Long-term influence of cultural practices on sunflower yields in commercial production in Serbia

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ABSTRACT

- Sunflower is one of the main crops in Serbia, with average acreage of 200000 ha. Economic difficulties associated with the transition have caused significant reduction in sunflower yields. The aim of this paper was to compare results from experiments and commercial production in order to identify the shortcomings, emphasize and quantify the definite average perennial influence of cultural practice implementation quality and timing on sunflower yields. This will enable sunflower growers to determine the relative effects of particular cultural practice on yield and thereby potentially increase the profitability.
- During 1994-2002 Institute of field and vegetable crops Novi Sad, conducted annual surveys among sunflower growers to gather data on sunflower growing technology used in Serbia. The interviewed growers hold 6.0-20.5% of the total sunflower acreage. This sample size should be sufficient to obtain a realistic picture of the used cultural practices. We also believe that the nine-year period is long enough for a reliable estimate of average long-term effect of applied cultural practice.
- Inadequate preceding crop, crop rotation range, sowing dates, timing of plowing (basic tillage) and harvesting, fallowing, fertilizer application and between-row cultivation may, in that order, bring about grain yield losses ranging between 400 and 170 kg ha^{-1}. Improper timing, implementation quality and insufficient quantities have been particularly pronounced in the case of measures that require major inputs (no fertilizer has been used on 71% of the acreage on average; on the rest fertilized fields 12, 8 and 7 kg ha^{-1} of N, P_2O_5 and K_2O were applied; spring plowing was used on 22% of the acreage, fallowing was performed only on 29% of the acreage of preceding small grain crops). The less demanding cultural practices, which also have significant effect on sunflower yield, have been poorly implemented to a lesser extent (20% of the acreage had a shorter than tree-year rotation, late planting (May) and late harvesting time (October) were done on 10 and 15 % of the area, respectively; and 2% of area had an inadequate preceding crop;). Preceding crops have not significantly influenced the yield, but after the soybean, the yield was lower by 400 kg ha^{-1}. Sunflower rotation shorter than 4-5 years yields 370 kg ha^{-1} less. Sowing during end of March and beginning of April was best, and late sowing in May yielded 340 kg ha^{-1} less. Spring plowing gave a 270 kg ha^{-1} lower seed yield compared to autumn plowing which is considered the best. The share of spring plowing is diminishing and in the last 3 years is below 5%. Winter plowing (20.XII-20.II) yields 150 kg ha^{-1} more than spring. The harvest in the first two decades of September gave better yields than the too early or too late harvest by 210 kg ha^{-1}. On small grain preceding crops where fallowing has been conducted, a 200 kg ha^{-1} higher yield has been gained. On plots without any fertilizers the average yield was lower by 170 kg ha^{-1}, and in certain years even by 510 kg ha^{-1}. Average of one and two pass of between row cultivation give a 170 kg ha^{-1} higher yield in comparison to uncultivated plots.
- For sunflower in Serbia and similar environment optimal: crop rotation is 4-5 years, sowing date at the beginning of April, autumn deep plowing and harvesting in the first half of September. There were no significant differences in the yield of sunflower after previous crop: wheat, corn and sugar beet and only bed preceding crop is soybean. Fallowing after small grains and between row cultivation of sunflower should be economically approved. Concerning fertilizations should be doubled amount of fertilizers to reach optimal N level of 60 kgha^{-1} like in low-input rainfed management *(*Debaeke et al., 1998)
- A long-term experience from Serbia, in applied growing technology of commercial sunflower production, is very interesting for all producers with similar environmental condition and can contribute to world overall enhanced production and profitability of sunflower.

Key words: grain yield - growing technology - Serbia - survey - sunflower

INTRODUCTION

Sunflower is one of the main crops in Serbia, with average acreage of 200000 ha. The growing technology is a chronological sequence of cultural practices, which adapt environmental conditions in the region to the requirements of the plants, in the aim to realize more genetic yield potential (Andrade et al., 2005). Cultural practices influence mostly on land, and through it's indirectly, on the other environmental conditions. Sunflower growing technology, the most important oil crops in Serbia, is well known and mostly was created based on long term experiments as well as on confirmed results from a commercial production (Crnobarac et al., 2000). Only timely and well implemented cultural practices, in the entire production process, yielding positive results. The influence of cultural practices depends on weather conditions, i e from the moment of occurrence, intensity and duration of adverse weather factors. Due to the volatility and unpredictability of weather conditions, growing technology for a particular region must be based on multi-year average values, although extremes of weather conditions can significantly influence yields. Also, subjective failures or objective circumstances that deviate from the approved production technology can significantly reduce the profitability of sunflower. The main objective circumstance was economic difficulties associated with the transition period and embargo.

The aim of this paper was to compare results from experiments and commercial production in order to identify the shortcomings, emphasize and quantify the definite average perennial influence of cultural practice implementation quality and timing on sunflower yields. This will enable sunflower growers to determine the relative effects of particular cultural practice on yield and thereby potentially increase the profitability.

MATERIALS AND METHODS

This paper analyzes nine-year survey data (1994 to 2002) from commercial sunflower production on the impact of quality and timeliness performance of cultural practice on the yield of sunflower in Serbia. The survey organized by the Institute of Field and Vegetable Crops in Novi Sad, with the help of extension services, oil factories and the producers. The survey in dependence of the years covered 6.0-20.5% of the total area under sunflower in Serbia, or on average of 12.5%, and in total for all 9 years covered 186386 ha (Table 1). This sample size should be sufficient to obtain a realistic and representative picture of the used cultural practices. Also, the nine-year period should be long enough for a reliable estimate of the average long-term effect of applied cultural practices, and that could be basis for improving sunflower growing technology in the region.

Table 1. Sunflower area covered by survey 1994-2002

Year	1994	1995	1996	1997	1998	1999	2000	2001	2002	∑(ξ)
Covered by survey (ha)	14804	18053	12354	32488	32750	24906	16353	19763	14915	**186386**
Area in Serbia (ha)	160850	169389	205262	160325	159776	184000	146415	163155	150183	**166595**
% surveyed area	9.2	10.6	6.0	20.2	20.5	13.5	11.2	12.1	9.9	**12.6**

For any conclusion on the basis of a large number of data is necessary to summing up them, usually in the form of mean values. But the use of other indicators of the data variability, like median, percentiles, minimum and maximum obtained more complete interpretation. If the range of percentile between 25 and 75% is shorter, this means that in narrow interval around the mean values are ½ data frequency, and we could more reliably with less risk make conclusion based on the mean values.

A long-term experience from Serbia, in applied growing technology of commercial sunflower production, is very interesting for all producers with similar environmental condition and can contribute to world overall enhanced production and profitability of sunflower

RESULTS AND DISCUSSION

In the analysis of numerous data from surveys unavoidably are their summing up, but also it can be beneficial use of data variability. By displaying the years we have not received a clear perception of treatment effect, except the range of their action (Fig. 1a). Grouping of years by the treatments we get a clearer representation, with a treatment frequency in the form of the normal curve (Fig. 1b). Further within each treatment, can be made group with certain intervals (Fig. 1c). The final step in summing up the view is as a box wishkers chart (Fig. 1d). Percentage frequency of cases between 25% to 75% is shown within the lower and upper side of box, while the central line shows the median (central value of distribution). The mean value is shown as filled squares and it is equal to median if the frequency distribution is symmetric, and below it if the distribution is asymmetric the left and vice versa. The lines that go up from the middle of polygon show the maximum (+) or down minimum (-) values. On example of impact of crop rotation length (Fig. 1a to 1d) is given a detailed explanation, while the impact of all other cultural practices will be only concisely presented graphically as in Fig. 2a, which refers to the crop rotation.

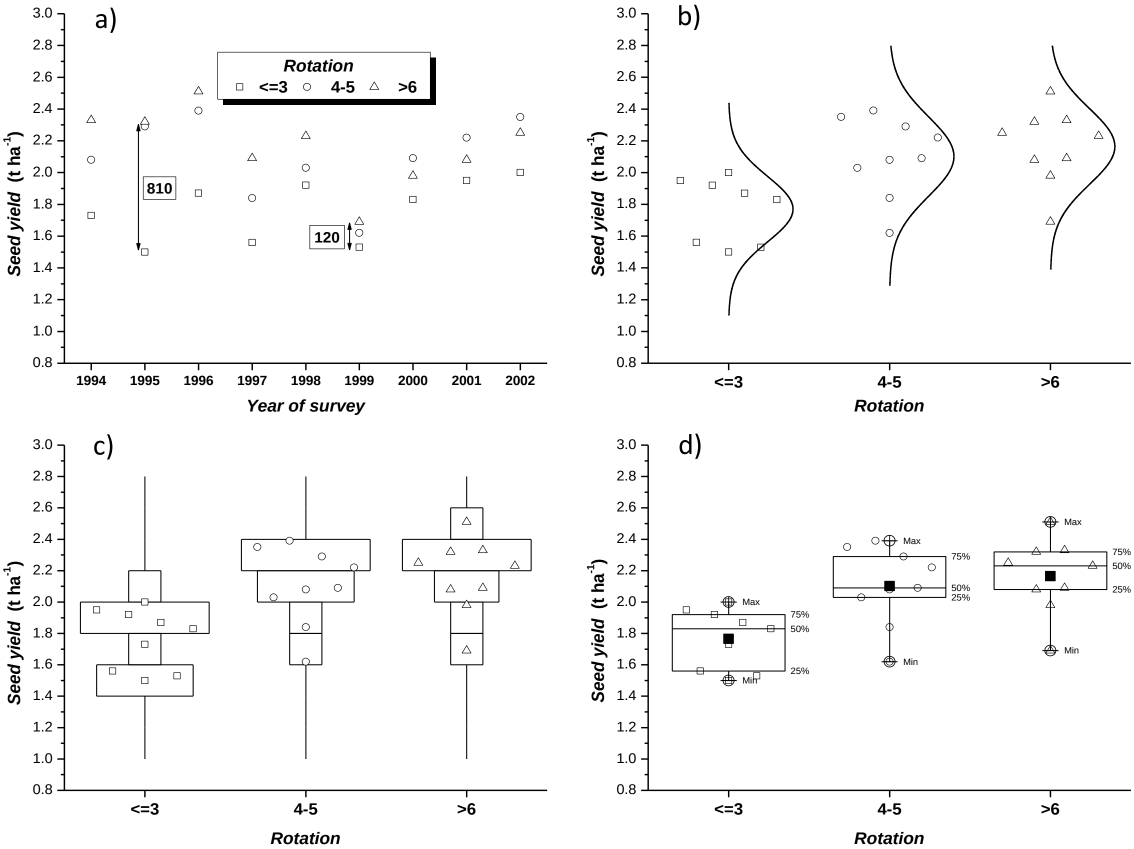

Fig. 1. The effect of rotation period in years (a) the effect of years by rotation period (b) grouping years by rotation period (c) and final box chart presenting (d)

Breeding and especially after the introduction of hybrids has effectively assisted sunflower growers to suppress the negative effects caused by dominant diseases and pests. Nevertheless, crop rotation remains an important preventive and integral measure of crop protection (Debaeke et al., 2003). Sunflower fits well into cereal-based crop rotations but should not be grown more than once every 3 or 4 year due to persistence of the damaging plant disease (Johnston et al., 2002). Nine-year average data from the commercial production show that, in relation to the recommended rotation of 4-5 years, the rotations of 3 years or less reduced the yields by 370 kg ha^{-1}, while the rotations of 6 years or more increased the yields by 170 kg ha^{-1} (Fig. 2a). The rotations of 3 years or less were practiced on 19.7% of the sunflower acreage on average, but in some years this figure was as high as 58%. Obviously, short rotations should be avoided because they cause significant yield reductions. Opposite to all other cultural practices applying proper crop rotation does not require additional costs.

The sunflower being a spring crop, there are no limitations in the choice of preceding crop regarding the time of its harvest (Crnobarac et al., 2000). On the level of 9-year average results, there were no significant differences in the yield of sunflower preceded by wheat, corn and sugar beet. When preceded by soybeans, sunflowers suffered yield reductions of 400 kg ha^{-1} mainly because of same diseases (Fig. 2b). Because of insufficient fertilization that has been practiced in Yugoslavia at those years, the yields of sunflower grown after crops that are more intensively fertilized (sugar beet and corn) are on the level of the yields of sunflower grown after wheat. In the practice, wheat was used as a preceding crop to sunflowers in 46.3% of the cases, corn in 43.9% of the cases, sugar beet in 8.1% of the cases and soybean in only 1.7% of the cases

Due to the large proportion of small grains it is important to monitor effect of fallow (Aboudrare et al., 2006). We analyzed the impact of fallowing after wheat on the sunflower yield (Fig. 2c). The effect of fallowing monitored in total for nine-year period, at about 68950 ha. In areas where summer plowing was done sunflower yield was less variable and the average was higher by 200 kg ha^{-1}, and such differences for individual year ranged from 20-370 kg ha^{-1}. Unfortunately fallowing procedures occurred on average only on 28.5% of the area under small grains.

Because of a relatively small harvest index (20-30%) and the biological characteristic of efficient use of nutrients from soil reserve and deep soil layers, the sunflower reacts less readily to the directly added mineral

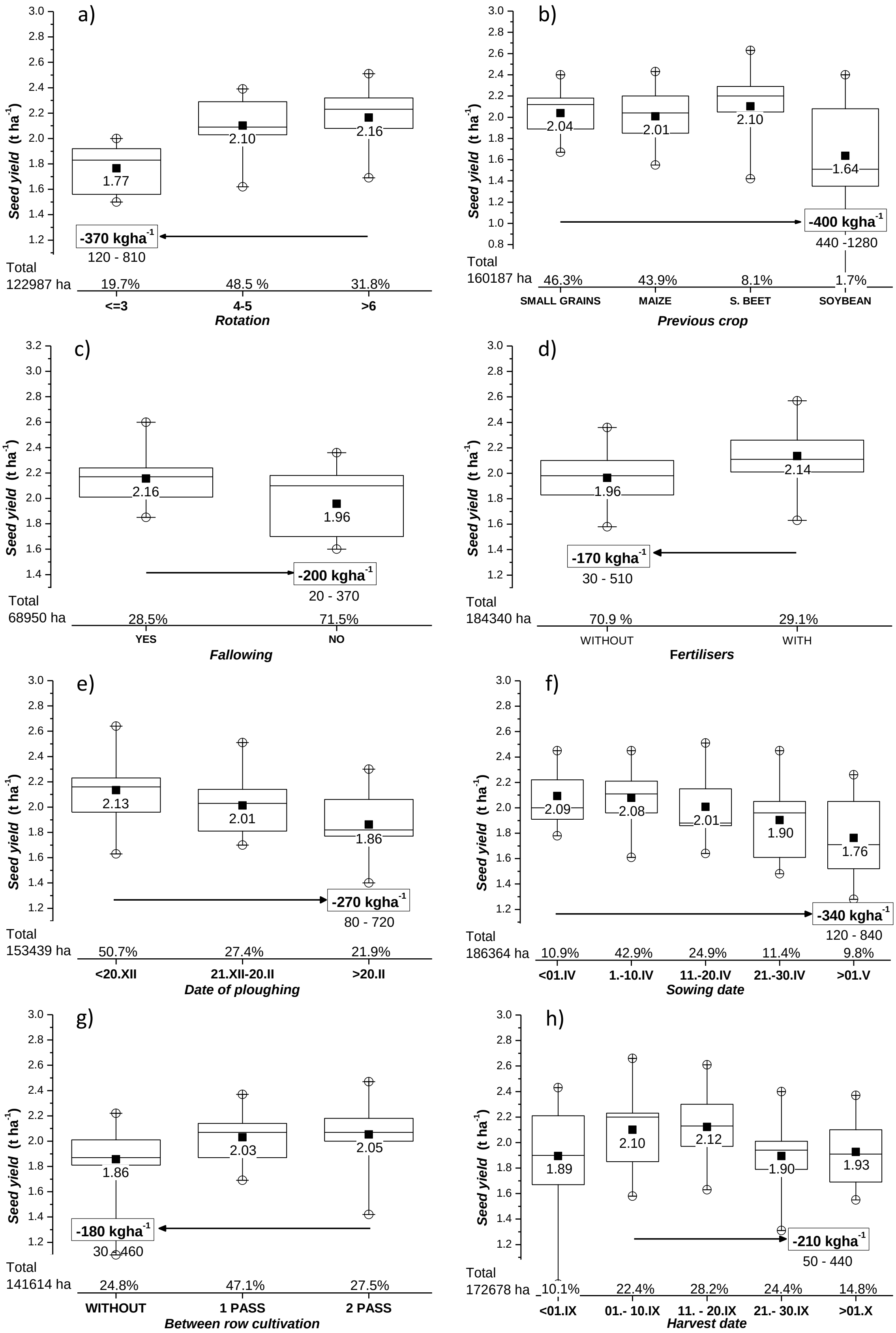

Fig.2. The influence of rotation (a), previous crop (b), fallowing (c), fertilizers (d), date of plowing (e), date of sowing (f), between row cultivation (g) and harvest date (h) and their treatments on sunflower yield

fertilizers than other field crops. It is also necessary to keep in mind another specific characteristic of the sunflower that excess nitrogen affects negatively its oil content in seed and disease resistance. On the 9-year average, the unfertilized fields produced 170 kg ha^{-1} less than the fertilized ones. The annual variations ranged from 30 to 510 kg ha^{-1} (Fig. 2d). On the 9-year average, only 29.1% of the sunflower fields were fertilized. The ratio of fertilized fields, after 1995 when was minimum of 10%, gradually increasing to 49% in 2002. This suggests that the situation is slowly improving with fertilization. On the nine-year average applied only 12, 8 and 7 kg ha^{-1} of N, P_2O_5 and K_2O, respectively. In 1995, the most critical year, the respective amounts were 2, 3, 3, and in 2002 reached the most suitable 24, 20, 12 kg ha^{-1} active ingredient of nitrogen, phosphorus and potassium, which is not yet half of the recommended dose.

Although the sunflower is in the group of most drought-tolerant spring crops, it is simultaneously a large water consumer. To help the plants withstanding water shortage, which is especially frequent in the second half of the growing season, it is necessary to make deep plowing in the fall, for better accumulation of winter precipitation (Stone et al., 2002). The fields plowed in the spring yielded 270 kg ha^{-1} less than those plowed in the fall, the annual variations ranging from 80 to 720 kg ha^{-1} (Fig. 2e). In the years with increased rainfall during growing season, the differences were smaller, and vice versa. The winter plowing (from 20 December to 20 February), on average was less effective then fall plowing, but invariably better than the spring plowing, out yielding it by 150 kg ha^{-1}. The share of spring deep plowing in nine-year average was 21.9%, but in the first half of the investigated years was more, with a record 58% in 1996, and in the last three years decreased to below 5%.

Correct sowing time facilitates seed germination and seedling emergence and improves the vitality of the emerged plants. It also affects the duration of the growing period and the length of the development stages (Barros et al., 2004). Thus it may be used to avoid anticipated critical periods with regard to weather conditions and disease occurrence. In 9-year period the impact of sowing time was monitored at total 186364 ha (Fig. 2f). Planting in late March and the first decade of April were the best (2.08 t ha^{-1}) and in the second decade of April were slightly lower yields. This means that early sowing of quality seeds is advantage, because it certainly achieved the highest yield, due to their lower variability. In the later sowing, the third decade of April, yield are more variable and lower than the earlier date for 20-100 kg ha^{-1}. The May planting gives the lowest yield, compared to the first two terms the average yield decreased by 340 kg ha^{-1}, and depending on the years in the range 120-840 kg ha^{-1}. On average the highest share in sown area has the first decade of April (42.9%), followed by the second with 24.9% and the third decade with 11.4% and the March sowing with 10.9%. The problem is the relatively high share of May sowing (9.8%), although in the last three years its share and share of third decade of April reduced, because the first three sowing term cover 90%.

The wide acceptance of weed control with herbicides has triggered a question of the purpose of between-row cultivation. Although there is disagreement in the professional community concerning the effectiveness of this measure, all seem to agree that the measure is necessary in the case of crusting or poor performance of herbicides. Fig. 2g shows that one between-row cultivation increased the yield by 170 kg ha^{-1} and two pass cultivations by 190 kg ha^{-1} in relation to the non-cultivated fields. In individual years, the gains ranged from 30 to 460 kg ha^{-1}. The average proportion of the non-cultivated fields was 24.8%, ranging in individual years from 12% to 72%. Taking in account the low cost of this operation, its use is strongly recommended.

Being an early row crop in the local environmental conditions, the sunflower typically matures in early September. Due to a high sensitivity to diseases and weather conditions at the time of maturation, the sunflower crop should be harvested as soon as the moisture content in seed permits it. Besides weather conditions, the length of the harvest period was affected by the availability of harvesters as well as by their technical condition. A timely harvest reduces field losses, harvest losses, the percentage of seed damage and the need for additional drying. The harvest is most effective when performed between 1 and 20 September (average yield 2.11 tha^{-1}). Any delay causes yield reduction (Fig. 2h). Also, too early harvest before September regularly reduced the yields and usually necessitated by diseases or strong drought. In relation to the harvest in the optimum period, too early and too late harvesting on average reduced the yields by 210 kg ha^{-1}. The annual variations ranged from 50 to 540 kg ha^{-1}. On the all years average 50.6% of the acreage were harvested in the optimum period, between 1 and 20 September. Problems that deserve attention are 24.4% of the acreage which harvested between 20 and 30 September, and more serious is 14.8% of the acreage which harvested in October.

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