obtain the optimum position (i.e., degree of inclination) then the head bed as thin as possible and ability of the head to dry as fast as possible in the period of achene maturation.

A suitable type is also a direct, narrow connection of the stem top with the middle part of head bed and a flat head without curvature on the outer or inner side.

A favourable trait for limitation of head diseases is the lack of leaves below the head. A greater distance between leaves and head causes some extension of the vein transport between the nearest source of assimilates and achenes, however, leaves in the upper part of the stem are usually less developed and participate in the formation of achene yield only to a limited extent. The decisive leaves located in the middle part of the plant are not more distant from the head in this sunflower type with "long neck" than in the standard type.

The mentioned traits increase the yield potential of sunflower stand or enable its maximum realization. In harmony with the increase of stand density, yield potential of the single plant can be increased by limiting the so-called "empty center", hence by obtaining equal filling of the head by achenes of full value. This is connected first of all with mutual harmonization of physiological traits of the plant as efficiency of the root system and photosynthetic apparatus on the one hand and vascular capacity particularly in the stem part entering the head on the other hand. As shown by the following data, environmental factors such as soil, nutrition and locality affect progressive traits.

| *Localities* | Vrakuna | N.Zámky | Pohr.Ruskov | Trebišov |
|---|---|---|---|---|
| optimum number of individuals (in thousands) | 72.70 | 63.77 | 60.50 | 46.60 |
| maximum yield (t/ha) | 5.39 | 4.96 | 5.25 | 3.90 |

| | Romsum 90 | VNIMK 6540 | Romsum 52 |
|---|---|---|---|
| *Cultivars* at three stand density levels (50, 66.5 and 83.3 thousands/hectare) | | | |
| optimum number | 67.28 | 63.21 | 55.57 |
| maximum yield | 4.97 | 5.00 | 4.92 |
| *Cultivars* at two stand density levels (62 and 75 thousands/hectare) | | | |
| optimum number | – | 59.61 | 63.81 |
| maximum yield | – | 4.97 | 5.68 |

| *Soil* | madium heavy | light |
|---|---|---|
| optimum number | 72.47 | 51.25 |
| maximum yield | 6.31 | 4.34 |

| *Nitrogen fertilization* | 120 kg/ha | 150 kg/ha |
|---|---|---|
| optimum number | 70.92 | 52.80 |
| maximum yield | 5.61 | 5.04 |

A comparison of localities shows a certain trend of decrease of optimum stand density in the direction from west to east. Higher stand density does not always mean a higher yield per unit area.

For instance at the locality Pohronsky Ruskov, high yield is obtained also at a relatively low stand density. An extreme case is the locality Trebišov, where the results indicate that for present cultivars agroecological conditions in East Slovakia are bad, not enabling increase of stand density and comparably high yield per area unit. However, the production per plant is higher at the locality Trebišov than at the locality Vrakuna, where the highest yield per area is obtained due to the possibility of a high stand density.

A comparison of soil conditions indicates a possibility of increasing stand density on medium–heavy soils in comparison with light soils. At the some time the yield per plant in the thinner stands on light soils does not increase.

On the contrary at the high nitrogen dose (150 kg/ha can be considered as over–fertilization) the yield per area decreases, but at the lower dose the optimum stand density yield per plant increases.

As for the cultivars, early hybrid Romsun 90 requires high stand density to achieve a comparable yield with a medium early hybrid or population.

The yield potential in the first trial almost does not differ in single cultivars (it varies between 4.9 and 5.0 t/ha) but it is achieved at various optimum stand densities.

If we compare the results of the first and second trial for the genotypes (VNIMK 6540 and Romsun 52), it becomes obvious that the hybrid responds more expressively to environmental conditions by the change of optimum density than the varietal population. The later cannot utilize the improved level of factors in the second trial for increases of stand density and yield as the hybrid.

## CONCLUSION

The results of the trials carried out in the ČSFR for several years show that the yield potential of hybrids is under average growing conditions realized to 40–50%. The best growers reach the realization up to 70%.

The maximum utilization represents 95% of the corresponding achene yield of 4.5 t/ha. By breeding for increase of the stand yield potential the achene yield up to 6.3 t/ha can be reached i.e., 3 t/ha of oil. This represents an increase of the present yield potential, of 140%.

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**UTILIZACION DEL RENDIMIENTO POTENCIAL DEL GIRASOL EN RELACION A LA ESTRUCTURA DE LA POBLACION Y CONDICIONES DE CRECIMIENTO**

RESUMEN

Loc rocultades de ensayos llevados a cabo en el ČSFR durante varios años muestran que el rondimiento potencial de los híbridos está por debajo de la media de las condiciones de crecimiento con un porcentaje de 40–50%. Los mejores cultivadores llegaron hasta el 70%.

La utilización máxima representa el 95% de correpondiente rendimiento en aquenios de 4.5 T/ha. mediante la mejora en incremento del rendimiento potencial de aquenios hasta 6.3 T/ha i.e. 3 T/ha de aceite puede ser alcenzada. Esto representa un incremento del rendimiento potencial actual del 14%.

La densidad óptima varía de acuardo con la locallded, textura del suelo, tipo de híbrido y algunas vaces de acuerdo con el nivel de nutrición y manejo, de 50.000 a 75.000 individuos por hectárea, con una media óptima de 60–65.000 y rendimiento potencial has 5.5 t/ha en campos experimentales y en campos de producción de 4.5 t/ha.

La mayor productividad está conectada con el incremento de plantas por unidad de superficie. Sin embargo, las plantas que toleran un incremento de densidad deben poscor caracteres adaptativos.

**UTILISATION DU POTENTIEL DE RENDEMENT DU TOURNESOL EN FONCTION DU TYPE DE STRUCTURE ET DES CONDITIONS DE CULTURE.**

RÉSUMÉ:

Les résultats des essais effectués en Tchécoslovaquie au cours de plusieurs années montrent que le rendement potentiel des hybrides est réalisé à 40-50% en fonction des conditions de culture. Les meilleurs cultivateurs atteignent 70% de ces réalisations.

Le maximun d'utilisation représente 95% d'un rendement en grain correspondant à 4,5 t/ha. Grâce à la sélection visant à l'amélioration du rendement potentiel, le rendement en grain peut atteindre 6,3 t/ha c'est à dire 3,0 t d'huile par hectare. Cela représente une augmentation de 140% du rendement potentiel actuel.

Le niveau optimal de densité varie selon la localité, la texture du sol, le type d'hybride et quelquefois selon le niveau de nutrition. Cet optimun varie de 50 000 à 70 000 individus par hectare avec une moyenne optimale de 60 - 65 000 ce qui correspond à un rendement potentiel de 5,5 t/ha en champ expérimental et de 4,5 t/ha en champ de production.

Un plus haut niveau de productivité est relié à une augmentation du nombre d'individus par surface. Cependant les plantes tolérant une augementation de densité doivent posséder des caractéres nouveaux.