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AGROGEL USAGE IN CULTIVATION OF TREES PLANTED IN RIDGES

Dariusz Dereń, Adam Szewczuk
and Ewelina Gudarowska

Wroclaw University of Environmental and Life Sciences
Pl. Grunwaldzki 24 A, 50-363 Wrocław, POLAND
e-mail:gewa@poczta.onet.pl ewelina.gudarowska@up.wroc.pl

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A B S T R A C T

The experiment was conducted in the years 2005-2008 in the Research – Development Station in Samotwór, of the Wroclaw University of Environmental and Life Sciences. Apple trees of 'Ligol' and 'Pinova' grafted on M.26 were planted in the spring 2005, in 3.5 x 1 m spacing (2857 trees/ha). The trees were planted in a traditional way, into pits or in ridges. The second factor was the usage of agrogel as a soil additive. Agrogel was applied in the form of a tape made of thick agro–textile with a granulate preparation closed inside, what is called a geo–textile. The tape was soaked in water for 24 hours and then spread on the soil in a line along the future row of trees. The experiment was established according to the method of randomized split–blocks, in four replications, with four trees on each plot. A combination of planting trees in ridges with simultaneous use of agrogel proved to be an advantageous way to improve the yielding of 'Ligol'. The trees of 'Pinova' were characterized as having a smaller yield size, in the first three years after the trees were planted in ridges, regardless of the agrogel application. In the case of 'Ligol' planted in ridges, agrogel brought about an evident tendency to improvement of tree vegetative growth, measured by TCSA in all the years that the experiment was carried out. As far as 'Pinova' was concerned, the poorer tree growth when planted in ridges, proved to be more evident when agrogel was simultaneously used.

Key words: apple tree, planting in ridges, agrogel, yield, growth

INTRODUCTION

Water deficit is a serious problem in gardening. Due to diminishing water resources, especially in recent years, there has been an increased interest in the issues connected with the improvement of sorptive properties of soils. Application of polymeric supersorbents is one of possible solutions to this difficult problem (Leciejewski, 2008). Agrogel is a non-toxic polimer of acrylic acid, polyethenol or ethyl polyoxide, featuring strong properties of absorption and accumulation. Agrogel has these properties both in water solutions of different substances, like fertilizers or pesticides and in water itself (Paluszek, 2003). These sorptive properties allowed agrogel to be used in different fields of horticulture (Gudarowska and Szewczuk, 2009a; Koc et al., 2009), applied in the form of what is called Geo – textile, placing a sorbent in a sleeve made of a thick textile. Used in this way, agrogel positively affected the qualitative parameters of one-year old peach tree, produced in a nursery.

Placing trees directly on the soil surface and then hilling their root system with the soil from the interrows is a modification of the traditional way of tree planting. In this process, there are ridges formed where trees can grow within the whole cultivation period. This way of planting can provide disadvantageous conditions because of the soil overdrying when there is a lack of precipitation. It is also disadvantageous because of the possibility of the root system freezing (Sosna, 2002). On the other hand, air–water conditions, and the temperature of the soil can favour fruit trees growing in formed ridges (Sako and Laurinen 1986). Sosna and Szewczuk (1998) recorded poor growth of apple trees in elevated earth banks during the first years after planting. Treder and Mika (2001) observed that trees planted in ridges were characterized by poor growth, but only after the third year they had been planted. This way of planting can be introduced when replantation occurs. Bootsma (1995) analyzing the mutual effect of replantation disease and the way trees were planted, reported that in the beginning, there was more vigorous growth of trees which had been planted in ridges. Then, over the years, tree growth followed a gradually slower pace. Therefore, planting trees in ridges in unfavourable environmental conditions can contribute to the improvement of tree growth and development. Perry (1996) stressed another aspect of ridges influencing trees, namely, the possibility to minimize the negative effect of high ground water level on the development of tree roots. Yet trees can be more exposed to drought, as considerable overdrying of the soil in ridges is a well known fact (Treder and Mika, 1996). Due to the reasons mentioned above, when planting trees in ridges, there is a need to provide trees with appropriate conditions of soil moisture, e.g. through the use of supersorbents. The aim of the experiment was to assess the effect of water absorbing preparation, on trees planted according to the ridge method.

MATERIAL AND METHODS

The experiment was carried out in the years 2005-2008 at the Research – Development Station in Samotwór, Poland. This station belongs to the Wroclaw University of Environmental and Life Sciences. Apple trees of 'Ligol' and 'Pinova' cvs budded on M.26 rootstock were planted in the spring 2005 on lessive soil developed from light boulder clay with ground water at a level of 3 m. Trees were planted in 3.5 x 1 m spacing (2857 trees/ha). According to the traditional method, trees were planted into pitches dug earlier or in ridges. The second factor of the experiment was the application of agrogel as a growing medium additive. Agrogel was used in the form of tape made of a thick textile, with a granulated preparation of about 0.5-0.7 g/cm^3 in density closed inside, to form a so–called geo–textile. The tape was soaked in water for 24 hours before planting and then spread on the soil along the future tree rows. Strips of the tape, with gel granulate storing water, were placed in a soil medium 25 cm deep in the traditional planting way, and directly on the soil surface - when the method of planting trees in ridges was introduced. In both cases the tape with agrogel was situated directly under the root system of the apple trees planted. The length of the geotextile strips was adjusted to a length of a plot. One meter, 10 cm wide tape of geotextile can absorb and accumulate 5 dm^3 of water.

The experiment was established following the randomized split–blocks method, in four replications, with 4 trees on each plot. In the course of the experiment, yield size and quality were assessed. Tree vigour was assessed on the basis of biometric measurements of the increase in cross section area of a tree trunk. Trees were trained in the form of a spindle crown. In trees rows, herbicide fallow was maintained, and in interrows there was introduced a sward in the second year after tree planting.

Because of the low level of ground water, the water rise did not have an influence on water conditions in the experiment. The only source of water for trees was rainfall. In the course of the weather in the years 2005-2008, there was a water deficit in June 2005, in May, and July 2007, and in July 2008 in relation to the long period of 1981-2000 (Tab. 1). The water soil potential was not measured in the experiment.

In order to statistically compare yielding results and tree vigour, the method of analysis of variance was applied. Estimation of differences was done according to t-Studenta test at significance level $\propto = 0.05$.

RESULTS AND DISCUSSION

The experiment proved the different response of trees to the factors applied. In the case of 'Ligol', which showed a tendency to alternate fruiting, it was found that the way of planting did not significantly influence the obtained yield

Table 1. Monthly rainfalls in the vegetative season in the years 2005-2008, compared to the multiyear mean in the Experimental Station in Samotwór

Month	III	IV	V	VI	VII	VIII	IX	X
Multiyear (1981-2000) mean rainfall [mm]	40.7	36.5	52.7	76.6	79.5	65.7	46.0	32.9
Monthly rainfalls in 2005 [mm]	2.9	26.2	122.8	28.8	100.8	56.2	18.6	2.7
Relation to the multiyear mean	-37.8	-10.3	+70.1	-47.8	+21.3	-9.5	-27.4	-30.2
Monthly rainfalls in 2006 [mm]	48.6	8.2	52.3	104.2	123.9	57.0	54.9	30.2
Relation to the multiyear mean	+7.9	-28.3	-0.4	+27.6	+44.4	-8.7	+8.9	+2.7
Monthly rainfalls in 2007	24.0	46.5	21.3	67.6	22.7	229.3	20.5	54.3
Relation to the multiyear mean	-26.7	+10.0	-31.4	-10.0	-56.8	+163.6	-25.5	+21.4
Monthly rainfalls in 2008 [mm]	36.5	74.5	50.5	32.9	42.2	78	31.5	43.0
Relation to the multiyear mean	-4.2	+38.0	-2.2	43.7	-37.3	+12.3	-14.5	+10.1

size (Tab. 2).The results are in agreement with the investigation conducted by Perry (1996), as well as by Treder and Mika (2001), who did not record any considerable effect of the method of tree planting on tree yielding. Yet the effect of agrogel became quite evident in the years of advantageous fruiting. Taking into account the mutual effect of the factors subjected to analysis, it was possible to state that in the years 2006 and 2008, the use of agrogel with the simultaneous planting of trees in ridges did favourably affect the level of tree yielding. Considering the sum of yield sizes from the years 2006-2008, it is an obvious fact that combining tree planting in ridges with the simultaneous introduction of agrogel, is a successful way to improve the yielding of young 'Ligol' trees. The difference in yielding, in relation to the control trees, amounted to about 5.2 kg, which, when counted over an area unit, increased yield size by nearly 15 tons per hectare. Trees of 'Pinova', however, reacted to the combined ridge and agrogel way of planting, by an apparent decrease in yielding. Analysis of mean values for the ways of planting within the first three years of fruiting undoubtedly indicates that the traditional way of tree planting proved to be more advantageous in comparison to planting trees in ridges. Similar conclusions were

Table 2. The yielding of 'Ligol' and 'Pinova' apple trees depending on the way trees were planted and the use of agrogel in the years 2006-2008

Treatment		Yield [kg tree^{-1}]			Total yield for the years 2006-2008
		2006	2007	2008	
Ligol					
Traditional planting	Control	3.72	0.16	8.37	12.26
	Agrogel	4.32	0.04	9.89	14.25
Ridges	Control	4.02	0.34	6.68	11.05
	Agrogel	5.86	0.42	11.13	17.42
NIR $_{(\alpha=0.05)}$ a x b		1.138	n.i.	2.227	2.765
NIR $_{(\alpha=0.05)}$ b x a		1.081	n.i.	n.i.	3.039
Mean value for the ways of planting					
Traditional planting		4.02	0.10	9.13	13.25
Planting in ridges		4.94	0.38	8.91	14.23
NIR $_{(\alpha=0.05)}$		n.i.	n.i.	n.i.	n.i.
Mean value for agricultural measures					
Control		3.87	0.25	7.53	11.65
Agrogel		5.09	0.23	10.51	15.83
NIR $_{(\alpha=0.05)}$		0.805	n.i.	1.575	1.955
Pinova					
Traditional planting	Control	4.40	8.09	8.40	20.90
	Agrogel	3.61	8.62	9.50	21.73
Ridges	Control	2.59	6.44	6.62	15.65
	Agrogel	3.19	6.83	6.67	1.69
NIR $_{(\alpha=0.05)}$ a x b		0.675	n.i.	n.i.	n.i.
NIR $_{(\alpha=0.05)}$ b x a		0.748	1.290	1.730	2.994
Mean value for the ways of planting					
Traditional planting		4.00	8.36	8.95	21.31
Planting in ridges		2.89	6.63	6.64	16.17
NIR $_{(\alpha=0.05)}$		0.748	0.813	1.346	1.596
Mean value for agricultural measures					
Control		3.5	7.26	7.51	18.27
Agrogel		3.40	7.73	8.08	19.21
NIR $_{(\alpha=0.05)}$		n.i.	n.i.	n.i.	n.i.

a x b – comparison of different agricultural measures within the same way of planting
b x a – comparison of different ways of planting according to the same agricultural measure

drawn by Wagenmakers and Tazelaar (1998), who believed that only in the case of some cultivars of trees was it possible to notice the effect of the way of planting apple trees, on their yielding. Based on the mean values involved in the use of agrogel, it was observed that in none of the experimental years did its application affect yield size of 'Pinova' trees. The mean values for particular combinations proved significantly poorer for fruiting of trees planted in ridges, both in the research years and for the sum of many years. In 2006-2008, no significant effect of agrogel application on the yielding of 'Pinova' trees planted in ridges was recorded.

Paluszek (2003) showed that appropriately introduced polymers provided for higher yields of plants by up to several per cents. This conclusion is associated with the capacity of permanent aggregates to form soil compaction, and water-air conditions, as well as physical, chemical and biological properties of the soil. All of these factors are decisive, as far as soil fertility and yielding potential are concerned.

In the case of 'Ligol', in 2008 only, it was possible to detect a positive influence of the combined introduction of planting trees in ridges with the use of agrogel on the quality of fruits, as compared to the control trees. It should also be noted that trees traditionally planted tended to produce larger fruits after agrogel usage, yet it was not statistically proven. Comparing the mean weight for fruit originating from the control trees and those dealing with agrogel application within each particular way of planting, it is possible to state that the examined factors did not significantly affect mean differences for the years 2006-2008. Only in 2008, the year of the most abundant tree fruiting, did planting trees in ridges and the simultaneous application of agrogel, result in improved quality of 'Ligol' fruit. Yield quality of 'Pinova', determined with the use of the mean weight of one fruit, was comparable within all the experimental years in which trees were planted traditionally, and grown in ridges. These results are in agreement with the investigation by Treder and Mika (2001). In reporting about one cultivar planted in two ways, they did not report that planting in ridges could significantly improve fruit quality. In the first two years of 'Pinova' tree fruiting, agrogel placed in the soil before planting the tree did not influence mean fruit weight. Yet in 2008, as well as for the mean value of the years 2006-2008, a markedly higher mean weight of one fruit, in trees treated with agrogel in comparison to the control trees, was recorded (Tab. 3).

Planting trees in ridges brought about weaker growth of 'Ligol' trees. The weaker growth can be confirmed by the summary increase in TCSA for the years 2005-2008, and by statistically proven significant differences in 2006 and 2007 (Tab. 4). It can be assumed that this way of planting reduced the growth of 'Ligol' apple trees by approximately 34%. Similarly, in the case of 'Pinova' trees, the effect of poorer growth of trees planted in ridges was

Table 3. Mean weight of one fruit from 'Ligol' and 'Pinova' apple trees depending on the way of planting and agrogel applied, in the years 2006-2008

Treatment		Mean weight of one fruit [g]			Mean value for the years 2006-2008
		2006	2007	2008	
Ligol					
Traditional planting	Control	173	335	110	142
	Agrogel	160	280	141	151
Ridges	Control	138	298	103	121
	Agrogel	157	345	155	156
NIR $_{(\alpha=0.05)}$ a x b		n.i.	n.i.	32.6	n.i.
NIR $_{(\alpha=0.05)}$ b x a		n.i.	177.2	n.i.	n.i.
Mean value for the ways of planting					
Traditional planting		167	203	126	146
Planting in ridges		148	321	129	138
NIR $_{(\alpha=0.05)}$		n.i.	n.i.	n.i.	n.i.
Mean value for agricultural measures					
Control		156	316	107	131
Agrogel		159	208	148	153
NIR $_{(\alpha=0.05)}$		n.i.	n.i.	23.1	n.i.
Pinova					
Traditional planting	Control	134	126	83	114
	Agrogel	132	143	105	127
Ridges	Control	126	132	91	116
	Agrogel	126	128	110	121
NIR $_{(\alpha=0.05)}$ a x b		n.i.	15.3	10.7	7.7
NIR $_{(\alpha=0.05)}$ b x a		n.i.	14.5	n.i.	n.i.
Mean value for the ways of planting					
Traditional planting		133	134	94	120
Planting in ridges		126	130	101	119
NIR $_{(\alpha=0.05)}$		n.i.	n.i.	n.i.	n.i.
Mean value for agricultural measures					
Control		130	129	87	115
Agrogel		129	135	107	124
NIR $_{(\alpha=0.05)}$		n.i.	n.i.	7.6	5.4

a x b – comparison of different agricultural measures within the same way of planting
b x a – comparison of different ways of planting according to the same agricultural measure

Table 4. The increase in the cross sectional area of 'Ligol' and 'Pinova' apple tree trunks depending on the way of planting and agrogel applied, in the years 2005-2008

Treatment		The increase in cross section area of tree trunk [cm^2]				Summary of the increase in the years 2005-2008
		2005	2006	2007	2008	
Ligol						
Traditional planting	Control	0.53	1.67	4.68	1.35	2.06
	Agrogel	0.59	1.50	5.04	1.43	2.14
Ridges	Control	0.62	1.25	2.59	0.99	1.36
	Agrogel	0.83	1.53	5.42	1.48	2.32
NIR $_{(\alpha=0.05)}$ a x b		n.i.	n.i.	1.012	n.i.	0.481
NIR $_{(\alpha=0.05)}$ b x a		n.i.	0.304	0.999	n.i.	0.439
Mean value for the ways of planting						
Traditional planting		0.56	1.59	4.86	1.39	2.10
Planting in ridges		0.73	1.39	4.00	1.23	1.84
NIR $_{(\alpha=0.05)}$		n.i.	n.i.	n.i.	n.i.	n.i.
Mean value for agricultural measures						
Control		0.57	1.46	3.64	1.17	1.71
Agrogel		0.71	1.52	5.23	1.46	2.23
NIR $_{(\alpha=0.05)}$		n.i.	n.i.	0.715	n.i.	0.340
Pinova						
Traditional planting	Control	0.72	2.39	1.48	1.21	5.81
	Agrożel	0.63	2.36	1.62	1.36	5.98
Ridges	Control	0.83	1.75	1.35	1.00	4.93
	Agrogel	0.74	1.76	1.25	0.88	4.62
NIR $_{(\alpha=0.05)}$ a x b		n.i.	n.i.	n.i.	n.i.	n.i.
NIR $_{(\alpha=0.05)}$ b x a		n.i.	0.553	0.321	0.341	0.853
Mean value for the ways of planting						
Traditional planting		0.68	2.38	1.55	1.29	5.89
Planting in ridges		0.78	1.76	1.30	0.94	4.78
NIR $_{(\alpha=0.05)}$		n.i.	0.407	0.157	0.313	0.314
Mean value for agricultural measures						
Control		0.78	2.07	1.41	1.11	5.37
Agrogel		0.68	2.06	1.43	1.12	5.30
NIR $_{(\alpha=0.05)}$		n.i.	n.i.	n.i.	n.i.	n.i.

a x b – comparison of different agricultural measures within the same way of planting
b x a – comparison of different ways of planting according to the same agricultural measure

also noticeable in the values of increment of TCSA for the four year period. On the basis of the mentioned index values, it is possible to conclude that planting trees in ridges did reduce tree growth by about 19%, regardless of the use of agrogel. Research by Sosna and Szewczuk (1998), showed reduction of apple tree growth on elevated earth banks within the first several years of cultivation. The mentioned disadvantageous effect resulting from planting trees in ridges, was also maintained in the case of simultaneous application of agrogel in 'Pinova' trees. A disadvantageous effect, however was not observed for 'Ligol' trees. This fact can prove, that in the case of a vigorously growing cultivar, improved on a semidwarf rootstock featuring strong root system, a growth – reducing effect of being planted in ridges is minimized through agrogel introduction into the growing medium. The addition of a supersorbent caused an evident improvement in tree growth in this variety. The improvement was because it provided for better air–water conditions of the soil. According to Paluszek (2003), 95% of water absorbed and accumulated by supersorbents is available to the root system of the plant. This is because water losses, resulting from evaporation and percolation to deeper soil layers, are reduced to a minimum. Similarly, research by Gudarowska and Szew-czuk (2009b), on the same apple tree cultivars, indicated that application of agrogel did favourably affect tree growth.

In conclusion, the practice of combining the planting of trees in ridges, with simultaneous use of agrogel, can be a successful way to improve the yielding of 'Ligol' trees on M.26 rootstock, planted in 3.5 x 1 m spacing. Trees of 'Pinova' on M 26 rootstock showed a lower level of yielding within the first three years after being planted in ridges, regardless of the agrogel application.

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WYKORZYSTANIE AGROŻELU W UPRAWIE DRZEW POSADZONYCH W REDLINY

Dariusz Dereń, Adam Szewczuk i Ewelina Gudarowska

S T R E S Z C Z E N I E

Doświadczenie przeprowadzono w latach 2005-2008 w Stacji Badawczo-Dydaktycznej w Samotworze należącej do Uniwersytetu Przyrodniczego we Wrocławiu. Drzewa odmian ‘Ligol’ i ‘Pinova’ na podkładce M.26 posadzono wiosną 2005 roku w rozstawie 3,5 x 1 m (2857 drzew/ha) sposobem tradycyjnym we wcześniej wykopane dołki lub w redliny. Drugim czynnikiem było użycie agrożelu jako dodatku do podłoża. Agrożel zastosowano w postaci taśmy z grubej włókniny, w której zamknięto granulat preparatu, tworząc tzw. geowłókninę. Taśmę przed posadzeniem moczono 24 godziny w wodzie, po czym rozkładano na glebie w linii przyszłego rzędu drzew. Doświadczenie założono metodą losowanych podbloków w 4 powtórzeniach po 4 drzewa na poletku. W latach trwania doświadczenia oceniano wielkość i jakość plonu oraz wzrost drzew na podstawie przyrostów pola powierzchni przekroju poprzecznego pnia (PPPPP). Połączenie sadzenia drzew w redliny z równoczesnym zastosowaniem agrożelu okazało się dobrym sposobem na poprawę plonowania odmiany ‘Ligol’ na podkładce M.26 posadzonej w rozstawie 3.5 x 1 m. Natomiast drzewa odmiany ‘Pinova’ na podkładce M.26 plonowały słabiej w trzech pierwszych latach po posadzeniu w redliny bez względu na zastosowanie agrożelu. W przypadku drzew odmiany ‘Ligol’ posadzonych w redliny, agrożel spowodował we wszystkich latach badań, wyraźną tendencję do poprawy wzrostu wegetatywnego, mierzonego wskaźnikiem PPPPP. Natomiast osłabienie wzrostu drzew odmiany ‘Pinova’ przy sadzeniu w redliny, w silniejszym stopniu ujawniło się w przypadku równoczesnego zastosowania agrożelu.

Słowa kluczowe: jabłoń, sadzenie w redliny, agrożel, plon, wzrost