Effects of Different Growing Practices on Agronomic Properties and Usability of Flue-Cured Tobacco

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SUMMARY

The quality and usability of tobacco is defined by genetic properties of the cultivar, enviromental conditions of production and growing practice. Besides the significant improvement of cultivation, some Croatian farmers still grow tobacco at the traditional extensive way. The aim of our study was to determine the contribution of the growing practice to the realization of agronomic properties, usability, and economic effects in the production of flue-cured tobacco in Croatia. The three year field trial was conducted on three cultivars grown in two cultivation systems - traditional and improved one. Each of the systems was investigated under conditions of irrigation and non irrigation. Thus, the experiment involved four growing models. There were differences among individual varieties within the same growing model, but the bigger differences among distinct growing models were noted. Statistically reliable differences among cultivation models for all studied parameters were found. The average yield in the A1 model was 40% higher than in the check B2 model, and the value of production per hectar was higher even 46%. The quality and usability of tobacco based on the visual estimation and chemical properties were also more dependent on the cultural practice. More bodied tobacco with good smoking properties was obtained in the intensive cultivation. At the same time, light tobacco of filler type without emphasized smoking characteristics in the traditional growing model was produced. Incrimental value in the intensive cultivation was significantly higher than were the incrimental costs, and the marginal profitability was 1.37. The results of this study have shown that the growing practice has greater impact on yield and quality of tobacco, as well as on profitability of production than the genetic potential of the cultivar.

KEY WORDS

tobacco growing, extensive, intensive, agronomic properties, usability, profitability

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Utjecaj različitih načina uzgoja na gospodarska svojstva i upotrebnu vrijednost flue-cured duhana

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SAŽETAK

Upotrebna vrijednost duhana određena je genetskim svojstvima sorte, prirodnim uvjetima proizvodnje i tehnologijom uzgoja. U proizvodnji virdžinijskog duhana u Hrvatskoj, i pored značajnog unapređenja tehnologije, dio proizvođača još uvijek uzgaja duhan na ekstenzivan način. Cilj našeg istraživanja bio je utvrditi doprinos uzgojnog sustava u ostvarenju gospodarskih svojstava, upotrebne vrijednosti i ekonomskog učinka u proizvodnji virdžinijskog duhana. Izveden je trogodišnji pokus s tri sorte različitog genetskog potencijala koje su uzgajane u dva različita uzgojna sustava, intenzivnom i ekstenzivnom. Svaki sustav je, uz to, izveden u dvije varijante, s navodnjavanjem i bez navodnjavanja, tako da je istraživanje provedeno na 4 uzgojna modela. U istom uzgojnom modelu utvrđene su razlike među pojedinim soratama, ali su još veće razlike postojale između različitih uzgojnih modela. Nađene su statistički pouzdane razlike između uzgojnih modela za sve ispitivane parametre. Prosječan prinos u modelu A1 bio je za 40% viši nego u kontrolnom modelu (B2), a vrijednost proizvodnje po ha bila je viša za 46%. Kvaliteta duhana i njegova upotrebna vrijednost temeljene na vizualnoj ocjeni i kemijskim svojstvima, također su bile uvjetovane načinom uzgoja. U intenzivnom uzgoju dobiven je sadržajan duhan skladnog okusa pušenja. S druge strane u ekstenzivnom uzgoju dobivena je lagana sirovina filer tipa bez naglašenih svojstava u pušenju. Razlika dobiti u intenzivnoj proizvodnji bila je značajno viša od dodatnih ulaganja u intenziviranje proizvodnje, s koeficijentom intenziviranja od 1.37. Rezultati istraživanja pokazali su da način uzgoja ima veći učinak na prinos i kvalitetu duhana, te na ekonomičnost proizvodnje nego genetski potencijal sorte.

KLJUČNE RIJEČI

uzgoj duhana, ekstenzivni, intenzivni, gospodarska svojstva, upotrebna vrijednost, ekonomičnost

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INTRODUCTION

Yield, quality and usability of tobacco depend on three important factors: genetic potential of a cultivar, environmental conditions of production and cultural practice. All the experiments conducted so far indicate that each factor contributes to production efficiency and it is difficult do discern which is more important (Bowman et al 1984, Terrill et al. 1985). The genetic potential of each tobacco cultivar contains possible theoretical limits to the realisation of a particular characteristic. How much potential shall be realised depends on the effect of external factors, which also include the activities taken by tobacco growers through the growing measures (Chaplin, 1978). Each agricultural operation affects tobacco yield and quality in the adequate way.

There are two radically different cultivation methods of flue-cured tobacco in Croatia: intensive and extensive; although in practice there are several methods which, more or less, conform to the one of mentioned methods. For all considerable progress achieved in growing practice, some growers still use traditional growing methods. These methods include transplanting on flat surfaces in close spacing, growing without topping and suckering, not to mention that there are very few farmers who implement irrigation. With these growing conditions, regardless of the cultivar's genetic potentials, it can not be expected to achieve the raw material quality required by the present-day tobacco market. On the other hand, yield produced is relatively poor, and the yield increase is an important prerequisite for productivity increase as far as this production is concerned (Budin et al., 1994).

In order to meet the requirements of domestic industry and external demand, on the cultivation areas in Croatia, efforts are put into further development of growing technology so as to increase productivity and obtain the raw material whose usability will be able to meet the established standards. A great number of experiments carried out so far have showed that the growing measures such as plant spacing (McKee, 1978, Hawks et al., 1987), topping and suckering (Arsenault et al., 1986, Čavlek et al., 1992), and irrigation (Martin, 1987, Čavlek et al., 1997) affect the realisation of tobacco plant's genetic potential. The purpose of this experiment was to examine the contribution of genotype and cultural practice to the realisation of agronomic characteristics, tobacco usability and production productivity of flue-cured tobacco in Podravina's environmental conditions.

The research lasting three years had also a demonstrative aim, since the tobacco growers could see the effects of the appropriate farming method "in situ", in the Podravina conditions, and compare them to the methods they use on the cultivation area.

MATERIAL AND METHODS

In Pitomača experimental station three tobacco varieties, DH10, VaD and VBP143, with different genetic potential were tested by means of two cultivation systems, extensive, i.e. traditional, and intensive - with application of modern cultural practices for three years. Each of the systems was investigated with and without irrigation. Thus, the experiment involved four growing models: A1 - intensive growing with irrigation, A2 - intensive growing without irrigation, B1 - extensive growing with irrigation and B2 - extensive growing without irrigation, which could also be considered as check model (table 1). The same tillage and fertilization systems were adopted in all four models.

The experiment was set up according to split-split plot design in four replications with random plot arrangement. Each plot contained 4 rows 10 metres long, but the two middle rows were considered in calculation. During the experiment the following characteristics were studied: days to flowering, disease incidence, yield, visual quality, value of production, chemical composition and smoking properties. The economical aspects of production of each growing model were established as well. The experiment results were analysed statistically, and it was also defined the extent to which the interaction of production factors affects the realisation of individual agronomic characteristics.

RESULTS AND DISCUSSION

Characteristics of tobacco in the field

During growth in the field tobacco showed different performances depending on growing model. Intensive growing system produced larger leaf, and taken on the average, tobacco flowered something earlier than the one in the extensive growing system. In addition, tobacco in closer spacing was more susceptible to blue mould.

The advantage of transplanting on ridges was manifested during rainy 1997. A great amount of rainfall during a short period in June caused the soil flood, so that the first replication of the flat planting treatment was for the most part unsuccessful, while in

Table 1. Growing model characteristics

Growing model	Transplanting method	Plants per ha	Topping and suckering	Irrigation
A1	Ridges	24 000	+	+
A2	Ridges	24 000	+	-
B1	Flat	35 000	-	+
B2	Flat	35 000	-	-

the other three replications tobacco growth was slowed down, what reduced the yield. In the plots with planting on ridges, the concequences were negligible because the plants were raised from the soil level, and excess water was lost easily.

The differences among tobaccos produced with different growing systems were evident especially after curing. The tobacco from extensive growing was more of a lemon yellow tinge with light body, while the tobacco produced in intensive system was of orange colour with full bodied, more elastic and textured.

Agronomic characteristics

The most important agronomic characteristics which effect production profitability such as yield, quality expressed by means of average price, and income per hectar were analysed. Average yield in model A1 was almost 40% higher than in model B2, and in certain years the yield increase was even higher (table 2). Differences among single varieties in each growing model were ascertained, although, owing to great fluctuations, they were not statistically reliable. Cultivar value rank was the same for each model, although all cultivars did not react to the intensive growing system in the same manner. As for the VaD variety, the yield in model A1 was on average 150% higher in relation to model B2, while the difference between the other varieties was smaller and ranged from 132 to 135%.

The yield in model A1 i.e. intensive growing system without irrigation, was also considerably higher than the yield achieved in traditional cultivation system. It is obvious that the combination of modern cultural practices such as planting on ridges, topping and suckering contributed to the yield increase without irrigation, while irrigation only intensified their effect to the maximum realisation of genetic potential.

If the yield of specific years is analysed, the effect of irrigation to the realisation of this factor is obvious. In 1996 irrigation considerably increased the yield in irrigated models, and since the year was quite dry, in certain periods additional water proved to be beneficial to the plants. On the other hand, in 1997, a year with the satisfied rainfall uniformity, there was almost no difference between irrigated and unirrigated treatments. However, owing to widely plant spacing, topping and suckering in 1997 there was a considerable difference between intensive and extensive growing model. Taking into consideration that in these areas the years with unfavourable rainfall schedule are much more frequent, and comparing of the obtained results, the conclusion about the benefit which could be obtained by introducing irrigation into Croatian tobacco production can be easily drawn.

Visual tobacco quality was evaluated on the basis of the existing purchasing standards and was expressed by means of average price. The average price relations of the specific varieties to crop models remained the same for all tested years. The highest average price was found in model A1, but the price difference among individual models was not statistically reliable. The differences among the models would probably have been greater if the tobacco had been graded in accordance with the new grading system which would have attributed a better grade to the full bodied orange tobacco, which was produced in larger quantity in growing system A. The tobacco from system B was more of lemon colour, and by existing grading such colour is graded as orange colour, even though cigarette manufacturers do prefer the orange tinge.

However, great and statistically reliable differences of production value, which combines yield and quality, among the individual cultivation models were found. Depending on the year, the differences between model A1 and control model B2 ranged from 41 and 58 %, while the differences among cultivars were not statistically justified. The table 3 shows the average

Table 2. Yield in kg/ha

Model	Genotype	Year			Average	Index
		1995	1996	1997		
A1	DH10	2770	2832	2556	2719	134
	VBP143	3085	3265	2855	3102	137
	VaD	2915	2674	2170	2586	152
	Average	2923	2924	2560	2802	140
A2	DH10		2272	2344	2308	118
	VBP143		2522	2846	2684	120
	VaD		2142	1998	2070	129
	Average		2312	2395	2354	122*
B1	DH10		2216	1895	2056	105
	VBP143		2404	2220	2312	103
	VaD		1742	1689	1716	107
	Average		2121	1935	2028	105*
B2	DH10	2200	2076	1828	2034	100
	VBP143	2340	2295	2176	2270	100
	VaD	1910	1600	1604	1704	100
	Average	2150	1990	1870	2003	100

*Index was calculated on the basis of the results achieved in 1996 and 1997

Table 3. Indexes of the realised production value

Model	1995	1996	1997	Average
A1	145^{++}	158^{++}	141^{++}	148
A2		119	131^{++}	123
B1		110	108	106
B2	100	100	100	100
LSD 5%	19	21	18	
1%	32	34	30	

Table 4. Chemical quality indicators (three-year average)

Model	Nicotine (%)	Total N (%)	Sugars (%)	Total N/nicotine	Sugars/nicotine
A1	1.85^{++}	1.53	21.37	0.83^{++}	11.55^{++}
A2	1.93^{++}	1.41	24.46	0.73^{++}	12.67^{++}
B1	0.79	1.37	25.32	1.73	32.05
B2	0.90	1.40	20.37	1.56	22.63
LSD 5%	0.27	NS	NS	0.30	4.72
1%	0.46	NS	NS	0.49	7.85

production value of each cultivation model expressed in relative ratios in relation to the check model.

There are no significant differences between models B1 and B2, which means that the influence of irrigation on the extensive growing system is smaller than on the intensive cultivation.

Chemical properties and usability of tobacco

We analysed the content of nicotine, total nitrogen and soluble sugars, which are the main chemical components as far as flue-cured tobacco is concerned. The interrelation of these components is considered to be the basic indicator of usability of flue-cured tobacco.

All the varieties and types of treatments show a relatively high sugar content and there were no statistically reliable differences among the tested models. Flue cured tobaccos are characterised by high sugar content, although it should not be too high since it decreases the balanced manifestation of other qualities. As for our experiment, sugar content ranged from 19.0 to almost 30.0% what is considered quite high, since the other components which are supposed to neutralise the negative effects of sugar are relatively low.

There were no considerable deviation in total nitrogen content neither among single models nor among tested varieties. In certain years total nitrogen content was higher in extensive production and in other in intensive production, and in irrigated and unirrigated models the average nitrogen content was approximately the same.

Obvious differences in nicotine content among the varieties and growing models were found. Although nicotine is a chemical component whose manifestation is influenced by the hereditary factors of the plant (Chaplin, 1987), its content varries under the influence of enviroment. Plant spacing, topping and especially soil moisture (Nielsen and Collins, 1985, Beljo et al., 1995) are the factors which most influence tobacco nicotine content. Our study showed that nicotine content in the intensive system was almost twice high than that in the extensive growing. According to Chaplin (1987), flue-cured tobacco with higher nicotine content is usually of higher quality.

Our research has shown that tobacco irrigation reduces the nicotine content. In dry years differences between irrigated and nonirrigated variants were noted, while in rainy year, such as 1997, there were almost no differences between irrigated and nonirrigated tobacco as far as nicotine content is concerned.

In general, flue-cured tobacco quality is evaluated in view of the ratio of total nitrogen to nicotine and sugar-to-nicotine ratio. The most favourable sugar/nicotine ratio for good quality flue-cured tobaccos ranges between 7-10. Index over 10 denotes light and thin bodied tobaccos of filler type, while index under 7 stands for coarse heavy bodied tobaccos. In our intensive growing system the sugar/nicotine ratio amounted to 11.55 and 12.76 respectively, what is still satisfactory, considering the natural growing conditions prevalent in our region. However, the ratio of these two components in extensive growing method was extremely high, what is a clear indicator of poor usability of this type of raw material (table 4). The total nitrogen/ nicotine ratio for the quality tobaccos should range between 0.7 and 1.0, which was found only in tobacco from intensive growing model.

Smoke analyses was also conducted; by means of the smoking machine and smoke panel. Tobacco grown in intensive system was characterized by more distinctive flavour, harmonious taste and with more strength, which are the characteristics sought by the cigarette manufacturers. Tobacco obtained by the extensive crop method was evaluated as filler with minor defects and with less distinctive flavour. Such tobacco can be used in cigarette production, but only as material to be added to the tobacco with the above mentioned characteristics.

The interaction among individual parameters.

Since the influence of variety, growing technology and irrigation to the expression of the agricultural characteristics was analysed, we also analysed the influence of the interaction among these parameters to the realisation of each characteristic. It was found out that the interaction of a variety with other two factors did not produce statistically reliable changes in any of the characteristics. However, the interaction between cultivation and irrigation showed considerable yield deviations between model A1 and A2 compared with model B2 (table 5). Mutual effect of irrigation and growing practice also showed that the increase of production value in model A1 was statistically reliable, especially in the dry 1996. Still, in rainy 1997 year, when the results obtained in irrigated and unirrigated treatments were similar, the interaction between these two parameters was not recorded. Therefore the table shows the results of the interaction effect the dry year only.

The analysis of the effect of the single parameter interaction to the expression of some of the important chemical components showed that there were no statistically reliable differences resulting from the interaction.

Economic effects of particular growing models

Economic aspects of tested production methods are interesting from the point of view of the transition from traditional growing model (B2) to intensive method. For this purpose the value of the main variable costs items whose changes are related to the tested production models was established.

Comparative indicators of production, yield and costs clearly indicate the extent to which intensified production contributes to the efficiency of this type of production (table 6). In order to obtain much higher yield, much smaller number of leaves is to be harvested and manipulated, and at the same time quality and production value are increased.

The results show that the transition from the traditional cultivation system to the intensive production is quite profitable, therefore a priority. If, in addition to such production, irrigation as an additional method is introduced, the results shall be even better. The study showed that irrigation is a relative measure which is not cost-effective in extensive production regardless of its effect to the yield increment. The obtained marginal profitability shows that additional costs of investments into irrigation system were much higher than incrimental value.

On the other hand, the introduction of irrigation into intensive crop system has proved to be a very profitable investment. The transition from the extensive to the intensive production model A1 indicates high profitability. Marginal profitability of A1 shows that each 100 HRK invested in production intensification yield income increase amounting to 38 HRK. Besides being profitable in relation to both B2 and A2 models, in greater stability of yield and quality, which can not be seen from these simplified calculations.

Table 5. Cultivation x irrigation interaction effects

Model	Yield (kg/ha)	Value (000 HRK/ha)	Nicotine (%)
A1	2924^{++}	25.8^{++}	1.19
A2	2312	19.4	1.68
B1	2122	17.6	0.71
B2	1990	16.3	0.99
LSD 5%	288	3.4	NS
1%	463	5.5	NS

Table 6. Economic aspects of different models

Parameter	Model			
	A1	A2	B1	B2
Number of plants per ha	69	69	100	100
Number of harvested leaves per plant	86	86	100	100
Number of harvested leaves per ha	59	59	100	100
Yield per plant	200	172	105	100
Yield per ha	147	122	105	100
Average price	108	102	101	100
Production value	158	118	108	100
Total special costs*	155	118	108	100
Incrimental value (ΔVP) in relation B2 expressed in HRK	9,520	3,020	1,310	
Incrimental costs (ΔT) in relation to B2 expressed in HRK	6,952	2,257	2,871	
Marginal profitability (ΔVP/ΔT) in relation to B2	1.37	1.35	0.46	
Marginal profitability A1 in relation to A2	1.38			

*Including ridging, topping, suckering, harvesting, curing, irrigation and insurance costs

CONCLUSIONS

The results of this study enable us to draw the following conclusions:

Further improvement of growing technology considerably increases yield and production value, and the produced tobacco has better visual properties and usability.

Greater fluctuations of yield and production value among individual varieties were recorded in the extensive than in the intensive growing.

The applied growing practices influence the realisation of yield, production value, chemical composition and tobacco usability more than genetic characteristics of a cultivar.

Improvement of growing technology was profitable even from the economic point of view. Marginal profitability of A1 indicated that each 100 HRK invested in production intensification yield additional income increase of 38 HRK. The study showed that irrigation is profitable only in intensive production, while in extensive production this measure does not justify the investment.

Finally, the investigation clearly indicates the potentials hidden in the quality and yield development, which can be activated by the introduction of irrigation after exploiting all the possibilities of dry farming intensification and of the selection of suitable varieties.

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