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THE EFFICIENCY OF DIFFERENT MOISTURE AND NUTRITION CONDITIONS IN EARLY POTATO GROWING UNDER DRIP IRRIGATION IN SOUTHERN UKRAINE

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Abstract: The article presents field research results on the effectiveness of different moisture and nutrition conditions at the cultivation of early potato under drip irrigation in southern Ukraine. The scheme of the experiment included the treatment with the complex Mochevyn K as an additional control and different methods and correlation of fertilizers Plantafol (treatment of tubers before planting, fertilizing, at budding and their combination), as well as different soil moisture conditions (irrigation rates of 100 and 200 m^3/ha). Studies have shown that the average yield of early potato without irrigation was 10.44 t/ha. Moisture conditions significantly affected the yield of young tubers – irrigation at a rate of 200 m^3/ha provided 21.61 t/ha, whereas reducing the irrigation rate to 100 m^3/ha led to a decrease in yield – 19.86 t/ha. The first treatment of planting tubers, treatment of plants at sprouting and during budding provided almost the same yield. The second and the third treatments of plants and tubers did not lead to a significant increase in yield. The highest productivity of potato was provided by Plantafol treatment of tubers and combination of tuber treatment with foliar feeding at mass sprouting phase with a 200 m^3/ha irrigation rate for two years: 24.16 and 23.22 t/ha.

Key words: potato seed material, early harvesting, water consumption, tuber treatment, foliar feeding.

Introduction

The issue of fertilizer efficiency in the conditions of each zone needs constant improvement, as evidenced by research conducted in our and other scientific organizations. It is determined that the correct use of fertilizers provides a 40–50% and even higher increase in yield (Bondarchuk and Molotsky, 2007; Yaroshko, 2012; Hamayunova and Iskakova, 2015; M″yalkovs′kyy, 2017). Plant growth stimulants are natural or synthetic compounds, which in small doses, at a relatively

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low cost and ease of use, regardless of weather conditions, allow obtaining additional 3–5 t/ha of tubers from a hectare. (Kuchko and Mytsko, 1995; Romashchenko and Shatkovsky, 2014). The balanced content of a complex of biologically active substances in the preparations determines their high efficiency, due to which the growth of the vegetative mass, root system and tuber formation are accelerated in plants. They promote the active use of nutrients, increase plant resistance to disease, stress and adverse weather conditions (Buhayeva and Snihovy, 2002; Alva et al., 2012).

As you know, the Southern Steppe of Ukraine, according to agrometeorological indicators, is a zone of risky agriculture, so for the cultivation of many crops, it is necessary to use irrigation. In recent years, the method of drip irrigation has become widespread (Kyslyachenko, 2014; Romashchenko and Shatkovsky, 2014). However, some techniques of potato growing technology with this method of watering need further study and refinement. It should be noted that providing plants with all the necessary conditions for their growth and protection from temperature stress, there is a need to use growth regulators, biopreparations and micronutrients when using drip irrigation (Fateyev et al., 2001; Tuchin et al., 2010).

In the South of Ukraine, moisture is the main limiting factor for increasing potato productivity. The hydrothermal coefficient in the Steppe does not exceed 0.9, and in the Southern Steppe – 0.6–0.7. Therefore, without irrigation, it is almost impossible to obtain stable yields. Irrigation softens the microclimate in plantings, and creates conditions for high sustainable yields (Bugaeva and Balashova, 1992; Bugaeva and Balashova, 1997; Fesenko and Kozlovsky, 1997). The effectiveness of irrigation has been proven by numerous studies conducted in the steppe (Boyko, 1976; Balashova, 2010; Romashchenko et al., 2011). According to many researchers (Inst. of Irrigated Agriculture NAAS, Inst. of Potato NAAS (2012) irrigation allows optimizing the processes of moisture exchange of plants, their growth and development, and increases plant productivity by 1.5–4.0 times (Vozhehova et al., 2015). Based on many years of research, the positive effect of drip irrigation on potato yield has been proven (Romashchenko et al., 2006; Romashchenko and Plotnikova, 2006).

However, along with the positive experience of using drip irrigation, there are research results that indicate the negative environmental consequences of the drip irrigation method – the creation of water that is limited to irrigation, the so-called ‘salt bags’, i.e. local areas with soil secondary salinization (Stashuk, 2011). Irrigation of early potatoes, regardless of the irrigation method and the nature of the weather in the years of research, increased the yield of potatoes by 1.3–1.6 times, compared with non-irrigated conditions. The use of drip irrigation on early potatoes can significantly reduce irrigation rates, compared to irrigation by sprinkling and furrows, with a close level of yield (Vozhehova et al, 2015; Kokovikhin and

Golovatsky, 2009). The Institute of Irrigated Agriculture of NAAS studied the regime irrigation for summer planting potatoes. For the conditions of the middle of the year, the irrigation regime of 70–80% field capacity was developed during the period of tuber formation which involved four waterings (irrigation norm of 2000 m^3/ha) (Pisarenko and Golovatsky, 2005). Later, the Institute has updated the data: total water consumption of potato is 2100–4100 m^3/ha by vegetation, an irrigation rate for medium loamy soils during sprinkling is 350–400 m^3/ha, with drip irrigation – 250–280 m^3/ha (Balashova and Yuzyuk, 2016; Kyslyachenko, 2014; Yuzyuk and Balashova, 2017).

Material and Methods

The experimental part of the research was performed on irrigated lands of the Institute of Irrigated Agriculture of NAAS (IIA NAAS), located on the right bank of the Dnieper; the Dnieper district of Kherson in the area of the Ingulets irrigation system.

The soil of the experimental plots is dark chestnut medium-loamy slightly saline on the carbonate loess, typical for the irrigated zone of the South of Ukraine. The content of humus in the arable layer is 2.2%, total nitrogen – 0.17%, mobile phosphorus - 30 mg/kg and exchangeable potassium – 300 mg/kg.

Field capacity in a meter layer of soil (FC) is 21.3%, wilting moisture (WM) – 9.5% by weight of dry soil, structure density – 1.41 t/m^3, pH of the aqueous extract of the arable soil layer is 6.8–7.2. Groundwater lies at a depth of 18–20 m and has virtually no effect on the water-air regime of the zone of active moisture exchange.

The data of the Kherson agrometeorological station located on the territory of the Institute were used to characterize the weather conditions during the research years.

Agrotechnic in the experiment corresponded to the technology of growing potatoes in the South of Ukraine, the requirements of research methods and guidelines for conducting research with potatoes; mathematical processing of experimental data was carried out according to generally accepted methods (Kutsenko et al., 2002; Ushkarenko et al., 2014; Vozhehova et al., 2014).

The task of the research was to establish water consumption of potato plants depending on the conditions of hydration and fertilization with macro- and microelements; to determine the influence of drip irrigation and fertilization with macro- and microelements on the growth, development of potato plants, crop formation; to establish the effectiveness of various irrigation standards and fertilizing; the substantiation of the economic efficiency of technology elements of potato plant watering and feeding for obtaining early potatoes. To solve the tasks in the laboratory of potato biotechnology IIA NAAS during 2014–2015, a field experiment was conducted, the scheme of which is given in Table 1.

Table 1. The scheme of the experiment.

Factor A (soil moisture conditions)	Factor B (plant nutrition)
1. Without irrigation 2. Irrigation rate of 100 m³/ha 3. Irrigation rate of 200 m³/ha	1. Without treatment 2. Treatment with the complex Mochevyn K 3. Treatment of tubers with Plantafol 4. Foliar feeding with Plantafol in the sprouts phase 5. Foliar feeding with Plantafol in the budding phase 6. Treatment of tubers + feeding with Plantafol in the sprouts phase 7. Treatment of tubers + feeding with Plantafol in the sprouts + feeding in the budding phase

The following preparation was used for the experiment:

Mochevyn K is a developer and manufacturer of Limited Liability Company Research and Production Association "Agronaukovets". Active substances include N (13%), P_2O_5 (0.3%), K_2O (0.15%), microelements (0.1%), succinic acid (0.1%), organic acids, and tricarboxylic acid complex.

Mochevyn K6 accelerates the formation of the root system and the emergence of sprouts. The method of application is the treatment of seed tubers. The consumption for potato is 1 l/t of tubers. Mochevyn K1 stimulates the development of the root system, aboveground mass, strengthens the immune system of plants. The method of application is fertigation, foliar feeding. The consumption potato is 1 l/ha. Mochevyn K2 increases the drought resistance of plants, thickens stems due to the blockade of growth hormones and growth regulators, forms additional sprouts. The method of application includes foliar feeding. The consumption for potato is 1 l/ha (data of Limited Liability Company Research and Production Association "Agronaukovets").

The treatment with the complex Mochevyn K includes the treatment of tubers before planting of Mochevyn K6, treatment in the sprouts phase of Mochevyn K1, treatment in a budding phase of Mochevyn K2.

Plantafol is a complex water-soluble fertilizer containing microelements for fertilization during the growing season and the treatment of tubers. The treatment of planting tubers implies Plantafol $N_{10}P_{54}K_{10}$ at the rate of 1 kg/t of tubers, and the consumption of a working solution of 20 l/t. The treatment in the sprouts phase implies Plantafol $N_{30}P_{10}K_{10}$ at the rate of 3 kg/ha, and the consumption of a working solution of 250 l/ha. The treatment at the budding phase implies Plantafol $N_5P_{15}K_{45}$ at a rate of 3 kg/ha, and the consumption of a working solution of 250 l/ha.

The study was conducted with a medium-early potato variety Nevska. The area of the first-order plots was 54.9 m^2, the accounting area was 41.2 m^2, the area of the second-order plots was 7.8 m^2, the accounting area was 6.37 m^2. The feeding area was 70 × 32 cm, three repetitions.

Potato in the experiment was planted in spring and harvested after mass flowering (early harvest); the predecessor was winter wheat. Planting density ware recorded in the experiment after emergence and before harvesting; observations of soil moisture were conducted during planting and at the following phases: sprouting, budding, flowering, after harvesting at 0.5-m depth; crop accounting with the definition of its structure was carried after the end of mass flowering.

The following methods were used in the study: field, biometric, measuring-weight, variance and correlation-regression analysis, system analysis and synthesis, economic analysis.

Results and discussion

To provide the specified conditions of moisture before early harvest in 2014, 4 waterings were required at the rate of 200 m^3/ha, and 7 at the rate of 100 m^3/ha, and in 2015, 5 waterings at the rate of 200 m^3/ha, and the rate of 100 m^3/ha – 8. The irrigation norm in 2014 at an irrigation rate of 200 m^3/ha was 800 m^3/ha, and at 100 was 700 m^3/ha; in 2015 – 1000 and 800 m^3/ha. The average irrigation norm for two years at an irrigation rate of 200 m^3/ha was 800 m^3/ha, and by 100–750 m^3/ha (Table 2).

Table 2. Parameters of the potato irrigation regime for early harvesting in 2014 and 2015.

Humidification conditions	Number of waterings by years, pcs.		Irrigation rate, m^3/ha		
			over the years		average for 2014–2015
	2014	2015	2014	2015	
Without irrigation	0	0	0	0	0
Irrigation rate of 100 m^3/ha	4	5	800	1000	900
Irrigation rate of 200 m^3/ha	7	8	700	800	750

Observations of soil moisture in 2014 showed that in variants without irrigation, the humidity of the 0.5-m layer was at 72% of the field capacity due to precipitation in early May, before budding. Moreover, at the beginning of flowering, soil moisture decreased to 60% of the field capacity, and the plants began to suffer significantly from its lack (Figure 1).

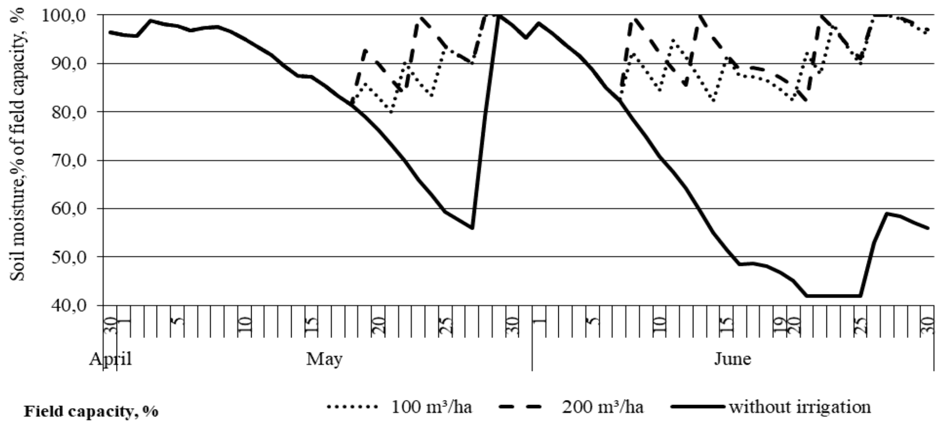

Figure 2. The humidity of the 0.5-m soil layer during the growing season of young potato in different moisture conditions, % of field capacity, 2015.

Irrigations at a rate of 200 m³/ha provided soil moisture during the budding phase at the level of 81–100% of field capacity, and during flowering not less than 82%. Before harvesting, due to precipitation (June 17–28 in 2014 and June 26–27 in 2015), soil moisture amounted to 77–98% of field capacity. With irrigation at a rate of 100 m³/ha, soil moisture did not decrease less than 82% of field capacity before harvest.

Potato water consumption without watering from a layer of 0.5 m before early harvesting was 1877 m³/ha, on the average of two years; of which 49.1% were provided at the expense of precipitation, and 50.9% at the expense of soil moisture reserves (Figure 3).

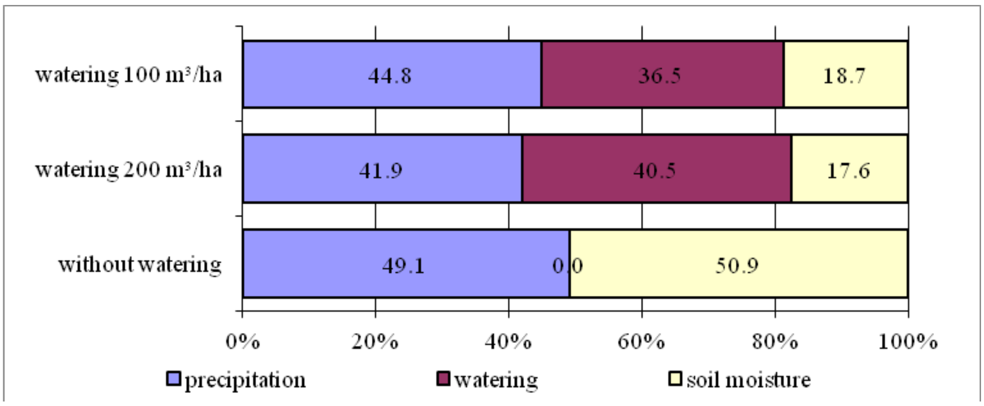

Figure 3. The structure of the water consumption of potato under different conditions of moisture (average for 2014–2015).

The application of irrigation at 100 m³/ha reduced the share of soil moisture to 18.7%, and precipitation provided 44.8% of total water consumption. Increasing the irrigation rate to 200 m³/ha increased the share of irrigation water to 40.5% due to less soil moisture and precipitation.

Over the years of research, the average yield of early potato without irrigation was 10.44 t/ha. Humidification conditions significantly affected the yield of young tubers – watering at 200 m³/ha provided 21.61 t/ha, reducing the watering rate to 100 m³/ha led to a reduction 19.86 t/ha. However, it should be noted that, compared with the option without irrigation, the yield increased by 51.3%.

At the same time, the lowest yield – 9.68 t/ha was recorded in the variant with the treatment with the Mochevyn K complex without irrigation. Plantafol treatment of planting tubers and the treatment of plants during germination and budding without watering provided almost the same yield. The second and the third treatments of plants and tubers did not lead to a significant yield increase. The highest productivity of potato was provided by the treatment of tubers with Plantafol and the combination of tuber treatments and plant treatments during germination with a 200 m³/ha irrigation rate – on average for two years, 24.16 and 23.22 t/ha, respectively (Figure 4).

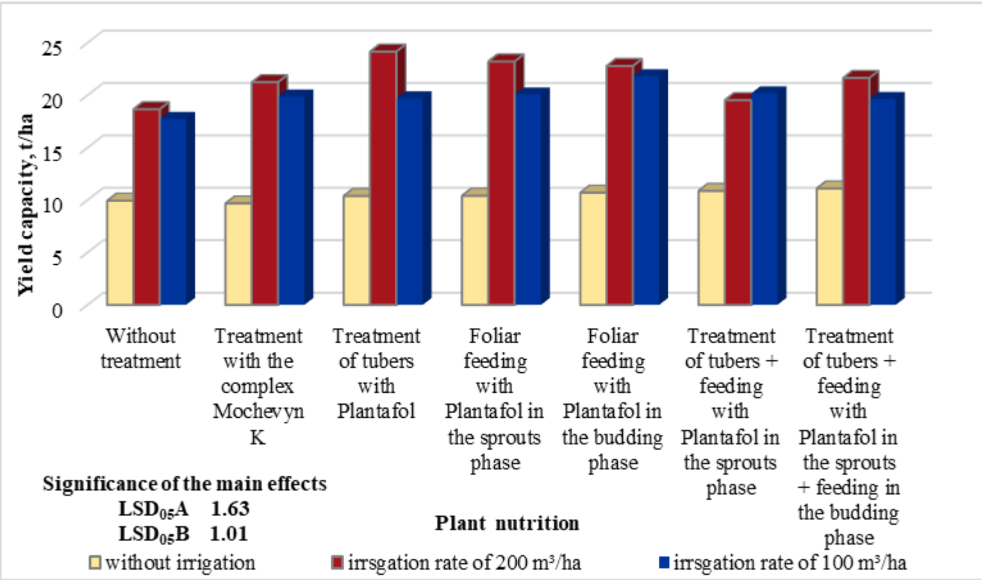

Figure 4. The influence of nutrition and moisture conditions on the yield of potato tubers at early harvest (average for 2014–2015).

It is known that the density of the relationship between the studied factors and the level of yield is estimated by the absolute value of the correlation coefficient (Figure 5).

The results of the correlation-regression analysis indicate a strong positive relationship (r = 0.95, 0.87 and 0.91) in all variants of the experiment. The coefficient of determination showed that the share of the total variation of potato yield was determined by the studied factors (R2 = 0.91, 0.75 and 0.81). In addition, 91%, 75% and 81% of the total fluctuations in potato yield were caused by differences in nutrition and moisture, and the remaining 9%, 25% and 19% – by other factors, which were not taken into account.

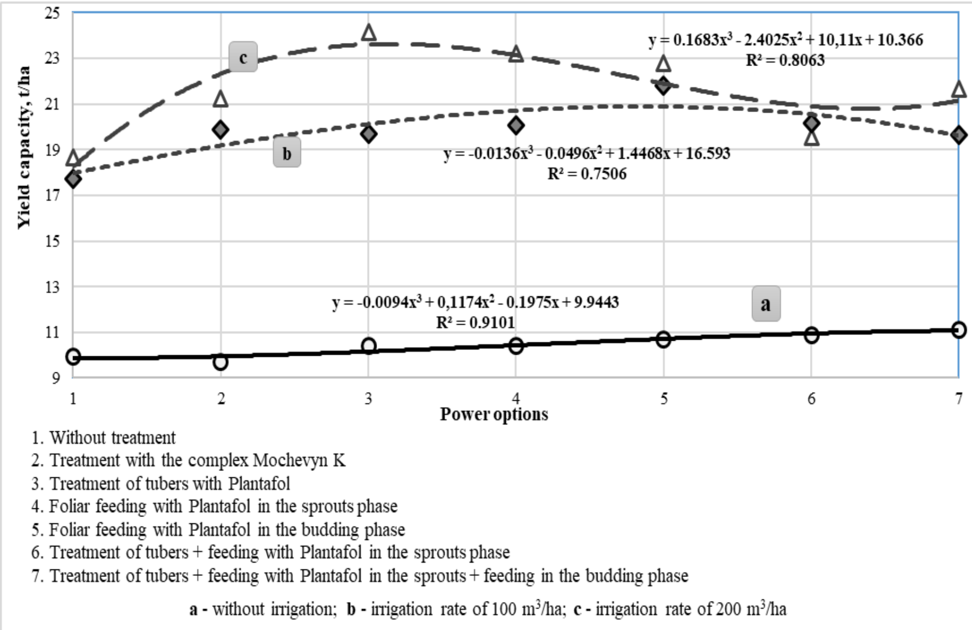

Figure 5. Models of the statistical dependence of the yield capacity from the nutrition and moisture supply (average for 2014–2015).

Given the strong degree of connection (R^2 = 0.91) and the variable dependence (r = 0.95) between the crop and the studied factors, we had two negative coefficients in the calculated equations of the correlation-regression dependence on the options without irrigation and with the irrigation rate of 100 m^3/ha. This indicates an acute shortage of moisture and a significant shortage of crops in options without irrigation. Due to the treatment of tubers before planting and feeding with Plantafol without irrigation, a slight increase in yield was observed. With the increase of moisture supply by 100 m^3/ha, we observed a significant increase in yield compared to non-irrigated variants, but the trend of the impact of treatment of tubers and plants with macro- and micronutrients on this indicator has not changed. In the equation describing the conditions of sufficient water supply (replenishment of moisture deficit by 200 m^3/ha), a negative coefficient indicates that the second treatment of tubers and plants with Plantafol at the sprouting phase and the budding phase contributed only to a slight increase in yield compared to control without micronutrients.

According to the yield capacity, there was a difference in the efficiency of moisture and irrigation water use (Table 3).

Table 3. The efficiency of young potato moisture and irrigation water use depending on plant nutrition in different soil moisture conditions (average for 2014–2015).

Humidification conditions	Plant nutrition	Yield capacity of tubers, t/ha	Water consumption coefficient, m^3/t	Efficiency of irrigation water use, kg/m^3
Without irrigation	without treatment	9.94	189	-
	treatment with the complex Mochevyn K	9.68	194	-
	treatment of tubers with Plantafol	10.39	181	-
	foliar feeding with Plantafol at sprouting	10.41	180	-
	foliar feeding with Plantafol at budding	10.70	175	-
	treatment of tubers + foliar feeding with Plantafol at sprouting	10.88	173	-
	treatment of tubers + feeding with Plantafol at sprouting + feeding at budding	11.11	169	-
Irrigation rate of 200 m^3/ha	without treatment	18.67	119	20.7
	treatment with the complex Mochevyn K	21.24	105	23.6
	treatment of tubers with Plantafol	24.16	92	26.8
	foliar feeding with Plantafol at sprouting	23.22	96	25.8
	foliar feeding with Plantafol at budding	22.79	97	25.3
	treatment of tubers + foliar feeding with Plantafol at sprouting	19.53	114	21.7
	treatment of tubers + feeding with Plantafol at sprouting + feeding at budding	21.65	103	24.1
Irrigation rate of 100 m^3/ha	without treatment	17.74	117	23.7
	treatment with the complex Mochevyn K	19.88	104	26.5
	treatment of tubers with Plantafol	19.71	105	26.3
	foliar feeding with Plantafol at sprouting	20.07	103	26.8
	foliar feeding with Plantafol at budding	21.81	95	29.1
	treatment of tubers + foliar feeding with Plantafol at sprouting	20.18	102	26.9
	treatment of tubers + feeding with Plantafol at sprouting + feeding at budding	19.65	105	26.2

The water consumption coefficient was 194–169 m^3/t of tubers in the variants without irrigation. Its maximum value (194 m^3/t) was recorded in the variant with the use of the treatment with the Mochevyn K complex. The yield herewith was the lowest in the experiment and amounted to 9.68 t/ha, which is 2.6% less than in control. The treatment with Plantafol at sprouting and the budding phase in non-irrigated conditions provided an increase in yield by 11.8%, and reduction of water consumption by 20 m^3/t or 10.6%, compared with the control.

The use of irrigation reduced this indicator to 92–119 m^3/ha. At the same time, one cubic meter of irrigation water provided 20.7–29.1 kg of tubers. Moisture was best used with applying the irrigation norm of 200 m^3/ha and the treatment of tubers with Plantafol – water consumption ratio of 92 m^3/t and the maximum yield in the experiment – 24.16 t/ha, which exceeded the control indicator (without treatment, with watering – 200 m^3/ha) by 29.4%. Irrigation water was used most economically when applying an irrigation norm of 100 m^3/ha and foliar feeding with Plantafol at the budding phase – 1 cubic meter provided 29.1 kg of tubers, with a water consumption ratio of 95 m^3/t; the yield exceeded the control indicator (without treatment) by 4.07 t/ha or 22.9%.

The calculation of economic efficiency has shown that growing young potato without irrigation provides 8.05–15.41K UAH/ha of conditional net profit and 15–35% of profitability (Table 4).

The use of irrigation increases production costs in the variant with an irrigation rate of 100 m^3/ha by 0.57–9.3K UAH/ha, with 200 m^3/ha by 2.44–11.39K UAH/ha. However, the cost of potato decreased through increased yields. The net profit increases to 47.08–67.21K UAH/ha and 51.01–77.56, respectively, which provides the profitability of 93.2–127.4% with 100 m^3/ha and 98.7–140% at 200 m^3/ha.

The best economic indicators were formed with the Plantafol $N_{10}P_{54}K_{10}$ treatment at a norm of 1 kg/t with an irrigation rate of 200 m^3/ha: production costs were 55.32 K/ha. The cost of potato in this variant was the lowest and amounted to 2.29 K UAH/t, and the highest conditional net profit was 77.56 K UAH/ha and profitability of production – 140.0%.

In different climatic zones, scientists from different countries studied the influence of plant nutrition on the growth, development and yield of potato using the pre-planting treatment of tubers and foliar feeding. Thus, in Belarus, with the use of complex fertilizers and the growth regulator Phenomenelan, they managed to increase yields by 2.6–4.9 t/ha, while improving the quality of tubers. The foliar fertilization of the potato variety Zhukovskaya early by Kristalon brown in the budding phase caused an increase in yield capacity 2.8 t/ha in the Kursk region of Russia. The results of research in Ukraine (Sydorchuk and Kalitsky, 2009; Molots′kyy et al., 2009; M″yalkovs′kyy, 2018;), and in Europe (Van der Saag, 1993; Pomykalska, 1988; Burakov, 2007) indicate that the application of micronutrients for foliar feeding of potato plants helps to increase the yield and quality of tubers. However, with the advent of new forms of preparations of different composition, there is a need to study them in the technology of potato growing (Button and Hawkins, 1958; Laughlin, 1962; Kuisma, 1989; Haider et al., 2012; Jasim et al., 2013; Noaema et al., 2016).

Table 4. The economic efficiency of plant nutrition in different conditions of soil moisture at early potato growing (2014–2015).

Humidification conditions	Plant nutrition	Production costs, K UAH/ha	The cost of potato K UAH/t	Conditional net profit, K UAH/ha	Profitability of production, %
Without irrigation	without treatment	42.48	4.27	12.19	28.7
	treatment with the complex Mochevyn K	44.44	4.59	8.80	19.8
	treatment of tubers with Plantafol	43.93	4.23	13.21	30.1
	foliar feeding with Plantafol at sprouting	43.86	4.21	13.39	30.5
	foliar feeding with Plantafolat budding	43.44	4.06	15.41	35.5
	treatment of tubers + foliar feeding with Plantafol at sprouting	44.88	4.13	14.96	33.3
	treatment of tubers + feeding with Plantafol at sprouting + feeding at budding	53.05	4.78	8.05	15.2
Irrigation rate of 200 m³/ha	without treatment	51.67	2.77	51.01	98.7
	treatment with the complex Mochevyn K	54.77	2.58	62.05	113.3
	treatment of tubers with Plantafol	55.32	2.29	77.56	140.2
	foliar feeding with Plantafol at sprouting	54.76	2.36	72.95	133.2
	foliar feeding with Plantafol at sprouting	53.96	2.37	71.39	132.3
	foliar feeding with Plantafol at budding	53.59	2.74	53.83	100.4
	treatment of tubers + foliar feeding with Plantafol at sprouting	55.50	2.56	63.58	114.6
Irrigation rate of 200 m³/ha	without treatment	50.49	2.85	47.08	93.2
	treatment with the complex Mochevyn K	53.36	2.68	55.98	104.9
	treatment of tubers with Plantafol	52.28	2.65	56.13	107.4
	foliar feeding with Plantafol at sprouting	52.39	2.61	58.00	110.7
	foliar feeding with Plantafol at budding	52.74	2.42	67.21	127.4
	treatment of tubers + foliar feeding with Plantafol at sprouting	53.22	2.64	57.77	108.5
	treatment of tubers + feeding with Plantafol at sprouting + feeding at budding	53.62	2.73	54.46	101.6

Irrigation creates conditions for the full return of fertilizers, and those, in turn, increase the efficiency of irrigation. For example, according to the results of long-term studies in Moldova, the increase in the yield of tubers from fertilization without irrigation was only 3 centners/ha, against the background of irrigation – 25, from irrigation without fertilizers – 82, from the combined action of fertilizers and irrigation – 10,7 t/ha (Bugaeva and Snihovyy, 2002).

Fertigation, or the application of fertilizers with irrigation water, helps to solve the problem of providing nitrogen, potassium, phosphorus and other elements (Potato grower, 2010). According to research, the effectiveness of applying fertilizers locally during planting and using irrigation water during the growing season is almost the same. The use of fertilizers in this way involves the use of fully soluble or liquid forms. As for the introduction of fertilizers into the soil, their dose is prescribed based on the presence of nutrients in the soil according to the results of the analyses. Feeding is carried out before flowering. Specialized fertilizers for drip irrigation or filtered extracts of combined fertilizers are used (Pisarenko, 2003). The use of this method of watering in the cultivation of crops allowed increasing yields by 30–50% while saving irrigation water by 3–5 times, mineral fertilizers by 20–40%, energy resources by 50–70%, etc. (Karmanov, 1964; Molyanov and Moiseev, 2003; Koryunenko and Matviyets′, 2004). Based on many years of research, the positive effect of drip irrigation on potato yield has been proven (Ivenin et al., 2012; Shuravilin et al., 2013).

Conclusion

The study of the influence of moisture and nutrition conditions on seed potato growing using drip irrigation showed that the maximum yield – 24.16 t/ha was obtained by treating potato tubers with Plantafol $N_{10}P_{54}K_{10}$ at a norm of 1 kg/t and replenishing the deficit of water consumption by 200 m^3/ha. The best use of moisture was recorded – the water consumption coefficient was 92 m^3/t, and the lowest cost of potato was 2.29 K UAH/t. The highest conditional net profit was 77.56 K UAH/ha and profitability of production – 140.0%.

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References

Alva, A.K., Moore, A.D., & Collins, H.P. (2012). Impact of Deficit Irrigation on Tuber Yield and Quality of Potato Cultivars. *Journal of Crop Improvement*, *26* (2), 211-227.

Balashova, G.S. (2010). Problems of potato seed production in the south of Ukraine under irrigation conditions. *Irrigated agriculture, 54,* 187-190.

Balashova, G.S., & Yuzyuk, S.M., (2016). Potato productivity in the south of Ukraine depending on moisture conditions and methods of fertilizer application by drip irrigation. *Taurian Scientific Bulletin, 96,* 10-16.

Button, E.F., & Hawkins, A. (1958). Foliar application of urea to potatoes. *American Potato Journal, 35*, 559-572.

Bondarchuk, A.A., & Molotsky, M.Ya. (2007) Potatoes. *Bila Tserkva*, 3. 536 p.

Burakov Y. Y. (2007). Foliar fertilization. Maximum profit at minimum cost. *A real master*. 3, 6-10.

Boyko, M.S. (1976). *Two-crop irrigation of potato* : monograph. Odesa: Mayak

Bugaeva, I.P., & Balashova, G.S. (1992). Potato productivity depending on irrigation regimes, type of nutrition and methods of basic soil preparation in the conditions of the south of Ukraine. *Irrigated Agriculture, 37,* 55-59.

Bugaeva, I.P., & Balashova, G.S. (1997). Potato productivity depending on technological methods in the south of Ukraine. *Potato Growing, 27,* 128-133.

Bugaeva, I.P., & Snihovyy, V.S. (2002). *Potato culture in the South of Ukraine.* Kherson.

Bugaeva, I.P., & Snihovyy, V.S. (2002). *Requirements of potatoes to the conditions of growth and developmen*t. Kherson.

Fateyev, A.I., & Bulygin S.Yu. 2001). *Micronutrients in agriculture*. Kharkov.

Fesenko, G.P., & Kozlovsky, G.I. (1997). *Potato seed production in the south of Ukraine: Integration of science in production is the main way to increase the collection of agricultural products, reduce the cost of its production.* Mykolaiv.

Haider, M.W., Ayyub, C.M., Pervez, M.A., Asad, H.U., Manan, A., Raza, S.A., & Ashraf, I. (2012). Impact of foliar application of seaweed extract on growth, yield and quality of potato (*Solanum tuberosum L.*). *Soil & Environment* 31 (2), 157-162.

Hamayunova, V.V., & Iskakova, O.Sh. (2015). Influence of fertilizers and growth regulators on the yield and quality of tubers of summer planting in the south of Ukraine. *A collection of scientific works of Vinnitsa NAU Series: Agricultural Sciences*, 27-34.

Ivenin, V., Ivenin, A.V., & Tikhonov, P. (2012). Cultivation of potatoes on drip irrigation: the impact on its disease incidence and yield. *Agronomist: scientific and production journal*, *1*, 162-163.

Inst. Of Irrigated Agriculture NAAS, Inst. Of Potato NAAS. (2012). *Potato varieties under irrigation of the Southern Steppe of Ukraine: scientific and practical recommendations.* Kyiv: KVITS LLC.

Jasim, A., & Al-Shareefi, Mohammed, H., & Nayef, M. (2013). Effect of foliar fertilizer (high in potash) on growth and yield of seven potato cultivars (*Solanum tuberosom L.*). *Euphrates Journal of Agriculture Science, 5,* 1-7.

Karmanov, S.N. (1964). Influence of watering on potato yield and fertilizer efficiency. *Tr. NIIKH*, 3, 45-50.

Kokovikhin, S.V., & Golovatsky, O.I. (2009). Influence of irrigation methods on water consumption and productivity of soybeans and potatoes in the conditions of the Southern Steppe of Ukraine. *Irrigated agriculture, 52,* 107-114.

Koryunenko, V.M., & Matviyets', O.H. (2004). Drip irrigation is the basis of agricultural technologies of the XXI century. *Panorama,* 14.

Kuisma, P. (1989). The effect of foliar application of seaweed extract on potato. *Journal of Agricultural Science in Finland Maataloustieteellinen Aikakauskirja.* 61, 371-377.

Kyslyachenko, M.F. (2014). Efficiency of drip irrigation of potatoes and vegetable crops in Ukraine. Kyiv: *Ukrainian Research Institute of Productivity of Agroindustrial Complex: Economic Sciences*, *25,* 102-107

Kuchko, A.A., & Mytsko, V.M. (1995). Potential productivity of potatoes and the main factors of its formation.//*Potato growing: intern. of sciences. topics. Sat.* Kyiv. 26. 3-8

Kutsenko, V.S., Osipchuk, A.A., & Podgayetsky, A.A. (2002). *Methodological recommendations for conducting research with potatoes.* Institute of potato. Nemishaevo.

Laughlin, W.M. (1962). Soil and foliar applications of nutrients affect potato yields, dry matter, and foliar necrosis. *American Potato Journal, 39,* 125-134.

M″yalkovs′kyy, R.O. (2017). Influence of fertilizers on the productivity of potato tubers in the conditions of the Right-bank Forest Steppe of Ukraine. *Bulletin of the Poltava State Agrarian Academy*, 56-58.

M″yalkovs′kyy, R.O. (2018). Yield of potato tubers depending on foliar fertilization with microfertilizers. *Naukovi dopovidi NUBiP/Scientific reports of NUBiP* Kyiv.*, № 2 (72). Seriya «Ahronomiya»/Agronomy series.*

Molots′kyy, M.YA., Fedoruk, YU. V., & Zhytets′kyy, K.V. (2009). Productivity of potatoes for complex application of fertilizers and plant growth regulator in the conditions of the Central Forest-Steppe. *Kartoplyarstvo Ukrayiny, 3-4*, 40-49.

Molyanov, V.D., & Moiseev, M.Yu. (2003). Drip irrigation on potato fields. *Potatoes and Vegetables*, *1,* 24-25.

Noaema, A., Sawicka, B., Kiełtyka-Dadasiewicz, A. & Bienia, B. (2016). The application of foliar fertilizer in potato. *International Conference: "Bioeconomy in agriculture",* (pp. 56-57), At Pulawy.

Pisarenko, V.A. (2003). Efficiency of irrigation of agricultural crops in the south of Ukraine. *Ecological and economic problems of water management and construction complex of the South of Ukraine*, 1, 63-67.

Pisarenko, V.A., & Golovatsky, O.I. (2005). Efficiency of methods of irrigation of agricultural crops in the South of Ukraine. *Irrigated Agriculture,* 21-25.

Pomykalska, A. (1988). Wydajnosc i udzial sadzeniakow w plonie w zaleznosci od poziomu nawozenia mineralnego i wielkosci sadzeniakow ziemniaka w rejonie srodkowej Lubelszczuzny. *Agrotechnika ziemniaka 1,* 169-173.

Potato grower. (2010). Foliar Fertilization. Can potato growers benefit? URL: http://www.potatogrower.com/2010/12/foliar-fertilization.

Romashchenko, MI, & Plotnikova, TA (2006). Technology of growing potatoes under irrigation. *Chemistry, Agronomy, Service*, *9-10*, 21-22.

Romashchenko, M.I., Koryunenko, V.M., & Plotnikova, T.A. (2006). Some aspects of growing two-crop potato crops under drip irrigation. *Chemistry, Agronomy, Service, 21,* 10-11.

Romashchenko, M., Shatkovsky, A., Kapelyukha, T., Yatsyuk, Z., Barletov, E., & Smetana, P. (2011). *Scientific publications of the laboratory of micro-irrigation systems of IVPiM NAASU*: *Water consumption and yield of potatoes for spring planting under drip irrigation.* Kyiv: IVPiM NAASU.

Romashchenko, M.I., & Shatkovsky, A.P. (2014). Trends in the development of drip irrigation system. *Agribusiness Today newspaper*. 21 (292).

Shuravilin, A.V., Surikova, T.I., & Tabuk, M.A. (2013). Water consumption of potatoes by drip irrigation on light loamy soils of Oman. *Melyoratsyya y vodnoe khozyaystvo/Land Reclamation and Water Management*, *5*, 15-17.

Stashuk, B.A. (Ed.). (2011). *Management of ecologically safe, water-saving and economically justified irrigation regimes in various ecological and agro-ameliorative conditions of the Southern Steppe of Ukraine.* Kherson: Green D.S.

Sydorchuk, A.A., & Kalits′kyy, P.F. (2009). Efficiency of terms of introduction of new fertilizers at foliar feeding of potato plants*. Potato growing. Agrarian Science,* 145-151.

Tuchin, S.S., Timoshina, N.A., & Kravchenko, A.V. (2010). Efficiency of foliar top dressing of potato with chelated micronutrient fertilizers. *Potatoes and vegetables*, *8,* 8-9.

Ushkarenko, V.O., Vozhehova, R.A., Goloborodko, S.P., & Kokovikhin, S.V. (2014). *Methods of field experience (Irrigated agriculture).* Kherson: Grin D.S.

Van der Saag, D.E. (1993). *Potatoes and Their Cultivation in the Nethelands. 75.*

Vozhehova, R.A., Lavrynenko, Yu.O., & Malyarchuk, M.P. (2014). *Methods of field and laboratory studies on irrigated lands.* Kherson: Grin D.S.

Vozhehova, R.A., & Lavrinenko, Yu.O (2015). *Growing potatoes under drip irrigation.* Kherson: Grin D.S.

Yaroshko, M. (2012). Effect of fertilizers on the quality and harvest of potatoes. *Agronom, 4,* 104-106.

Yuzyuk, S.M., & Balashova, G.S. (2017). Efficiency of fertilizer application in a variety of moisture conditions at potato cultivation in Southern Ukraine. *Proceedings of X International scientific conference "Scientific thought transformation".* Morrisville.

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EFIKASNOST RAZLIČITIH USLOVA VLAŽNOSTI I PRIHRANE KOD GAJENJA RANOG KROMPIRA NAVODNJAVANJEM KAP PO KAP U JUŽNOJ UKRAJINI

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R e z i m e

U radu su predstavljeni rezultati terenskih istraživanja efikasnosti različitih uslova vlažnosti i prihrane pri gajenju ranog krompira navodnjavanjem kap po kap u južnoj Ukrajini. Shema eksperimenta podrazumevala je tretiranje kompleksom *Mochevyn K* kao dodatnom kontrolom i primena đubriva *Plantafol* u različitim fazama razvoja (tretiranje krtola pre sadnje, đubrenje pri klijanju, pupljenju i njihova kombinacija), kao i različite uslove vlažnosti zemljišta (norma navodnjavanja od 100 i 200 m³/ha). Studije su pokazale da je prosečan prinos ranog krompira bez navodnjavanja 10,44 t/ha. Uslovi vlažnosti značajno su uticali na prinos mladih krtola – navodnjavanjem od 200 m³/ha postignut je prinos od 21,61 t/ha, dok je smanjenje norme navodnjavanja na 100 m³/ha dovelo do smanjenja prinosa – 19,86 t/ha. Prvo tretiranje krtola prilikom sadnje, tretiranje biljaka pri klijanju i tokom pupljenja obezbedili su gotovo isti prinos. Drugo i treće tretiranje biljaka i krtola nije dovelo do značajnog povećanja prinosa. Najveća produktivnost krompira obezbeđena je prilikom tretiranja krtola preparatom *Plantafol* i kombinacijom tretiranja krtola sa folijarnim prihranjivanjem u fazi masovnog klijanja uz navodnjavanje od 200 m³/ha tokom dve godine: 24,16 i 23,22 t/ha.

Ključne reči: semenski materijal krompira, rana berba, potrošnja vode, tretman krtola, folijarno prihranjivanje.

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