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Zeszyt 22

The effect of irrigation and fertilisation in repland orchard

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Abstract: *The effect of irrigation and fertilisation in repland orchard.* In the years 1994-1999 on the Agricultural Experimental Farm in Przybroda, studies were carried out on the effect of different fertilisation and irrigation regimes on apple tree growth and yield in the replanted area.

Key words: replantation, irrigation, fertilisation, apple-tree, water management.

INTRODUCTION

Increasing production demands and specialisation of horticultural farms have created the need for plantation of new trees directly or in a short time after liquidation of the earlier orchard. Replantation should be performed having previously restored the production properties of the soil, and one of the conditions determining success of the procedure is the restoration of the soil resources. Plantation of the same species on the area it had previously occupied may lead to the replantation disease manifested as poor assimilation of new trees, their delayed growth, delayed vegetation and in extreme cases death of the newly planted trees (Rebandel 1987, Szczygieł 1988), The disease may be caused by specific (pathogenes and toxins) as well as non specific reasons (soil structure degradation, deficiency or excess of water , inappropriate nutrient components (Swell & Whithe 1979). It has been recognised that the occurrence of the replantation disease can be restricted by applying proper fertilisation and irrigation procedures (Pacholak 1992, Pacholak, Przybyła 1996, 1997, 1999, 2000, Rebandel 1998).

The necessity for replantation has created the need to find the best possible procedures

and establish their right timing in order to minimise the negative consequences of the process. The factors which should be taken into regard include: The time interval between replantations, fertilisation and irrigation prior to and after replantation. Irrigation of the orchard after replantation is particularly important because of the changes in the soil environment. The aim of the study reported was to assess the effect of many year applications of different fertilisation and irrigation procedures on the growth of and yield from replanted apple trees as well as on the physical and chemical properties of the soil.

MATERIAL AND METHODS

The study was conducted in the years 1994-1999 in the orchard of the experimental farm of the Agricultural University, in Przybroda (Poland). In the autumn of 1993 the apple trees which had been growing there since were dug up and in the spring of 1994, preserving the same combination of fertilisation and irrigation, new tress were planted. Having prepared the soil, apple trees Sampion were planted in special P60 supports, in spacing of 3.5 x 1.5 m (1900 trees/ha), in the Drilling from and supported with special constructions.

The soils in Przybroda are typical of Wielkopolska. The soil in the orchard studied is p³owa, w³aœciwa, with the upper layer from 0 to 50 cm of light sandy – clay or strong sandy – clay. The deeper support layer is light clay, Table 1. The ground water table varied from 130 cm in spring to 180 cm in autumn. The soil analysis was based on determination of granulometric composition as well certain physical – water characteristics and chemical properties for 6 soil profiles, Tables 1 and . In the years 1976 – 1993, on each level of irrigation, 4 modes of fertilisation were applied, while in 1994 eight modes of fertlisation were used, designed on the basis of analysis of the growth and development of tree and nutrition qualities of the soil.

The area of the fertilised plots was 84 m^2 till 1993, and since 1994 their area was reduced to 42 m^2, there were 8 trees growing in each plot. Each mode of fertilisation was four times repeated.

A far as irrigation is concerned, the effects of three variants were compared (since 1976):

1. W0 – control plots with natural precipitation only,

2. W1 – sprinkling applied to maintain the soil moisture at the level of 0.03 MPa of the water potential,
3. W2 – sprinkling applied to maintain the soil moisture at the level of 0,01 MPa of the water potential.

Table 1. Texture of the soils studied.

Profile No	*Depths [cm]*	*Textu-re symbol*	*Selection particles [%]*		*Soil size fraction [%] (mm)*							
			>2 mm	*2-1 mm*	*1-0,5*	*0,5-0,25*	*0,25-0,1*	*0,1-0,05*	*0,05-0,02*	*0,02-0,006*	*0,006-0,002*	*< 0,002*
1.	0-50	pgl	2,1	1	8,2	17,5	36,3	13	9	6	5	5
	50-95	gl	1	1,1	7,5	15,3	30,2	11	6	7	4	19
	95-100	gl	2,7	1,3	7,3	14,7	31	13	8	7	3	16
2.	0-50	pgl	1,6	1,5	8	17,7	34,3	16	10	8	3	3
	50-95	gl	1,5	1,3	6,7	14,2	30	11	7	8	3	20
	95-100	gl	1,7	1,2	7,5	16	31,5	13	7	8	4	13
3.	0-30	pgm	0,9	1	9,2	17	34,8	16	8	6	5	4
	30-50	gl	0,9	1,2	6,7	14	30,3	10	7	7	3	22
	50-80	gl	1,9	1,9	8,2	14,8	33	11	8	8	4	15
	80-120	gl	1,9	1,3	8,7	15,5	31,8	12	9	7	5	13
4.	0-60	pgl	3,6	1,5	8,7	17,3	37	14	9	6	5	3
	60-110	gl	1,1	0,9	7,5	16,5	31	11	7	6	4	17
	110-150	gl	1,6	1,4	7,3	15	30,7	12	8	7	5	15
5.	0-45	gl	1,1	0,9	7,7	17,3	35	15	10	6	5	4
	45-90	gl	1	1,2	6,5	13	28,5	12	9	7	6	20
	90-145	gl	2	1,5	7,5	14,5	29	13	7	10	6	13
6.	0-35	pgl	1	0,9	7,3	16,7	35	15	10	6	5	4
	35-70	gl	0,7	1	6,5	13,8	28,7	12	6	7	3	23
	70-100	gl	1,8	1	7,3	14,2	30,5	11	7	7	4	19
	100-150	gl	2,9	1,2	7,5	14,7	28,8	12	7	11	5	14

The sprinkling was performed which a permanent sprinkler of the nozzle diameter of 4 and 6 mm, the rate flow of the water of 7 mm/h and doses ranging from 14 to 35 mm. The source of sprinkling water was the Pami¹tkowskie Lake was pumped to an equalising tank near the orchards, its quality corresponded to that of the third grade purity.

The results were subjected to many – ways analysis of variance, and the significance of differences was established by the Duncan test at the probability level of a=0.05.

Table 2. Physical and chemical properties of the soil profiles studied.

Profile No	*Depths [cm]*	*Texture symbol*	*Organic mater [%]*	*Densinity particle [gcm^3]*	*Water hygroskopicity*	*Hygroscopic water capacity [%]*	*pH*		*$CaCO_3$ [%]*	*Fe_2O_3 [%]*
							In H_2O	*In KCl*		
1.	0-50	pgl	0,93	2,62	0,55	0,94	5,3	4,7	0	0,46
	50-95	gl	1,47	2,65	2,65	4,16	7,1	6,2	0	1,73
	95-100	gl	1,14	2,65	2,2	3,67	7,3	6,3	0	1,4
4.	0-50	pgl	0,58	2,63	0,32	0,73	4,6	4,3	0	0,48
	50-95	gl	1,44	2,65	2,83	4,57	6,1	5,1	0	1,71
	95-100	gl	0,9	2,65	1,82	2,9	7	6,2	0	1,27
5.	0-30	pgm	1,39	2,6	0,67	1,55	4,4	3,9	0	0,43
	30-50	gl	1,64	2,66	3,14	5,05	5,2	4,4	0	1,81
	50-80	gl	1,28	2,68	2,19	3,57	7	6,1	0	1,57
	80-120	gl	0,87	2,62	1,29	2,03	8,1	7,6	6,6	0,98
6.	0-60	pgl	0,46	2,64	0,4	0,63	5,1	4,9	0	0,43
	60-110	gl	0,92	2,67	2,51	3,6	5,4	4,6	0	1,61
	110-150	gl	0,58	2,65	2,22	3,39	7,9	7,1	1,5	1,3
7.	0-45	gl	1,15	2,57	0,7	1,15	4,9	4,4	0	0,38
	45-90	gl	1,18	2,63	3,03	4,71	6,4	5,8	0	1,82
	90-145	gl	0,73	2,61	1,44	2,59	8,2	7,6	10,2	1,1
8.	0-35	pgl	1,08	2,6	0,66	1,19	5,5	5	0	0,4
	35-70	gl	1,28	2,68	3,08	4,79	5,9	5	0	1,98
	70-100	gl	0,99	2,67	2,81	4,4	6,9	6,4	0	1,86
	100-150	gl	0,38	2,67	1,45	2,6	8,1	7,6	10,4	1,09

CHARACTERISTICS OF METEOROLOGICAL CONDITIONS AND THE IRRIGATION APPLIED

Over the 20 years of study climatic conditions in Przybroda were caracterised by variable total precipitation and its unfavorable distribution in vegetation season. The periods of water deficiency were irregular, there were 7 dry years, 6 medium moist years and 7 moist years.

Table 3 presents the total monthly precipitation (P), potential evapotranspiration (ETP), real evapotranspiration (ETR) and water deficiency calculated from the difference between the real precipitation in deficiency months of the vegetation season and the potential evapotranspiration calculated by the Penmann method in the simplified version, for subsequent vegetation seasons from 1994 to 1999.

Table 3 Monthly totals of precipitation, evapotranspiration and water deficiency in the years 1994-1999.

Year	*Month*	*Precipitation P in*	*ETP [mm]*	*ETR [mm]*	*N=P-ETP [mm]*
1994	IV	42	59	43	-17
	V	59	68	42	-9
	VI	40	98	47	-58
	VII	82	89	64	-7
	VIII	55	77	60	-22
	IX	37	32	29	5
	Suma	315	423	285	-108
1995	IV	13	51	41	-38
	V	56	68	55	-12
	VI	86	102	88	-16
	VII	16	130	80	-114
	VIII	66	72	45	-6
	IX	61	35	30	26
	Suma	298	458	339	-160
1996	IV	10	49	39	-39
	V	56	75	65	-19
	VI	47	91	85	-44
	VII	224	125	44	99
	VIII	77	126	22	-49
	IX	50	78	55	-28
	Suma	464	544	310	-80
1997	IV	34	46	39	-12
	V	63	68	53	-5
	VI	56	97	55	-41
	VII	119	90	76	29
	VIII	23	83	44	-60
	IX	34	35	26	-1
	Suma	329	419	293	-90
1998	IV	42	50	39	-8
	V	37	84	68	-47
	VI	79	104	99	-25
	VII	50	98	83	-48
	VIII	57	74	51	-17
	IX	73	37	27	36
	Suma	338	447	367	-109
1999	IV	72	42	33	30
	V	27	70	60	-43
	VI	85	70	65	15
	VII	30	87	73	-57
	VIII	33	65	24	-32
	IX	16	42	37	-26
	Suma	263	376	292	-113
Mean 1994-1999	IV	35	49	39	-14
	V	50	72	57	-22
	VI	65	91	73	-29
	VII	87	103	70	-16
	VIII	52	83	41	-31
	IX	45	43	34	2
	Suma	334	447	314	-110

In the years 1994 –1999 the totals of precipitation in the vegetation seasons varied from 298 mm (1995) to 464 mm (1996). The total potential evapotranspiration was 423 mm in 1994, 458 in 1995 and 544 mm in 1996, whereas the total real evapotranspiration was 285, 339 and 310 mm in the same years. The precipitation deficiency was the greatest in 1995 – 160 mm and the lowest in 1996 –only 108 mm. These values indicate the need for irrigation of the area (Przybyła 1994). The irrigations applied expressed as total doses are given in Table 4, for particular years.

Table 4 Total doses of irrigation water applied in the deficiency vegetation periods in the years 1994 – 1999.

Year	*Precipitation*	*Combination of irrigation*	
	W_0 [mm]	*W_1 [mm]*	*W_2 [mm]*
1994	315	419	535
1995	298	414	534
1996	463	519	597
1997	329	409	479
1998	338	429	506
1999	263	331	399
Mean 1994-1999	334	420	467

Table 5. Fertilization and the content of available nutrient in the soil (mg/100g of soil).

No	*Fertilisation variants kg/ha*	*Nutrient (mg/100g of soil)*			
		P	*K*	*Mg*	*pH*
1	Control	2,6a*	6,a	6,4d	5f
2	65N	2,9ab	6,2a	6,2cd	4,8f
3	65N; 95K_2O	3,0ab	10,3b	5,4bc	4,6de
4	65N; 95K_2O+Ca	3,1ab	10,3b	5,4bc	4,4cd
5	130N; 190K_2O+Ca	3,3b	12,3c	4,3a	4,1b
6	130N; 190K_2O+Ca	3,2b	14d	4,8ab	4,2bc
7	No fertilization	3,5b	10,8b	4a	3,9a
8	No fertilization +Ca	3,3b	9,7b	3,8a	3,8a

*Means followed by the same letter do not differ at of significance $\alpha = 0,05$

Table 6. Irrigation and the content of available nutrients in the soil (mg/100g of soil).

No	*Irrigation variants*	*Nutrient (mg/100g)*			
		P	*K*	*Mg*	*pH*
1	W_0 No irrigation	3,2a	8,4a	3,2a	4,0a
2	W_1 (-0,03 MPa)	3,1a	11,0b	5,1b	4,4b
3	W_2 (-0,01 MPa)	3,0a	10,8b	6,8c	4,7c

*Means followed by the same letter do not differ at the level significance $\alpha = 0,05$

Table 7. Increase in the circumference of tree trunks and the percent of dead trees.

Fertilisation variants (dosage in kg/ha)	*Irrigation variants*					
	W_0 No irrigation		*W_1 (-0,03 MPa)*		*W_2 (-0,01 MPa)*	
	The lost trees [%]	*The lost trees [cm]*	*The lost trees [%]*	*The lost trees [cm]*	*The lost trees [%]*	*The lost trees [cm]*
Control	4,16	1,4c-e**	16,64	0,8a	33,28	0,7a
65N	4,16	1,6ef	8,32	1,1b	24,96	0,9a
65N; 95K_2O	0	2,1h	8,32	0,9ab	12,48	1,3c
65N; 95K_2O+Ca	0	2h	16,64	1,2bc	4,16	1,1b
130N; 190K_2O+Ca	0	1,5d-f	8,32	1,3cd	12,48	1,6ef
130N; 190K_2O+Ca	0	1,5d-f	12,48	1,3cd	4,16	1,5de
No fertilization	0	2h	0	1,7fg	4,16	1,8gh
No fertilization +Ca	0	1,9gh	0	2h	4,16	1,7fg
Mean for irrigation	1,04	1,8b	8,84	1,3a	12,36	1,3a

* Circumference in 1996 minus circumference in 1994.

** Means followed by the same letter do not differ at the level significance $\alpha = 0,05$

Table 8. The yield of Sampion apple trees in the year after replantation.

Fertilisation variants (dosage in kg/ha)	*Irrigation variants*					
	W_0 No irrigation		*W_1 (-0,03 MPa)*		*W_2 (-0,01 MPa)*	
	kg per tree	*t/ha*	*kg per tree*	*t/ha*	*kg per tree*	*t/ha*
1. Control	2,2 de	4,2	1,2 el	2,3	0,5 f	1,0
2. 65N	4,8 b	9,1	1,9 de	3,6	1,2 ef	2,3
3. 65N; 95K_2O	7,8 a	14,8	2,5 d	4,8	2,1 de	4,0
4. 65N; 95K_2O+Ca	6,6 a	12,5	2,9 d	5,5	1,3 ef	2,5
5. 130N; 190K_2O+Ca	5,9 a	11,2	2,6 d	4,9	5,2 ab	9,9
6. 130N; 190K_2O+Ca	5,2 ab	9,9	3,7 cd	7,0	4,8 b	9,1
7. No fertilization	5,8 a	11,0	3,5 cd	6,6	3,6 cd	6,8
No fertilization +Ca	5,7 a	10,8	3,0 cd	5,7	4,1 bc	7,8
Mean for irrigation	5,5 a	10,4	2,6 b	4,9	2,4 b	4,6

* Means followed by the same letter do not differ at the level of significance $\alpha = 0,05$

RESULTS OF THE STUDY

Analysis of the nutrients in the soil of the orchard studied proved a significant effect of fertilisation and irrigation procedures on their amount and composition. Fertilisation (Table 5) caused a substantial increase in the amounts of phosphorus and potassium (in a 60 cm deep soil layer), while the content of magnesium and pH value decreased. Irrigation (Table 6) irrespective of the level of fertilisation did not affect the contents of phosphorus in the soil. Under the effect of irradiation, the amount of potassium increased, however, the differences between the variants D1 and D2 were not

statistically significant. Moreover, the contents of magnesium and pH depended on the size and frequency of irradiation applied.

The results led to a conclusion that in the optimum conditions of fertilisation and irrigation, much diversity was observed in the growth and yield of the orchard.

Although the Sampion apple trees planted on P-60 supports were of approximately the same size, much diversity was observed in their growth already in the first year after replantation. With increasing intensity of irrigation, the percent of dead and dying trees increased. The variants under intense irrigation were characterised by a low dynamics of growth measured as an increase in tree trunk circumference. The application of fertilisation significantly increased the yield (Table 8). The lack of mineral fertilisation for 20 subsequent years resulted in inhibition of tree growth and an increase in the percent of dying trees.

The most surprising result of the studies is the decrease in yields with growing intensity of irrigation. The highest yield of the orchard was observed in the variant for which natural conditions of tree growth were preserved.

CONCLUSIONS

1. Fertilisation and irrigation procedures applied in replanted orchard had significant influence on the contents of assimilable nutrients in the soil.
2. Mineral fertilisation and irrigation doses applied significantly affected the rate of growth and yield in the replanted orchard.
3. Irrespective of the intensity of fertilisation and irrigation applied, the yield in the replanted orchard of Sampion trees on P-60 supports was lower than in the conditions of the original plantation.

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