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A STUDY OF N-ALLYL-N'-2-PYRIDYLTHIOUREA AND g-IRRADIATION TREATMENT ON GROWTH, YIELD AND QUALITY OF PEAS AND WHEAT

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Summary. The effect of N-allyl -N´-2-pyridyl-thiourea and γ-irradiation on growth, yield and quality of peas and wheat have been studied. The γ-irradiation of peas with 10000 R led to an increase in yield of green mass and grain of peas and treatment with 15000 R led to a decrease of yield. These changes also correlate with the protein content in the green mass and in the grain.

Such an effect was also observed in wheat cv. Sadovo-1 which is very resistant to γ-irradiation and a following treatment with a growth regulator led to an increase in grain yield and in protein content (rich in essential amino acids).

Key words: N-allyl-N´-2-pyridylthiourea, γ-irradiation, growth, yield

Introduction

It is well-known that *o*-allyltioureidobenzoic acid displays a radioprotective action in γ-irradiated pea plants and in γ-irradiated wheat leaves (Mashev et al., 1975, 1979; Vassilev et al., 1976). On the other hand the independent role of allylthiourea derivatives as cytokinin agents (Vassilev and Mashev, 1973; Vassilev and Mashev, 1974) and the stimulating effect of low doses of γ-rays on seeds are also known.

The study on N-allyl-N´-2-pyridylthiourea as a radio-protective cytokinin substance following irradiation with higher γ-ray doses of leguminous and wheat seeds

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is also of interest for the purpose of discovering means of regulating the growth, yield and quality of protein in these crops.

Material and Method

A cultivar of fodder peas and 5 cultivars of durum and soft wheat (Apiculum, Rakita, Tito, Sadovo - 1 and Slavianka) have been used. The seeds were irradiated with γ-rays at doses of 10000 to 15000 R and the plants were treated at the stage of budding of the leguminous plants and at the stage of spike-formation of wheat with a water solution of N-allyl-N´-2-pyridylthiourea at a concentration of 0.1 to 1.0 g/l in an amount of 400 to 1000 l per hectare.

The experiments lasted three years (1991–1993) and had four replications with size of the experimental plot 4 m^2. Untreated and unirradiated plants were used as controls. The irradiated plants and the ones that were also chemically treated were compared with the controls. At the time of vegetation the following criteria were registered in the leguminous plants: number of pods, number of seeds per pod, weight of seeds per pod, absolute weight of 1000 seeds in grams.

After harvesting, the yield of seeds from each variant was recorded and calculated and for the green mass variants, yield of green mass was measured.

The chemical composition of the seeds and the green mass was determined – total nitrogen, total protein, phosphorus, potassium, mineral residue, extract substances, cellulose and extract substances devoid of nitrogen (ESDn).

During wheat vegetation in the mentioned years have also been recorded: plant height in cm, number of fertile suckers, length of central spike in cm, number of seeds in the central spike, weight of the seeds in the central spike in grams, absolute weight of 1000 seeds in grams.

After harvesting the grain yield of a particular variant was recorded and calculated in kg/hectare. The chemical composition – protein, starch and total aminoacids of the grain was determined.

Results and Discussion

Seed irradiation before sowing with 5000 and 10000 R led to an increase of the pea green mass yield and the treatment with 15000 R led to a decrease in yield. Plant treatment with N-allyl-N´-2-pyridylthiourea reduced to some extent the harmful effect of γ-rays and led to an augmentation of pea green mass yield.

The grain yield from peas was greatly reduced only at high doses of irradiation – 15000 R, while at doses from 2500 to 5000R the yield was increased. A tendency for reduction of the γ-ray harmful effect on the seed yield was also observed (Table 1).

Table 1. Peas – yield of green mass and grain

Variance		Dose of irradiation (R)				Control
		2500	5000	10000	15000	
Green	1	42660	65060	66660	27330	61000
mass	2	56260	70000	40000	26660	
(kg/ha)	3	57330	62530	48530	—	
		2000	4000	8000	10000	
	1	7660	7400	6660	5860	7150
Grain	2	7260	7800	5600	5800	
(kg/ha)	3	7200	7800	5600	4400	

1 – control; 2 and 3 – experimental repetitions

Table 2. Chemical analysis of peas' grains

Index		Dose of irradiation (R)					Control
		2000	4000	6000	8000	10000	
Crude	1	19.56	19.69	18.63	19.38	20.06	20.19
protein	2	20.25	19.38	19.38	20.13	20.25	
(%)	3	19.38	19.00	18.81	19.91	20.44	
P_2O_5	1	0.64	0.73	0.66	0.61	0.66	0.63
(%)	2	0.65	0.71	0.72	0.60	0.64	
	3	0.65	0.69	0.70	0.65	0.56	
K_2O	1	1.26	1.28	1.28	1.25	1.25	0.99
(%)	2	1.39	1.28	1.29	1.30	1.11	
	3	1.24	1.26	1.24	1.15	0.97	
Mine-	1	2.52	3.17	2.69	2.61	2.90	2.90
rals	2	2.82	3.11	3.08	3.18	2.64	
(%)	3	2.78	2.82	2.92	3.07	2.47	
ESDn	1	77.92	77.14	78.68	78.01	77.04	76.91
	2	76.93	77.51	77.55	76.69	77.11	
	3	77.84	78.18	78.27	77.74	77.09	

1, 2 and 3 – experimental repetitions; ESDn – extract substances devoid of nitrogen

The results from the phenological observations showed that γ-irradiation and combined treatment with the growth regulator influenced plant growth in cm and the number of pods of some plants.

These changes were related to the quality of the grain and of the green mass and particularly to their protein content (Tables 2 and 3). The change of protein quantity in green mass was more significant than the one observed in its grain. γ-irradiation and the combined treatment of the plants had a positive effect on the protein content when seeds were irradiated prior to sowing with doses of 2000 to 8000 R. From our five-year-long observations of wheat, the effect of irradiation up to 15000 R was insignificant as far as tillering was concerned. The individual deviations, increase of sucker number or their decrease as compared to the controls in all five cultivars were not confirmed in the various years of investigation.

Table 3. Chemical analysis of peas' green mass

Index		Dose of irradiation (R)					Control
		2000	4000	6000	8000	10000	
Crude protein (%)	1	18.00	18.94	16.88	20.00	16.55	15.56
	2	18.00	18.63	18.94	18.63	17.13	
	3	18.00	19.00	18.25	18.00	20.00	
P_2O_5 (%)	1	0.59	0.63	0.56	0.61	0.58	0.46
	2	0.62	0.67	0.65	0.63	0.58	
	3	0.64	0.66	0.63	0.61	0.60	
K_2O (%)	1	1.66	1.98	1.82	1.84	2.04	2.00
	2	1.70	1.99	2.03	1.92	1.76	
	3	1.73	1.82	2.00	1.75	2.11	
Minerals (%)	1	8.05	8.12	8.17	9.47	11.36	11.87
	2	8.05	7.55	8.43	8.12	8.41	
	3	7.80	8.09	7.89	7.86	8.50	
Fats (%)	1	2.97	3.43	2.30	3.03	2.86	3.34
	2	2.78	3.05	2.56	3.31	2.96	
	3	2.96	2.86	3.25	3.04	3.03	
Cellulose (%)	1	18.34	18.37	18.85	19.81	20.82	18.28
	2	20.63	18.12	19.44	19.69	18.20	
	3	19.45	19.13	20.18	18.46	20.74	
ESDn	1	52.64	51.14	53.80	47.69	48.40	50.95
	2	52.49	52.65	50.63	50.25	53.30	
	3	51.79	50.92	50.43	52.64	47.72	

1, 2 and 3 – experimental repetitions; ESDn – extract substances devoid of nitrogen

The treatment of the plants with both growth regulators did not influence the process.

Height of plants (Table 4) was influenced by the irradiation dose and by the growth regulators depending on cultivar and dose of irradiation. The softer the wheats were the more sensitive comparison to the durum ones in which a slight elongation of the stalk was observed at doses up to 5000 R. In durum wheats this effect was revealed at lower doses – 1000 to 2500 R.

Table 4. Height of wheat plants (cm)

Cultivars		Dose of irradiation (R)					Control
		1000	2500	5000	10000	15000	
Apulikum	1	127.3	130.5	128.5	110.4	83.1	125.0
	2	127.0	127.6	123.9	115.4	80.7	
	3	124.4	127.1	125.7	113.3	69.3	
Rakita	1	78.6	82.0	81.2	63.5	–	80.0
	2	77.1	80.1	81.8	64.7	–	
	3	79.8	79.5	78.7	64.5	–	
Tito	1	86.0	90.0	76.3	41.1	–	71.5
	2	85.8	87.0	77.1	42.9	–	
	3	90.3	86.3	79.9	38.8	–	
Sadovo-1	1	92.7	92.8	92.6	79.4	–	91.0
	2	92.1	90.6	89.0	76.5	–	
	3	94.1	89.9	93.8	77.1	–	
Slavianka	1	91.8	86.5	89.0	45.0	–	90.2
	2	95.9	94.7	88.2	44.3	–	
	3	94.3	90.2	88.8	45.0	–	

1, 2 and 3 – experimental repetitions

Grain yield was greatly affected both under the influence of irradiation dose and by the growth regulator. Out of the cultivars under study the one with the best pronounced tendency for increase of grain yield was established in cv. Sadovo-1 soft wheats and in cv. Tito of the durum ones. Besides that cv. Sadovo-1 proved highly resistant to γ-iradiation and the yield decrease at the high doses (10000 to 15000 R) was lowest. Reversely, in 1991 and 1993 a 5 to 20 percent of yield increase was observed at irradiation doses of 5000 to 10000 R. Cv. Tito was the most sensitive one in which the yield dropped down by 70 percent when compared to the control at an irradiation with 15000 R (Table 5).

Table 5. Yield of seed from wheat (kg/ha)

Cultivars		Dose of irradiation (R) 1000	2500	5000	10000	15000	Control
Apulikum	1	4580	5080	4830	3290	–	5000
	2	4920	4200	4790	2960	–	
	3	4965	5210	6380	2670	–	
Rakita	1	4125	3500	3830	541	–	4500
	2	3666	4500	3333	583	–	
	3	4166	3916	3458	1083	–	
Tito	1	6000	5541	4833	208	–	5700
	2	5458	5375	4625	333	–	
	3	5541	5125	3291	166	–	
Sadovo-1	1	6833	6541	6333	3833	–	6000
	2	6875	6542	6083	3541	–	
	3	6165	6375	6250	3333	–	
Slavianka	1	6416	6417	6125	4125	958	6500
	2	6166	6166	6125	3625	833	
	3	6250	5416	6208	4750	1125	

The protein content in the studied cultivars of wheat varied from 13 to 18 percent (Table 6). Soft wheat cultivars increased the protein content more intensively than the durum ones depending on γ-irradiation. Even though, the protein content was increased by 2 to 3 percent in comparison with the non-irradiated controls at 15000 R. Spraying with a solution of N-allyl-N´-2-pyridylthiourea exerted a positive influence on the protein in cvs. Apiculum and Rakita at irradiation doses of 2500–5000 R and 10000 R. The higher protein content in the grain following irradiation and treatment at 10000 R had also an impact on the content of essential amino acids (Table 7).

The results showed that γ-irradiation combined with treatment of the plants can be successfully applied in the production of plants for selection purposes at even higher doses of irradiation – 10000 to 15000 R.

It was established that cv. Sadovo-1 is distinguished by high resistance to γ-rays so that application of γ-irradiation and treatment with the growth regulator can be used as a practical means for increasing grain yields and protein content rich in essential amino acids.

Our studies on the radio-protective activity of some new thiourea derivatives as well as of urea will be continued so that new, highly active radio-protective agents could be found.

Table 6. Total protein in wheat plants (%N×6.25)

Cultivars		Dose of irradiation (R)				Control
		2500	5000	10000	15000	
Apulikum	1	16.75	15.93	15.50	16.21	15.12
	2	17.56	16.31	15.50	15.50	
	3	15.56	15.50	15.87	16.68	
Rakita	1	16.31	19.06	20.00	19.18	17.31
	2	19.06	18.87	18.75	19.75	
	3	18.43	18.68	19.31	19.18	
Tito	1	15.26	17.93	19.37	22.68	17.93
	2	15.93	16.00	19.75	22.06	
	3	17.12	17.81	21.81	21.81	
Sadavo-1	1	15.75	15.62	16.00	15.62	13.31
	2	15.75	15.87	17.12	16.81	
	3	14.77	15.82	16.62	16.90	
Slavianka	1	18.37	16.25	17.25	18.50	16.75
	2	16.62	17.62	18.81	18.81	
	3	18.37	17.25	19.06	20.37	

1, 2 and 3 – experimental repetitions

Table 7. Content of essential amino acids in the grain of the wheat cv. Sadovo-1

Amino acids	Standard		5000 R		10000 R		15000 R	
	untreated	treated	untreated	treated	untreated	treated	untreated	treated
Lysine	0.27	0.26	0.23	0.26	0.30	0.31	–	0.37
Arginine	0.45	0.33	0.37	0.35	0.45	0.46	–	0.47
Treonine	0.30	0.27	0.21	0.27	0.31	0.27	–	0.31
Cystine	–	–	–	–	–	–	–	–
Valine	0.28	0.33	0.30	0.27	0.39	0.44	–	0.45
Methionine	0.12	0.12	0.11	0.11	0.15	0.16	–	0.16
Isoleucine	0.24	0.26	0.26	0.27	0.35	0.25	–	0.38
Leucine	0.64	0.61	0.55	0.62	0.77	0.78	–	0.85
Phenylalanine	0.45	0.41	0.38	0.43	0.51	0.53	–	0.55
Total protein (%N x 6.25)	15.73	16.48	16.33	15.82	20.84	22.09	–	–

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References

Mashev, N. P., M. Giacomelli, D. Dekov, 1975. Studies on the effect of cytokinins in some biochemical processes of γ-irradiated plants. Plant Physiol., 1 (4),12–20 (In Bulg.).

Mashev, N. P., G. N. Vassilev, 1978. Radioprotective agent for dicotyledonous plants. Bulg. Pat. No. 26 560.

Mashev, N. P., G. N. Vassilev, E. Mihalska, 1979. Radioprotective action of allylthioureidobenzoic acid and its influence on the level of the phytohormones in *Pisum sativum* L. Compt. rend. Acad. bulg. Sci., 32 (6), 813–816.

Vassilev, G. N., N. P. Mashev, 1973. Chemical structure and cytokinin activity of some new derivatives of N-allyl-N´- aryl-thiourea and their effect on the incorporation of amino acids in plant seedlings. Compt. rend. Acad. bulg. Sci., 26 (3), 391–394.

Vassilev, G. N., N. P. Mashev, 1974. Chemical structure and cytokinin activity of some new derivatives of N-allyl-N'- aryl-thiourea and their effect on the uptake of amino acids. In : Plant Physiology, Sofia, 3, 333–347.

Vassilev, G. N., P. A. Yonova, Y. P. Yonov, 1976. Herbicidal agent. Bulg. Pat. No. 23443.