EFFICIENCY OF USE OF CHLOROPHYLL METER AND CARDY-ION METER IN POTATO NITROGEN NUTRITION SUPPLY

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Abstract: Chlorophyll contents and NO_3-N concentration in vegetation depend on soil nitrogen availability and crop nitrogen uptake. Crop nitrogen uptake is important as nitrogen is needed for chlorophyll formation. Sap nitrate is more sensitive to changes in N application compared to total N and the leaf petiole sap accumulate nitrates more then other parts of plants. We use this method to reduce sampling time required for precisely determining fertilization and for prevention over fertilization. The objective of this study was to estimate leaf nitrogen and nitrates contents by SPAD meter and Cardy-ion meter and to link observations by comparing optical recording techniques at leaf with laboratory results of total nitrogen and fresh tuber yield. Thus, collected results will directly reflect the nutrient soil supply. Field data are from potato experiment in Bosnia and Herzegovina in 2005, comprising three potato varieties: Liseta, Cleopatra and Adora, receiving similar nitrogen treatments (0, 100, 200 and 300 kg N ha^{-1}). In four field sampling periods (65, 75, 85 and 95 days after sowing) the SPAD readings were performed and correlated with total nitrogen contents and obtained fresh tuber yield at the end of season. Measurement by Cardy-ion meter are performed on leaf petiole sap and tuber sap of potato and compared with percentage of nitrogen in leaf and tuber. In experiment we found highly significant relationship between SPAD indexes as well and concentration of NO3-N mg^{-1} with laboratory results of total nitrogen and at the end of the season with tuber yield. Meter readings indicate a significant potato yield responses to N fertilization doses. This result clearly shows more accurate quantification of the nitrogen status of a potato crop by SPAD and Cardy-ion meter, which is important information in potato crop management.

Keywords: Cardy-ion meter, SPAD Chlorophyll meter, total nitrogen, yield, early potato

Introduction

The maintenance of soil fertility was based mainly on the application of mineral fertilizers (Németh and Kádár, 1991). During the last few decades, therefore, farmers applied more nitrogen than the crop demanded, and the overall nitrogen balance became positive (Csathó, 1994). Restoring the nutrient supply improves the quality and quantity of yield for all agricultural plants as well (Nagy, 2006). The yield quality, macro element content and their ratios correlate with the amount of fertilizer (Poljak et al., 2007). The N concentration of plant tissues is closely correlated with the N supplying capacity of the soil. A determination of the chlorophyll content thus allows the N nutrition level of the plant, and indirectly the N supplying capacity of the soil, to be estimated (Izsáki and Németh, 2007). Nitrogen deficiency can be indicated by the SPAD value with great security. It can provide a possibility for the development of an environmentally friendly nutritive management (Széles, 2007) by predicting the N status of various crops and determining their fertilization requirements (Bonneville and Fyles, 2006). Portable Cardy-ion meter is used for quick nitrate sap analysis to improve N management in crop growing and utilization of N. Nitrate levels in plant sap varied with soil mineral nitrogen supply and with time throughout the growing season (Rodrigo and Ramos, 2007). Meter is provided with a specific ion electrode, allowing rapid determinations of ion concentrations in the field of soil solution and plant sap. The

main advantage is the short time required for sap tissue analyses which are directly measured by dripping a sap sample on the electrode. The research has been made on potato crop measuring the level N fertilization by using field diagnostic methods for evaluation of nitrates and chlorophyll content. Study has two main goals: to improve knowledge of the N crops status and to improve soil mineral N utilization.

Materials and methods

Field trial was conducted in Jasenica (Bosnia and Herzegovina) in year 2005 with three early potato varieties (cv. Adora, Cleopatra and Liseta). The seed tubers were sown in March in experimental plots with space 0.70 m between rows and 0.20 m in a row. Three different doses of nitrogen nutrition (N 100, N 200, N 300 kg N ha^{-1}) including unfertilized-control plots (N 0 kg N ha^{-1}) were distributed in randomized block design with three replications. Size of the experimental plots was 270 m^2 and data considered for evaluation were taken from central plot of 30 m^2. Soil fertilization with phosphorus and potassium was determined on the basis of soil analyses. We have performed measuring with Chlorophyll meter and Cardy-ion meter from the uppermost, fully expanded mature leaf, which generally fell in the fourth or fifth node of canopy below the top of the crop. Measurement for named methods was conducted during 65, 75, 85 and 95 DAS (days after sowing) on five plants per treatment. Total nitrogen concentration of potato tuber was analyzed by Kjeldahl method (AOAC, 1970). Analyses of variance (ANOVA) were used for testing differences in SPAD values, concentration of NO_3-N mg kg^{-1} and percentage of total nitrogen in potato leaves and crop yield. Pearson's correlation coefficient (*, **, $p < 0.05$ and $p < 0.01$) model was used for identifying correlations between: the total nitrogen (determinate on dry matter basis) and values collected with meters, as well as with potato yield. Data were analyzed by using SPSS for Windows v 13.0 (SPSS, 2004).

Results and discussion

During this study we have used SPAD meter and Cardy-ion meter as indicators of N status in potato crop. Research has showed that chlorophyll content in potato leaves reaches the maximum values in earlier stages of growth after that it gets lower. The same happened with concentration of NO_3-N in petioles of potato leaves. As we mentioned before data were collected during four growth stages. The important thing is that the highest yield has been obtained with application of 300 kg N ha^{-1} and the average yield was 3.16 kg $plant^{-1}$. N doses increased plant nitrogen content generally (Németh et al., 2007). Results presented by Majić et al., (2007) shows that the nitrogen fertilizer results in increments of potato yield as well as on few quantitative traits as dry matter weight, percentage of raw ashes and plant biomass.

From results collected during a vegetation season in 2005 we have found a very significant correlation between SPAD readings and fresh tuber yield with coefficient of r=0.19ns, r=0.48**, r=0.46**, r=0.30ns. SPAD index reaches the maximum values from 53 to 63 at 75 DAS and at the end of the season it's getting lower from 30 to 47 units. Chlorophyll meter (SPAD) values and the leaf N concentration (Figure 1) show a highly significant correlation at various days after sowing 65, 75, 85 and 95 (r values ranged from 0.51** to 0.81**) which presents major physiological growth stages. A similar result for winter barley (r=0.84) was reported by Izsáki and Németh, (2007) in

relationship between SPAD index and total leaf N. According to Booij et al. (2000) average values collected by SPAD chlorophyll were between 40 and 41 units in 7 to 8 weeks after the emergency of potato crop. According to Széles (2007) not only nitrogen supply, but also water supply is reflected in the amount of SPAD value and the higher amount of nitrogen increases the chlorophyll content to the maximum.

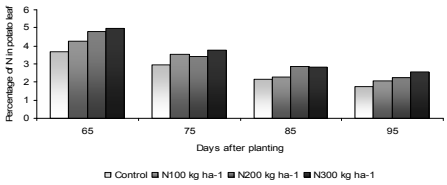

Figure1. Percentage of total leaf nitrogen during 4 growth stages and different fertilizations

Very significant correlations between nitrate readings in leaf petioles sap and fresh tuber yields with correlation of r=0.53**, r=0.51**, r=0.61**, r=0.34* were found. Thus, correlation between concentration of NO3-N mg kg^{-1} in leaf petiole sap and percentage of total leaf nitrogen show coefficients of r=0.80**, r= 0.41*, r=0.72** and r=0.73**. The meter readings showed the average values from 1220 to 6833 at the beginning of season and at the end of season they varied from 932 to 5388 NO_3-N mg kg^{-1} (Table 1). Measurements performed on potato tuber revealed very significant relations between percentages of nitrogen and concentration of NO_3-N in fresh tuber sap at level 0.46** (Table 1). The values of NO_3-N mg kg^{-1} in tuber sap varied from 43 to 69 mg kg^{-1} in the season. Buturac (2003) implies that average concentrations of nitrates in potato tuber are between 30 to 80 mg kg^{-1} while appreciations are about 140 to 233 mg kg^{-1}.

Table1. Readings obtained by SPAD meter and NO_3-N mg kg^{-1} in potato leaves 65, 75, 85 and 95 days after sowing (DNS) and fresh tuber yield per plant; NO_3-N mg kg^{-1} and % of N in potato tuber (ANOVA)

Treatment	Days after sowing (DNS)								% of N in tuber of potato	NO_3 – N in tuber of potato mg kg^{-1}	Yield kg $plant^{-1}$
	65	75	85	95	65	75	85	95			
	SPAD index				NO_3-N mg kg^{-1}						
Control	53	48	38	30	1220	682	524	932	1,36	43	1,2
N100	57	56	41	34	4000	2955	1510	2637	2,30	50	2,47
N200	61	58	53	42	5366	4200	3811	3958	2,60	64	2,97
N300	63	60	56	47	6833	4744	5188	5388	3,00	69	3,16
F-test											
Treatment	**	**	**	**	**	**	**	**	**	**	**
Variety	**	**	**	NS	NS	NS	NS	**	NS	**	*
T x V	NS	NS	*	NS	NS	NS	NS	NS	NS	NS	NS

NS – non significant; *- significant (p<0.05); **-significant (p<0.01)

Concentrations of NO3-N significantly increased with the applied N rates, therefore the seasonal fluctuation of NO3-N was dynamic (Koós-Németh, 2006). Cardy-ion meter for

potato crop plant sap-testing have been calibrated to find a system that growers can use in the field for managing nitrogen (N) and which will stop them from applying excessive amounts of fertilizer what contributes to groundwater pollution by nitrate. N fertilization is one of the most effective agro-technical devices for increasing yield and N concentration (Berecz and Németh, 2002). To achieve healthy growth and optimal yield levels of the crop, nutrients must be available not only in the correct quantity and proportion, but also in the right time.

Conclusions

The SPAD chlorophyll and Cardy-ion meter can be used for monitoring the N status of potato crop. From these results we concluded that variation in values derived from state of soil nitrogen supply and for that reason we can notice decadency of nutrition with the ageing of plant crop. Thus, measured nutrient level in plant tissues are in great deal affected by soil status of the nutrients. The tests could be practiced in situ by the farmer, and the necessity of nitrogen fertilizer application could be decided immediately.

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