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INFLUENCE OF CULTIVATION METHOD AND BULBS PLANTING DEPTH ON THE GROWTH AND YIELDING OF TULIPS

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Abstract. Tulips belong to one of the most important bulbous plants from the economic point of view. Bulbs are reproduced in order to force for cut flowers. The biggest problem for the Polish producers is to obtain high yield of good quality bulbs, so that it is advisable to verify other than traditional methods of cultivation. The field experiment was conducted in 2006–2009. 'Ballerina' tulips were cultivated with a traditional method flat and on the ridges. Bulbs were planted at the depth of 9, 12, 15 and 19 cm. Cultivation methods used in the experiment did not affect the length of tulips flowering shoots. Tulips cultivated on the ridges produced longer tepals. Flowering shoots and tepals were shorter in case of tulips cultivated at the depth of 19 cm in comparison to those cultivated at the depth of 9–12 cm. Cultivation on the ridges led to production of 7.5% more of daughter bulbs and 8.2% of commercial bulbs. Weight of daughter bulbs was higher in ridge cultivation on average by 10.8%, and the weight of commercial bulbs on average by 14% in relation to flat cultivation. Cultivation on the ridges also increased the amount and weight of first grade bulbs (of circumference of >12 cm) by respectively 19.5 and 23.3% in comparison to traditional cultivation. The highest yield of commercial bulbs in ridge cultivation was obtained when bulbs were planted at the depth of 12–15 cm. In flat cultivation, greater amount and weight of commercial yield bulbs and first grade bulbs was obtained by planting tulips at the depth of 15–19 cm. Cultivation on the ridges ensures better aeration of soil, what results in smaller share of bulbs infected with pathogens in the total yield, in comparison to flat cultivation.

Key words: bulbous plants, crop quality, ridge cultivation

INTRODUCTION

90% of the global area planted with flowering bulbs is designed for reproduction of six species – tulip, lily, narcissus, gladiolus, hyacinth and iris [Le Nard and De Hertogh

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2002]. Among them, mainly by tulip, whose crops are concentrated in a dozen countries around the world. The largest growing area is in the Netherlands, about 87% of the global area. Other countries with significant global surface cultivation of tulips are Japan (300 ha), France (293 ha), USA (280 ha) and Poland (200 ha) [Buschmann 2005]. The farms producing flower bulbs use them for two purposes – for further reproduction and for protected cultivation of cut flowers [Wróblewska 2009]. Poland is currently the third country in Europe with the largest cultivation area of ornamental bulbous plants, yet national production does not meet all the needs of cut flowers producers for initial material and exportation is also limited. One of the problems that Polish producers face is to ensure high quality of first and second choice bulbs used for forcing. The basic system of tulip cultivation in our farms is cultivation on the field. Only in the area of Vistula fenlands due to high level of ground water and high soil coherence cultivation on the ridges is used. In the Netherlands, such a system of tulip cultivation on heavy soil has already been used for a long time. In gardening, ridge cultivation is applied to produce root vegetables such as carrot, parsley, parsnip and root chicory. This method of cultivation guarantees to obtain higher commercial yield by 20–30% than in flat cultivation, better quality of yield and easier harvesting [Polak et al. 1999, Babik and Dudek 2000, Sady and Cebulak 2000, Nawrocki et al. 2003, Wierzbicka et al. 2004]. Aggregates are used to form ridges and ensure deep loosening and coherence of soil. Soil coherence and proper shaping of the ridge is obtained by attaching reel roller to a ridge forming device. Therefore, on a moderately condensed ridge, soil coherence at the depth from 3 to 18 cm is stable unlike in flat cultivation where soil coherence increases with the increase of depth. Pressing (condensing) soil of the ridge also guarantees good water ascension. During cultivation, outer layer of the ridge (approx. 3 cm) gets harder and drier and hence even intensive rainfall does not cause their degradation and safeguards the plant from uncovering roots. Ridge interior remains loose and allows better access of air to the root system. If soil coherence is proper, ridge can bear pressure of up to 70 kg [Babik and Dudek 2000]. Cultivation on the ridges also significantly limits primary weed infestation of root in comparison to flat cultivation [Ferens 2007, Konopiński and Ferens 2007].

Due to the common application of ridge cultivation technology for root vegetables, it is important to check how to adapt this method to the cultivation of ornamental bulbous and tuberous plants especially in coherent loess soil. Climate changes lead to the necessity of reanalysis of the influence of previously set cultivation standards. Therefore, the aim of the research conducted in the Institute of Ornamental Plants and Landscape Architecture was to define optimum depth for tulip bulbs planting in traditional flat cultivation and on the ridges.

MATERIALS AND METHODS

A two-factor field experiment was conducted between 2006 and 2009 at the Felin Experimental Farm of the University of Life Sciences in Lublin in typical grey-brown podzolic soil (Haplic luvisol) containing 1.6% organic matter. Bulbs of 'Ballerina' tulips (lily-shaped group) of 10–11 cm circumference (17.6 g) were used in the research.

The first factor in the experiment was the cultivation method: flat and on the ridges. Four depths of planting: 9, 12, 15, 19 cm served as the second factor. The experiment was set up in the system of random blocks in 5 repetitions. The repetition was a single plot of 1 square meter with 45 bulbs planted. The spacing between rows was 25 cm. The bulbs were planted in the third decade of October. Before planting bulbs were soaked in 1.5% solution of Topsin for 30 minutes. The ridges were done with a unit for ridges AUR2 (2-rows) of Weremczuk production. The spacing between rows was 67.5 cm and the height of a single ridge was 20 cm.

After bulbs were planted, fields were sprayed with herbicides and after first frost appeared they were covered with 15 cm straw bedding in both methods of cultivation. Azofoska fertilizer was applied in two doses of 25 g m^{-2} in autumn and in spring. The plants were not watered. During flowering the length of flower shoot and the length of tepals were measured. Moisture-content determination in soil was conducted with gravimetric drying method in metal cylinders at 4 studied depths of planting for both flat and ridge cultivation twice, in the middle of May and before bulb harvest in June. In 2009 rainfall between second decade of May and the end of June did not allow for proper determination of moisture content in soil. Total rainfall in June was 91% higher than mean rainfall of the month taken in several years (tab. 2). Clones of daughter bulbs were dug at the beginning of third decade of June. After cleaning and drying, number and weight of bulbs of total and commercial yield (bulbs of circumference of 11–12 cm and >12 cm) were determined. Also the number of bulb clones infected with fungal and bacterial pathogens was counted. Results of biometric measurements were processed statistically with the Tukey's test of multiple confidence intervals at the significance level where $\alpha = 0.05$.

RESULTS AND DISCUSSION

During the three vegetation seasons when the research was conducted, no damage due to frost was noted in the plants (tab. 1). Tulips of the examined cultivar flowered in the first decade of May and no significant differences were noted in the length of flowering shoot regardless of the studied cultivation method. Tulips cultivated on the ridges produced longer tepals compared to those cultivated flat. The analysis of depths of bulb planting in the range of 9–19 cm significantly differentiated the length of shoots and tepals. Tulips cultivated at the depth of 19 cm were lower and had shorter tepals than those that were planted at the depth of 9–12 cm, the difference between plants cultivated at a depth of 15 and 19 cm was not noted (tab. 3).

The number and weight of bulbs of total yield were significantly higher when cultivated on the ridges than flat. Tulips growing on the ridges produced 12.5 more daughter bulbs. Weight of bulbs of total yield was higher by 10.8% with the same system of cultivation. Significantly greater number and mass of bulbs were produced by tulips cultivated at the depth of 19 cm when compared to those planted at the depth of 9 cm. In a flat cultivation there were no significant differences in total yield between bulbs cultivated at a depth of 15 and 19 cm (tab. 4).

Table 1. Average air temperatures the measurements of the Experimental Meteorological Station of University of Life Science in Lublin in cultivation of tulips 'Ballerina' in the years studies 2006–2009

Growing season	Months	Decade means (ºC)			Minimum temp. (ºC)	Means mouthly (ºC)	Means of many years 1951–2005 (ºC)
		I	II	III			
	X	13.3	7.4	9.6	-4.5	10.1	7.8
	XI	2.6	6.8	6.4	-5.3	5.3	2.5
	XII	5.8	2.6	0.9	-6.3	3.0	-1.4
	I	4.7	5.0	-1.4	-12.6	2.6	-3.5
2006/2007	II	0.5	-1.4	-4.6	-14.4	-1.6	-2.7
	III	5.2	6.3	6.9	-1.4	6.2	1.1
	IV	6.2	9.5	10.6	-4.0	8.7	7.4
	V	9.9	15.1	19.5	-4.1	15.0	13.0
	VI	18.1	20.0	16.2	7.5	18.1	16.2
	X	9.5	6.1	7.3	-1.5	7.6	7.8
	XI	1.1	-2.8	-1.7	-6.2	-1.1	2.5
	XII	2.8	1.1	-6.1	-10.0	-0.7	-1.4
	I	-4.2	2.5	2.7	-1.3	0.4	-3.5
2007/2008	II	2.7	1.5	5.6	-9.7	2.2	-2.7
	III	3.4	3.4	3.3	-5.5	3.4	1.1
	IV	7.8	9.4	10.8	-3.1	9.3	7.4
	V	11.3	13.3	13.6	3	12.8	13.0
	VI	18.0	16.4	18.8	6.7	17.7	16.2
	X	10.7	10.6	9.0	1.6	10.1	7.8
	XI	8.9	4.5	0.9	-6.7	4.8	2.5
	XII	3.8	0.5	-1.4	-9.2	0.9	-1.4
	I	-7.1	-2.2	0.9	-18.7	-2.7	-3.5
2008/2009	II	1.5	-3.1	-2.3	-16.7	-1.2	-2.7
	III	0.2	0.9	3.1	-11.5	1.4	1.1
	IV	11.4	9.3	13.5	-1.2	11.4	7.4
	V	13.6	13.1	14.2	0.7	13.6	13.0
	VI	15.3	14.9	19.1	6.2	16.4	16.2

Correlation was noted between the method of cultivation and the depth of bulb planting in relation to the weight of daughter bulbs. In flat cultivation the highest weight of bulbs of total yield was produced by tulips whose bulbs were planted at the depth of 19 cm in relation to those planted less deep (9–12 cm). In ridge cultivation higher weight of bulbs was obtained from tulip cultivation at the depth of 12 cm, and the lowest from the depth of 9 cm.

Number of bulbs of commercial yield was higher by average 8.2%, whereas weight by average 14% in ridge cultivation compared to traditional flat cultivation. No effect of

the depth of planting in the range of 9–19 cm was noted on the number of commercial bulbs. Weight of bulbs of commercial yield was higher when tulips were planted at the depth of 12–19 cm compared to less deep planting of bulbs at the depth of 9 cm (tab. 4).

Analysis of the number of commercial yield showed correlation between the cultivation method and the depth of planting. In flat cultivation, significantly more commercial bulbs were produced by tulips planted at the depth of 15–19 cm compared to less deep planting at the depth of 9–12 cm. In ridge cultivation the depth of planting in the range of 9–19 cm did not significantly differentiate the number of produced commercial bulbs.

Table 2. The rainfall after the measurments of the Experimental Meteorological Station of University of Life Science in Lublin in cultivation of tulips 'Ballerina' in the years studies 2006–2009

Growing season	Months	Decade sums (mm)			Monthly sums (mm)	Many years sums 1951–2005 (mm)
		I	II	III		
2006/2007	X	4.4	0.9	8.9	14.2	40.1
	XI	30.0	10.9	0.3	41.2	38.1
	XII	5.2	11.4	2.0	18.6	31.5
	I	5.2	9.7	11.0	25.9	22.7
	II	12.0	2.1	8.2	22.3	25.6
	III	6.6	11.8	11.8	30.2	26.3
	IV	8.8	5.6	3.0	17.4	40.2
	V	13.5	29.9	37.1	81.5	57.7
	VI	52.4	25.4	10.0	87.8	65.7
2007/2008	X	2.8	12.4	2.5	17.7	40.1
	XI	2.3	0.6	1.0	3.9	38.1
	XII	0.7	0.4	0.0	1.1	31.5
	I	6.3	13.5	16.4	36.2	22.7
	II	3.5	7.6	6.7	17.8	25.6
	III	16.6	27.0	20.2	64.8	26.3
	IV	17.6	35.3	2.9	55.8	40.2
	V	57.1	34.7	9.8	101.6	57.7
	VI	0	19.6	6.3	25.9	65.7
2008/2009	X	33.5	16.8	5.2	55.5	40.1
	XI	0.0	18.9	14.2	33.1	38.1
	XII	18.1	16.2	9.5	43.8	31.5
	I	1.8	0.4	18.0	20.2	22.7
	II	5.9	20.5	10.5	36.9	25.6
	III	15.4	28.9	25.3	69.6	26.3
	IV	1.1	1.8	0.0	2.9	40.2
	V	3.6	34.8	32.9	71.1	57.7
	VI	28.2	32.7	64.6	125.5	65.7

Tulips cultivated on the ridges produced 19.5% greater number and 23.3% greater weight of bulbs of circumference of >12 cm compared to the tulips cultivated flat. Fewer bulbs of first size were produced by tulips growing at the depth of 9 cm compared to those cultivated at the depth of 12–19 cm (tab. 5). Bulbs cultivated without ridges formed more daughter bulbs of 11–12 cm circumference than those cultivated in ridges. The most bulbs of 11–12 cm circumference were formed when tulips were cultivated at 9 cm depth and the least at the depth of 12 cm.

It was noted that mean weight of one bulb of first grade (>12 cm) was higher when tulips were cultivated on the ridges (tab. 3). Irrespective of the method of cultivation, weight of bulbs increased along with the increase of the depth of tulip planting. In flat field cultivation, the increase of the planting depth from 9 to 19 cm increased the weight of bulbs of the biggest circumference, whereas in ridge cultivation the depth of planting did not influence the analyzed trait.

Table 3. Influence of cultivation method and planting depth on the length of the flower shoot, tepals, and the mass of an bulb with a circumference > 12 cm 'Ballerina' tulips

Plant cultivation method	Planting depth (cm)	Length of flower shoot (cm)	Length of tepals (cm)	Mass of one bulbwith circufeence > 12 cm (g)
Flat cultivation	9	49.9a	7.87a	25.7d
	12	50.1a	7.92a	26.3cd
	15	49.6a	7.90a	27.5bc
	19	48.2a	7.78a	28.7a
Ridge cultivation	9	50.0a	8.08a	26.8bcd
	12	51.0a	8.10a	28.2ab
	15	49.2a	7.92a	27.8ab
	19	48.1a	7.79a	28.0ab
Mean for cultivation method	flat	49.4a	7.87b*	27.1b
	ridge	49.6a	7.97a	27.7a
Mean for planting depth	9	49.9a	7.97a	26.2c
	12	50.5a	8.01a	27.2b
	15	49.4ab	7.91ab	27.6ab
	19	48.2b	7.79b	28.4a
Mean for years	2007	48.4b	7.70c	27.3a
	2008	49.0b	8.20a	27.6a
	2009	51.1a	7.90b	27.3a

* – Means indicated by the same letter do not differ significantly at $P \leq 0.05$. Statistical analysis was made separately for each characteristic

In 2007 greater amount of rainfall was noted in May (41%) and June (33.6%) compared to multi-year mean of these months (tab. 2). Based on the analysis of moisture-content in soil it was concluded that in the middle of May 2007 moisture of soil at the studied depth was higher in flat cultivation than in ridge cultivation (fig. 1). The lowest

level of moisture was noted in soil in the ridge sampled at the depth of 9 cm (26.9%) and the highest level of moisture was noted in soil sampled at the depth of 19 cm in flat cultivation (31.4%). Soil moisture in the second decade of June was significantly lower than in May. It was noted that at the depth of 9 and 19 cm soil moisture in flat cultivation and on the ridges was comparable, whereas soil sampled at the depth of 12 and 15cm on the ridges had significantly lower moisture content than at the same depth but in flat cultivation (fig. 1). In the year 2008, the mean monthly precipitation in May was 76% higher than the many years mean for that month. Based on the moisture content determination in the middle of May, the highest moisture content was noted in soil at the depth of 9cm in flat cultivation (20.1%) and the lowest in soil on the ridges at the depth of 15 cm (16.6%). June of 2008 was relatively dry, amount of rainfall was 60.6% lower than mean of that month taken in several years. Soil moisture at the depth of 9–15 cm before bulb gathering was higher in flat cultivation (15.6–16.2%) than at the same depths in cultivation on the ridges (14.2–15.7%). At that time, moisture at the depth of 19 cm was similar in both cultivation methods (fig. 2).

Table 4. Influence of cultivation method and planting depth on the total and commercial yield of 'Ballerina' tulip bulbs

Plant cultivation method	Planting depth (cm)	Commercial yield		Total yield	
		(psc. m^{-2})	g m^{-2}	(psc. m^{-2})	g m^{-2}
Flat cultivation	9	35.9c*	874.1a	157.4a	1408.1e
	12	38.1bc	960.0a	164.9a	1464.7de
	15	41.1ab	1055.0a	165.1a	1543.9cde
	19	41.4ab	1082.7a	178.3a	1627.0abc
Ridge cultivation	9	40.9ab	1048.4a	174.4a	1578.0bcd
	12	43.5a	1170.0a	181.9a	1728.3a
	15	42.6a	1163.7a	180.4a	1706.6ab
	19	42.0ab	1148.0a	179.1a	1682.8abc
Mean for cultivation method	flat	39.1b	993.0b	166.4b	1510.9b
	ridge	42.3a	1132.5a	178.9a	1673.9a
Mean for planting depth	9	38.4a	961.2b	165.9b	1493.1b
	12	40.8a	1065.0a	173.4ab	1596.5a
	15	41.8a	1109.4a	172.8ab	1625.2a
	19	41.7a	1115.4a	178.7a	1654.9a
Mean for years	2007	40.1a	1034.5b	154.3c	1554.5b
	2008	40.3a	1042.1b	185.7a	1571.9b
	2009	41.7a	1111.7a	178.1b	1650.9a

* – Explanations, see Table 3

Table 5. The influence of cultivation method and planting depth on the yield of bulbs circumferences > 12 cm and 11–12 cm 'Ballerina' tulips

Plant cultivation method	Planting depth (cm)	Yield of bulbs >12 cm circumference		Yield of bulbs 11–12 cm circumference	
		(psc.·m$^{-2)}$	g·m^{-2}	(psc.·m^{-2}	g·m^{-2}
Flat cultivation	9	26.6a	692.2a	9.4a	182.0a
	12	29.8a	794.0a	8.3a	166.1a
	15	31.3a	858.8a	9.9a	197.3a
	19	31.6a	900.0a	9.7a	165.8a
Ridge cultivation	9	33.1a	890.7a	7.8a	157.8a
	12	37.2a	1046.7a	6.3a	123.2a
	15	36.2a	1037.5a	6.5a	126.2a
	19	35.8a	1026.3a	6.3a	121.8a
Mean for cultivation method	Flat	29.8b*	811.2 b	9.3a	182.0a
	Ridge	35.6a	1000.3 a	6.7b	132.3b
Mean for planting depth	9	29.9b	791.4 b	8.6a	169.9a
	12	33.5a	920.3 a	7.3a	144.7b
	15	33.8a	948.1 a	8.2a	161.8ab
	19	33.7a	963.1 a	8.0a	152.2ab
Mean for years	2007	31.0b	843.3 b	9.1a	191.5a
	2008	32.1b	889.6 b	8.4ab	152.6ab
	2009	35.1a	984.4 a	6.7b	127.2b

* – Explanations, see Table 3

Large amount of rainfall and quite high temperatures in June 2007 and 2009 (tab. 1, 2) led to deterioration of bulb health. Bulbs were infected more intensively with bacterioses and mycoses. Evaluation of share of infected clones in total number of planted bulbs at studied depths in flat cultivation and on the ridges showed that number of infected bulbs increases proportionally along with the increase of planting depth. On the ridges, at the depth of 9 cm, only 0.4–2.2% of infected clones were noted in the consecutive years. This amount increased to 2.7–9.3% when bulbs were planted at the depth of 19 cm. In flat cultivation, number of infected bulbs at the depth of 9 cm remained within the range of 1.8–4.0 and increased to 12.0–23.1% along with the increase of planting depth (fig. 3, 4, 5).

Positive effects of tulip cultivation on the ridges require further research. Only light and loose soil is not appropriate for ridge formation, however this method can be very useful in tulip cultivation on soils that are tight, heavy and wet. With a formed ridge in the spring soil becomes warmer and drier more quickly, and on the ridges, soil crust is less dangerous as ridges prevent from strong integration of soil particles.

Growing tulips on ridges comes from the Netherlands, from the flat marsh, where the ground water is sometimes too high in the wintertime. Rasmussen [1980] tested four

different growing methods with the following advice. The normal planting method, 4 rows on a bed gives the best result for many varieties, but for very vigorous varieties like 'Apeldoorn' the yield of saleable bulbs can be increased by using a new method on double ridges. Tulip bulbs, cvs Apeldoorn and Danton, planted in 2 double rows on a double ridge, gave similar or greater yield than tulips growing on beds [Rasmussen 1982].

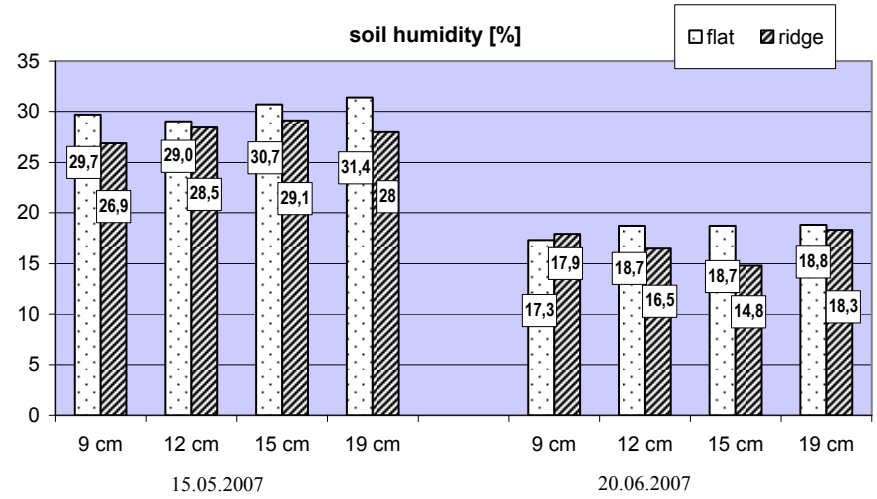

Fig. 1. Soil moisture at different depths of planting tulip bulbs, depending on cultivating method in 2007

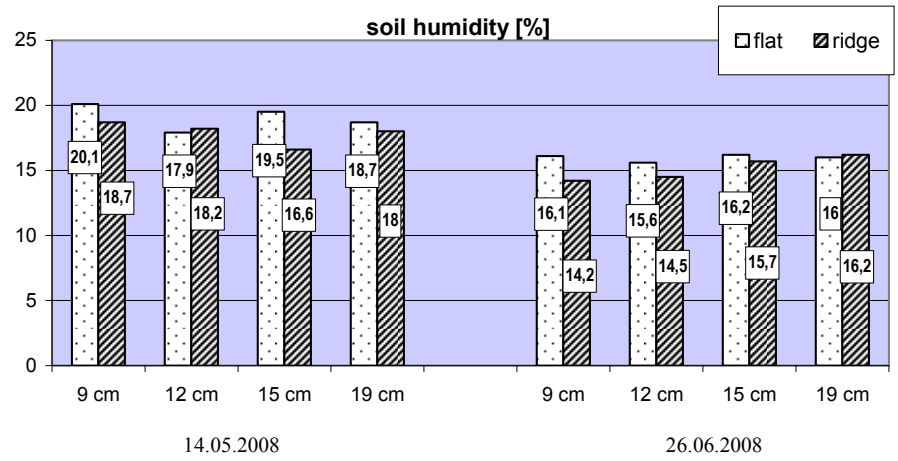

Fig. 2. Soil moisture at different depths of planting tulip bulbs, depending on cultivating method in 2008

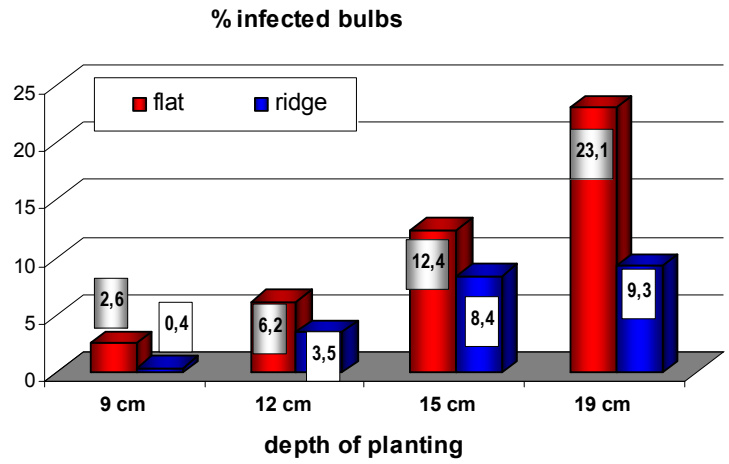

Fig. 3. The percentage of infected clonal bulbs, depending on the cultivation method and depth of tulips planting in 2007

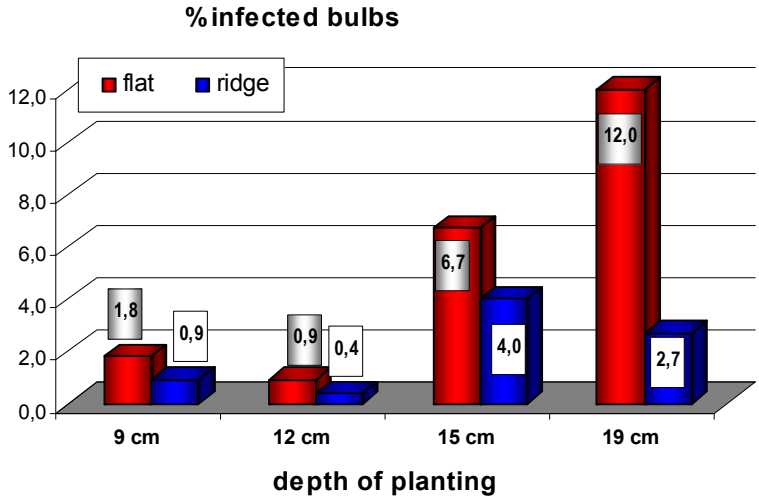

Fig. 4. The percentage of infected clonal bulbs, depending on the cultivation method and depth of tulips planting in 2008

Research conducted on the cultivation of carrot shows that root yield from cultivation on the ridges is usually greater, but it depends on a set of weather conditions in a given year and on the studied cultivar. Polak et. al. [1999] obtained 80% carrot yield increase and 78% parsley yield increase from cultivation on the ridges. According to

other authors mean increase of carrot commercial yield ranges between 7 and 19% dependent on the cultivar [Wierzbicka et. al. 2004]. Similar observations have been made on cellery yield which, per plant, was 3–16% higher in cultivation on the ridges than in other tested plants [Michalik 2003]. In case of chicory, dependent on the year of research, no differences in yielding were noted or increase of first grade root yield amounted to 15–17% in cultivation on the ridges compared to flat cultivation [Babik 2000]. Konopiński [2009] recorded significantly higher yield of common salsify roots when grown on ridges versus flat soil cultivation. Similar effect was observed referring to carrot [Cebulak and Sady 2000]. Growing scorzonera on ridges significantly affected the increase of total root yield, as compared to growing on flat soil [Konopiński 2011, Konopiński and Ferens 2011].

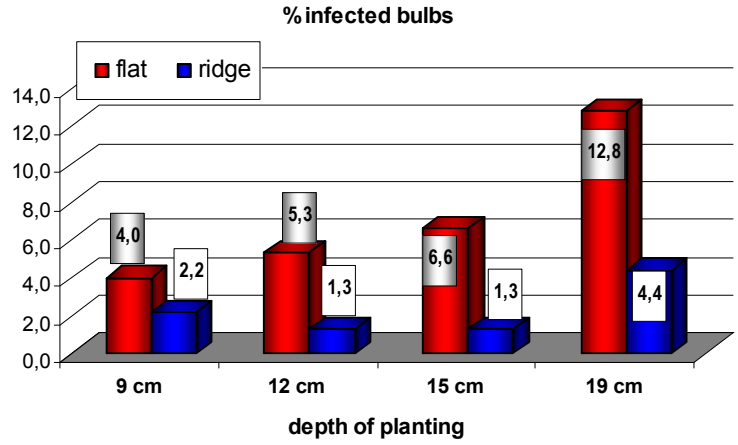

Fig. 5. The percentage of infected clonal bulbs, depending on the cultivation method and depth of tulips planting in 2009

The most crucial issue in tulip cultivation on the ridges is formation of appropriately stiffish and moderately packed ridges to ensure water ascension from deeper soil layers. The easiest solution is to use special machines for ridge formation. However, they need adaptions because machines available on the market are set to sowing seeds on the surface of the ridge and tulips require placement of bulbs at the exact depth within the ridge, like potatoes. Success of cultivation with this method depends on a set of weather conditions. Vegetables cultivated on the ridges require more intensive irrigation than in flat cultivation, but it depends on type of soil and amount of rainfall in a given year.

According to recommendations, optimum depth for tulip bulb planting is 10–12 cm. In Polish literature there is no current research in that subject. Experiments conducted in China by Zhou [1998] on 'Golden Apeldoorn' tulips show that the highest increase of daughter bulbs is obtained when small (6–7 g) and medium (8–10 g) bulbs are planted at the depth of 10 cm and the big ones (12–13 g) at the depth of 20 cm. Bing et al. [2008] cultivated botanical tulips (*Tulipa edulis*) at the depth of 5–20 cm. The yield and the number of harvested bulbs increased along with the increase of sowing depth and

the best sowing depth was 20 cm. On the basis of previously conducted experiments it was shown that in traditional flat cultivation, increase of depth of planting to 15–19 cm increased number and weight of commercial bulbs and bulbs of first choice. Deeper planting of bulbs can make harvest difficult. Tulips planted on the ridges gave the best yield when bulbs had been planted at the depth of 12 cm. With this method of cultivation, the increase of planting depth up to 19 cm did not increase the number and weight of first choice bulbs.

CONCLUSIONS

1. Method of cultivation does not affect length of 'Ballerina' tulip's flowering shoot. Plants cultivated on the ridges produce longer tepals than those cultivated flat.

2. Ridge cultivation of tulips increases the number of commercial bulbs by average 8.2% and yield of first grade bulbs by 19.5% compared to flat cultivation.

3. The highest yields of daughter and commercial bulbs of tulips 'Ballerina' were obtained when maternal bulbs were planted on the ridges at the depth of 12–15 cm and in flat cultivation at the depth of 15–19 cm.

4. In both cultivation methods, planting maternal bulbs at the depth of 12–19 cm has beneficial effect on the increase of weight of first grade bulbs. There is, however, a risk of increased bulb infestation by bacterioses and mycoses.

5. Better aeration of soil in the ridge cultivation can, to a large extent, improve health of daughter bulbs.

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WPŁYW SPOSOBU UPRAWY I GŁĘBOKOŚCI SADZENIA CEBUL NA WZROST I PLONOWANIE TULIPANÓW

Streszczenie. Tulipany należą do najważniejszych gospodarczo roślin cebulowych. Cebule reprodukuje się głównie z przeznaczeniem do pędzenia na kwiat cięty. Dla polskich producentów największym problemem jest uzyskanie dużych plonów cebul o dobrej jakości. Celowe jest więc sprawdzenie innych niż tradycyjne metod uprawy. Doświadczenie polowe przeprowadzono w latach 2006–2009. Tulipany odmiany 'Ballerina' uprawiano metodą tradycyjną na płasko i na redlinach. Cebule sadzono na 4 głębokościach: 9, 12, 15 i 19 cm. Analizowane w doświadczeniu sposoby uprawy nie miały wpływu na długość pędów kwiatowych tulipanów. Tulipany uprawiane na redlinach wytworzyły dłuższe listki okwiatu. Długość pędu kwiatowego i listków okwiatu była mniejsza u tulipanów uprawianych na głębokości 19 cm, w porównaniu z uprawianymi na głębokości 9–12 cm. Na redlinach uzyskano więcej o 7,5% cebul potomnych i o 8,2% cebul handlowych. Masa cebul potomnych była większa przy uprawie na redlinach średnio o 10,8%, a handlowych o 14% w odniesieniu do uprawy na płasko. Uprawa na redlinach zwiększyła też liczbę i masę cebul pierwszej wielkość (o obwodzie >12 cm) odpowiednio o 19,5 i 23,3% w porównaniu z uprawą tradycyjną. Największy plon cebul handlowych przy uprawie na redli-

nach uzyskano, sadząc cebule na głębokości 12–15 cm. Przy uprawie na płasko większą liczbę i masę cebul plonu handlowego oraz cebul pierwszego wyboru uzyskano, sadząc tulipany na głębokości 15–19 cm. Uprawa na redlinach zapewnia lepsze napowietrzenie gleby, dzięki czemu udział w plonie cebul porażonych przez patogeny jest mniejszy w porównaniu z uprawą na płasko.

Słowa kluczowe: rośliny cebulowe, jakość plonu, uprawa w redlinach

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