Effect of Drainpipe Spacing on the Yield of Field Crops Grown on Hydroameliorated Soil

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SUMMARY

The research objective was to investigate the effect of different drainpipe spacing variants on the yield of field crops grown on hydroameliorated soil and to determine, applying the analysis of variance, the significance of the difference in yields between the tested variants.

Investigations were carried out on hydroameliorated Gleyic Podzoluvisol on the experimental amelioration field Jelenščak-Kutina (central Sava valley) in the 1990-1993 and 1995-1999 periods. Four different variants of drainpipe spacing were tested in the trial (15 m, 20 m, 25 m and 30 m) in four replications. The same crop was grown and the same agricultural practices applied at the same time in all trial variants and in all trial years.

During the research period, maize was grown in five years, winter wheat in three and oats in one year. Yields of the same crops differed per years and per different drainpipe spacings due to different factors, such as the genetic characteristics of the cultivars, or hybrids, different quantities and distribution of precipitation during the trial years, soil moisture before drilling, number of plants per unit area, total fertilizer applied and top-dressing pattern in the growing season, as well as the time of harvest.

The highest maize yield was achieved in 1991 and ranged from 88.00 dt/ha (15 m spacing) to 71.74 t/ha (30 m). The lowest maize yield was recorded in 1996 - from 58.20 dt/ha (15 m) to 43.48 dt/ha (30 m). The highest wheat yield was achieved in 1991 - from 57.96 dt/ha (15 m) to 52.35 dt/ha (30 m), and the lowest in 1998 - from 38.88 dt/ha (20 m) to 30.88 dt/ha (30 m). Oats yield ranged from 42.19 dt/ha (15 m) to 37.59 t/ha (30 m).

Analysis of variance, done separately for each trial year, rendered highly significant differences ($p<0.01$) between yields of particular crops in dependence on the drainpipe spacing in six trial years (1990, 1991, 1992, 1996, 1997 and 1998). Significant differences ($p<0.05$) between yields were recorded in 1999, while the 1993 and 1995 differences between yields, depending on the drainpipe spacing, were not significant.

In the agroecological conditions of the central Sava valley, satisfactory yields can be obtained with the drainpipe spacing of 15 m. Drainpipe spacing of 20 m, supplemented by repeated vertical deep loosening of soil, may give satisfactory results in years when the drainage system is adequately maintained.

KEY WORDS

yield, maize, winter wheat, oats, hydroameliorated Gleyic Podzoluvisol, pipe drainage, drainpipe spacing

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Utjecaj razmaka cijevne drenaže na prinos ratarskih kultura na hidromelioriranom tlu

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SAŽETAK

Cilj istraživanja bio je ispitati utjecaj različitih razmaka cijevne drenaže na prinos ratarskih kultura na hidromelioriranom tlu i utvrditi analizom varijance opravdanost razlike u visini prinosa između testiranih varijanata.

Istraživanja su provedena u razdoblju od 1990-1993. i od 1995-1999. god. na melioracijskom pokusnom polju "Jelenščak"-Kutina (srednja Posavina), na hidromelioriranom tlu Gleyic Podzoluvisol. U pokusu su bile testirane četiri varijante razmaka cijevne drenaže:15 m, 20 m, 25 m i 30 m, postavljene u četiri ponavljanja. Tijekom svake godine istraživanja na svim varijantama razmaka cijevne drenaže uzgajana je ista kultura i bili su primjenjeni jednaki agrotehnički zahvati i rokovi njihovih izvođenja.

Tijekom istraživanja kukuruz je bio uzgajan pet godina, ozima pšenica tri i zob u jednoj godini. Prinos istih kultura bio je različit po godinama istraživanja i po različitim razmacima cijevne drenaže, što je prouzročeno različitim čimbenicima, kao što su: genetske značajke kultivara, odnosno hibrida, različita količina i raspored oborina tijekom godina istraživanja, vlažnost tla pred početak sjetve, broj biljaka na jedinicu površine, ukupna količina gnojiva i raspored prihrane usjeva u vrijeme vegetacije te vrijeme žetve-berbe usijeva.

Tako je prinos kukuruza bio najviši u 1991. god. i kretao se od 88.00 dt/ha (za razmak od 15 m) do 71.74 t/ha (30 m). Najniži prinos kukuruza utvrđen je 1996. u visini od 58.20 dt/ha (15 m) do 43.48 dt/ha (30 m). Najviši prinos pšenice utvrđen je 1991. u visini od 57.96 dt/ha (15 m) do 52.35 dt/ha (30 m), a najniži 1998. od 38.88 dt/ha (20 m) do 30.88 dt/ha (30 m). Prinos zobi bio je od 42.19 dt/ha (15 m) do 37.59 t/ha (30 m).

Analizom varijance posebno za svaku godinu istraživanja utvrđene su visoko signifikantne razlike ($p<0.01$) između prinosa pojedine kulture ovisno o razmaku cijevne drenaže u šest godina ispitivanja (1990, 1991, 1992,1996, 1997 i 1998). Signifikantne razlike ($p<0.05$) između prinosa utvrđene su 1999. godine, dok 1993. i 1995. razlike između prinosa ovisno o razmaku cijevne drenaže nisu bile signifikantne.

U agroekološkim uvjetima srednje Posavine zadovoljavajući prinosi postižu se na razmacima cijevne drenaže 15 m. U godinama kada se pravilno održava sustav odvodnje može zadovoljiti i razmak cijevne drenaže od 20 m, uz obnavljanje agrotehničke mjere-vertikalnog dubinskog rahljenja.

KLJUČNE RIJEČI

prinos, kukuruz, ozima pšenica, zob, hidromeliorirani Gleyic Podzoluvisol, cijevna drenaža, razmak cijevi

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INTRODUCTION

Plant production potentials are restricted both in Croatia and globally due to limited agricultural areas. Besides land area constraints, there are also constraints with regard to soil quality (various production capacities). Production areas (and thereby also plant production) could be, to a certain extent, increased by developing non-agricultural land and/or improving the production capacity of poor agricultural land.

Soils that cannot be cultivated because of excessive water (impaired water-air relationship in the solum) can be efficiently developed into arable agricultural land by the application of hydro and agroameliorative treatments. Ameliorative measures may also improve unfavourable soil properties on arable land and thereby enable a more reliable and higher agricultural production. Drainage systems play a special role in both of the above-mentioned cases. Their justification is best confirmed by increased yields of the tested crops, and especially by their stabilization in further production (Čamdžić, 1988; Vidaček et al., 1991, 1993;Tomić et al., 1994 Šimunić,1995)

As Croatia has 161,530 ha of underground drainage systems (Marušić, 1995), it is interesting to find out the extent to which drainpipe spacing effects the yields of crops grown.

MATERIALS AND METHODS

Yields of different crops grown on soil developed by hydro- and agroameliorative measures were studied in the 1990-1993 and 1995-1999 periods.

Trials were carried out on the experimental amelioration field "Jelenščak"- Kutina (central Sava valley) on soil type defined as hydroameliorated Gleyic Podzoluvisol. Trial variants involved pipe drainage spacing of 15 m, 20 m, 25 m and 30 m, set up in four replications. All variants were combined with gravel as contact material (ø 5-25 mm) in the drainage ditch above the pipe. Drainpipe characteristics were: length 95 m, diameter 65 mm, average slope 3‰ and average depth 1 m. Drainpipes discharged directly into open channels. Variants covered areas of: 1425 m², 1900 m², 2375 m² and 2850 m².

The same crop was grown, the same fertilizer rates were applied, and harvest/picking was carried out at the same time in all drainpipe spacing variants and in all trial years (Table 1). Harvest/picking was done with a combine-harvester, whereby the yield from the overall area of trial variants was analyzed.

Analysis of variance between variants was done for each trial year separately, while Duncan's Multiple Range test was used to compare the mean values of crop yields in dependence on the spacing variant.

Table 1. Crops grown, dates of drilling, fertilization and harvest/picking, in the 1990-1993 and 1995-1999 periods.

Year	Crop	Drilling	Fertilization			Harvest/picking
			Date	Rate (kg/ha)	Total N (kg/ha)	
1990	Wheat	15/10/1989	14/10	90-180-120	190	12/07
	(Cultivar-Marija)		24/02	59 N		
			26/03	41 N		
1991	Maize	30/04	29/04	115-90-135	192	20/10
	(Hybrid-Bc 492)		15/04	54 N		
			10/07	23 N		
1992	Zob	30/03	29/03	30-90-60	50	27/07
	(Cultivar –Fleming regent)			20 N		
1993	Maize	01/05	30/04	117-156-156	171	14/10
	(Hybrid-Bc 318)		18/06	54 N		
1995	Wheat	20/10/1994	19/10	90-170-120	180	14/07
	(Cultivar –Sana)		26/02	40 N		
			28/03	50 N		
1996	Maize	22/05	20/05	115-80-120	145	16/11
	(Hybrid-Bc 272-Eta)		08/07	30 N		
1997	Maize	06/05	05/05	121-90-135	175	18/10
	(Hybrid-Bc 3901-Eva)		24/06	54 N		
1998	Wheat	19/10/1997	15/10	109-120-80	203	07/07
	(Cultivar –Srpanjka)		25/02	54 N		
			07/04	40 N		
1999	Maize	25/05	23/05	101-106-106	155	20/10
	(Hybrid-Bc 318)		29/06	54 N		

Table 2. Quantity and distribution of precipitation during the growing seasons (mm)

Year	01	02	03	04	05	06	07	08	09	10	11	12	Σ
1989										93.0	29.9	32.1	
1990	31.4	22.4	46.0	47.8	47.5	93.5	24.6						911.3
1991					155.9	19.9	160.1	51.5	49.7	142.5			579.6
1992				53.9	15.8	142.3	48.5						260.5
1993					44.2	134.0	30.2	119.0	90.0	34.6			452.0
1994										49.7	13.1	53.7	
1995	79.9	70.2	45.7	40.2	115.0	174.0	6.2						647.7
1996					12.5	30.6	90.5	82.5	191.0	46.3	7.2		460.6
1997					4.1	81.3	102.8	62.8	29.8	62.8	126.5	85.6	343.6
1998	65.3	5.3	57.5	59.2	103.2	107.1	31.4						641.1
1999					0.0	88.9	85.9	65.6	95.4	31.6			367.4

Site factors

Efficient plant production requires an appropriate site, that is, vegetation factors such as light, warmth, air (oxygen), nutrients and water. In the conditions of field growing, the first three factors (light, warmth and air) are left to nature and cannot be influenced. However, it is possible to influence the two remaining factors (nutrients and water) by the fertilizing system and measures aimed at regulating soil water (drainage and/or irrigation). In our conditions, care is taken of nutrient application during the growing season of crops grown, but soil moisture is often left to nature. Hence, the ultimate achievement of yield generally depends on the amount and distribution of precipitation, or on the year being dry or humid.

Table 2 presents the quantity and distribution of precipitation during the growing seasons in the trial years.

RESULTS AND DISCUSSION

The mean values of crop yields, in dependence on the drainpipe spacing variant, are presented in Table 3.

As can be seen from Table 3, maize participated in the crop rotation in five years, winter wheat in three years and oats only once. Yields of the same crops differed in different trial years due to various factors, such as genetic characteristics of the cultivars, or hybrids (Table1), different quantities and distribution of precipitation during the growing season (Table 2), soil moisture (Tomić and Marinčić, 1988; Šimunić, 1995; Cupa, 2000), drilling date, number of plants per unit area (Megyes and Nagy,1999), total fertilizer applied, topdressing pattern in the growing season (Table 1), and the harvest/picking time. Yields of the same crops differed in different drainpipe spacing variants. As a rule, the highest yields were achieved in the drainpipe spacing variant of 15 m, and the lowest in that involving 30 m spacing, which the authors attribute to the efficiency of particular drainage systems (Tomić et al., 1994).

Analysis of variance, done separately for each trial year, rendered highly significant differences ($p<0.01$) between yields of particular crops in dependence on the drainpipe spacing in six trial years (1990, 1991, 1992,1996, 1997 and 1998). Significant differences ($p<0.05$) between yields were recorded in 1999, while the 1993 and 1995 differences between yields, depending on the drainpipe spacing, were not significant.

Duncan's test revealed that crop yields were significantly higher in drainpipe spacing variants of 15 m in five trial years. In 1998, winter wheat yield was not significantly different between drainpipe variants of 15 m and 20 m while in 1999 maize yield was not different in spacing variants of 15 m, 20 m and 25 m.

The authors maintain that the reason why there were no differences in yields in 1993 was soil compaction in the sub-plough horizon, which reduced drainage discharge and disturbed the water-air relationship in soil, impairing the efficiency of particular drainage variants (Šimunić, 1995; Tomić et al., 1994; Petošić et al., 1998). Levelling and vertical deep loosening of soil were applied to the trial areas in 1994. Small surface depressions were corrected by levelling, whereby occasional stagnation of surface water was eliminated. Vertical deep loosening provided favourable water-air relationships in soil (quick and efficient draining of excess surface water). Therefore, no efficiency of particular drainage variants was recorded in 1995 and yield differences were not significant (Petošić et al., 1998). In 1998, and even more so in 1999, new soil compaction and disturbed water-air relationship reduced the drainage spacing functionality, and thereby also yield differences.

Accordingly, satisfactory yields can be achieved in the agroecological conditions of the central Sava valley with the drainpipe spacing of 15 m. Drainpipe spacing of 20 m, supplemented by repeated vertical deep loosening, may give satisfactory results in years when the drainage system is adequately maintained.

Table 3: Duncan's Multiple Range test of the mean values of crop yields (dt/ha) in dependence on the drainpipe spacing variant

Drain-pipe spacing variant	Dry grain yield (dt/ha)								
	Winter wheat (1990)	Maize (1991)	Oats (1992)	Maize (1993)	Winter wheat (1995)	Maize (1996)	Maize (1997)	Winter wheat (1998)	Maize (1999)
15 m	57.96 a	88.00 a	42.19 a	64.28 a	48.20 a	58.20 a	84.53 a	38.43 a	62.30 a
20 m	56.91 b	81.30 b	40.41 b	63.50 a	48.40 a	53.43 b	80.18 b	38.88 a	61.60 a
25 m	56.05 b	78.66 c	40.15 b	60.80 a	48.90 a	49.15 c	78.03 b	32.83 b	57.70 ab
30 m	52.03 c	71.74 d	37.57 c	60.10 a	48.90 a	43.48 d	72.68 c	30.88 b	56.20 b

Values marked by the same letter are not significantly different according to Duncan's test ($p>0.05$)

Hence, drainpipe spacing of 20 m is recommended for Gleyic Podzoluvisol, along with appropriate and regular maintenance of the drainage system and application of vertical deep loosening of soil.

CONCLUSIONS

Research work done in the 1990-1993 and 1995-1999 periods on the experimental amelioration field "Jelenščak"- Kutina, on hydroameliorated Gleyic Podzoluvisol, in four different drainpipe spacing variants, points to the following conclusions:

Yields of the same crops differed in particular trial years due to various factors, such as genetic properties of the cultivars, or hybrids, different quantities and distribution of precipitation during the growing season, soil moisture before drilling, number of plants per unit area, total fertilizer applied and topdressing pattern in the growing season, as well as the date of harvest/picking.

Yields of the same crops differed also between different drainpipe spacing variants. As a rule, the highest yields were achieved in the drainpipe spacing variant of 15 m, and the lowest in that involving 30 m spacing, which is attributed to the efficiency of particular drainage systems.

Analysis of variance, done separately for each trial year, rendered highly significant differences ($p<0.01$) between yields of particular crops in dependence on the drainpipe spacing in six trial years (1990, 1991, 1992,1996, 1997 and 1998). Significant differences ($p<0.05$) between yields were recorded in 1999, while the 1993 and 1995 differences between yields, depending on the drainpipe spacing, were not significant.

Satisfactory yields can be achieved in the agroecological conditions of the central Sava valley with the drainpipe spacing of 15 m. Drainpipe spacing of 20 m, supplemented by repeated vertical deep loosening, may give satisfactory results in years when the drainage system is adequately maintained.

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