Effect of Fifteen Years of Tobacco Production in Monoculture and in Crop Rotation on the Yield and Quality of Flue-Cured Tobacco under Agroecological Conditions of Croatia

15 years of Long Term Investigation

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Einfluss der Fruchtfolge auf Ertrag und Qualität von Flue-Cured-Tabak in einem 15-jährigen Dauerversuch unter kroatischen pedoklimatischen Verhältnissen

1 Introduction

Flue cured tobacco is grown on about 6000 hectares in northern Croatia where, owing to its most favourable pedoclimatic conditions for tobacco, there is a tradition of 50 years of tobacco production. Since mainly small farms have been found in this region certain problems occured in tobacco production due to its frequent growing in a very narrow crop rotation or even in monoculture. Negative effects of such growing include spreading of diseases and pest partial exhaustion of nutrients and reduction of tobacco yield and quality (BUTORAC et al., 1995; BUTORAC et al., 1999;

Zusammenfassung

Die landesüblichen Fruchtfolgen lauten Tabak, Weizen, Mais, Sojabohne. Der Versuch des Tabakinstituts umfasste Tabak in Monokultur, eine zweischlägige Fruchtfolge mit Weizen und Tabak, eine dreischlägige mit Mais, Weizen und Tabak und schließlich eine vierschlägige mit Mais, Sojabohne, Weizen und Tabak. Die Auswahl dieser Fruchtfolgen erfolgte unter Bedachtnahme auf die landwirtschaftliche Praxis und die ökologischen Bedingungen in Kroatien. Für Tabak in Monokultur ergab sich eine Ertragsabnahme von 1,24 t/ha bei einem Ertrag im ersten Jahr (1987) auf einen Ertrag 1,39 t/ha im 15. Jahr (2001). Signifikant geringere Erträge waren schon im 4. Jahr in Tabakmonokultur gegenüber Tabak in Fruchtfolge festzustellen. Die Erträge in Fruchtfolgeanbau blieben während der 15 Jahre relativ stabil. Tabak in Fruchtfolge wies zusätzlich eine bessere Qualität auf.

Schlagworte: Tabak aus Anbau in Fruchtfolge, Monokultur, Fruchtfolge, Ertrag und Qualität Tabak.

Summary

Typical crop rotations, with tobacco in Croatia include wheat, maize and soybean. The investigation was set up on the experimental field of the Tobacco Institute and was planted in monoculture, two-crop (wheat, tobacco), three-crop (maize, wheat, tobacco), four-crop (maize, soybean, wheat, tobacco) and five-crop (maize, soybean, wheat, oil-seed rape and tobacco) rotation. Standard agricultural practices, based on the experience gained in ecological conditions in Croatia, were applied to the crops included in the crop rotation. Tobacco grown in monoculture had a yield of 2.63 t/ha in the first year (1987) compared to 1.39 t/ha in the fifteenth year (2001). A significantly lower yield was obtained for the first time in the fourth year of tobacco monoculture compared to tobacco grown in crop rotation. Tobacco grown in crop rotation had a higher percent age of high quality leaves.

Key words: Flue-cured tobacco, monoculture, crop rotation, yield and quality of tobacco.

TURŠIĆ et al., 1997). Hence, recognizing the factors mentioned above as well as some other factors (lower chemical and physical properties of the soil), there was a need to explore some types of crop rotation including tobacco under ecological conditions prevailing in this region. Crop rotation, commonly, involved crops are tobacco, winter wheat, maize, soybean, oil rape, red clover. Though our investigations focused on tobacco, they also included other crops which are important in Europe. Crop rotation is generally recognized as very comply agro-economic function, with influences on agro-technical, phytosanitary and economic effects as well (BUTORAC et al., 1999; BUTORAC et al., 2000; KARLEN et al., 1994). Crop rotation plays both a direct and an indirect role in preserving soil fertility and assuring good-quality of tobacco production. Crop rotation is a biological buffer system that disrupts the adverse biological cycles of diseases, pest and weeds, and conserves the soil organic matter more effectively than monoculture.

The aim of these investigations was to study tobacco productions in monoculture, compared with production in crop rotation on their influence on the yield and quality of tobacco.

2 Material and methods

These investigations were carried out for fifteen years on the experimental field of the Tobacco Institute Zagreb.

Several types of crop rotation were tested: tobacco monoculture, two-crop (winter wheat – tobacco), three-crop (winter wheat, tobacco, maize), four-crop (winter wheat, tobacco, maize, soybean) and five-crop (maize, soybean, winter wheat, oil-seed rape, and tobacco) rotation. Tobacco is the key crop in these investigations while winter wheat and oil-seed rape were the preceding crops in trials.

Investigations started in 1987 and were carried out on semigley soil (sandy loam), which is characteristic soil of the area where flue-cured tobacco is grown in northern Croatia. The soil is of poor porosity in the eluvial (E/Bt) and illuvial (Bt) horizons.

There was an average water capacity of 34.0 %, while the air capacity was low in the sub-plough layers (8.6 %). Soil compaction increased with depth. The plough layer had acid reaction (pH = 5.4).

Tobacco was grown for fifteen-years in monoculture and in four types of crop rotation (1:2, 1:3, 1:4, 1:5). Seven two-crop rotations, five three-crop rotations, three four-crop rotations and three five-crop rotations have been completed to date.

The trial was set up according to the method of randomized block design in four replications, with a systematic layout of trial plots within the blocks. Each trial plot covers an area of 50 m^2 and each block 200 m^2. The domestic tobacco cultivar Drava which is resistant on black root rot was planted.

Standard cropping practices as well as standard fertilizations were applied to all trial crops. Fertilizer rates in $kgha^{-1}$ are, for N, P_2O_5 and K_2O respectively: 30, 60 and 160 for flue-cured tobacco; 160, 160 and 140 for winter wheat; 180, 150 and 170 for maize; 50, 90 and 100 for soybean (before sowing the seed was inoculated with *Bradirhyzobium japonicum*) and 160, 100 and 250 for oil-seed rape.

Tobacco was harvested in six harvests. After the cured leaves were investigated on quality and yield by classifying and weighing. The data of leaf yield and quality (% class I-III) were statistically processed by analysis of variance as well as the t-test to estimate the significance of the differences between average values in different crop rotations.

3 Results and discussion

The climate conditions during tobacco vegetation had a particular influence on the yield, especially on the quality of tobacco (LITTLEMORE et al., 1991). According to the data obtained from the meterological station situated in the immediate vicinity of the experimental plot, there were considerable differences in the amount and distribution of precipitation (Table 1).

A minimum precipitation of 255 mm was recorded during the vegetation period in 1992, and a maximum precipitation of 476 mm in 1995. The average amount of precipitation during the tobacco vegetation period (May to September) over fifteen years amounted to 353 mm. No

Table 1: Precipitation during tobacco growing season (May–September), 1987–2001
Tabelle 1: Niederschläge während der Vegetationsperioden für Tabak (Mai–September), 1987–2001

Year	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
mm	285	281	399	261	438	255	310	335	476	398	376	394	410	286	397

Table 2: Tobacco yield (t/ha) according to crop rotation type
Tabelle 2: Tabakerträge (t/ha) in den unterschiedlichen Fruchtfolgen

Cultivation Type	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	Average
	Tons per hectare															
Monoculture	2.63	2.21	2.66	1.92	1.86	1.79	1.82	1.65	1.80	1.68	1.60	1.57	1.61	1.53	1.39	**1.85**
Two-year rotation	2.72	2.42	2.81	2.54*	2.48*	2.35*	2.12	2.05*	2.29*	2.07*	2.31**	2.40**	2.43*	2.38	2.56	**2.36***
Three-year rotation	2.70	2.46	2.80	2.43*	2.40*	2.53**	2.35**	2.14**	2.28*	2.20**	2.43**	2.45**	2.51*	2.48*	2.76*	**2.46***
Four-year rotation	2.76	2.43	2.86	2.38	2.59**	2.39*	2.34*	2.25**	2.33**	2.31**	2.48*	2.60**	2.73*	2.58*	2.63*	**2.51***
Five-year rotation	2.62	2.45	2.85	2.70*	2.50*	2.46*	2.40*	2.30*	2.38*	2.58*	2.51*	2.65*	2.68*	2.61*	2.59*	2.55*
LSD (P=0.05)	NS	NS	NS	0.32	0.28	0.27	0.26	0.21	0.28	0.33	0.32	0.29	0.35	0.19	0.21	0.25

negative temperatures, i.e. no late spring or early autumn frosts were registrated during the tobacco vegetation periods during the 15 years of investigations.

The results obtained for yields during the fifteen years of investigation are presented in Table 2.

The average values of flue-cured tobacco leaf yields for the 15-year period indicate a trend more or less analogous to that for particular years. Significantly higher yields were recorded in all kinds of crop rotations compared to tobacco monoculturecropping (BUTORAC et al., 1995; BUTORAC et al., 1999; TURŠIĆ et al., 1997; LITTLEMORE et al., 1991). A significantly lower tobacco yield was obtained after three years of flue cured tobacco monocropping.

Tobacco grown in wider crop rotation was less infected with viruses, which resulted in better yield and quality.

Significantly higher yields were recorded in all crop rotations relative to tobacco monocropping. Thus, the advantage of crop rotation over monoculture is evident, and even that of crop rotation with a longer duration over crop rotation of shorter duration. Although the results obtained allow to conclude that a winter wheat-tobacco 2-year rotation may be quite acceptable in the main tobacco-growing area in northern Croatia. To recommend 3-year rotation including maize in addition to these two crops, as well as the other crop rotations tested, might be more justified in agricultural practice. Average long-term values show that the results of the 3-year, 4-year and 5-year crop rotations were better.

The common indicator of tobacco quality is the proportion of cured quality leaves belonging to the six particular classes. After each harvest (generally five to six), tobacco was classified into six classes according to the standard criteria for flue-cured tobacco in Croatia. In this case, our attention was focused on the influence of tobacco monoculture and the different crop rotations, also including to a certain extent, the crop rotation value and crop sequence on the tobacco quality.

Table 3: Influence of crop rotation on the quality of harvested tobacco leaves (% class I–III)
Tabelle 3: Qualität der geernteten Tabakblätter (% Klasse I–III)

Cultivation Type	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	Average
	Percent class I–III															
Monoculture	37.6	13.9	12.4	0.0	19.4	11.4	20.6	18.0	17.3	18.4	15.1	12.3	15.3	16.4	13.8	16.1
Two-year rotation	39.7	18.3	11.5	18.6*	49.9*	37.7*	22.6	10.0	28.8	26.8	21.3	28.1*	31.3*	18.3	23.6	25.7*
Three-year rotation	38.7	20.2	12.9	19.1*	48.3*	48.4*	38.6*	8.0	42.0*	44.1*	30.6*	38.3*	34.2*	26.4	31.4*	32.7*
Four-year rotation	34.9	26.4	18.3*	20.3*	41.3*	48.2*	39.0*	14.3	40.2*	40.3*	29.6*	38.6*	38.4*	30.4*	33.6*	32.9*
Five-year rotation	36.4	23.4	19.6*	23.6*	43.5*	39.6*	43.1*	19.3	41.4*	41.5*	31.7*	41.3*	36.3*	27.4*	29.6*	33.8*
LSD (P=0.05)	NS	NS	3.6	2.5	7.5	6.7	6.6	NS	8.3	7.4	5.1	6.3	5.6	8.3	6.5	4.6

The percent age tobacco leaves classified as belonging to of quality class I–III are presented in Table 3 according to the defined types of crop rotation and trial years.

The first three classes include better quality tobacco which has a considerable effect on the financial result of the tobacco production. A substantially lower percent age of better quality tobacco leaves was recorded in tobacco grown in monoculture, which, along with lower leaf yield, had a significant effect on the overall value of the productivity per hectare.

It is noticeable at first sight that, according to the long term investigation, the proportion of quality classes I-III showed an almost straight-line upward trend in the monoculture, with average 16.1 % respectively to average 25.7 % in the 2-year winter wheat-tobacco rotation. This was followed by a further rise to average 32.7 % in the 3-year rotation involving, besides tobacco, winter wheat and maize.

The 5-year rotation (33.8 %) average was slightly better than the 4-year rotation (32.9 %) average. Besides winter wheat, tobacco and maize, soybean and oil-seed rape were included in the 5-year rotation.

Better quality and higher yield of tobacco has resulted in better value of dried tobacco leaf.

4 Conclusions

Tobacco grown in croprotation for 15 years gave a significantly higher yield than tobacco planted in monoculture. Tobacco grown in the four types (2-, 3-, 4-, and 5 years) of crop rotation had a significantly higher yield and better quality leaves than grown in monoculture.

In monoculture the average yield was 1.85 t/ha with 16.1 % leaves in classes I–III ,while in crop rotation the average yield was 2.36 t/ha to 2.55 t/ha with average of 25.7% to 33.8 % leaves class I–III.

An increase in yield and quality has been detected from 2-crop rotation to 3-crop rotation, while between 3,4 and 5-crop rotations the increase was not significant.

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