IMPORTANCE OF CROP ROTATION IN POTATO PRODUCTION

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Abstract

Cropping sequence and length of rotation play an important role in potato production. Potato yield are very sensitive to the selection and sequence of rotation crop. Usually minimum 3-4 years rotation is used, however often growers allay for short-term, cropping system or monoculture. This is happening due to limited irrigated areas, or respective predecessor crop, but some time also due to quick economical interest which potato crop offer. In researches with 3 and 4 years crop rotation gradually was increase a percentage of potato from 25-33 till 100%. This led to yield reduction with 13 and 19% comparing with rotation 33% of potato, and with 9.17 and 26% comparing with 25% of potato. Shorter rotation drive up production cost, reduce yield and tuber quality, and increase the percentage of tuber attacked by *Fusarium, Rhisoctonia, Streptomyces scabies,* in special using low class planting material.

Key words: crop rotation, productivity, yield, tuber quality, diseases

Crop rotation was and continue to remain one of the main factor in agriculture, and there importance cannot be ignored or changed by others measures, also in the case if the pedoclimatic and growing condition are favorable for potato plants. From general and superficial point of view crop rotation means distribution of crops in space and time, but from special, scientific and practical point of view crop rotation means a good orchestrated system of deferent's production and technological crop systems. Crop rotation means a good planning which aloud the farm better to use sources for production.

Crop rotations, in general, provide numerous benefits to potato production, and serve multiple functions. First of all it help to conserve, maintain, or replenish soil resources, including organic matter, nitrogen and other nutrient inputs, and physical and chemical properties. Crop rotations have been associated with increased soil fertility, increased soil tilts and aggregate stability, improved soil water management, and reduced erosion. Probably most importantly, for potatoes as well as many other crops, rotations are essential to maintain crop productivity and reduce the build-up of soil borne plant pathogens and diseases, and weeds, which can devastate crops grown in multiple consecutive years.

Plants productivity and yield quality growth up, parallel with degrees of optimizing and harmonizing vegetative factors. So, high and stable yield could be obtained only having a positive interaction of growing conditions. This led to better consume and use of fertilizers, pesticides, energetically resources etc.

An important role for potato in crop rotation system play a soil structure, quantities of organic and mineral matter needed for plant nutrition, water supply, fitosanitary conditions etc. and of courses using potato as a successor crop.

Usually a common practice is applied to use 3 years rotation in table potato production and 4 years in seed potato production. The best successor's crops are those which left the field with les weeds, soil borne pathogens and pests. These are the legumes plants (bean, peas, soya), corn for animals nutrition and grain production, cereals, multiannual forages (alfalfa and clover), vegetables (onion, early cabbage, crucifiers). Following a respective rotation of the crops could be obtained a important supplementary yield advantage without others financials and materials efforts. A good successor crop can increase the yield by 15 – 30% (Măzăreanu H. et al, 1981; Vos J., Van Loon C., 1988; Смирнов А., 2001; Ianoşi I. et al, 2002; Зейрук, 2015).

Is not recommended to plant potato after the crops from the same botanical family, such as tomato, eggs plant sweet papers which have common diseases, pests and consume the same nutrition elements in the same quantities. From this point of view should be avoid the crops such as sun flower, tobacco, carrots, beets for animal feeding.

In function of the soil type and production

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zone it is necessary to create special systems of crop rotation which have to increase productivity, quality and optimizing technological processes.

In the same time potato is considered as a good successor for many others crops, due to leaving clean fields from weeds and quite rich quantities of the nutrition elements in special nitrogen in nitrates form, which remain in soil after harvest.

Cropping sequence and rotation impacts soil chemical, physical, and biological properties, such as nutrient cycling, erosion potential, compaction, organic matter, and biological diversity and activity.

However, the different crops and rotation practices used vary considerably and can greatly affect the efficacy of crop rotations in enhancing potato production. Shorter rotations can drive up input costs and reduce yield and tuber quality

Cropping sequence and length of rotation play an important role in potato production, but to often, growers are forced to base their cropping system decisions on short-term economic survival.

Factors of constraining and limiting crop rotation in Republic of Moldova are the following:

- High dispersion and field fragmentation;
- Good profit growing potato and small profit doing others crops;
- Insufficiencies of irrigated areas in potato production zones;
- Using rented fields for the more profitable crops;
- Reduction or eliminating from crop rotations forages plants.

One of the major problems of potato producers is quite a high production costs, and insufficiencies of favorable plots in special of irrigated fields, which are constrained by limited quantities of water in the lakes using for local irrigation. These facts push growers to growers to return often on the same field or even to grow potato in monoculture. As a result soil become pour in organic matter, nutrition, tired, accumulate weeds, soil borne pathogens and pests, specifically for potato, productivity and quality goes dawn, production costs rise up.

Taking into the consideration the above mentions facts one of the our major task vas not to demonstrate the advantage of crop rotation but to determine the effect of potato cropping frequency on marketable potato yield, the disadvantage and problems which appeared if cropping sequence and rotation are not respected.

Limited available areas for potato production with soil and climatic conditions

More frequent potato cropping, 2 years in 3 (66%) and especially continuous potatoes (100%), the soil and lowers both total and marketable potato yields.

MATERIAL AND METHOD

Two crop rotation system where studied in two location in different climatic zone of the country. In the south part potato vas cultivated in 3 years crop rotation system on relative easy soils on bench of Dnester river (village Talmaz, district Stefan Vodă). Traditionally in this zone is produced early potato and potato in second crop. The 4 years crop rotation system was studied in the north part of the republic, the largest area of potato production, on black relative heavy soil (village Corjeuti, district Briceni). Traditionally this zone produces potato for autumn and winter compsumtion and partial seed potato. In 3 years rotation system 3, this included: potato, winter wheat, and peas. In 4 years rotation system: potato, peas, rape, and winter wheat. In the both rotation was studied different frequency of potato, from 33% till 100% in 3 years system (*table 1*), and from 25% till 100% in 4 years system (*table 2*)

Table 1

Scheme of potato production with 3 years crop rotation

Number of crop rotation	Years			Frequent of potato in crop rotation,%
	2004	2005	2006	
1	Potato	Green peas	Winter wheat	33
2	Potato	Wheat/Peas	Potato	67
3	Potato	Potato	Potato	100

During the vegetation period water condition were assured by using irrigation. Fertilizers, weeds, pests and diseases control vas done according local recommendation (Iliev P., Ilieva I., 2003). Monitorizing a plant growing, yield, quality, pest and disease control was done according to the methodologies in potato research, 1999, 2002).

Table 2

Scheme of potato production whith 4 years crop rotation

Number of crop rotation	Years				Frequent of potato in crop rotation,%
	2004	2005	2006	2007	
1	Potato	Peas	Ripe	Winter wheat	25
2	Potato	Winter wheat	Potato	Winter wheat	50
3	Potato	Potato	Whinter wheat	Potato	75
4	Potato	Potato	Potato	Potato	100

RESULTS AND DICUSSIONS

Analyses of the results of early potato production in 3 years crop rotation system demonstrate a surplus of 7 t/ha or 19 % in comparison with more frequent potato cropping, one time in two years (66%) or especially in continuous potatoes (100%). Increasing frequent and using potato into the rotation two years and only one year cereals or peas decrease the productivity, by 2 t/ha or 6% in comparison with rotation including 33% of potato. In the same tames crop rotation system with potato frequent 66 % and using one times in 3 years a cereals or peas, under the irrigation conditions, guaranteed a yield growing till 5 t/ha or 13 % in comparison with monoculture (*table 3*). South zone usually is used to produce under the irrigation the green peas and a part of field are used to produce potato in the second crop. Including in to the rotation of legumes contributed on soil riche in nitrogen by fix it from the atmosphere with the help of nitrobacteria's (Vos J., Van Loon C., 1988; Petrescu,1999; Boincean B.,1999). In view of the above we can remark that only a simple introduction of potato in crop rotation has a positive effect on total yield by 13-19%.

Table 3

Productivity of potato in 3 years crop rotation (v.Talmaz, Stefan Vodă)

Nr.	Crop rotation	Frequent of potato in crop rotation,%	Productivity of potato		
			t/ha	Diferences	
				t/ha	%
1	Potato, Green peas, Winter wheat	33	37	7	19
2	Potato, wheat/Peas, Potato	67	35	5	13
3	Potato monoculture	100	31	0	0
DL	0.95		3.1		

In the north part of the Republic in Briceni, Ocnița and Edineț districts are planted quite big areas with potato and a frequent of potato in crop structure is relative high. In the same times the tentative to place or to increase potato areas on irrigated and riche fields, or closely to the basic storages, in cases the charging of rather week crop rotation systems and in many cases potato is cultivated 2-3 years on the same field or in monoculture.

Results obtained in our researches in different cropping rotations demonstrate a substantial yield increase till 9 t/ha or 26%, when potato is growing in 4 years crop rotation in compared with monoculture. Increasing frequency of potato in crop rotation till 50%, using the scheme: potato, winter wheat, potato winter wheat increase the yield with 6 t/ha in compared with continuous potatoes or 17%, but reduce the yield by 3 t or 9% in compared with 4 years crop rotation. In cases of planting potato 2 years on the same field plant productivity is 6 t/ha less in compared with normal 4 years crop rotation, and only 3 t/ha more than in monoculture.

Introduction in to the rotation of cereals after 2 years continuous potato stimulated microbiological soil process, refresh it and show the tendency of yield grow (table 4).

Table 4

Productivity of potato in 4 years crop rotation (v.Corjeuți, 2004-2009)

Nr.	Crop rotation	Frequent of potato in crop rotation,%	Productivity of potato		
			t/ha	Differences	
				t/ha	%
1	Potato, Peas, Ripe, Winter Wheat	25	44	9	26
2	Potato, Winter Wheat	50	41	6	17
3	Potato, Potato, Winter wheat, Potato	75	38/40	3/5	9/14
4	Potato, monoculture	100	35	0	0
DL	0.95		2.3		

Results obtained in different crop systems in the north part in 4 years rotation as in the south part in 3 years rotation clearly pointed the necessity to place potato in crop rotation which served as an important factor in productivity increasing.

In the modern agriculture the roll of crop rotation is not limited only on plants productivity but in specially as an effective method of controlling weeds insects, disease, and fungi in potato production systems (Иванюк В. и др. 2005; R.P. Larkin *et al*, 2011, 2012).

Probably it may not be possible to eliminate these pests through rotations with cereals, grasses, legumes, but rotating these crops with potatoes can reduce the pest damage caused to potatoes thereby decreasing the need for costly alternative control measure.

There are some opines that potato grow well even in monoculture, but also they remarks that

this practice could led to increasing diseases and pests in special of potato beetle. Tubers remained in soil after harvest can produce a varieties mixture. In one of the scientific report (Barada, 1963, cited by Ianosi, 2002) mentioned that after 14 years potato growing in monoculture productivity results was sufficient, but in the same time the number of plants attached by Verticillium spp. increased by each year's till 98%, when in to the rotation of 3 years numbers of affected plans vas only 35%. According to the (Mărgineanu T., 1969) potato production in monoculture reduced yield starting with the second year. In the researches done by (Смирнов А., 2002) monoculture not only reduce the productivity, but also degrades the soil quality by reducing humus amount, which become less with 0.16% after 4 years and 0.44% after 8 years. Potato cultivation with limited crop rotation and using relative low quality of the tubers for planting, more than two replication, (practice still common for some growers) increased much more the number of affected plants and new yield tubers. Our studies confirm this phenomenon of yield reduction and infection accumulations in soil and plants (table 5). In case of using good quality seeds (class A), from Holland or local production, and 3 years crop rotation there are only around 1% of diseases infected tubers. Lower quality seed used for planting increase the number of infected tubers till 7.5%, in normal crop rotation. Increasing potato frequent in to production system till 66% or monoculture led to much more tubers infection, in special using for planting lower quality seeds.

Table 5

Influence of cropp rotation and sequence on fitosanitary status and tubers quality in 3 years cropp system c. Agata (average 2004-2009)

Nr.	Crop rotation	Quality of the planting material	Tubers attached by Common scab, %	Tubers attached by *Fusarium*, %	Tubers attached by *Rhizoctonia*, %	Total affected tubers,%
1	Peas, Wheat, Potato	1 repr. import	0.5	0	0.3	0.8
		2 repr. loc.	3	2	2.5	7.5
2	Potato, Wheat, Potato	1 repr. import	1.5	0	1.2	2.7
		2 repr. loc.	5	4	4.3	13.3
3	Potato, Potato, Potato	1 repr. import	6	2	3.4	11.4
		2 repr. loc.	10	6	5.8	21.8

Practically the same situation where observed in the 4 years crop rotation system. There are one small difference, when the potato frequent is less - 25% the number of affected tubers are lower in compared with 3 years crop rotation, increasing frequent of potato into rotation till 100%, number of affected tubers rise till 17% in case of using class A seeds and till 30 % in case of using local seeds which is much higher in compared with 3 years crop rotations. This don't means that 3 years rotation system is better, this means that the longer times potato grow in monoculture the more soil and tuber born infection is accumulated.

Table 6

Influence of cropp rotation and sequence on fitosanitary status and tubers quality in 4 years cropp system c. Roko (average 2004-2009)

Nr.	Crop rotation	Quality of the planting material	Tubers attached by Common scab, %	Tubers attached by *Fusarium*,%	Tubers attached by *Rihzoctonia*,%	Total affected tubers,%
1	Potato, Peas, Ripe, Winter Wheat	1 repr. import	0	0.1	0.1	0.2
		2repr. loc.	1.8	3	2.1	6.9
2	Potato, Winter Wheat	1 repr. import	0.9	0,3	2.9	4.1
		2repr. loc.	5.6	3.8	3.4	12.8
3	Potato, Potato, Winter wheat, Potato	1 repr. import	3.7	2.3	3.4	9.4
		2repr. loc.	7.5	8.2	4.1	19.8
4	Potato, monoculture	1 repr. import	6.2	4.7	6.2	17.1
		2repr. loc.	12.3	9.8	8.3	30.4

During the vegetation period plants permanently are under the pressure of deferent diseases. Respecting crop rotation and using good quality seeds the health status of the plants and normal growing condition are assured. Increasing potato frequent in crop rotation and planting non certified seeds led to increasing a number of the plants attached by deferent holms diseases (*table 7*).

Table 7

Diseases manifestation during the growing period in dependence of sequency and planting material category before flowiering (average 2004-2009)

Nr.	Crop rotation	Quality of the planting material	*Erwinia*,%	*Alternaria solani*, %	*Rhizoctonia*, %	Total, %
1	Potato, Green peas, Winter wheat	1 repr. import	0	2.1	1.2	3.3
		2repr. loc.	1.2	4.1	1.8	7.1
2	Potato, Wheat/Peas, Potato	1 repr. import	0.1	3.6	1.5	5.2
		2repr. loc.	2.3	7.5	5.1	14.9
3	Potato, monoculture	1 repr. import	2.6	9.7	4.1	16.4
		2repr. loc.	5.4	16.1	8.3	31.9

Rotation plays an important role in reducing pests number. In result of our observations we can remarks the following when the 3 or 4 years rotation is respected potato Colorado beetle appeared in 10-14 days after plant emergence. In case of using the same field 2-3 years for potato planting the first adults of potato beetle appeared on plants emergent time, because the insect spend the winter time in the same field. That is why the first beetle eggs are observed 8-12 days earlier, and first larvs with 5-7 days earlier that in normal crop rotation. So ignorance or limiting crop rotation, using low quality seeds and others possible lacks in technology reduce quantity and quality of the yield and grow up costs for production. For example in the last years potato production in Republic of Moldova has been constrained by deferens factors such as over production and low market price, climatic conditions (long term high temperatures) devaluation of local currency or these means automatically high price for imported seeds etc. and as a result many farmers in special small and medium farmers use for planting their own seeds multiplied several years. The recent dates obtained in 2015 production year in one of the farm from the north region where potato vas cultivated in two years rotation (potato –cereals) and planted with local seeds after two years multiplication was obtained the yield of 31,3 t/ha and from this more than 5 t of tubers or approximately. 16% remain in to the field because of strong attack of *Fusarium* spp.

Taking in to the considerations a main idea that potato can't be excluded from the context of crop rotation, but for limited the negative effects when it's happen we recommended to be introducing the organic fertilizers.

CONCLUSIONS

Analyzing the results obtained by us and others researches (Barada. L., 1963; Mărgineanu T., 1969; Немчин Ф., Глянько Г., 1975; Vos J. şi al., 1988; Боинчян Б., 1999 ; Смирнов А., 2002; Ianoşi I., 2002; R.P. Larkin *et al*, 2011, 2012; Зейрук В., 2015) we can formulate the following conclusions that economical and energetically efficiency of crop rotation are the results of organizing, agronomic and ecological advantages:

- maintain or improving the soil characteristics;
- improve the soil water and nutrition distribution mechanism;
- maintain the better balance between mineralization and humification;
- soil layers are used more uniformly;
- reduce the fenomem of sol tiredness;
- reduce soil erosion;
- reduce the number of weeds, pest and diseases pathogens without any others investments;
- improve yield and quality of the tubers and others crops used in to the rotation.

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