THE ROLE OF GENOTYPE AND FERTILIZATION IN SUNFLOWER PRODUCTION

Pepo Peter, Attila Vad

University of Debrecen CAAES
Faculty of Agricultural and Food Sciences and Environmental Management
Institute of Crop Sciences

Abstract

Arable land use structure has simplified in Hungary in the last three decades. Cereals (small grains and maize) have ~67% and oil crops have ~19% of arable land. The most important oil crop is the sunflower in Hungary. In the past decade the country average yield dinamically increased (~2500 kg ha^{-1}) but the yield fluctuation remained on the high level (~52%). So it is very important issue how to develop the environmental friendly, sustainable sunflower production. Our scientific results proved that the selection the appropriate hybrid is very important agrotechnical factor. In the very early maturity group the yields varied between 2500-4900 kg ha^{-1}, in early maturity group the yields were 2500-5200 kg ha^{-1} and in middle maturity group the yields of genotypes fluctuated between 2300-5400 kg ha^{-1} in 1998-2006 years, respectively. Our long-term experiments pointed out, that the sunflower can utilize well the natural nutrient stock of the soil. So the optimum fertilizer doses varied 30-100 kg ha^{-1} N, 40-80 kg ha^{-1} P_2O_5 and 50-120 kg ha^{-1} K_2O on chernozem soil depending on cropyear, phytosanitery status, sowing time, plant density and genotypes. According our scientific results it is very important to use hybrid-specific fertilization in sunflower production.

Key words: sunflower, genotype, fertilization, yield, oilcontent.

INTRODUCTION

Oil crops constitute the second most significant group of crops worldwide, after cereals. Their production has significantly increased especially for the last 2-3 decades.

The rapid increase in plant oil production was verified by the increased demand originating from the propagation of healthy nutrition, a considerable increase in demand by processing industries and the huge increase in its utilization as a fuel (biodiesel).

In Hungary, sunflower had been 'the oil crop' for decades and the production of other oil crops was negligible. For the past ten years, there has been a spectacular growth in rapeseed sowing area due to the increased demand. Presently, the sowing areas of sunflower and rapeseed in Hungary are 500-550 000 hectares and 250 000 hectares, respectively.

Hungary, with sunflower sowing area of 500-550 thousand hectares, can be considered a significant grower. Hungarian yields (2000 kg ha^{-1}) were favourable in the 1980s. It was an especially positive feature that yield fluctuation was also moderate in these years (15.4%), proving the excellent adaptive ability of sunflower. The economic, financial and other problems of the 1990s resulted in a significant reduction in yields (1600-1700 kg ha^{-1}). The fact that yield fluctuation tripled (54.2%) was also especially unfavourable. Development in biological bases and agrotechnique had resulted in the increase of national yields to 2100 kg ha^{-1} by the 2000's. However, the level of yield fluctuation remained unfavourably high (51.6%).

The production technology of sunflower changed considerably in the past decade primarily due to the cardinal changes in the biological bases of the crop. With the significant enrichment of the hybrid portfolio, the formerly homogenous species-specific requirements of sunflower have become differentiated, consequently, there is a need for developing hybrid-specific technologies (*Pepó et al.* 2003).

According to *Pepó* (2007), the hybrid assortment quadrupled between 1990 and 2005, while the majority of hybrids (83%) had to be moved from the extensive agrotechnique group into the mid-tech or intensive group.

Sunflower is a crop which can utilize well the natural nutrient stock of the soil. Excessive fertilization may result in phytopathological, agronomical problems, while fertilization deficiencies reduce the yield. The effects and efficiacy of fertilization are greatly influenced by the agro-ecological (soil, weather) and agrotechnical conditions (*Bíró* and *Pepó* 2008). The effects of the year (*Borbélyné et al.* 2007) and global climate change (*Várallyay* 2007) are manifested partly in yield quantity and yield stability (*Birkás et al.* 2006). The utilization of fertilizers, especially that of nitrogen, is strongly influenced by the processes of the soil-plant system (*Németh* 2006). Domestic and foreign research results proved that, depending upon the conditions, the fertilization requirements of sunflower ranged within lower (40-60 kg ha^{-1} N+PK) (*Stulin* 1991, *Taha et al.* 1999, *Pepó* 2001) and higher (75-120 kg ha^{-1} +PK) intervals (*Malik et al.* 1992, *Reddy* and *Shaik* 2000). According to the experiment of *Kádár* and *Vass* (1988) on acidic sandy soil in the Nyírség, the yield of sunflower was 750 kg ha^{-1} without fertilization. As a result of a harmonized NPK fertilization, the yields almost doubled (1430 kg ha^{-1}) and the effect of meso-elements (Ca, Mg) was also very significant (2645 kg ha^{-1} yield in the NPK + CaMg treatment). On chernozem soil with a good nutrient supply, P and K had a minimal and N had a moderate effect (*Kádár et al.* 2001). According to their results, excess fertilization increased susceptibility to diseases (infection by *Macrophomina*, Alternaria and *Sclerotinia* increased) and not the yield. In contrast to other crops (maize, wheat), there has been only limited research providing relevant data on the hybrid-specific fertilization of sunflower hybrids (*El Nakhlawy* 1993, *Vasudevan et al.* 1997, *Pepó et al.* 2002, *Pepó* and *Bíró* 2003).

MATERIAL AND METHOD

The small- and medium-plot field experiments in replications were set up on calcareous chernozem soil at the Látókép experimental site located 15 km from Debrecen along the main No.33. The experimental soil had excellent water and nutrient management qualities.

The experimental soil has excellent water uptake and water bearing capacity.

The long-term experiment was set up in 1983. Since then, the different plots have continuously received the determined treatments.

The structure of the other experiments was determined in accordance with the experimental objectives.

In the experiments, the same optimal agrotechniques were applied apart from the treatments, which provided an opportunity to compare the effect of the studied agrotechnical factors and the year.

In the experiments, the development of sunflower stands was continuously monitored, the phenological, phenometrical and phytopathological parameters were assessed and yield quantity and quality were determined.

The obtained data were evaluated using the SPSS 13.0 mathematical-statistical programme.

RESULTS AND DISSCUSIONS

Using the results of our almost two-decade long research on sunflower production, the effects of the different factors on yield in different technologies were evaluated (*Table 1*). When applying an extensive technology, the ecological factors have an influence of 55% on the quantity of yield. The year effect (35%) is especially significant. When applying a more intensive (mid-tech) technology, the impact of environmental factors became substantially weaker (the joint impact of soil and year was only 25%). However, the effect of hybrid selection, crop protection, fertilization and sowing technology on yield increased at an average input use.

Table 1

Role of technological factors in sunflower production
(Peter Pepó, 2009)

Extensive technology		Factor		Mid-tech technology
35 %	←	**Cropyear**	→	**15 %**
20 %	←	**Soil**	→	**10 %**
5 %	←	**Hybrid**	→	**20 %**
15 %	←	**Tillage**	→	**5 %**
5 %	←	**Fertilization**	→	**15 %**
15 %	←	**Sowing**	→	**15 %**
5 %	←	**Crop protection**	→	**20 %**
100 %				**100 %**

Table 2

Effects of cropyear, infection on the yields of sunflower
(Debrecen, 1997-2008)

Year	**Opt. plant density (thousand/ha)**	**Infection**	**Yield (kg ha^{-1})**
1997	40	high	2250
1998	40	high	2000
1999	40	medium	3800
2000	60	low	4500
2001	50	medium	3300
2002	50-60	low	4150
2003	50	low	4200
2004	50	medium	3300
2005	40	medium	2950
2006	40-45	medium	3300
2007	55-60	low	4900
2008	45-50	medium	3900

The agro-ecological conditions of sunflower production changed considerably during the past decades. This means more extreme weather conditions during the vegetation period on the one hand and the deterioration of soil quality on the other hand. Our research results proved that the cropyear significantly modified the yields of sunflower (*Table 2*). The amount and distribution of precipitation in the different years had a significant effect on the level of infections by plant pathogens, on the dynamics of epidemics. The level of infection had an essential impact on the realized yields. The highest yields were obtained in years warmer and drier than the average (e.g. 2000, 2003, 2007) (4200-4900 kg ha^{-1} depending on the year); in these years, the level of infection by stalk, leaf and head diseases was remarkably low. In seasons with average precipitation and temperature (1999, 2001, 2004, 2005, 2006, 2008), diseases infections were higher, which reduced the actual yield (3000-3900 kg ha^{-1} depending on the year). The lowest yields were obtained in those years (1997, 1998) when the infections were strong, which caused a significant reduction in sunflower yields (to 2000-2300 kg ha^{-1} depending on the year).

Our results have proved that the cropyear has a significant impact on sunflower production. However, although the unfavourable effect of the year can not be totally eliminated, it can be considerably mitigated by applying the proper production technology.

For almost ten years, we have tested 40-50 hybrids annually from the different maturity groups (very early, early, medium) (*Figures 1, 2 and 3*). In all three maturity groups, our results showed that hybrid selection has very high significance as regards the yield realized at a given growing site and using a given production. technology.

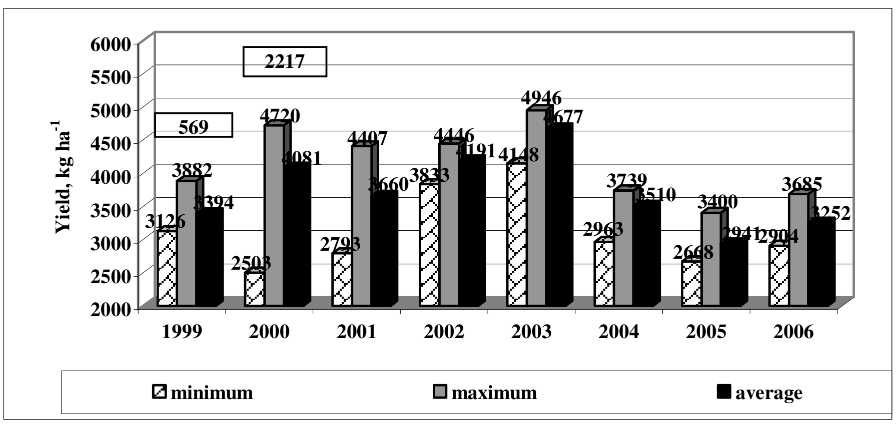

Fig. 1. Role of genotype in sunflower production
(Debrecen, 1998-2006)
Very early maturity group

Depending on the cropyear, the differences between the minimum and maximum yields in a maturity group were 569-2217 kg ha^{-1}, 857-1908 kg ha^{-1} and 791-2284 kg ha^{-1} in the very early, early and medium maturity group, respectively. Regardless of the year (favourable, average, unfavourable), significant differences could be observed between the yields of the tested sunflower hybrids. Considerable differences were found also in the oil content of the hybrids. These results proved that a key factor of the effective technology adapted to the changing climate conditions is the proper hybrid selection.

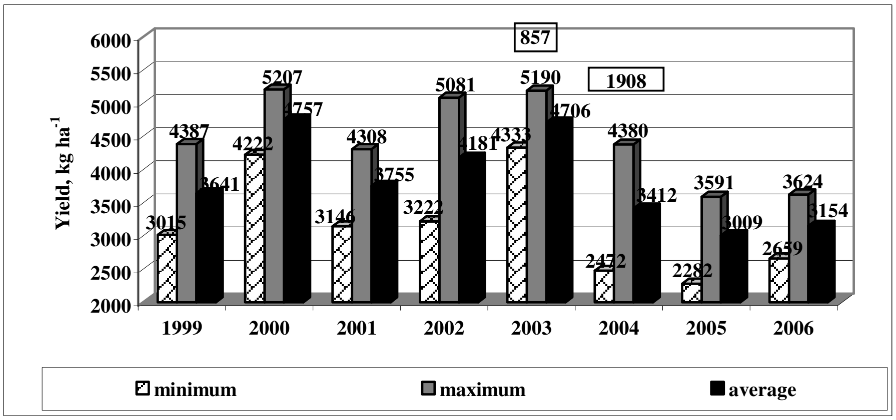

Fig. 2. Role of genotype in sunflower production
(Debrecen, 1998-2006)
Early maturity group

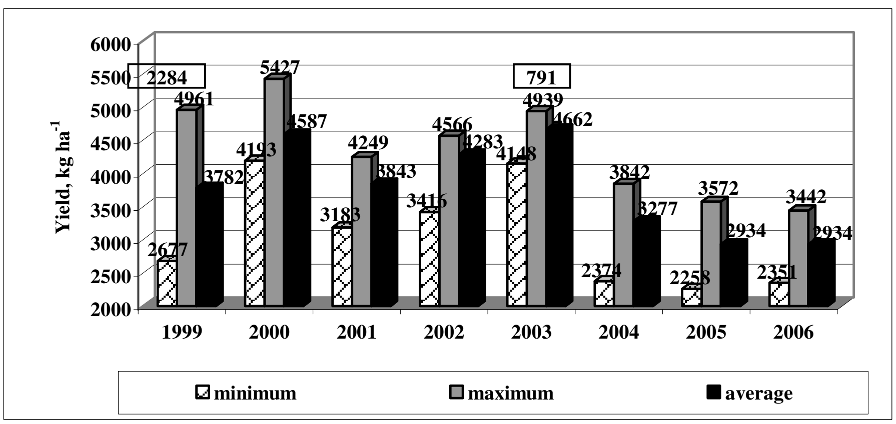

Fig. 3. Role of genotype in sunflower production
(Debrecen, 1998-2006)
Middle maturity group

According to the results of our long-term experiments, the optimum fertilizer requirements of sunflower are as follows:

N	30-100 kg ha^{-1}
P_2O_5	40-80 kg ha^{-1}
K_2O	50-120 kg ha^{-1}

Apart from the soil nutrient stock and the planned yield, the fertilizer dose of sunflower is influenced by several factors.

Our studies have also proved that the fertilizer response of sunflower hybrids can be significantly modified by the cropyear (*Figure 4*). In a dry year, the sunflower hybrids – due to the low infection level – showed a favourable fertilizer response (results of 2007 year). In years with an average water supply, the yield of the hybrids reduced (from a lower yield level) with increasing fertilization as a result of the increasing fungal infection due to fertilization (results of 2008 year).

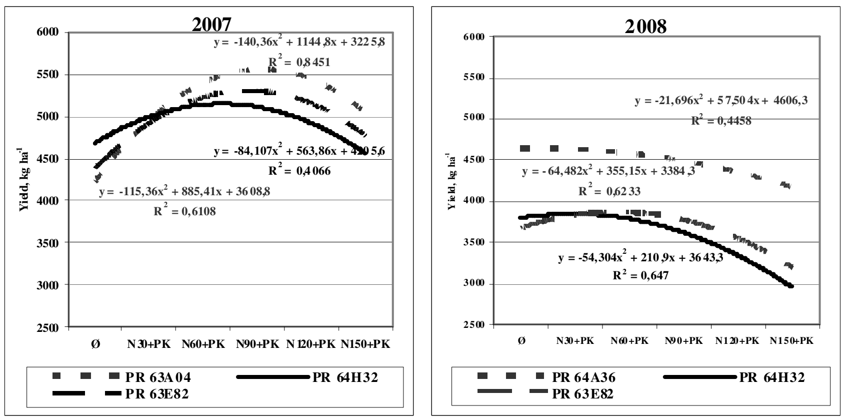

Fig. 4. Fertilizer responses of sunflower genotypes
(Debrecen, 2007-2008)

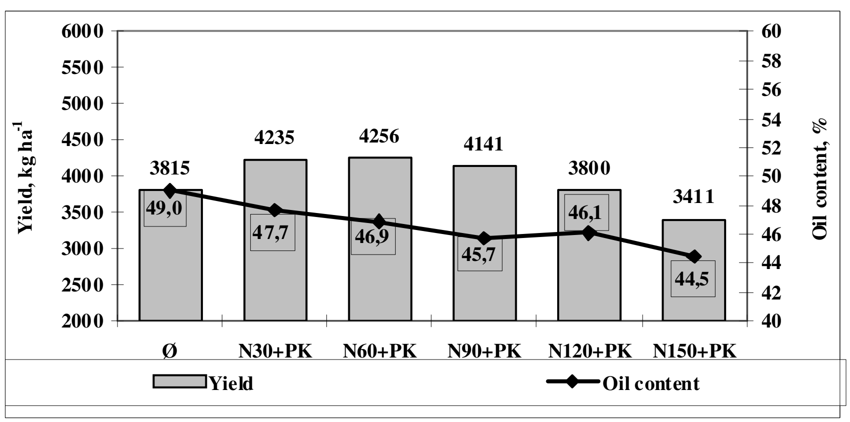

Fig. 5. Effect of fertilization on the yield and oil content of sunflower
(Debrecen, 2009)
(average of the hybrids)

Fertilization had an effect not only on the amount of sunflower yield but also on its quality, that is on oil content (*Figure 5*). Results of 2009 year showed – as an average of the tested hybrids – that increasing fertilizer dosages reduced the oil content. Thus, the optimum NPK dose for maximum yield and maximum oil content differed. For the highest oil yield (kg ha^{-1}), the fertilizer dosage optimal for obtaining the maximum yield should be applied as this has the determinative effect.

CONCLUSIONS

As compared with other field crops, sunflower has a different response to climate change. This is primarily due to its better adaptation ability and stress tolerance. However, even in the case of sunflower, the further development of the production technology elements and their site- and variety-specific adaptation are of exceptional importance. Among the technological elements, hybrid selection, fertilization, sowing technology and crop protection have the special importance. Via the harmonization of these elements, the unfavourable effects of climate change can be mitigated and yields above 4000 kg ha^{-1} can be obtained in the practical sunflower production.

REFERENCES

1. Birkás M.-Dexter. A.R.-Kalmár T.-Botllik L.: 2006. Soil quality – soil condition – production stability. Ceraal Research Communications. 35. 2, 257-260.
2. Bíró J.-Pepó P.: 2008. Néhány eltérő genotípusú napraforgó (Helianthus annuus L.) hibrid trágyareakciójának vizsgálata. Növénytermelés. 57. 2, 149-157.
3. Borbélyné H.É.-Csajbók J.-Lesznyákné M: 2007. Relations between the yield of sunflower and the characteristics of the cropyear. Cereal Research Communications. 35. 2, 285-288.
4. EI Nakhlawy F.S.: 1993. Defoliation effects on yield components and quality of sunflower. Alexandria Journal of Agricultural Research. 38. 3, 257-267.
5. Kádár I.-Lukács D-né-Vörös J.-Szilágyi J.: 2001. A napraforgó (Helianthus annuus L.) műtrágyázása mészlepedékes vályog csernozjom talajon. Növénytermelés. 50. 2-3, 297-308.
6. Kádár I.-Vass E.: 1988. Napraforgó műtrágyázása és meszezése savanyú homoktalajon. Növénytermelés. 37. 6, 541-547.
7. Malik M.A.-Akram M.-Tanyir A.: 1992. Effect of planting geometry and fertilizer on growth, yield and quality of a new sunflower cultivar 'SF-I 00'. Journal of Agricultural Research Lahore. 30. 1, 59-63.
8. Németh. T: 2006. Nitrogen in the soil-plant system, nitrogen balances. Cereal Research Communications. 34 1, 61-65.
9. Pepó P.: 2001. Napraforgó–eredményesen. Magyar Mezőgazdaság. 56. 47, 12-13.
10. Pepó P.: 2007. A hibridspecifius napraforgó-termesztés néhány agrotechnikai elem. Agrofórum. 18. II, 10-14.
11. Pepó P.-BÍró J.: 2003. A napraforgó,hibridspecifikus trágyázása. Növénytermelés. 52. 1, 75-85.
12. Pepó P.-Bíró J.-Zsombik L.: 2003. Az évjárat, a trágyázás és a genotípus hatása a napraforgó néhány agronómiai tulajdonságára. Növénytermelés. 52.1, 87-101.
13. Pepó P.-Zsombik L.-Borbélyné H.É.: 2002. A napraforgó termesztés agrotechnikai fejlesztési lehetőségei. Gyakorlati Agrofórum. 13. 1, 19-22.
14. Reddy M.P.-Shaik M.M.S.: 2000. Influence of nitrogen and phosphatic fertilizer on growth, yield components and yield of sunflower. Crop Research Hisar. 20. 2, 293-296.
15. Stulin A.F.: 1991. Productivity of sunflowers under systematic application of fertilizers in a crop rotation on leached chernozem in the central chernozem zone. Agrokhimiya. 10, 64-70.
16. Taha M.-Acharya N.-Mishra B.K.: 1999. Effect of irrigation and nitrogen on yield and quality of sunflower (Helianthus annuus L.). Journal of the Indian Society of Soil Science. 47. 4, 695-700.
17. Várallyay Gy.: 2007. Láng István, Csete László és Jolánkai Márton (szerk.): A globális klímaváltozás: hazai hatások és válaszok (A VAHAVA Jelentés). Agrokémia és Talajtan. 56. 1, 199-202.
18. Vasudevan S.N.-Virupakshappa K.-Venugopal N.-Bhaskar S.: 1997. Response of sunflower (Helianthus annuus L.) to phosphorus, sulphur, micronutrients and humic acid under irrigated conditions on red sandy-loam soil. Indian Journal of Agricultural Sciences. 67. 3, 110-112.