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INVESTIGATION OF CHLORIDE CONCENTRATION IN BURLEY TOBACCO VARIETIES

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ABSTRACT

The effects of different rates of chloride application on growth parameters, yield and Cl accumulation in cured leaves of six Burley cultivars have been studied in stationary field trial. Chloride treatments were 0, 65 and 130 kg Cl ha^{-1}. The chloride source was KCl. The accumulation rates of chloride in the leaves of six Burley tobacco varieties (Burley 1317, Burley 1000, Burley 1351 from Bulgaria and TN 86, Banket 102, Kentucky 908 from the United States) were compared.

Statistically significant linear dependence was noted between chloride treatments and Cl concentration in the leaves. The concentrations of chloride in cured leaves were 0.10-0.40%, 0.30-0.99% and 0.37-1.87% respectively for 0, 65 and 130 kg Cl ha^{-1} treatments. In most cases the chloride content increased above 1% at the 130 kg ha^{-1} Cl level. There were significant variety differences in chloride accumulation and significant variety x soil chloride application interactions. Therefore, in order to limit adverse effects of fertilization with high KCl rates the appropriate varieties should be carefully selected.
Key words: Burley tobacco, chloride

ИСТРАЖУВАЊЕ НА КОНЦЕНТРАЦИЈАТА НА ХЛОРИД ВО ТУТУНСКИТЕ СОРТИ ОД ТИПОТ БЕРЛЕЈ

Во стациониран полски опит извршени се проучувања на ефектите од различни применети дози на хлорид врз параметрите на развој – приносот и акумулацијата на Cl во сувите листови од шест берлејски сорти. Третирањата со хлорид беа во дози од 0, 65 и 130 kg Cl ha^{-1}. Изворот на хлорид беше KCl. Компарирани се акумулативните дози на хлорид во тутунските листови од шест берлејски сорти (Берлеј 1317, Берлеј 1000 и Берлеј 1351 берлеј од Бугарија и ТН 86, Банкет 102 и Кентаки 908 од САД). Констатирана е статистички значајна линеарна зависност помеѓу третирањата со хлорид и концентрацијата на Cl во листовите. Концентрациите на хлорид во сувите листови беа 0.10-0.40%, 0.30-0.99% и 0.37-1.87% соодветно за третирањата од 0, 65 и 130 kg Cl ha^{-1} . Во повеќето случаи содржината на хлорид се покачи над 1% при третирање со 130 kg Cl ha^{-1}. Постојат значајни разлики меѓу сортите во однос на акумулацијата на хлорид, како и значајни интеракции помеѓу сортата и почвата во поврзани со примената на хлоридот. Оттаму, за да се намалат непожелните ефекти од ѓубрењето со високи дози на KCl, потребно е внимателно да се одбираат најсоодветните сорти.
Клучни зборови: берлејски тутун, хлорид

INTRODUCTION

Chloride is an essential micronutrient and there is considerable evidence that beneficial effects arise with tobacco from the presence of small amounts of chloride in the fertilizer (McCants & Woltz, 1967). Elliot and Vickery (1961) reported that chlorine from 20 to 50 pounds per acre had no effect on yield or leaf-grade quality of flue-cured tobacco, but increased applications of chlorine increased the chlorine content, moisture uptake, and decreased the burning rate of the cured leaf. Mulchi (1982) found significant reductions in average price, quality index, and leaf burning at chloride application rates above 44 kg/ha or above 0.53% chloride in the cured Maryland tobacco. Various soil and fertilization conditions, as well as various types of tobacco, varieties and methods of harvesting might contribute to the differences in absorption and distribution of chloride with respect to stalk positions and the total leaf chloride content (Tso, 1990). The quality of tobacco is known to be adversely affected by excessive amounts of chloride in the media and fertilization with KCl leads to accumulation of unacceptable levels of chloride, which impairs the quality of the cured leaf. The preferred source of potassium is potassium sulfate but the cost of fertilization tempts tobacco growers to use the cheaper muriate of potash source (Palmer and Pearce, 1999). Gul et al. (2006) illustrated that tobacco cultivars showed different response to the KCl induced chloride toxicity. The same authors reported that chloride, reducing sugars, nitrogen, nicotine and K contents of leaves increased with increasing KCl. Darvishzadeh et al. (2011) observed that Cl uptake by oriental tobacco varied with genotypes and suggested that Cl accumulation is genetically controlled. According to Karaivazoglou et al. (2004) the differentiation among varieties in accumulation rate of chloride with increased chloride level indicate that, when the chloride concentration in the available irrigation water is high, a choice exists to select among Oriental, Virginia and Burley tobacco varieties that exhibit the less adverse effect from chloride.

The objective of the current study was to investigate the influence of Cl addition on growth parameters, yield of cured leaves and Cl accumulation in cured leaves from different primings of six Burley cultivars.

MATERIAL AND METODS

The effect of chloride applied in the soil on the growth, yield and chloride concentration in Burley tobacco genotypes was investigated in 2006. The study was conducted in a stationary field trial. The soil used was sandy loam, alluvial-meadow with low chlorine content - 1,78 mg kg^{-1}; humus – 1,82%; total nitrogen - 0.076%; P_2O_5 - 16 mg kg^{-1}; K_2O - 266,5 mg kg^{-1}; bulk density - 1,3 g/cm^3; $pH_{(H2O)}$ - 8,43.

The stationary plots (1,5 m long and 1,5 meters wide) had a depth of 0,5 m and area of 2,25 m^2. During field preparation, each plot received P broadcast at a rate equal to 100 kg ha^1, using triple superphosphate as fertilizer. Nitrogen was applied at a rate of 140 kg ha^{-1} as ammonium nitrate. Chloride treatments were 0, 65 and 130 kg Cl ha^{-1}. The chloride source was KCl. Before transplanting, the fertilizers (ammonium nitrate and potassium chloride) were uniformly broadcast over the soil surface of each plot and incorporated into the soil.

The accumulation rates of chloride in the leaves of six Burley varieties - Burley 1317, Burley 1000 and Burley 1351 from Bulgaria and TN 86, Banket 102 and Kentucky 908 from the United States were compared.

Cultural practices were applied according to the recommendations for commercial plantations.

The following measurements were taken: plant height and number of leaves per plant (as measured at flowering), yield of cured leaves per plant and chemical analyses of the leaves. Cured leaves at first (lower leaves), second (middle leaves) and third (upper leaves) priming were collected for analyses. All samples were oven-dried at 65^{0}C and ground. The chlorine content was determined by titration using the silver nitrate method.

The analysis of variance was used for statistical processing of data. Regression analysis was used to establish relationships between chloride treatments rates and changes in chloride contents in cured leaves.

RESULTS AND DISCUSSION

Chloride toxicity in green tobacco has been characterized as thickened leaves which are exceedingly brittle with upward curling of leaf margins (McCants & Woltz, 1967). No symptoms of chloride toxicity appeared under our experimental conditions during the growing season.

Growth parameters including plant height and leaf number per plant were not significantly affected by Cl addition (Table 1). Genotype differences were significant, but varieties x soil chloride application interactions were significant for plant height only. Differences in crop yields were not significant among rates of chloride applications and variety x soil chloride application interaction. However, genotype differences for yield of cured leaves were statistically significant. Gul et al. (2006) in outdoor pot experiment with tobacco cultivars observed that all growth parameters increased with the initial dose of 4 mmol $kg^{-1}$of KCl, but then decreased with higher levels. Our results indicate that chloride treatments up to 130 kg Cl ha^{-1} did not influence growth processes of Burley tobacco plants and yield of cured leaves.

Table 1. Effect of soil chloride application and variety on growth parameters and yield of cured leaves

Soil chloride application, kg ha^{-1}	Variety	Plant height, cm	Total number of leaves per plant	Yield, g $plant^{-1}$
0	Burley 1317	123.2	23.8	78.0
	Burley 1000	140.2	23.8	80.2
	Burley 1351	141.2	25.2	84.2
	TN 86	138.6	23.6	74.0
	Banket 102	135.0	25.0	85.0
	Kentucky 908	121.6	23.6	74.2
65	Burley 1317	122.5	23.5	80.2
	Burley 1000	137.1	23.6	83.0
	Burley 1351	137.5	25.4	81.4
	TN 86	135.0	23.5	81.0
	Banket 102	134.5	25.3	78.4
	Kentucky 908	120.0	23.8	76.0
130	Burley 1317	125.3	22.9	76.4
	Burley 1000	145.0	24.0	78.8
	Burley 1351	141.5	25.6	87.8
	TN 86	139.7	24.0	80.4
	Banket 102	130.5	24.5	80.2
	Kentucky 908	113.8	24.0	77.4
Significance of F-tests				
Cl Application (Cl A)		NS	NS	NS
Variety (V)		**	**	*
Cl x V		*	NS	NS

*, ** Significant at the 0.05 and 0.01 probability levels, respectively; NS – not significant

Variations of Cl concentration in tobacco leaves due to Cl addition and variety differences are shown in Table 2. The chloride content in tobacco leaves varied from 0.10 to 1.87%. According to Flower (1999), the highest concentration of chloride is found in the lower leaves and it decreases progressively to the top of the plant. Generally, the chlorine concentration in our investigation was the highest in the lower priming and diminished with successive

primings. The variation in Cl contents in the second and third priming was not related to leaves' stalk position, which could be explained by the fact that Cl^- is mobile within the plant.

The CL concentration in cured leaves from control treatment is not high - from 0.10 to 0.40%. With the increase of chloride application rates the Cl content in leaves from the first, second and third priming was significantly increased. Chloride concentrations in tobacco leaves grown under the highest KCl rates were 4-5 times higher than those grown on plots without Cl addition. Chloride concentrations in excess of 1% can produce poor quality tobacco (Flower, 1999). In our experiment, the tobacco from 0 and 65 kg Cl ha^{-1} treatments did not reach this detrimental accumulation rate. In most cases the chloride content rose above 1% at the 130 kg ha^{-1} Cl level.

Table 2. Effect of soil chloride application and variety on chloride concentration in cured leaves (% of dry weight)

Soil chloride application, kg ha^{-1}	Variety	Lower leaves	Middle leaves	Upper leaves	Average
0	Burley 1317	0.25	0.12	0.12	0.16
	Burley 1000	0.20	0.10	0.13	0.14
	Burley 1351	0.40	0.23	0.14	0.25
	TN 86	0.22	0.21	0.17	0.20
	Banket 102	0.31	0.17	0.16	0.21
	Kentucky 908	0.21	0.22	0.15	0.20
65	Burley 1317	0.54	0.99	0.42	0.65
	Burley 1000	0.61	0.70	0.58	0.63
	Burley 1351	0.98	0.30	0.53	0.60
	TN 86	0.76	0.43	0.38	0.52
	Banket 102	0.69	0.49	0.50	0.56
	Kentucky 908	0.73	0.38	0.80	0.64
130	Burley 1317	1.51	0.72	0.84	1.02
	Burley 1000	1.29	0.53	0.37	0.73
	Burley 1351	1.04	0.62	1.21	0.96
	TN 86	1.62	1.17	1.24	1.34
	Banket 102	1.75	1.19	1.54	1.49
	Kentucky 908	1.87	1.37	1.85	1.70
Significance of F-tests					
Cl Application (Cl A)		**	**	**	
Variety (V)		*	**	*	
Cl x V		*	**	*	

*, ** Significant at the 0.05 and 0.01 probability levels, respectively

Statistically significant linear dependence was noted between chloride treatments and the concentration of Cl in the leaf tissues. The equations in Table 3 can be used to predict the maximum chloride rate to keep leaf chloride concentrations from exceeding 1%. If y=1%, the corresponding Cl rates are 79, 136, and 113 kg ha^{-1} for lower, middle and upper leaves, respectively. These rates are higher than the chloride rate of 44 kg ha^{-1} obtained by Mulchi (1982) above which he observed significant reductions in some parameters of cured tobacco. Therefore, the calculated rates point to the highest acceptable levels above which the leaf quality is expected to be reduced. Peedin (1999) emphasize that the ***y*** intercept of the regression equation will vary depending on the amount and distribution of rainfall, soil types and some cultivation practices.

Table 3. Relationships between chloride treatment rates and changes in chloride contents in lower, middle and upper leaves of Burley tobacco

Leaf position	Relationship	Correlation coefficient (r)
Lower leaves	Y=0.21+0.010x	0.927**
Middle leaves	Y=0.18+0.006x	0.794**
Upper leaves	Y=0.10+0.008x	0.820**

** Significant at the 0.01 probability level

Evanylo et al. (1988) established nutrient norms for cured Burley tobacco and observed that the mean chloride concentrations for desirable yield and price were 9.6 and 9.9 mg g^{-1}. The same authors concluded that because of a large SD value for mean Cl concentration in the high-price subpopulation high-quality tobacco may be attained under a fairly wide rage of Cl.

Having in mind the emerging consensus views from the cited literature and the data obtained in our experiments, chloride application of 65 kg ha^{-1} should be considered as optimal for producing high cured-leaf quality under South Bulgarian conditions.

The accumulation rate of chloride in leaves at three chloride levels varied between cultivars (Table 2). There were significant variety differences in chloride accumulation and significant variety x soil chloride application interactions. The average Cl concentration of six genotypes ranged from 0.14 to 0.25% in plots not receiving KCl. In control treatments Burley 1351 was the highest Cl accumulator but the same did not apply to the application of 65 and 130 kg Cl ha^{-1}. Averaged for all primings, Burley 1317 had the highest chloride concentration in leaves as compared to other cultivars when Cl rate was 65 kg ha^{-1}. In the highest Cl treatment the average chloride concentration varied from 0.73 to 1.70% and all Bulgarian cultivars accumulated less chloride in the leaves compared to the three introduced varieties. These results indicate that, when properly applied, the cheaper muriate of potash source can be safely used by tobacco growers to increase the economic efficiency of fertilizer application.

CONCLUSIONS

Our results indicate that KCl applications should be planed carefully to prevent its adverse effects on quality of tobacco even when tobacco is grown on soils with low chlorine content.

Under our experimental conditions, no symptoms of chloride toxicity appeared during the growing season. Growth parameters and yield of cured leaves were not significantly affected by Cl addition but statistically significant linear dependence was noted between chloride treatments and the concentration of Cl in the leaves. The concentrations of chloride in cured leaves were 0.10-0.40%, 0.30-0.99% and 0.37-1.87% respectively for 0, 65 and 130 kg Cl ha^{-1} treatments. In most cases the chloride content rose above 1% at the 130 kg ha^{-1} Cl level.

There were significant variety differences in chloride accumulation and significant variety x soil chloride application interactions. In the highest Cl treatment, cultivars Burley 1317, Burley 1000 and Burley 1351 accumulated less chloride in the leaves compared with the three introduced varieties. Therefore, in order to limit adverse effects of fertilization with high KCl rates the appropriate varieties should be carefully chosen.

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