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THE EFFECT OF NITROGEN FERTILIZATION ON VIRUS INFECTION OF FIVE POTATO VARIETIES REPRODUCED IN ZONES OF DIFFERENT INFECTION PRESSURE

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In the literature it is usually assumed that whereas nitrogen fertilization increases the potato crop, the seed potatoes produced may be stronger virus-infected. Some authors indicate that the doses of nitrogen may be increased if more resistant varieties are cultivated in zones of low hazard of virus diseases [2, 6, 7]. In Poland it is recommended to limit nitrogen doses in cultivation of seed potatoes to 60 kg N/ha in the III and IV infection pressure zone, and to 90 kg N/ha in the remaining zones. According to Songin [8], under conditions of the III zone of infection pressure up to 100 kg N/ha can be applied for seed potato crops. In other publications giving no consideration to virus hazard it is recommended to use very big nitrogen doses, up to 140 kg N/ha [1].

The present studies were aimed at gaining insight into the effect of nitrogen fertilization and of its interaction with infection pressure zones, potato varieties and seed treatments - on seed potato infection with PRLV and PVY. An additional objective involved statistical evaluation of the importance of the investigated factors, as well as of their substitution.

MATERIAL AND METHOD

In years 1981-1984, two experimental series were carried out according to a similar scheme, consideration being given to zones of infection pressure (6 localities in 3 zones), potato varieties (5),

seed treatments (2) and nitrogen doses (3). Potato varieties selected from the angle of resistance to PLRV and PVY were cultivated during 2 years. Each series comprised a preliminary experiment (A) with application of various seed treatments and of different nitrogen fertilization levels, as well as a comparative experiment (B) for the determination of virus infection of plants. In experiments A, in autumn in all localities identical fertilization with manure, phosphorus and potassium was used, and only nitrogen fertilization was differentiated. Nitrogen (in the form of urea) was sown in spring, prior to planting, in doses of: 50, 100 and 150 kg/ha. The élite seed material of five varieties was reproduced during 2 years by the imposition method, with the use of the following treatments: a - - five-fold negative selection, as well as b - germination of tuber sprouts, fivefold negative selection, fourfold aphid control and defoliation with Reglone. Aphid control was performed in the first series with Bi 58 EC (dimethoat) and in the second one with Filitox - - methamidophos (owing to low effectiveness of the former). In comparative experiments B set up in Bonin, use was made of tuber sprouts derived from experiments A performed in six localities. In experiments B, fertilization with manure, phosphorus, potassium and nitrogen was identical, and no seed treatments were applied. Studies were performed in 2 series: experiments A - first series in 1981--1982, second series in 1982/83; experiments B - first series in 1983, second series in 1984.

In the experiments, selection of factors and of their levels was aimed at obtainment of great differentiation of virus infection. Therefore, the combinations of so selected the factors also contain extreme positions and reflect the conditions occurring in potato seed production.

METHOD FOR ANALYSIS OF THE RESULTS

Consistently with the described procedure for obtainment of percentile data, the following mathematical model (linear hypothesis) was applied:

$$Y_{ijklmn} = m + g_i + a_j + e_{ij} + e_l + b_k + ac_{jl} + ab_{jk} + e_{ijkl} + d_m + f_n + df_{mn} + ad_{jm} + af_{jn} + adf_{jmn} + dc_{ml} + db_{mk} + fc_{nl} + fb_{nk} + dfb_{mnk} + dac_{mjl} + dab_{mjk} + fac_{njl} + fab_{njk} + dfac_{mnjl} + dfab_{mnjk} + e_{ijklmn}$$

where:

m - mean for the population,

g_i - effect of experimental series,

a_j - effect of j-th potato variety,

c_l - effect of l-th infection pressure zone,

b_k - effect of k-th locality in l-th zone,

d_m - effect of m-th treatment,

f_n - effect of n-th level of nitrogen fertilization,

e_{ij}, e_{ijkl}, e_{ijklmn} - effects of interactions with experimental series.

The remaining components of the model represent the respective effects of interactions. In the above model, randomness, was assumed for the effect of experimental series (g_i), effects of interaction with series (e_{ij}, e_{ijkl}, e_{ijklmn}) and effect of locality in zone (b_k); the remaining components were assumed to be constant effects.

Consistently with the mathematical model, appropriate analyses of variance were performed, using the scheme of combination of cross classification with hierarchy classification (localities in zones). The obtained empirical values of mean squares were compared with the expected values. Solving of the resulting system of squations enabled evaluation of variance components; the interrelations of the evaluations of components and their percentile structure were the basis for determination of the sequence of the effect of the investigated factors on virus infection.

RESULTS

On account of extensive evidence, the paper in the first place presents discussion of the mean effects of the investigated factors and some of their interactions. In addition, for illustration of the level of PLRV and PVY infection after application of seed treatments and nitrogen fertilization of the potato varieties in different infection pressure zones, the highest interaction order is presented.

Potato plant infection with PLRV exceeded that with PVY (Table 1). The ratio of PLRV to PVY infection amounted in the 1st and 2nd experimental series to 20.8 : 1.0 and 4.6 : 1.0, respectively. It

seems that narrowing of this proportion in the 2nd series, as compared with the 1st one, was due to lower PLRV hazard in 1983 than in the earlier years.

Table 1

Seed potato infection with viruses in experimental series after differentiated nitrogen fertilization

Nitrogen dose kg/ha	Percentage of infection in experimental series					
	PLRV			PVY		
	1st	2nd	mean	1st	2nd	mean
50	16.0^{a}	2.6^{a}	7.7^{a}	0.8^{a}	1.2^{a}	1.0^{a}
100	22.0^{b}	4.3^{ab}	10.1^{b}	1.0^{ab}	1.4^{ab}	1.2^{ab}
150	24.9^{b}	6.3^{b}	13.2^{c}	1.2^{b}	1.9^{b}	1.5^{b}
Mean	20.8	4.6	10.1	1.0	1.5	1.2

Numbers denoted by the same letter (for the same virus and series) do not differ significantly at confidence level $\alpha = 0.05$.

1, 2 - Experimental series.

Nitrogen fertilization caused, on the average, a 1.7-fold increase in plant infection with PLRV (this increase fluctuating from a 1.6-fold to a 2.4-fold one, in dependence on the series), as well as a 1.5-fold increase in PVY infection irrespective of the series (Table 1).

Tuber sprouts treatments exerted different effects on virus infection (Table 2). Treatment combination „B", as compared with combination „A", resulted, on the average, in a 2.6-fold decrease in plant infection with PLRV, with fluctuations from a 1.8-fold (1st series) to a 3.5-fold decrease (2nd series), as well as in a 1.5-fold decrease in PVY infection, with fluctuations from a 1.6-fold (1st series) to a 1.3-fold decrease (2nd series). Upon use of treatment combination „B" in the 2nd series, plant infection with viruses was lower, owing to - among others - application of Filitox instead of Bi-58 EC.

Table 2

Virus infection in experimental series after application of seed treatments

Seed treatment	Percentage of infection in experimental series					
	PLRV			PVY		
	1st	2nd	mean	1st	2nd	mean
A	27.6[a]	8.5[a]	16.0[a]	1.3[a]	1.7[a]	1.5[a]
B	15:1[b]	2.4[b]	6.2[b]	0.8[b]	1.3[a]	1.0[b]
A:B	1.8	3.5	2.6	1.6	1.3	1.5

A - Negative selection.

B - Seed potato germination, negative selection, aphid control and early defoliation with Reglone.

Explanations see Table 1.

After 2-year reproduction of elite material, the varieties differed in the virus infection degree. The infection percentage was highest for PLRV in varieties Ina and Janka, and for PVY in varieties Certa and Janka (Table 3). There was good agreement between infection of varieties and evaluation of their resistance to PLRV and PVY.

Table 3

PLRV and PVY infection of varieties after 2-year reproduction

Virus	Infection of varieties with viruses				
	Ina	Janka	Ronda	Pola	Certa
PLRV	53.5[a]	18.0[b]	11.0[bc]	7.5[c]	0.7[d]
PVY	0.9[b]	3.1[a]	0.7[b]	0.2[c]	6.2[a]

Resistance of varieties (on a 9^{o} - scale):
PLRV - Ina 3, Janka 4, Ronda 5, Pola 5 and Certa 7,
PVY - Ina 7, Janka 5, Ronda 6, Pola 8 and Certa 5.

Explanations see Table 1.

Seed potatoes reproduced in the infection pressure zone, as compared with the I zone, were 32.1 and 6.5 times stronger infected with PLRV and PVY, respectively (Table 4).

Table 4

Virus infection of seed potatoes in dependence on reproduction site

Infection pressure zone	Percentage of infection	
I	1.6[a]	0.4[a]
III	7.6[b]	1.7[b]
IV	51.4[c]	2.6[c]

Explanations see Table 1.

It is stressed that the effect of nitrogen fertilization on infection with PLRV and PVY depended on the infection pressure zone, resistance of variety and seed treatments (Tabs 5, 6 and 7).

Table 5

The effect of infection pressure zones and nitrogen dose on virus infection of potatoes

Nitrogen dose kg/ha	Percentage of virus infection in infection pressure zones					
	PLRV			PVY		
	I	III	IV	I	III	IV
50	1.4[a]	5.2[a]	43.3[a]	0.4[a]	1.2[a]	2.1[a]
100	1.4[a]	8.0[b]	52.7[ab]	0.3[a]	1.8[ab]	2.7[a]
150	2.0[a]	10.6[b]	57.9[b]	0.5[b]	2.1[b]	3.0[a]

Explanations see Table 1.

Table 6

Infection of varieties with PLRV
after application of nitrogen fertilization

Nitrogen dose kg/ha	Percentage of PLRV infection of varieties after application of nitrogen fertilization				
	Ina	Janka	Ronda	Pola	Certa
50	43.8^{a}	10.1^{a}	9.9^{a}	5.4^{a}	0.7^{a}
100	54.1^{ab}	23.0^{b}	8.7^{a}	8.3^{a}	0.6^{a}
150	62.5^{b}	24.0^{b}	14.6^{a}	9.1^{a}	0.8^{a}

Explanations see Table 1.

Resistance of varieties to PLRV is presented in Table 3.

The increase in infection upon a rise of nitrogen dose was greatest in zones of higher infection pressure and in susceptible varieties, as compared with the I zone and resistant varieties (Tables 5 and 6). After application of treatment combination „B", a rise of nitrogen dose did not lead to an increase in PLRV infection (Table 7).

Table 7

The effect of seed treatments and nitrogen doses
on virus infection of potatoes

Nitrogen dose kg/ha	Percentage of infection after application of seed treatments			
	PLRV		PVY	
	A	B	A	B
50	11.5^{a}	5.2^{c}	1.3^{ac}	0.7^{b}
100	14.5^{b}	5.9^{c}	1.3^{ac}	1.0^{c}
150	20.5^{b}	8.0^{c}	1.8^{a}	1.3^{c}

Explanations see Table 1 and 2.

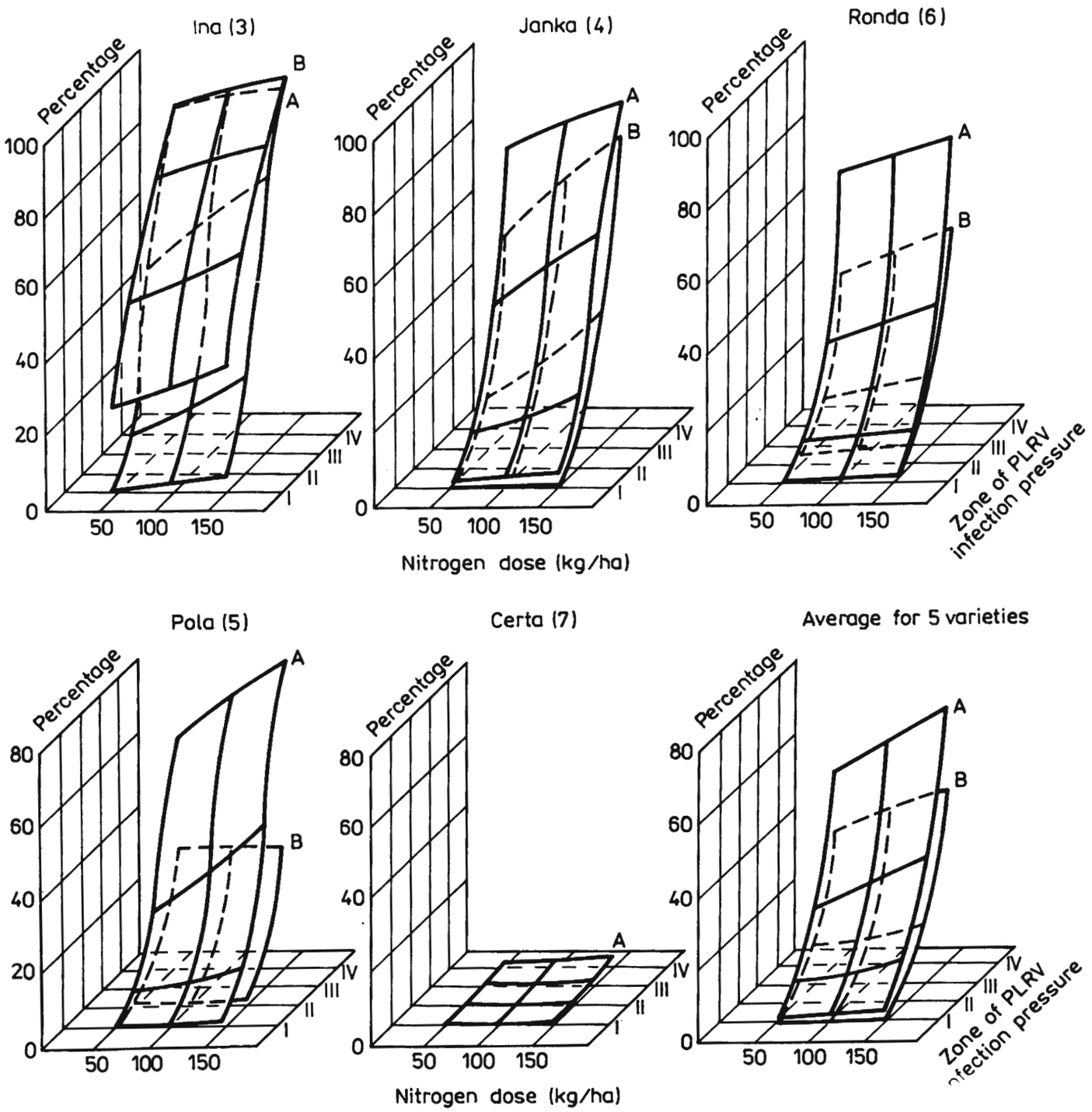

Fig. 1. Potato infection with PLRV after 2-year reproduction of élite of five varieties in infection pressure zones, upon use of seed treatments and nitrogen fertilization. Data for years 1983–1984.

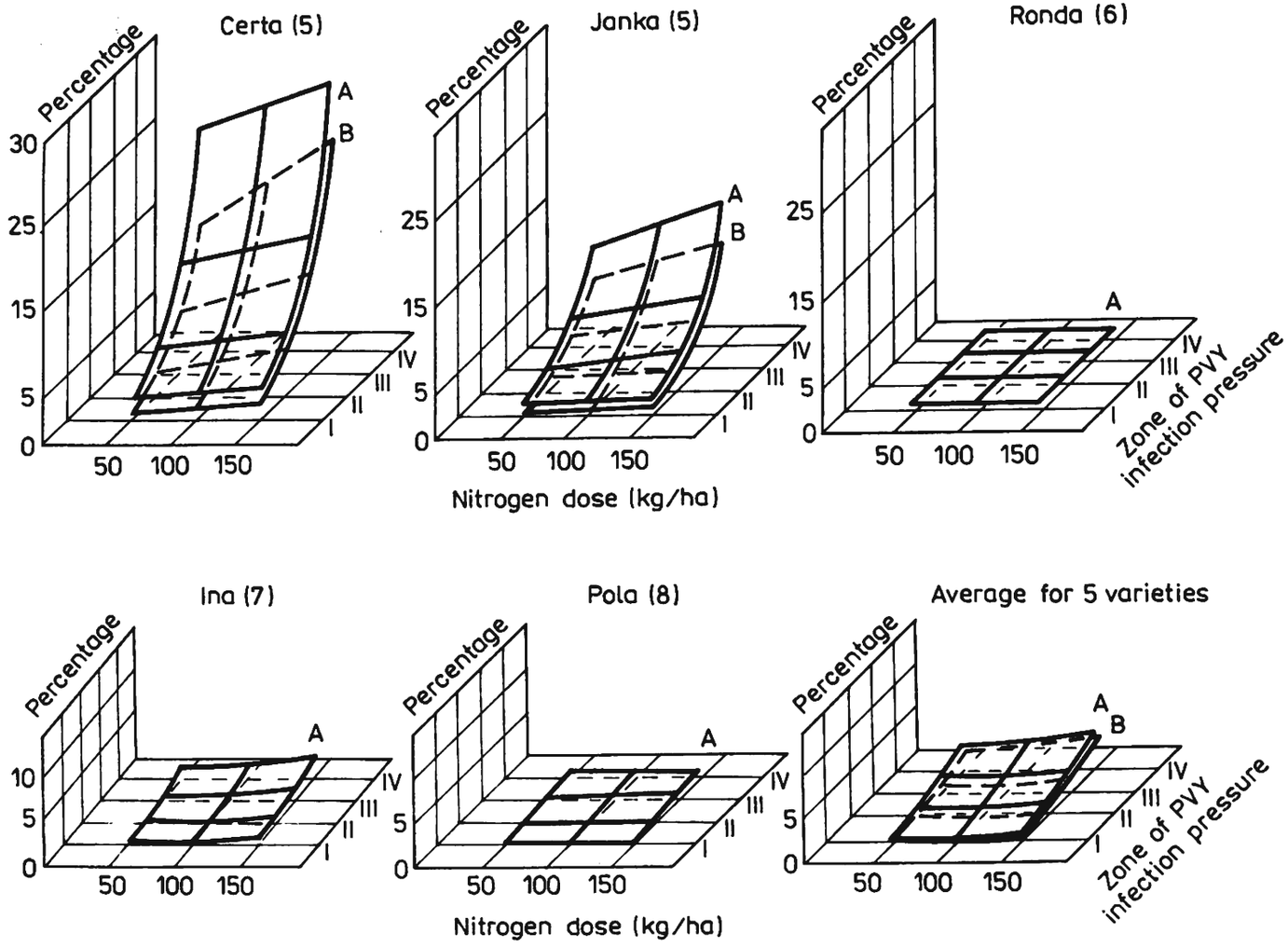

Fig. 2. Potato infection with PVY after 2-year reproduction of élite of five varieties in infection pressure zones, upon use of seed treatments and nitrogen fertilization. Data for years 1983-1984.

On the other hand, in case of reproduction with negative selection only (combination a), PLRV infection was significantly stronger for experimental plots fertilized with a dose of 150 kg N/ha, as compared with 50 kg N/ha. In case of PVY, these relationships were opposite.

In view of the strong effect of the investigated factors on potato infection with PLRV and PVY, for illustration of the relationships regression equations were used to determine the most probable percentages of infection for varieties, treatment combinations, infection pressure zones and nitrogen doses (Figs 1 and 2). The increase in PLRV and PVY infection in dependence on the infection pressure zone and nitrogen dose was bigger in a susceptible variety and upon use of negative selection only (treatment combination a), as compared with a resistant variety and after application of combination b. In case of the Ina variety, only combination b afforded slightly PLRV-infected seed potatoes in the I zone irrespective of the nitrogen dose and in the II zone at low nitrogen fertilization (Fig. 1); in the remaining zones, irrespective of the nitrogen dose and treatment combination, PLRV infection of this variety was very strong. Infection of the varieties resistant to PVY (Pola, Ina and Ronda) and resistant to PLRV (Certa) in the infection pressure zones was slight. Therefore, in case of reproduction of resistant varieties in the infection pressure zones, the kind of treatment combination and nitrogen dose were of no consequence.

For the determination of the importance of the investgated factors for an increase in potato infection with PLRV and PVY, the method of variance components was used (Table 8). There were differences between PLRV and PVY in the importance of factors. In case of PLRV, potato infection was most influenced by infection pressure zones and varieties, and somewhat less - by localities in zones, interaction of varieties with zones and treatment combinations; nitrogen fertilization and interactions of nitrogen doses with the investigated factors influenced PLRV infection in only 1.1%. On the other hand, with respect to PVY, potato infection was most influenced by resistance of variety, and less - by infection pressure zones and localities in zones; treatment combinations influenced only 1.7% of infections, and nitrogen fertilization - 0.8% of infections. In case of PVY, the effect of interactions of nitrogen fertilization with the investigated factors was less pronounced than that of treatment combinations.

Table 8

The effect of factors on virus infection of seed potatoes, determined by the method of variance components

Source of variation	Level of factors	Percentile of total variation	
		PLRV	PVY
Varieties	5	23.8	36.6
Infection pressure zones	3	27.7	14.2
Localities in zones	2	8.4	11.2
Interaction of variety x zone		7.3	0.0
Interactions of variety x x locality in zones		0.0	0.4
Seed treatments	2	3.9	1.7
Nitrogen doses	3	0.5	0.8
Sum of interactions with fertilization		0.6	1.5
Remaining interactions		3.7	2.2
Experimental series	2	10.1	1.1
Interactions with series		14.0	30.3

DISCUSSION

The presented preliminary results of a model experiment are a fragment of studies on the effect of nitrogen fertilization on seed value of seed potatoes under conditions prevailing in Poland. They confirm the validity of regionalization of seed potato production in infection pressure zones in dependence of resistance of the variety to PLRV and PVY [3, 4]; they also confirm some findings concerning the effect of nitrogen fertilization on health of seed potatoes [2, 6, 7]. Moreover, it is shown that nitrogen fertilization using higher doses does not deteriorate health of seed potatoes in case of cultivation of resistant varieties. The present results indicate that -- from the standpoint of production of healthy seed potatoes - the effect of nitrogen fertilization is less strong than that of infec-

tion pressure zones, varieties, localities in zones, interactions of varieties with zones and localities, as well as of treatment combinations. When consideration is given to these factors in the seed potato production practice, it is possible to maximize seed potato production by more abundant nitrogen fertilization. Attention to the dominant effect of infection pressure zones and variety resistance on health of seed potatoes has been called to by Gabriel et al. [3-5], Styszko and Trętowski [9] and Styszko [10].

As a novelty in the literature, in the present studies the random and systematic effects of infection pressure zones are distinguished. In the investigations of Gabriel et al. [5], classification according to regions has been the systematic component of infection pressure zones; the random component, i.e. localities in zones, was not set apart. Namely, the random component of these zones is related to differentiated soil conditions, weather, fluctuations of the occurrence of virus vector over years and precision of performance of seed treatments at the different Stations. In the present studies the random component of infection pressure zones was distinguished by location of two experimental sites in each zone.

CONCLUSIONS

1. Increased nitrogen fertilization leads on average to stronger infection of potatoes with PLRV and PVY. After application of higher nitrogen doses, infection with these viruses substantially increases in case of strong infection pressure, marked susceptibility of the variety, and lack of protection against spreading on virus infection. In varieties resistant to PLRV and PVY, and in the presence of effective protection against spreading of virus diseases, in all infection pressure zones nitrogen fertilization does not increase seed potato infection.

2. As concerns the intensity of the effect of the investigated factors on virus infection of potatoes, it is different for PLRV and PVY. With respect to PLRV, the factors listed in order of a decreasing effect assume the following sequence: infection pressure zones, varieties, localities in zones, interactions of varieties with zones, treatment combinations and nitrogen fertilization. In case of PVY, this sequence is as follows: varieties, infection pressure zones, localities in zones, treatment combinations, nitrogen fertilization and interactions of varieties with zones or localities.

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L. Styszko

WPŁYW NAWOŻENIA AZOTEM NA PORAŻENIE WIRUSAMI 5 ODMIAN ZIEMNIAKA REPRODUKOWANYCH W STREFACH O RÓŻNEJ PRESJI INFEKCYJNEJ

S t r e s z c z e n i e

Celem pracy było poznanie wpływu nawożenia azotem oraz jego współdziałania ze strefami presji infekcyjnej, odmianami i zabiegami na porażenie sadzeniaków PLRV i PVY. Dodatkowym celem było określenie ważności badanych czynników oraz ich substytucji. Ostatni cel realizowany był przy użyciu metod statystycznych. W badaniach uwzględniono strefy presji infekcyjnej (3), miejscowości w strefach (2), odmiany (5), zestawy zabiegów nasiennych (2) oraz trzy dawki azotu (50, 100 i 150 kg N/ha). Materiał nasienny w elicie rozmnażano przez 2 lata metodą nałożenia z zastosowaniem zabiegów: - tylko selekcja negatywna, - podkiełkowywanie sadzeniaków, selekcja negatywna, zwalczanie mszyc oraz wczesne niszczenie naci preparatem Reglone. Porażenie roślin wirusami określano w trzecim roku w doświadczeniu porównawczym w Boninie, gdzie stosowano jednakowe nawożenie oraz nie wykonywano żadnych zabiegów. Przeprowadzono dwie serie doświadczeń. Uzyskane wyniki wykazały, że zwiększone nawożenie azotem przeciętnie powoduje wzrost porażenia ziemniaków PLRV i PVY. Po zastosowaniu wyższych dawek azotu jest on znaczny w przypadku dużej presji infekcyjnej, dużej podatności odmiany oraz przy braku ochrony przed szerzeniem się infekcji wirusowej. U odmian odpornych na PLRV i PVY oraz przy skutecznej ochronie przed szerzeniem się chorób wirusowych we wszystkich strefach presji infekcyjnej nawożenie azotem nie zwiększa porażenia sadzeniaków. Uszeregowanie wpływu badanych czynników jest różne dla PLRV i PVY. W odniesieniu do PLRV znaczenie czynników w kolejności malejącej jest następujące: strefy presji infekcyjnej, odmiany, miejscowości w strefach, współdziałanie odmian ze strefami, zastosowane zabiegi oraz nawożenie azotem. Natomiast przy PVY analogiczny wpływ w kolejności malejącej jest następujący: odmiany, strefy presji infekcyjnej, miejscowości w strefach, zastosowane zabiegi, nawożenie azotem i współdziałanie odmian ze strefami lub miejscowościami.

Л. Стышко

ВЛИЯНИЕ АЗОТНОГО УДОБРЕНИЯ НА ПОРАЖЕНИЕ ВИРУСАМИ 5 СОРТОВ КАРТОФЕЛЯ РАЗМНОЖАЕМОГО В ЗОНАХ С РАЗНЫМ ИНФЕКЦИОННЫМ ДАВЛЕНИЕМ

Р е з ю м е

Целью работы было изучить влияние удобрения азотом и его взаимодействие с зонами инфекционного давления, сортами и мероприятиями против поражения посадочного материала PLRV и PVY. Дополнительная цель - определить вескость исследуемых факторов и их замену. При реализации последней цели использованы были статистические методы. В исследованиях учитивались зоны инфекционного давления (3), местности в зонах (2), сорта (5), комплекс семенных мероприятий (2) и три дозы азота (50, 100, 150 кг N/га). Семенной материал в элите размножали 2 года методом накладки, применяя мероприятия: „A" - только негативный отбор, „Ъ" - проращивание посадочного материала, негативный отбор, борьба с тлёй а также раннее уничтожение ботвы препаратом Reglone. Поражение растений вирусами определено было на третий год в сравнительном методе исследования в Бонине, где применялось одинаковое удобрение и не применялись никакие мероприятия. Проведены были две серии опытов. Полученные результаты показывают, что повышенное внесение азота средне повышает поражение картофеля PLRV, PVY. Усиление поражения этими вирусами после применения повышенных доз азота - значительно в случае сильного инфекционного давления, высокой воспримчивости сорта а также отсутствия защиты от расширения вирусной инфекции. В сортах устойчивых к PLRV и PVY а также применяя успешную борьбу с расширением вирусных заболеваний во всех зонах инфекционного давления, удобрение азотом не повышает поражения посадочного материала. Определённый порядок влияния исследуемых факторов является разным для PLRV и PVY. Что касается PLRV значение факторов в понижающейся последовательности следующее: зоны инфекционного давления, сорта, местности в зонах, взаимодействие сортов с зонами, применяемые мероприятия и удобрение азотом. В свою очередь, что касается PVY такое же влияние в понижающейся последовательности следующее: сорта, зоны инфекционного давления, местности в зонах, применяемые мероприятия, удобрение азотом и взаимодействе сортов с зонами или местностями.