Influence of sodium humate on the yield and quality of green pepper

L. VARGA, L. DUCSAY

Slovak University of Agriculture, Department of Agrochemistry and Plant Nutrition, Nitra, Slovak Republic

ABSTRACT: In greenhouse conditions a 3-year small-plot experiment was conducted on loamy Chernozem originating from the humus horizon to investigate the effect of sodium humate application on yield, nitrate content and vitamin C content in green pepper fruits. The application of 5 kg of sodium humate per hectare in the form of watering 3 weeks after planting of pepper seedlings under full NPK nutrition (N nutrition was divided as follows: 2/3 of total N before planting and 1/3 of total N together with sodium humate 3 weeks after planting) resulted in a statistically significant increase in pepper yield by 13.6% at a concomitant significant reduction of nitrate content in pepper fruits by 12% and increase in vitamin C content by 28.6%.

Keywords: sodium humate; green pepper; vitamin C; nutrition

Under the present circumstances when the inputs into vegetables production increase substantially more quickly than do the prices of vegetables, it is necessary to pay an extraordinary attention to nutrition which can markedly contribute to effective growing of vegetables. It is necessary to respect the requirements of the vegetable species for soil reaction and take into account the supply of nutrients in soil determined by agrochemical soil analyses and their utilization by plants.

Considerable attention is paid to stimulating effects of humates in the nutrition of agricultural crops both in research and practice. It is generally known that humus substances favourably influence the physical and chemical properties of soil, water and air regime, buffering soil capacity, binding of soil nutrients into available forms and soil microbial activity. The humates are not harmful from toxicological aspects and their composition is friendly to the environment (VERMEER et al. 1998). Calcium, sodium, ammonium and other humates have stimulating, adsorptive and protective properties and it is advantageous to apply them together with mineral fertilizers and plant protection products. Applied humates insert a considerable amount of surface energy into the soil solution that improves nutrition conditions at the level of ionic and molecular processes. As a consequence of these effects regulated nutrient uptake by plants is supposed resulting in positive impacts on yields and their quality (VRBA 1987; KRUGOV, MAYKOVA 1988; LOŽEK et al. 1997).

The main aim of the experiment was to quantify the effect of sodium humate on green pepper yield and to determine its influence on nitrate and vitamin C contents in green pepper fruits.

MATERIAL AND METHOD

A small-plot experiment with green pepper was established in a greenhouse with mechanical ventilation and irrigation. The soil was loamy Chernozem with neutral

Table 1. Agrochemical characteristics of soil before the experiment start in respective years

Characteristic	Content of available nutrients (mg/kg of soil)		
	1995	1996	1997
N_{an}	26.30	25.50	25.00
$N\text{-}NH_4^+$	4.00	6.00	5.50
$N\text{-}NO_3^-$	22.30	19.50	19.50
P – by Egner	31.00	33.00	32.00
K – by Schachtschabel	232.00	230.00	228.00
Mg – by Schachtschabel	355.00	350.00	348.00
PH/KCl	7.23	7.21	7.20
Humus – by Tjurin (%)	1.63	1.65	1.64

Table 2. Layout of experimental treatments

	Treatment
1	Unfertilized control
2	2/3 N + rate of P and K before planting
3	2/3 N + rate P and K before planting + 1/3 N 3 weeks after planting
4	2/3 N + rate P and K before planting + 1/3 N + sodium humate 3 weeks after planting
	N was added to reach the level of 45 mg N_{an}/kg of soil P was added to reach the level of 40 mg P/kg of soil K was added to reach the level of 250 mg K/kg of soil

Table 3. Characterization of applied sodium humate

Water content (%)	17–20
Dry matter content (%)	80–83
Ash content (%)	20.8–21.6
Organic matter content (%)	59.2–61.4
Humic acids (HA) in fresh mass (%)	48.0–51.9
HA in dry matter (%)	60.0–62.5
Content of function groups (-COOH and -OH)	5.8 mmol/g
Ratio of HA:FA (fulvic acids)	15:1
Content of Na in dry matter (%)	8.0
Content of Fe_2O_3 (%)	3.9
Content of K_2O (%)	0.8
Content of P_2O_5 (%)	0.14
Content of MgO (%)	1.23
Content of N (%)	1.1

reaction, high content of available magnesium, good content of potassium and inorganic nitrogen and medium supply of available phosphorus. The contents of these nutrients in soil are shown in Table 1.

Green pepper cultivar Andrea was used in this experiment. The plot size was 2.4 m^2. Plant spacing was 0.5 × 0.4 m. The experiment was organized in three replications with 12 plants per plot. The layout of experimental treatments is given in Table 2.

Experimental treatments were based on the optimization of NPK rates with the aim to fill up the supply of nutrients at a soil depth of 0.3 m to the standard level (Table 2). Nitrogen was applied to reach the level of 45 mg N_{an}/kg of soil and the calculated rate was divided into two rates as follows: 2/3 of total N rate plus total rates of phosphorus and potassium were applied before seedling planting and 1/3 of total N rate was applied 3 weeks after seedling planting.

Sodium humate was applied into the soil by watering at the rate of 5 kg/ha together with the 2nd partial N rate 3 weeks after planting. Table 3 gives the characteristics of sodium humate. Particular nutrient rates in the years of observation are illustrated in Table 4. The following fertilizers were applied in the experiment: DAM-390, triple superphosphate and potassium sulphate. In the course of the growing season 3 harvests of fruits were done. At each harvest, yield of fruits, content of NO_3^--N analyzed by a distillation method and content of vitamin C by titration with 2,4-dichlorophenolindophenol were determined. The yield of fruits was evaluated by analysis of variance using Statgraphics programme.

Table 4. The rates of nutrients in the experiment (average of 3 years)

Fertilization treatments	Fertilization before planting (kg/ha)			Fertilization after planting (kg/ha)	
	N	P	K	N	HS
1	–	–	–	–	–
2	58.2	36.0	90.0	–	–
3	58.2	36.0	90.0	29.1	–
4	58.2	36.0	90.0	29.1	5

HS – sodium humate

RESULTS AND DISCUSSION

Statistical evaluation of 3-year experiment with green pepper proves that the applied nutrition in treatments 2 and 4 increased fruit yield significantly in comparison with unfertilized control.

Significant differences for treatments:

$D_T = 0.05$ 3.070 t/ha

$D_T = 0.01$ 4.126 t/ha

Significant differences for years:

$D_T = 0.05$ 2.383 t/ha

$D_T = 0.01$ 3.196 t/ha

It results from the evaluation of average yields (Table 5) that the optimized rates of phosphorus, potassium and nitrogen before planting (i.e. full PK-nutrition and 2/3 of total nitrogen rate – treatment 2) increased average yield of fruits by 52.7%, which is a highly significant increase in comparison with unfertilized control (treatment 1). Dressing with nitrogen during the growing season (application of 1/3 of total N rate 3 weeks after planting) led to a yield increase by 6.5 t/ha compared to treatment 2. Thus the full NPK-nutrition (treatment 3) increased average yields even by 101.2% compared to control, and this is a statistically highly significant increase. At the same time the content of nitrates in fruits increased from 97.6 mg $NaNO_3$/kg (treatment 1) to 119.7 mg $NaNO_3$/kg of fresh fruits (treatment 3). However, this value did not exceed the standard limit value of 200 mg $NaNO_3$/kg.

The application of 5 kg/ha of sodium humate together with 1/3 of total N by watering 3 weeks after seedling planting showed a highly significant increase in fruit yield by 130.5%, which is an increase by 17.6 t/ha in comparison with unfertilized control. The addition of sodium humate to full NPK-nutrition (treatment 4) increased yield by 3.96 t/ha , i.e. by 14.5% compared to analogical treatment with only full NPK-nutrition (treatment 3).

Table 6 illustrates the effect of nutrition on nitrate content in pepper fruit. The application of 2/3 of total N rate and total PK rate before planting (treatment 2) and application of 1/3 N during the growing season with 2/3 N plus total PK rate before planting (treatment 3) resulted in an increase of nitrate content by 13.4 and 22.6%, respectively, in comparison with unfertilized control (treatment 1) on the average of 3 experimental years, when the higher value of nitrates was determined under the full NPK-nutrition (treatment 3). The application of 5 kg/ha of sodium humate together with full NPK-nutrition increased nitrate content in fruits by 7.9% against control.

Comparing the effect of humate applied together with full NPK-nutrition (treatment 4) with full NPK-nutrition (treatment 3), a marked reduction of nitrate content in pepper fruits by 12%, i.e. by 14.3 mg/kg, is observed.

Table 7 shows average content of vitamin C in pepper fruits. The content of vitamin C increased by 3.2% under the application of 2/3 total N rate and calculated P and K rates before planting (treatment 2). If 1/3 of N was applied 3 weeks after planting and NPK rates before planting, nearly the same value of vitamin C content as in unfertilized treatment was obtained. The difference was only 0.3 mg of vitamin C per 100 g of fresh pepper fruits. Simultaneous application of sodium humate and complete mineral NPK nutrition increased vitamin C content in fruits by 27.9% compared to treatment 1 (unfertilized control).

Table 5. Average yield of pepper fruits (t/ha) in the years 1995–1997

Fertilization treatments	Yield (t/ha)				Relation (%)	
	1995	1996	1997	3-year average	1 = 100	3 = 100
1	15.708	13.917	10.916	13.513 Aa	100.0	–
2	22.667	19.833	19.416	20.638 Bb	152.7	–
3	28.792	24.792	28.000	27.194 Cc	201.2	100.0
4	31.208	26.708	35.541	31.152 Cd	230.5	114.5

Averages indicated by different letters are statistically significantly different on the significance level of $P = 0.05$ (capital letters) and $P = 0.01$ (small letters)

Table 6. Content of nitrates in pepper fruits (average of the years 1995–1997)

Fertilization treatments	Content of $NaNO_3$ (mg/kg) (fresh mass)				Relation (%)	
	1995	1996	1997	3-year average	1 = 100	3 = 100
1	122.7	85.0	85.3	97.6	100.0	–
2	139.6	93.1	99.6	110.7	113.4	–
3	153.4	103.2	102.6	119.7	122.6	100.0
4	129.6	93.1	93.5	105.4	107.9	88.0

Table. 7. Average content of vitamin C in pepper fruits in the years 1995–1997

Fertilization treatments	Content of vitamin C (mg/100 g) (fresh mass)				Relation (%)	
	1995	1996	1997	3-year average	1 = 100	3 = 100
1	65.9	47.8	53.7	55.8	100.0	–
2	56.3	52.4	64.2	57.6	103.2	–
3	60.6	47.8	58.2	55.5	99.5	100.0
4	84.6	59.8	69.8	71.4	127.9	128.6

An even larger difference was observed if simultaneous application of sodium humate plus full NPK nutrition was compared with solo full NPK nutrition (treatment 3). In this case the level of vitamin C in pepper rose by 28.6% in favour of treatment 4, amounting to the value of 15.9 mg/100 g.

It can be concluded on the basis of the achieved results that the application of sodium humate increases the nutrient uptake of plants and leads to an increase in the content of proteins and other substances in the plants. On the other hand, it helps to reduce the content of nitrates in plant tissues. In addition, the plants are more resistant to unfavourable environmental conditions.

The addition of sodium humate participates in higher nutrient uptake from the soil, improving the utilization of nutrients taken up by plants. The increase in nitrate content in fruits at the additional fertilizing with DAM (fertilizer) can be explained by the fact that the plants do not utilize nitrogen uptake for amino acid and protein formation. A marked decline of nitrates occurs at the stage of ripening. Our data on nitrates in pepper fruits fully confirm the results of PRUGAR et al. (1986), who stated that pepper does not belong to the crops with high capability for nitrate accumulation.

Green pepper belongs to the crops with a high content of vitamin C (900–4,000 mg/kg). According to PRUGAR and PRUGAROVÁ (1985) this vitamin and fibre create a precondition of certain compensation against the increased nitrate content in vegetables.

A stimulating effect of simultaneous sodium humate and NPK application on the yield of vegetable species was confirmed by LOŽEK et al. (1998), who in experiments with tomatoes (cultivar Sláva Porýnia) discovered a statistically significant increase in fruit yield and a marked decline of nitrate content and increase in vitamin C content in tomato fruits. ČERNÁ et al. (1994) reported that the simultaneous sodium humate and DAM application exhibited significantly positive effects on the yield and quality of green pepper (cultivar PCR) in a pot trial conducted in a plastic house.

References

ČERNÁ K., KUBINEC S., PAKANOVÁ J., 1994. Vplyv humátu sodného na úrodu a kvalitu rýchlenej zeleniny. Ved. Práce Výskumného a šľachtiteľského ústavu zeleniny a špeciálnych plodín Hurbanovo, 8: 52.

KRUGOV V., MAYKOVA A., 1988. Peat – based growth promoters and their use in crop and livestock production. In: Proc.VIII. Int. Pet. Cong., Leningrad: 40.

LOŽEK O., FECENKO J., MAZUR B., MAZUR K., 1997. The effect of foliar application of humate on wheat grain yield and quality. Rostl. Výr., *43*: 37–41.

LOŽEK O., GRÁCOVÁ A., KOVÁČIK P., 1998. Utilization of stimulating effect of sodium humate in tomatoes growing. Acta Hort. et Regiotecturae, *1*: 219–220.

PRUGAR J. et al., 1986. Agroekologické faktory ve vztahu k hromadění dusičnanů v zelenině a bramborách. Rostl. Výr., *38*: 9–10, 875–881.

PRUGAR J., PRUGAROVÁ A., 1985. Dusičnany v zelenine. Bratislava, Príroda: 150.

VERMEER A.W.P., RJEMSDIJK W.K., KOOPAL L.K., 1998. Interactions between humic acid and mineral particles. Langmuir, *14*: 2810–2819.

VRBA V., 1987. Vliv humusového koncentrátu na růst rostlin v počátečním období vegetace. Rostl. Výr., *33*: 1197–1206.

Received for publication March 10, 2003

Accepted after corrections July 9, 2003

Vplyv humátu sodného na úrodu a kvalitu zeleninovej papriky

ABSTRAKT: V skleníkových podmienkach sa formou trojročného maloparcelového pokusu na zemine z humusového horizontu hlinitej černozeme sledovala účinnosť humátu sodného na tvorbu úrody, obsah dusičnanov a obsah vitamínu C v plodoch zeleninovej papriky. Aplikáciou 5 kg humátu sodného na hektár formou zálievky 3 týždne po výsadbe priesad papriky pri plnej

NPK výžive (dusíkatá výživa bola delená: 2/3 dávky N pred výsadbou a 1/3 dávky N spolu s humátom sodným 3 týždne po výsadbe priesad) spôsobila štatisticky významné zvýšenie úrody papriky o 13,6 % pri súčasnom signifikantnom znížení obsahu dusičnanov v plodoch papriky o 12 % a zvýšení obsahu vitamínu C o 28,6 %.

Kľúčové slová: humát sodný; zeleninová paprika; vitamín C; výživa

Corresponding author:

Ing. LADISLAV VARGA, Ph.D., Slovenská poľnohospodárska univerzita, Fakulta agrobiológie a potravinových zdrojov, Katedra agrochémie a výživy rastlín, Tr. A. Hlinku 2, 976 01 Nitra, Slovenská republika
tel.: + 421 376 508 380, fax: + 421 376 508 387, e-mail: ladislav.ducsay@uniag.sk