Co-operation of liquid manure and the PRP Fix preparation in shaping of plant crop volume and quality

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Introduction

The liquid manure produced in large volume and nutrients included in it point to the possibility of its use for fertilization purposes. According to the legal regulations in force the liquid manure cannot be introduced into soils during the period from the beginning of November till the end of February (Journal of Laws, 08.119.765). Farms must have tanks of relevant capacity to store it during this period. Incorrect storage and use of the liquid manure may lead to pollution of the environment and result in diminishing of the plant crop quality.

During the recent dozen or so years production of natural fertilizers has diminished in Poland, the mineral fertilizers assortment has changed and their prices have increased substantially in Poland. In the result of this situation doses of the natural and mineral fertilizers have been diminished. This situation may contribute in diminishing of productivity and fertility of soils (Krzywy 2005 [5], Mazur and Mokra 2009 [10]).

French company Procedes Roland Pigeon produces the PRP Fix preparation, which according to the producer, among other things, increases fertilization value of the liquid manure, influences crop increase of plants, contributes in diminishing of emission of odours from the natural fertilizers to the atmosphere, stimulates growth of micro organisms decomposing organic matter and influences the environment positively.

The undertaken studies were targeted to determine reacting of the liquid manure with addition of increasing doses of the PRP Fix preparation on the volume and some qualitative features of winter triticale grain and potato tubers crops.

Scope and methods of studies

Vegetative-field experiments were conducted from 2011 to 2013 at the Plant Variety Assessment Station in Szczecin Dąbie.

The soil used in the experiment featured slightly acidic pH_{KCL} 5.95, the total contents od nitrogen, phosphorus and potassium was 0.86; 1.55 and 2.70 g·kg respectively^{-1} s.m. and it was average for this kind of soils. Affluence in plant available forms was average for phosphorus (55.3 mg·kg^{-1} s.m.), magnesium (49.3 mg·kg^{-1} s.m.) and sulphur (11.0 mg·kg^{-1} s.m.) and high for potassium (132 mg·kg^{-1} s.m.). Content of organic carbon in soil was small (8.80 g·kg^{-1} s.m) and the relation C:N amounted 10.2:1 and was average for this kind of soils.

Early Autumn in 2011 a bi-factor experimental field experiment was set up according to the diagram presented in Table No. 1. The volume of the liquid manure dose introduced into the soil in the test Series I and II was determined on the basis of its nitrogen content, which corresponded to 100 kg N·ha^{-1}. The liquid manure without and with increasing doses of the PRP Fix preparation were introduced on the experimental fields on the following dates: for the winter triticale on 14.09.2011 and for potatoes on 17.04.2013.

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Fertilization was applied according to the study schedule after three days since the liquid manure was introduced into the soil mineral. In Spring 2012 and 2013, in Series I and II of the experiment, late top dressing was applied on all the fertilized objects, with nitrogen in the form of urea (46%N) at 45 kg N·ha^{-1} for winter triticale and at 30 kg N·ha^{-1} for potato.

In Series II of the experiment, on the basis of phosphorus and potassium content in the liquid manure, additional mineral fertilization was applied amounting 90 kg P_2O_5·ha^{-1} in the form of triple granulated superphosphate with content of 46% P_2O_5, which corresponded to a dose of 0.65 kg per filed and 100 kg K_2O·ha^{-1} in the form of potassium salt (KCl) with content of 60% K_2O, which corresponded to a dose of 0.55 kg KCl. The test plants in years 2011/2012 were: *Moderato* subspecies of winter triticale and in 2013 it was *Skawa subspecies of potato*.

Table 1

Testing diagram

Fertilization objects	Series I	Series II
	without additional mineral fertilization	with additional PK fertilization
Mineral fertilizers corresponding to the liquid manure dose	+	+
Liquid manure without PRP Fix	+	+
Liquid manure + 4 kg PRP Fix	+	+
Liquid manure + 8 kg PRP Fix	+	+
Liquid manure + 12 kg PRP Fix	+	+

After performing cultivation techniques and application of fertilization *Moderato* subspecies of winter triticale was sown on 21.09.2011, and in Spring *Skawa* subspecies tubers were planted on 24.04.2013. Harvesting of the triticale was executed on 02.08.2012 and of the potato tubers on 22.10.2013.

After the test plants reached harvesting maturity they were collected and the volume of crops was determined in Mg·ha^{-1}. Samples of triticale grains and potato tubers from each repetition for the particular fertilization object were taken. A mean sample was made, which was laboratory tested. Triticale straw and potato haulm were not collected for testing as they were left in the fields as the source of the organic matter for the soil.

Samples of triticale grains and potato tubers were dried and ground. Then they were connected forming mean samples from four repetitions for each fertilized object. Average plant samples were analysed chemically in three repetitions. Dry matter of plant material was marked using balance desiccators test method in temperature of 105°C, nitrogen with Kjeldahl's distillation method and after mineralization with concentrated sulphuric acid (VI) acc. to PN-75/A-04018/Az3; phosphorus – with Burton's method; potassium and calcium – with flame spectrometry method after "wet" mineralization; total sulphur – with nephelometric method; magnesium – with Atomic

Absorption Spectrometry method (ASA) acc. to PN-EN ISO 11212 and PN-EN ISO 11212–4 after prior "wet" mineralization in mixture of nitric acid(V) and perchloric acid(VII) in 3:1 rate.

The crop volume of triticale grain and potato tubers and macronutrients content was analysed statistically. Two-factor analysis variance for the split-block layout was used in the statistic calculations. Confidence semi-intervals were determined for $p = 0.05$, using Tuckey's test.

Study results

Use of the liquid manure only (Object 2) resulted in the smallest crop of winter triticale grain in Series I of the experiment (without additional phosphorus-potassium fertilization). Differences in crops of the winter triticale grain between this object and the remaining ones were significant.

The PRP Fix preparation introduced to the liquid manure increased the grain crop of the test plant on all the experimental objects in comparison with Object 2 (only liquid manure used). The largest crop of winter triticale grain was obtained in Series I of studies without additional mineral fertilization on the object with liquid manure and in addition of kg the PRP Fix preparation per 1 m^3 (Object 4). This was significantly larger crop as compared with the remaining fertilization objects (Tab. 2).

The significantly smallest crop of the winter triticale grain was obtained with use of the liquid manure without the PRP Fix (Tab. 2). Additional mineral fertilization in Series II of the study (PK) increased crop of the winter triticale grain in comparison to Series I by 5.54%. In this series of the experiment the largest crop of the winter triticale grain was obtained after application of mineral fertilizers corresponding to the liquid manure dose with additional PK fertilization (Object 6). Differences in crops of the winter triticale grain between this object and the remaining ones were significant. From among the experiment objects, on which the liquid manure was used with addition of the PRP Fix preparation, the largest crop of the winter triticale grain was obtained after introduction of 8 kg PRP per 1 m^3 of the liquid manure. Addition of 4 and 12 kg of the PRP Fix preparation per 1 m^3 of the liquid manure did not have significant influence on crop differentiation for the test plant.

Within Series I and II of the experiment conducted in 2013, use of the liquid manure only (Objects 2 and 7) resulted in increasing of potato tubers crop in respect to objects 1 and 6, in which the nutrient components corresponding to the liquid manure were introduced in the form of mineral fertilizers.

The largest crop of potato tubers in Series I and II of test was obtained using the liquid manure with addition of 8 kg of the PRP Fix preparation (Objects 4 and 9). This was significantly larger crop as compared with the remaining fertilization objects. The smallest crop of potato tubers was obtained in Series I and II of test using the liquid manure on the objects, in which 12 kg of the PRP Fix preparation was used per 1 m^3 (Objects 5 and 10) (Tab. 2). Addition of mineral fertilizers increased the crop of the test plant tubers on the fertilizing objects substantially. Differences of the crop volumes of the potato tubers between the particular objects were significant. The average growth of the tested plant crop between Series I and Series II of the test amounted 21.5%. The largest difference of the potato tubers crop was noticed between fertilizing Objects 5 and 9 (27.2%). Larger in average effects in the test plants crops were obtained in Series II of the experiment after application of PK fertilization (Tab. 2). The study results demonstrate that in order to obtain significantly larger crops of the winter triticale grain and potato tubers it is advisable to apply in 1 m^3 of liquid manure 8 kg of PRP Fix preparation.

Fertilization with the liquid manure with addition of the PRP Fix preparation and joint application of the PK fertilizers had positive influence on the test plant crop volume. In the opinion of Jamroz at al. (2004)[2], Łabętowicz at al. (2000)[7] and Maćkowiak (2000a)[9], natural fertilization exerts influence on crops of the farmed plants. The test results are confirmed by experiments of Kalembasa and Kuziemska (1993)[3] and Harasimowicz-Herman and Herman (2004)[1].

Content of nitrogen, phosphorus, potassium, calcium, magnesia and sulphur in the winter triticale grain and potato tubers was close to average values. This data demonstrates that application of fertilization in the experiment did not exert negative impact on quality of harvested crops of tested plants (Tab. 3 and 4). Differences in content of nitrogen, phosphorus, potassium, calcium, magnesia and sulphur in the winter triticale grain and potato tubers between the objects with the liquid manure and mineral fertilizers applied in doses corresponding to the liquid manure amount were not significant on most of the objects. These results were confirmed by studies of Sieradzki (2006)[13], Mazur and Mokra (2009)[10], that reacting of the liquid manure on crops of plants is closer to mineral fertilizers than to natural ones.

Table 2

The influence of the liquid manure and the PRP Fix preparation on crop volume of the winter triticale of *Moderato* subspecies and potato tubers of *Skawa* subspecies in Mg·ha^{-1} obtained with influence of the liquid manure and the PRP Fix preparation

Experiment series	Fertilization objects	Years of study	
		2012	**2013**
		winter triticale	**potato tubers**
Without PK fertilization Series I	1	9.40	63.1
	2	9.16	63.4
	3	9.25	63.7
	4	9.80	69.8
	5	9.33	62.5
	average	**9.39**	**64.5**
With additional PK fertilization Series II	6	10.8	78.2
	7	9.92	78.7
	8	9.83	79.0
	9	9.88	79.5
	10	9.83	75.9
	average	**9.91**	**78.4**
NIR for $_{0.05}$ for: I-doses of PRP Fix II- without and with PK interaction		0.04 0.02 0.04	0.45 0.11 0.47

*explanations of fertilization objects: **Series I of tests;** 1 – mineral fertilizers corresponding to the liquid manure dose, 2 – liquid manure without PRP Fix, 3- liquid manure + 4 kg PRP Fix, 4- liquid manure + 8 kg PRP Fix, 5- liquid manure + 12 kg PRP Fix, **Series II of tests;** 6 – mineral fertilizers corresponding to the liquid manure dose with additional PK fertilization, 7- liquid manure without PRP Fix + PK, 8 – liquid manure + 4 kg PRP Fix + PK, 9 – liquid manure + 8 kg PRP Fix + PK, 10 – liquid manure + 12 kg PRP Fix + PK

In average the test plants included more phosphorus, potassium, calcium, magnesium, and sulphur in Series II of tests (additional phosphorus-potassium fertilization) in comparison with Series I of tests, in which these fertilizers were not applied (Tab. 3 and 4). These results demonstrate that additional mineral fertilization (phosphorus-potassium) not only influenced increasing of phosphorus and potassium content in test plants, but also stimulated retrieving from soil of calcium, magnesium and sulphur. Only the potato tubers included more nitrogen in the series of the experiment with additional phosphorus-potassium fertilization in comparison with Series I (without fertilization with phosphorus and potassium (Tab. 3).

The largest content of nitrogen, phosphorus, potassium, calcium and magnesium was in the test plants on the object, in which to 1 m^3 of the liquid manure 8 kg of the PRP Fix preparation was added. These relations occur both in the Series (I) without additional mineral fertilization as well as in the Series (II) with additional phosphorus-potassium fertilization in the from of mineral fertilizers. Differences in the content of the particular macronutrients (N, P, K, Ca and Mg) in the winter triticale grain and potato tubers obtained on this experiment object were usually significant in comparison with the remaining objects of the experiment. Differences in content of sulphur in both test plants between the object, in which to 1 m^3 of the liquid manure 8 kg of the PRP Fix preparation was added and the remaining objects with addition of the PRP Fix were not significant.

Table 3

Content of nitrogen, phosphorus and potassium in the winter triticale grain and potato tubers obtained due to influence of the liquid manure and PRP Fix preparation

Experiment series	Fertilization objects	Nitrogen		Phosphorus		Potassium	
		content in g·kg^{-1}s.m.					
		winter triticale	potato	winter triticale	potato	winter triticale	potato
Without PK fertilization Series I	1	16.1	15.9	3.00	2.90	5.14	22.0
	2	16.0	16.8	3.10	3.06	5.20	23.5
	3	15.8	17.0	3.60	3.15	5.35	23.8
	4	16.5	18.0	3.93	3.36	5.55	24.2
	5	16.2	17.4	3.70	3.25	5.42	24.0
	average	**16.1**	**17.1**	**3.46**	**3.14**	**5.33**	**23.5**
With additional PK fertilization Series II	6	18.6	16.4	4.02	2.92	5.70	23.0
	7	18.3	16.9	4.05	2.98	5.72	23.5
	8	18.4	17.2	4.10	3.15	5.80	24.0
	9	19.0	17.3	4.21	3.30	5.89	24.6
	10	18.5	17.0	4.14	3.38	5.78	24.2
	average	**18.6**	**16.9**	**4.11**	**3.23**	**5.79**	**23.9**
NIR for $_{0.05}$ for: I-doses of PRP Fix II- without and with PK interaction		0.20 0.09 0.19	0.14 0.06 0.13	0.14 0.06 0.14	n.s. n.s. n.s.	0.02 0.08 0.19	0.17 0.08 0.16

*explanations of fertilization objects were given under Table 2

Table 4

Content of nitrogen, phosphorus and potassium in the winter triticale grain and potato tubers obtained due to influence of the liquid manure and PRP Fix preparation

Experiment series	Fertili-zation objects	Calcium		Magnesium		Sulphur	
		content in g·kg^{-1}s.m.					
		winter triticale	potato	winter triticale	potato	winter triticale	potato
Without PK fertilization Series I	1	0.75	1.10	1.01	0.82	1.21	1.62
	2	0.72	1.15	1.06	0.87	1.23	1.64
	3	0.81	1.25	1.12	0.86	1.30	1.66
	4	0.88	1.36	1.19	0.89	1.37	1.69
	5	0.82	1.30	1.16	0.87	1.42	1.68
	average	**0.80**	**1.23**	**1.11**	**0.86**	**1.31**	**1.66**
With additional PK fertilization Series II	6	0.72	1.08	1.03	0.83	1.20	1.70
	7	0.76	1.12	1.05	0.86	1.28	1.72
	8	0.83	1.29	1.10	0.88	1.41	1.75
	9	0.96	1.45	1.25	1.02	1.47	1.80
	10	0.91	1.40	1.21	0.96	1.51	1.78
	average	**0.84**	**1.27**	**1.13**	**0.91**	**1.37**	**1.75**
NIR for $_{0.05}$ for: I-doses of PRP Fix II- without and with PK interaction		n.s. 0.06 0.05	n.s. 0.09 n.s.	0.04 n.s. n.s.	0.10 n.s. 0.10	0.09 n.s. 0.07	0.09 n.s. 0.08

*explanations of fertilization objects were given under Table 2

Obtained study results demonstrate that introduction of the PRP Fix preparation in the amount of 12 kg per 1 m^3 of the liquid manure exerts no justified influence on increasing of the macronutrients content in the tested plants (Tab. 3 and 4).

Taking into consideration the studies by Korzeniowska and Stanisławska–Glubiak (2007)[4], Krzywy (2005)[5], Kutera (2004)[6], Możdżer and Krzywy (2014)[11] and Maćkowiak (2000)[8], which characterised plant crop quality factors depending on the content of macronutrients, it can be stated, that phosphorus-potassium fertilization with increasing doses of the PRP Fix preparation, did not exert negative influence on the quality of harvested test plants crops.

Conclusions

1. Equivalent mineral fertilization corresponding to the amount of macronutrients in the liquid manure influenced increasing of the crop of the potato tubers and diminishing of the effects for the crop of the winter triticale grain.
2. The liquid manure introduced with phosphorus-potassium fertilization caused increasing of the crops of the test plants and their content of macronutrients (nitrogen, phosphorus, potassium, calcium, magnesium and sulphur) in comparison to the objects without the PK addition.
3. The greatest effect in the test plant crops and their content of the macronutrients was noticed on the objects, in which per 1 m^3 of the liquid manure 8 kg of PRP Fix preparation was used (Objects 4 and 9) as compared to the objects, in which only liquid manure fertilization was applied (Object 2).
4. Use of larger doses than 8 kg of the PRP Fix preparation per 1 m^3 of the liquid manure did not have significant influence on the test plant crop increase and their content of macronutrients.

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