The effect of undersowing time of clover crops and weeds on silage maize yields

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ABSTRACT

In field experiments conducted on loamy luvic chernozem (170 m altitude, 48°34' N 17°45' E), the effects of undersowing time (5 days after maize was sown and into emerged stand) of lucerne, red clover and sainfoin on silage maize dry matter have been studied. The total dry matter yields were affected by time of undersowing of clover crops. The stands undersown after emergence of maize gave higher yields than former time of undersowing. The late time of undersowing improved conditions for growth of maize and formation of its yield. The number of maize plants had already insignificant effect on yields there. The dry matter weight, height, and number of maize plants and dry matter weight of weeds were main factors of formation of the total yield. The depressive effect of weeds on total yields was applied indirectly particularly through the decrease in the dry matter weight of maize plants. The path analysis in spite of the insignificant effect of clover crops undersown on total yields indicated some differences in the formation of yield. The number of maize plants reached the significant level of effect on yield only at stands with red clover undersown. On the contrary, the negative correlation of weeds dry matter weight with the number of maize plants reached level of significance in stands with lucerne undersown only.

Keywords: silage maize; time of undersowing of clover crops; weeds; effect on the yield

Relatively long period of soil without sufficient plant cover is one of the unfavorable facts in maize growing. Agroecologically positive in this context is undersowing of suitable crops (Werner 1995, Le Gall et al. 1997), which would cover the soil between rows and not compete with maize at the same time. From a similar aspect, maize can be used as a cover crop for clover crops (Charkov and Muginov1985, Jamriška 1995). Success in such compromise is mainly conditioned by the time of undersowing (Nordquist and Wicks 1974), by limitation of negative effect of weediness (Heyland and Werner1988) as well as selection of the crop undersown (Čakrov 1995). The aim of the research was to analyze the effect of two terms of undersowing lucerne, red clover, and sainfoin into silage maize on its yield. The object of the analysis was the effect of weight of undersown clover crops and weeds.

MATERIAL AND METHODS

Field experiments were established in three subsequent years in a maize production area on loamy luvic chernozem 170 m above sea level (Research and Breeding Station of RIPP in Borovce, 48°34' N, 17°45' E). Brief characteristics of weather conditions are shown in Table 1. Into maize variety TO-266 S (sowing date 13.4, 3.5 and 2.5) the clover crops were undersown in two terms (5 days after sowing and after emerging of maize in the phase of 3 leaves): lucerne Palava variety, red clover Branisko variety and sainfoin Bučiansky variety, before and after sowing harrows, sowing direction the same as maize; the control variants were maize without undersowing and clover crops without a maize. Seeding rates: maize 110 thousand of germinative seeds, both lucerne and clo-

Table 1. The weather conditions of experiments

Indicator		Month				Vegetative period	Year
		May	June	July	August		
Temperature (°C)	1989	14.59	16.15	19.58	18.66	15.78	9.3
	1990	15.10	17.53	18.74	20.14	15.41	8.8
	1991	10.76	16.60	20.12	19.29	15.17	9.1
Long-term average		14.70	17.50	19.30	18.60	15.73	9.1
Precipitation (mm)	1989	22.4	97.30	60.90	48.60	285.60	413.5
	1990	24.9	49.10	43.4	12.40	275.50	505.5
	1991	66.1	51.40	36.5	12.40	204.20	421.7
Long-term average		60.0	67.0	66.0	63.0	352.0	625.0

Table 2. The effect of time of undersowing clover crops into silage maize on dry matter yields of maize + undersown crops + weeds ($t.ha^{-1}$); average of three years

Undersown crop	Time of undersowing			Average
	5 days after maize sowing	after maize emergence	without undersowing	
Lucerne	7.79	9.41	10.00	9.07
Red clover	8.20	9.40	10.00	9.20
Sainfoin	7.54	9.94	10.00	9.16
Average	7.84	9.58	10.00	9.14

LSD for time of undersowing: $P_{0.05}$ = 0.37, $P_{0.01}$ = 0.46

ver 6.5 mil. germinative seeds and sainfoin 5 mil. germinative seeds per 1 ha. Row spacing: maize 0.75 m, clover crops 0.125 m. Fertilization: clover crops, after forecrop (spring barley) harvest $P_{35}K_{100} \times 3$ (for three years), under maize in spring during pre-sowing soil preparation $N_{120}P_{30}K_{90}$, N dose was split for two applications, N_{80} before sowing and N_{40} after emergence. Weed control was intentionally lowered and only consisted of pre-sowing application of EPTC (Eradicane 6E) 5 $l.ha^{-1}$.

Trial arrangement: split plots, main plots undersowing time, subplots clover crops, 10 variants, four replications, harvest area of the subplot: 10.5 m^2 for maize (7 × 1.5 m), 8.75 m^2 for clover crops (7 × 1.25 m).

Maize was harvested manually in milk ripeness or at the content of dry matter higher than 27% (harvest date 21., 27. and 19. 8.). Yield was determined by weighing all the mass from the plot. Before harvest, samples from areas of 1 m^2 of two replications were taken to determine the weight of undersowings and weeds. For maize plant, number and height were measured besides weight. Yields of maize with undersowing and weeds, after calculations for dry matter, were worked out by variance analysis and the differences evaluated by Tukey test. Data from botanical analyses were worked out by path analysis to find out both individual and reciprocal effect of weight of undersowings, weeds, and maize on total yield.

RESULTS

Yields of phytomass dry matter of undersowings; weeds and maize in total (Table 2) were affected by the

Table 3. Basic statistical characteristics

Factor of effect		Characteritics	Time of undersowing			Average
			5 days after maize sowing	after maize emergence	without undersowing	
Weight of dry matter of undersown clover crops ($g.m^{-2}$)	x_1	*x*	93.68	19.17	–	36.62
		SD	88.24	25.75	–	66.70
		v%	94.19	134.33	–	177.32
Weed dry matter weight ($g.m^{-2}$)	x_2	*x*	319.78	309.22	347.83	325.61
		SD	210.94	197.91	316.05	247.89
		v%	65.96	64.00	90.86	76.13
Maize plant height	x_3	*x*	1.28	1.44	1.44	1.39
		SD	0.32	0.28	0.30	0.31
		v%	25.24	19.70	20.77	22.50
Maize plant number.m^{-2}	x_4	*x*	11.9	9.8	11.6	11.2
		SD	2.41	2.08	2.59	2.48
		v%	20.26	20.32	22.36	22.03
Maize dry matter weight ($g.m^{-2}$)	x_5	*x*	528.17	661.67	802.00	663.94
		SD	395.32	507.06	661.29	544.12
		v%	74.85	76.63	82.46	81.95
Total dry matter yield ($g.m^{-2}$)	*y*	*x*	924.96	986.72	1149.83	1020.50
		SD	268.30	340.26	399.15	353.12
		v%	29.01	34.48	34.71	34.60

v% – variation coefficient (%), *SD* – standard deviation

Table 4. Portion of undersowing, weeds and maize on total dry matter yield in %; average data from three years

Average indication	Yield component		
	undersowing	weeds	maize
Undersowing 5 days after maize sowing	9.9	33.9	56.2
Undersowing into emerged maize	2.0	31.2	66.8
Maize without undersowing	–	30.2	69.8
Lucerne	5.3	28.7	66.0
Red clover	1.9	33.9	64.2
Sainfoin	3.7	32.6	63.7
Average	3.7	31.7	64.6

time of undersowing. Undersowing of clover crops 5 days after sowing maize caused its significant reduction. Undersowing into emerged maize resulted in yield reduction only by 0.42 $t.ha^{-1}$, compared with the variant without undersowing, which was at the level of 95% probability. Treated clover crops did not cause significant differences.

The highest variability of the tested yield formation factors was in the weight of undersowings and the lowest in maize plant height and number (Table 3). Maize dry

Table 5. Correlation matrices of the path analysis of the effect of undersowing clover crops and weeds on silage maize yield by undersowing time

Time of undersowing		Factor of effect				
		dry matter weight		maize		
		undersowing	weeds	height	number plants	total dry matter weight
		x_1	x_2	x_3	x_4	x_5
5 days after maize sowing	x_1	1				
	x_2	–0.569*	1			
	x_3	–0.106	–0.565*	1		
	x_4	0.402	–0.326	0.116	1	
	x_5	0.434	–0.835**	0.677**	0.536*	1
	y	0.420	–0.655**	0.521*	0.613**	0.943**
Dirrect effect		0.036	0.460	–0.190	–0.001	1.440
Indirect effect by means of	x_1	–	–0.020	–0.004	0.014	0.016
	x_2	–0.216	–	–0.260	–0.150	–0.384
	x_3	0.020	0.107	–	–0.022	–0.128
	x_4	–0.000	0.000	–0.000	–	–0.000
	x_5	0.626	–1.202	0.974	0.772	–
Significant determination coefficient B_5 (maize dry matter weight) 1.358**, total contribution x_1–x_5 to determination y: R = 0.97242**						
Undersowing after emergence of maize	x_1	1				
	x_2	–0.362	1			
	x_3	0.502*	–0.813**	1		
	x_4	0.745**	–0.091	0.169	1	
	x_5	0.292	–0.914**	0.800**	–0.006	1
	y	0.305	–0.801**	0.748**	0.003	0.972**
Dirrect effect		0.091	0.579	–0.021	–0.000	1.492
Indirect effect by means of	x_1	–	–0.032	–0.046	0.068	0.026
	x_2	–0.210	–	–0.471	–0.053	–0.530
	x_3	0.011	0.107	–	–0.004	–0.017
	x_4	–0.000	0.000	–0.000	–	0.000
	x_5	0.435	–1.365	1.195	–0.009	–
Significant determination coefficient B_5 (maize dry matter weight) 1.451**, total contribution x_1–x_5 to determination y: R = 0.99863**						

n = 18, LSD $P_{0.05}$* = 0.470, $P_{0.01}$** = 0.59

matter weight varied in an unusually expressive way, only in case of stands without undersowing it had lower variability than the weight of weeds.

The term of undersowing affected the portion of undersown clover crops and maize dry matter on total yield (Table 4). Undersowing 5 days after maize sowing the undersowings formed higher portion of total yield on average. Maize participated on yield the most – as expected – in stands without undersowings. Certainly remarkable is the obvious tendency of lower portion of weeds and higher portion of maize with lucerne undersowing than with clover undersowing. Percent portion of dry matter of harvested lucerne phytomass was marginally higher than in clover or sainfoin.

From path analysis of the effect of investigated factors by term of undersowing (Tables 5 and 6) resulted, that dry matter total yield was always negatively affected by weeds, positively by maize plant height and weight. Maize plant number did not affect yield only in case of undersowing into emerged maize. Yield was directly affected only by maize plant weight, which was reflected in significance of the corresponding determination coefficient. The effect of undersowings on yield never reached a significant level, it was relatively closest to significance in case of undersowing 5 days after sowing maize. The weight of undersowing was in a negative correlation with the weight of weeds in average evaluation (Table 6) and in case of undersowing 5 days after sowing maize (Table 5). On the contrary, the weight of undersowing positively correlated with maize plant height in undersowing after emergence and in the same time in average evaluation and with the number of maize plants. Direct influence of weeds on yield was positive, the most marked in stands without undersowings and/or

Table 6. Correlation matrices of the path analysis of the effect of undersowing clover crops and weeds on silage maize yield by undersowing time

Time of undersowing		Factor of effect				
		dry matter weight			maize	
		undersowing	weeds	height	number plants	total dry matter weight
		x_1	x_2	x_3	x_4	x_5
Maize without undersowing	x_1	–				
	x_2	–	1			
	x_3	–	–0.948**	1		
	x_4	–	–0.594**	0.553*	1	
	x_5	–	–0.904**	0.885**	0.651**	1
	y	–	–0.706**	0.716**	0.608**	0.941**
Dirrect effect			0.792	–0.000	0.000	1.657
Indirect effect by means of	x_1	–	–	–	–	–
	x_2	–	–	–0.750	–0.470	–0.716
	x_3	–	0.000	–	–0.000	–0.000
	x_4	–	–0.000	0.000	–	0.000
	x_5	–	–1.498	1.466	1.078	–
Significant determination coefficient B_5 (weed dry matter weight) –0.5589*, B_5 (maize dry matter weight) 1.55879**, total contribution x_2–x_5 to determination y: R = 0.9999**8, n = 18						
Without regard to undersowing time	x_1	1				
	x_2	–0.268*	1			
	x_3	–0.136	–0.745**	1		
	x_4	0.336*	–0.364**	0.220	1	
	x_5	0.057	–0.856**	0.783**	0.392**	1
	y	0.043	–0.670**	0.660**	0.398**	0.949**
Dirrect effect		0.115	0.615	–0.039	0.005	1.498
Indirect effect by means of	x_1	–	–0.031	–0.016	0.039	0.007
	x_2	–0.165	–	–0.458	–0.224	–0.527
	x_3	0.005	0.029	–	–0.0094	–0.031
	x_4	0.002	–0.002	0.001	–	0.002
	x_5	0.085	–1.282	1.172	0.587	–
Significant determination coefficient B_5 (weed dry matter weight) –0.4124*, B_5 (maize dry matter weight) 1.4215**, total contribution x_1–x_5 to determination y: R = 0.9899**8, n = 54						

LSD $P_{0.05}{}^{*}$ = 0.266, $P_{0.01}{}^{**}$ = 0.346

Table 7. Correlation matrices of the path analysis of the effect of undersowing and weeds on silage maize yield by kind of crop undersown

Time of undersowing		Factor of effect				
		dry matter weight		maize		
		undersowing	weeds	height	number plants	total dry matter weight
		x_1	x_2	x_3	x_4	x_5
Lucerne	x_1	1				
	x_2	−0.271	1			
	x_3	−0.269	-0.636^{**}	1		
	x_4	0.382	-0.510^{*}	0.359	1	
	x_5	−0.064	-0.837^{**}	0.770^{**}	0.405	1
	y	−0.082	-0.671^{**}	0.702^{**}	0.355	0.959^{**}
Dirrect effect		0.187	0.641	0.000	−0.000	1.507
Indirect effect by means of		x_2 −0.173	x_5 −1.261	x_2 −0.407	x_2 −0.327	x_2 −0.536
				x_5 1.160	x_5 0.610	
Significant determination coefficient B_5 (maize dry matter weight) 1.4453^{**}, total contribution x_1–x_5 to determination y: $R = 0.9999^{**8}$						
Red clover	x_1	1				
	x_2	−0.355	1			
	x_3	0.100	-0.863^{**}	1		
	x_4	−0.029	−0.271	0.300	1	
	x_5	0.174	-0.879^{**}	0.818^{**}	0.427	1
	y	0.106	-0.669^{**}	0.648^{**}	0.487^{*}	0.939^{**}
Dirrect effect y		0.101	0.764	−0.015	0.019	1.597
Indirect effect by means of		x_2 −0.271	x_5 −1.405	x_2 −0.660	x_2 −0.207	x_2 −0.672
		x_5 0.278		x_5 1.307	x_5 0.683	
Significant determination coefficient B_5 (maize dry matter weight) 1.4994^{**}, total contribution x_1–x_5 to determination y: $R = 0.9986^{**8}$						
Sainfoin	x_1	1				
	x_2	−0.256	1			
	x_3	−0.106	-0.754^{**}	1		
	x_4	0.406	−0.285	0.028	1	
	x_5	0.109	-0.859^{**}	0.781^{**}	0.346	1
	y	0.107	-0.678^{**}	0.650^{**}	0.369	0.949^{**}
Dirrect effect y		0.082	0.543	−0.088	−0.020	1.482
Indirect effect by means of		x_2 −0.139	x_5 −1.272	x_2 −0.409	x_2 −0.155	x_2 −0.466
		x_5 0.162		x_5 1.157	x_5 0.513	
Significant determination coefficient B_5 (maize dry matter weight) 1.4061^{**}, total contribution x_1–x_5 to determination y: $R = 0.9820^{**8}$						

$n = 18$, $P_{0.05}{}^{*} = 0.47$, $P_{0.01}{}^{**} = 0.59$

in average evaluation, which is also indicated by a significant determination coefficient. Indirect effect of weeds through maize weight was stronger and reversed originally positive tendency into resulting negative effect (Table 6). Weeds negatively correlated with weight and height of maize plants, negative relation with maize plant number reached significant level only in average evaluation and in the stands without undersowings (Table 6). Maize plant height influenced yield indirectly by means of maize weight, positively correlated with maize weight and in case of stands without undersowings also with the number of maize plants. Stand density and/or maize plant number influenced the yield also through plant weight; it positively correlated with this coefficient except undersowing after maize emergence.

The most expressive difference resulting from path analysis of the effect of the investigated factors on yield according to undersown clover crops (Table 7) resides in the fact that the effect of maize plant number reached a significant level only in the average of undersowing with red clover. Despite insignificant effect of undersowings on yield, certain differences between these clover crops are remarkable. While lucerne and sainfoin undersowings tended to negative correlation with maize plant height, relation of clover undersowing to this index had positive trend. Tendency of relations of undersowings to maize plant number was opposite. Another difference was the fact that negative correlation of weeds weight with maize plant number reached significant level only with lucerne undersowing but not with red clover and sainfoin undersowing.

DISCUSSION

Deficiency of rainfall in the growing period and insufficient weeds control discriminated maize in competition with weeds and undersowings (Ammon et al. 1995). Later term of undersowing improved conditions for maize yield formation, which was manifested (apart from other things) by insignificant effect of stand density (number of plants per m^2) on total yield. Double harrowing of the emerged stand before and after undersowing probably also had positive contribution, by means of some reduction in weed development despite the risk of damage or drop in number of maize plants. This relation indicates first the fact that the place with better conditions for maize may indicate better development of undersowing to a certain extent. Second, seemingly illogical relation implies higher number of maize plants could participate in forming worse conditions for development of weeds of the second line. These analyses indicate that undersowing of clover crops after maize sowing may compete with weeds by several authors (Liebman and Dyck 1993, Creamer et al. 1996), while undersowing into emerged stand competes much less with weeds (Carruthers et al. 1998). Undersowing of lucerne simultaneously with maize sowing in previous experiments (Jamriška 1995), on the contrary, significantly competed with maize itself.

Main yield-forming factors in our case apparently were dry matter weight, maize plant height and weight (not always) and weight of weeds dry matter. Maize plant weight realized directly, other factors indirectly especially through maize plant weight. Direct effect of weeds formed by their weight portion on yield was always positive, but their significant negative effect through reduction in maize plant weight changed the resulting effect to highly significantly negative. The most pronounced direct effect of weeds on yield in stands without undersowing and significant negative correlation of weight of undersowing with weight of weeds after the first term of undersowing indicate possibilities of weeds control using undersowings. Intensity of action of weed weight is illustrated by the level of correlations with maize plant weight, $r = -0.835$ to -0.914, with maize plant height, $r = -0.565$ to -0.948 and maize plant number, $r = -0.091$ to -0.594. In conditions of standard weed control, their negative effect is usually realized through maize plant height (Abdin et al. 1998).

Although undersown clover crops did not cause difference in total yields of dry matter, path analysis indicated some differences in yield formation. Maize plant number reached significant level of effect on yield only with undersowing of red clover. This difference obviously rises from different utilization of space by investigated clover crops in and above soil. This is also proved by contradictory tendencies in their relations with maize plant number, in lucerne and sainfoin positive, in clover rather negative. Their relations with maize plant height were opposite. These relations are complemented by tendency of lower portion of weeds and higher portion of maize with lucerne undersowing than with red clover undersowing. Better effect of lucerne undersowing on maize than that of red clover is also quoted by Exner and Cruse (1993). In our experiments these differences are probably also due to more suitable conditions for lucerne than for red clover.

REFERENCES

Abdin O., Coulman B.E., Cloutier D., Faris M.A., Zhou X., Smith D.L. (1998): Yield and yield components of corn interseeded with cover crops. Agron. J., *90*: 63–68.

Ammon H.-U., Scherrer C., Mayor J.-P. (1995): Vier Maisanbauverfahren 1990 bis 1993 Unkrautentwicklung und Bodenbedeckung. Agrar. Forsch., *9*: 369–372.

Carruthers K., Fe Q., Cloutier D., Smith D.L. (1998): Intercropping corn with soybean, lupin and forages: Weed control by intercrops combined with interrow cultivation. Eur. J. Agron., *8*: 225–238.

Charkov G.D., Muginov N.L. (1985): Sostojanije i perspektivy ľjucernosejanija v Tatariji. Kormoproizvodstvo, (11): 13–15.

Creamer N.G., Bennett M.A., Stinner B.R., Cardina J., Regnier E.E. (1996): Mechanism of weed suppression in cover crop-based production systems. Hort. Sci., *31*: 410–413.

Čakrov P. (1995): Vzmožnost za ottleždane na njakoj mnogogodišni furažni kulturi pod pokrov na carevica. Rasteniev. Nauki, *32*: 97.

Exner D.N., Cruse R.M. (1993): Interseeded forage legume potential as winter ground cover, nitrogen source, and competitor. J. Prod. Agric., *6*: 226–231.

Heyland K.U., Werner A. (1988): Ertragsbildung und Veränderung von Systemzuständen in Mischkulturen sowie deren mathematische Beschreibung am Beispiel von Beständen aus Mais und Beipflanzen. Bodenkultur, *39*: 233–250.

Jamriška P. (1995): Analýza účinku podsevu vybraných odrôd lucerny na úrodu silážnej kukurice. Rostl. Výr., *41*: 559–564.

Le Gall A., Legarto J., Pflimlin A. (1997): Place du mais et de la prairie dans les systémes fourragers laitiers. III. Incidence sur l'environnement. Fourrages, *150*: 147–169.

Liebman M., Dyck E. (1993): Crop rotation and intercropping strategies for weed management. Ecol. Appl., *3*: 92–122.

Nordquist P.T., Wicks G.A. (1974): Establishment methods for alfalfa in irrigated corn. Agron. J., *66*: 377–380.

Werner W. (1995): Situation und Massnahmen in Deutschland (Nährstoffverluste). Grüne, *4*: 12–15.

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ABSTRAKT

Vliv termínu podsevu jetelovin a zaplevelení na výnos silážní kukuřice

V polních pokusech byl sledován vliv dvou termínů podsevů (pět dní po setí a do vzešlého porostu kukuřice) tří jetelovin (vojtěška, jetel luční, vičenec vikvolistý) na výnos kukuřice na siláž. Termín podsevu jetelovin měl průkazný vliv na celkový výnos sušiny. Porosty s podsevy do vzešlé kukuřice měly vyšší výnosy než porosty podsévané v prvním termínu. Rostliny porostů kukuřice podsévané v druhém termínu měly lepší podmínky pro tvorbu výnosu. Počet rostlin nedosáhl průkazné hladiny vlivu na výnos. Rozhodujícími faktory tvorby celkového výnosu byly hmotnost a výška rostlin kukuřice a hmotnosti plevelů. Negativní vliv plevelů se uplatňoval snižováním hmotnosti a výšky rostlin kukuřice. Vliv podsevů sice nedosáhl průkazné úrovně, úseková analýza však naznačila jisté rozdíly mezi sledovanými jetelovinami. Počet rostlin kukuřice nedosáhl průkazného vlivu na výnos jen s podsevem jetele lučního. Hmotnost plevelů korelovala průkazně záporně s počtem rostlin kukuřice jen v porostech s podsevem vojtěšky.

Kľíčová slova: kukuřice na siláž; termín podsevu jetelovin; plevele; vliv na výnos

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