Annals of the Academy of Romanian Scientists
Series on Agriculture, Silviculture and Veterinary Medicine Sciences
ISSN 2069 – 1149 Volume 6, Number 1/2017

EFFECT OF IRRIGATION ON THE QUALITY OF POTATO VARIETIES

Éva Babett ÁBRAHÁM[1],
Mihály SÁRVÁRI[2],

Abstract. *Among agro-techniques, year effects, variety and irrigation factors have a considerable impact on potato yield quality and quantity. In Hungary, the biggest limiting factor of potato cultivation is the shortage of precipitation and the high average temperature during period of potato tuber development. Potato has a demand for high and even water supply, this crop can reach 100% of its growing capacity if properly irrigated, and the safety of growing and the quality can also be increased. The water shortage between May and August negatively affects the number of tubers, the tuber size and quality apart from the yield. For safe potato growing irrigation is essential.*

Keywords: Potato, varieties, irrigation, yield, quality

1. Introduction

In Hungary, the growing area of potato has dropped dramatically in the last few decades; moreover, we lag behind Western European countries as regards yields. The ecological and climatic conditions of Hungary are not suitable for potato growing everywhere [1], but the low yields also have other causes: the use of not suitable seeds, the low level of irrigation, nutrient supply and old-fashioned machines. The competitiveness of production is further decreased by the great alternation in yields from year to year, unpredictable market conditions, poor consumption habits and often the lack of quality products. For potato growing, considering its original place, humid areas are the most suitable, where the weather is slightly cool, and summer is moderately warm [2]. High temperature reduces the allocation of plant biomass to tubers and will result in smaller leaves, more nodes per stem, longer internodes, taller plants, higher leaf areas and lower rations of leaf/stem leaf [3]. Water stress causes yield loss by reducing the growth of crop canopy and biomass. Water at 3–5 mm per day is necessary for evapotranspiration (ET) and the maintenance of optimal soil moisture tension (10–50 kPa) in growing potatoes [4, 5]. In order to maintain at least our domestic market positions we should improve the level of production. To achieve this, quality should improve besides the enhancement of yield per hectare and the

[1]Title: PhD, University of Debrecen, Faculty of the Agricultural, and Food Sciences and Environmental Management Institute of Crop Sciences, Department of Crop Production and Applied Ecology, Debrecen, Hungary (e-mail: abraham.eva@agr.unideb.hu).
[2]Prof., University of Debrecen, Faculty of the Agricultural, and Food Sciences and Environmental Management, Debrecen, Hungary (e-mail: sarvari@agr.unideb.hu).

simultaneous reduction of production costs [6]. The higher average of yield and tuber quality could be achieved by improving technological elements in the production chain. Ecological limits could be overcome by irrigation and tuber yields of 40-50 t ha^{-1}, or even higher could be attained [7].

2. Materials and methods

In our experiment we examined the yield and some quality parameters of 9 medium-early varieties in large plots. Among the examined varieties, 3 were Dutch (Kuroda Desirée és Kondor), and 6 were Hungarian breeding (Rioja, Lorett, Góliát, Kánkán, Hópehely, White Lady). The 9 varieties were examined in 4 replications in randomized blocks: two replications were irrigated and two were non-irrigated. Beside the yield of the varieties, we examined the effect of irrigation on the quality parameters (dry matter-, starch-, protein content and index of frying).

2 way-anova and Pearson correlation coefficient were calculated using SPSS for Windows 13.0 statistical software package.

2.1. Weather conditions

In 2004, during the vegetation period of the potato, the amount of the precipitation was 342.6 mm, 2.6 mm lower than the 30 years' average (345.1 mm), but the distribution of precipitation was unfavourable. May was extremely dry; the monthly amount of precipitation was only 17 mm, 41.8 mm lower than the average. In July the quantity of rainfall was twice higher than the average (142 mm), which was unfavourable in terms of pathological parameters. The average monthly temperature was 19.3°C in June and 21.1°C in July, which is higher than the requirement of the potato (17-18°C).

In 2005, the amount of precipitation was sufficient during the vegetation period of the potato, and also the distribution of precipitation was relatively even. The amount of precipitation only in June (54.3 mm) was lower than the average of the last 30 years (79.5 mm). The amount of precipitation was higher than the 30 years' average in April, May, July, August (with 75 mm) and in September. The average monthly temperature was about the 30 years' average; the monthly average temperature only in July (21°C) was higher than the average (20.3°C).

In 2006, during the vegetation period of the potato the amount of rainfall was 326.2 mm, 18.9 mm lower than the 30 years' average (345.1 mm). The amount of precipitation in April (92.3 mm) was 49.9 mm higher than the average (42.4 mm), and the planting date was at the end of April. The amount of precipitation was about the 30 years' average in May, June and August, but the monthly amount of precipitation in July was almost the half of the average. September was droughty;

the amount of the rainfall was only 5.3 mm. The monthly average temperature was 1.4°C higher in April and 2.2°C higher in September than the average. In July, in the most critical period the average monthly temperature was 2.9°C higher than the 30 years' average (20.3°C).

2.2. Soil characteristics of the experimental site

The experiment was carried out at the experimental site of the Farm and Regional Research Institute, University of Debrecen, at Látókép. The soil of the experiment field was calciferous chernozem developed on loess with deep mould. The experiment's soil is in good condition, according to the soil physics it is classified as a middle bound loam soil. The thickness of the mould layer is between 80 and 90 cm, and the evenly mould layer's average mould content is 2.8%. $CaCO_3$ appears in the transitional layer of the soil profile, at the depth of 70–100 cm.

The cultivated layer's acidity (KCL pH) is between 6.3 and 6.5, the N content is 0.12-0.15%. The experimental site's soil has good potassium content (240 mg kg-1), the phosphorous content is variable, the average phosphorous content is medium (133 mg kg^{-1}). The minimum field water capacity (FCmin) ranges between 33.65 and 46 %, the non-available water (NW) ranges between 8.5-15.7 % in the 0-200 cm soil layer. Soil water table is in 8-10 m depth, the soil can store a substantial amount of water.

2.3. Agro-technology used in the experiment

The applied fertilizer dose was 165 kg ha^{-1} N, 210 kg ha^{-1} P_2O_5, and 220 kg ha^{-1} K_2O in all the 3 year. The experiment was set up on 50 m^2 parcels, after winter wheat (2004 and 2006) and two rowed barley (2005) as a forecrop. The plant density was 51.000 plants ha^{-1}.

Table 5) Main agro-technical parameters

Name	2004	2005	2006
Date of fertilizer	9 April: N: 160; P_2O_5: 120; K_2O: 220 kg ha^{-1}	18 April N: 160; P_2O_5: 120; K_2O: 220 kg ha^{-1}	24 April: N: 160; P_2O_5: 120; K_2O: 220 kg ha^{-1}
Planting date	21-22 April	2 May	24 April
Irrigation	22 May: 15 mm (all repetitions)	2 June: 30 mm	19 July: 30 mm
	5 June: 25 mm	28 July: 30 mm.	13 July: 30 mm
	11 June: 30 mm		
	8 July: 30 mm		
Harvesting	22 September	6-27 September	25 September

The replications were irrigated 4 times in 2004: on 22 May 2004 with 15 mm; on 05 June 2004 with 25 mm; on 11 June 2004 with 30 mm; on 08 July 2004 with 30 mm. In May we had to irrigate all of the repetitions, because of the drought and the chapped soil. In 2005 the dates of irrigation were 01 June and 28 July with 30 mm. In 2006 the repetitions were irrigated 2 times: 19 and 30 July with 30 mm. Table 1 shows the main agro-technical parameters.

3. Experimental results and discussions

3.1. The effect of irrigation on yield

In 2004, the yield of the non-irrigated experiments was 32.36 t ha^{-1}, and under irrigation the average yield of the 9 examined varieties was 34.64 t ha^{-1}. Irrigation did not increased the yield significantly ($LSD_{5\%}$=2.49 t ha^{-1}). Without irrigation the yield of Hópehely (55.37 t ha^{-1}) and White Lady (46.00 t ha^{-1}) varieties was salient. The yield of Desirée (non-irrigated: 17.27 t ha^{-1}, irrigated: 17.35 t ha^{-1}) and Góliát varieties was under 30 t ha^{-1}, as a consequence of diseases caused by the large amount of precipitation. The yield of Lorett, Rioja, White Lady and Hópehely varieties was higher than the yield of Desirée, Góliát, Kánkán and Kondor varieties respectively ($LSD_{5\%}$=4.50 t ha^{-1}) (figure 1).

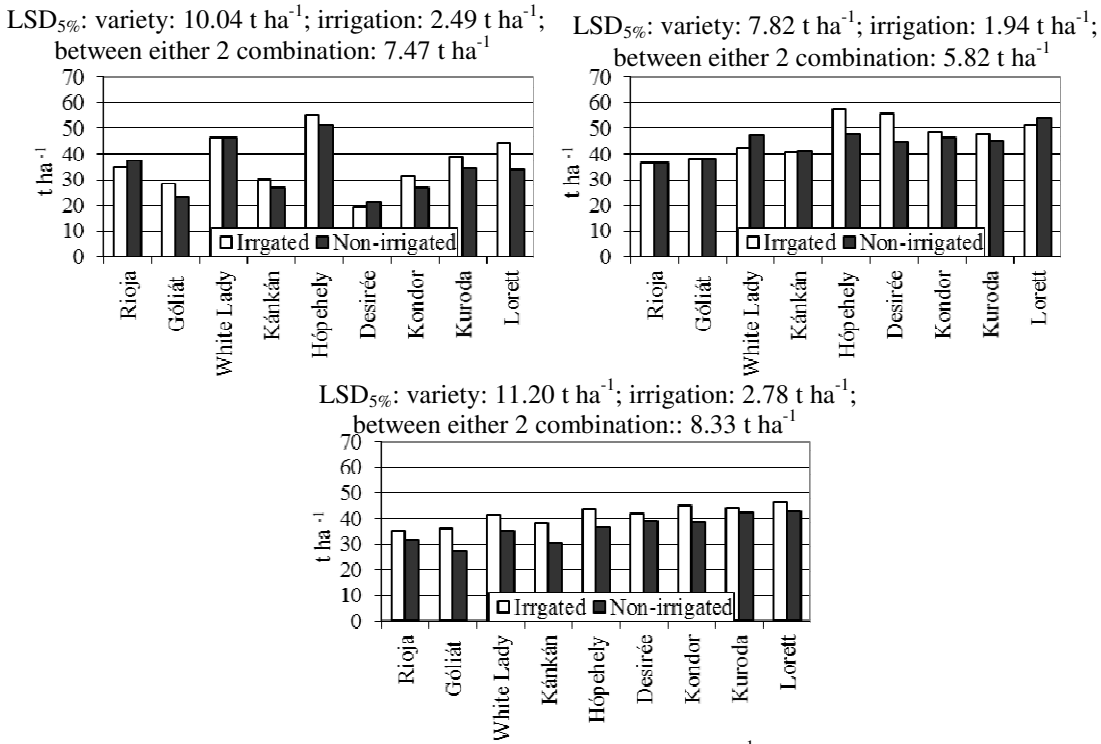

Fig. 1: The effect of irrigation on the yield of potato varieties (t ha^{-1}).Debrecen-Látókép, 2004-2006.

In 2005, there was not substantial difference between irrigated (46.45 t ha^{-1}) and non-irrigated (44.50 t ha^{-1}). Irrigation increased the yield significantly, but the difference between the yield of irrigated and non-irrigated treatments was on the edge of significance ($LSD_{5\%=}$1.94 t ha^{-1}). The yield of Rioja (36.35 t ha^{-1}; 36.55 t ha^{-1}) and Góliát (38.00 t ha^{-1}; 38.00 t ha^{-1}) varieties was lower than 40.00 t ha^{-1} both under non-irrigated and irrigated conditions. Under irrigated conditions the yield of Hópehely variety was 57.45 t ha^{-1}, and the yield of Desirée (55.28 t ha^{-1}) and Lorett (51.11 t ha^{-1}) varieties was higher than 50 t ha^{-1} as well. The yield of White Lady was higher than the yield of Rioja respectively ($LSD_{5\%}$=7.82 t ha^{-1}).

In 2006, the yield of the non-irrigated repetitions was 35.93 t ha^{-1}. Irrigation increased the yield respectively to 41.21 t ha^{-1} ($LSD_{5\%}$=2.49 tha^{-1}). Irrigation increased the yield of every variety which proves the importance of the even water supply in July. Without irrigation the yield of Lorett (42.69 t ha^{-1}) and Kuroda (42.16 t ha^{-1}) varieties was higher than 40 t ha^{-1}. Under irrigation the yield of the Lorett variety was the highest (46.24 t ha^{-1}), and the yield of Kondor, Kuroda, Hópehely, Desirée and White Lady varieties was over 40 t ha^{-1}. The yield of Góliát variety was lower than the yield of Kuroda and Lorett varieties ($LSD_{5\%}$=11.20 t ha^{-1}).

3.2. The effect of irrigation on the dry matter content

In 2004, the average dry matter content was 21.93% under non-irrigated and 22.00% under irrigated conditions. The dry matter content of Rioja variety was higher than 26% both under non-irrigated and irrigated cultivations. The dry matter content of Kuroda (non-irrigated: 25.35%), Hópehely (non-irrigated: 22.50%, irrigated: 24.53%) and White Lady (non-irrigated: 23.57%, irrigated: 23.46%) varieties was favourable. Without irrigation the dry matter contents of Desirée (18.95%) and Lorett (17.22%) varieties were under 20%, which is unfavourable in respect of storage and frying quality (table 2).

In 2005, the dry matter content of the non-irrigated replications was 22.35%, and with irrigation it was 21.62%. The dry matter content of Rioja variety was 24.83% under non-irrigated and 24.42% under irrigated cultivation. In 2005 the dry matter content of Desirée variety was favourable (non-irrigated: 24.42%, irrigated: 22.08%) in consequence of the even precipitation. Under non-irrigated cultivation the dry matter content of White Lady (22.71%) and Hópehely (22.54%) varieties was higher than the average of the 9 varieties as well. The dry matter content of Góliát (19.82%) and Lorett (18.19%) were under 20% under irrigation, too.

The dry matter content was lower in 2006 than in preceding years. The average dry matter content was 20.13% without irrigation. As a result of irrigation the dry matter content in the average of the examined varieties increased to 21.39%

($LSD_{5\%}$=1.02%). The dry matter content of Rioja (non-irrigated: 23.81%, irrigated: 24.48%) and Kuroda (non-irrigated: 23.16%, irrigated: 22.39%) varieties was the highest. Without irrigation the dry matter content of Lorett (17.98%), Kánkán (17.88%) and Kondor (17.00%) varieties was low. At such a low dry matter content the potato cannot been storage safely. The dry matter content of Kondor (19.69%) and Lorett (18.34%) varieties was lower than 20% under irrigation as well.

Table 6) The effect of irrigation on the dry matter content of potato varieties (%). Debrecen-Látókép, 2004-2006.

	2004		2005		2006	
	Irrigated	Non-irrigated	Irrigated	Non-irrigated	Irrigated	Non-irrigated
Rioja	26.44	26.40	24.42	24.83	24.48	23.81
Góliát	20.24	21.34	19.82	20.43	19.68	20.06
White Lady	23.46	23.57	21.20	22.71	21.81	22.18
Kánkán	23.24	21.51	23.89	22.16	23.19	17.88
Hópehely	24.53	22.50	21.08	22.54	22.08	20.90
Desirée	20.06	18.95	22.80	24.42	20.89	18.20
Kondor	18.62	21.13	21.69	21.15	19.69	17.00
Kuroda	22.96	25.35	21.47	21.74	22.39	23.16
Lorett	17.88	17.22	18.19	21.23	18.34	17.98
Average	21.93	22.00	21.62	22.35	21.39	20.13
$LSD_{5\%}$	Varieties: 5.25 Irrigation: 1.16 Interaction: 3.74		Varieties: 5.14 Irrigation: 1.16 Interaction: 3.74		Varieties: 4.10 Irrigation: 1.02 Interaction: 3.05	

The dry matter content of Rioja (25.06%) variety was the highest in every year, and the dry matter content of Kuroda (22.84%), White Lady (22.49%) and Hópehely (22.27%) varieties was favourable as well. The dry matter content of Kondor (19.88%) and Lorett (18.47%) was the lowest. In the average of the 3 year of the experiment, the dry matter content of Rioja variety was higher than the dry matter content of Lorett variety ($LSD_{5\%}$=4.25%).

In 2004 (0.846**) and 2006 (0.749**) there was positive correlation between the dry matter and the starch content and the protein content as well (2004: 0.711**, 2006: 0.443**). There was negative correlation between the dry matter content and the index of frying colour in each year during the experiment (2004: -0.712**, 2005: -0.592**, 2006: -0.375*) and between the content of reducing sugars (2004: -0.383*, 2005: -0.369*, 2006: -0.395*). The varieties with higher dry matter content had lower index of frying colour and reducing sugar content (Rioja, Kuroda).

3.3. The effect of irrigation on the starch content

In 2004, the starch content was 14.75% under non-irrigated and 15.52% under irrigated conditions. The starch content of Rioja variety was the highest both under non-irrigated (21.58%) and irrigated (17.91%) cultivation. Similarly to the dry matter content, the starch content of White Lady (non-irrigated: 16.66%, irrigated: 17.63%) and Kuroda (non-irrigated: 17.40%, irrigated: 16.05%) varieties was higher than the average of the 9 varieties. The starch content of Desirée (irrigated: 12.44%, non-irrigated: 13.45%) and Lorett (irrigated: 12.76%, non-irrigated: 12.37%) varieties was unfavourable. The starch content of Rioja variety was higher than the starch content of Góliát, Kánkán, Desirée, Kondor and Lorett varieties, respectively ($LSD_{5\%}$=5.02%) (Table 3).

Table 7) The effect of irrigation on the starch content of potato varieties (%). Debrecen-Látókép, 2004-2006.

	2004		2005		2006	
	Irrigated	Non-irrigated	Irrigated	Non-irrigated	Irrigated	Non-irrigated
Rioja	21.58	17.91	18.77	16.63	17.37	17.53
Góliát	13.27	14.12	15.97	18.02	14.94	14.08
White Lady	17.63	16.66	16.18	20.77	16.02	15.05
Kánkán	15.58	12.38	17.69	15.54	16.40	14.02
Hópehely	16.62	14.44	18.45	16.08	14.73	11.65
Desirée	13.45	12.44	18.45	16.13	12.62	11.33
Kondor	13.19	14.67	15.00	15.48	12.30	13.00
Kuroda	16.05	17.40	18.98	17.96	16.46	15.81
Lorett	12.37	12.76	14.89	14.57	12.68	12.30
Average	15.52	14.75	17.15	16.79	14.83	13.86
$LSD_{5\%}$	Varieties: 5.02 Irrigation:1.24 Interaction: 3.73		Varieties: 10.56 Irrigation: 1.42 Interaction: 4.25		Varieties: 2.98 Irrigation: 0.56 Interaction: 1.68	

The even water supply is favourable in a respect of the starch content of potato; the highest starch content was measured in 2005. The average starch content was 16.79% under non-irrigated and 17.15% under irrigated conditions. In spite of the even water supply the starch content increased in case of 6 varieties. Under non-irrigated cultivation the starch content of White Lady variety (20.77 %) and under irrigation the starch content of Rioja variety (18.77 %) was the highest. The starch content of Lorett (non-irrigated: 14.57%, irrigated: 14.89%) and Kondor (non-irrigated: 15.48%, irrigated: 15.00%) varieties was low.

During the experiment the starch content was the lowest in 2006. The amount of precipitation was only 31 millimetres in July, and the irrigation increased the starch content respectively ($LSD_{5\%}$=0.56%), which proves that the even water

supply during the development of tubers is very important. The average starch content was 13.86% under non-irrigated and 14.83% under irrigated conditions. With irrigation the starch content increased in case of 7 varieties. The starch content of Rioja variety was the highest both under non-irrigated (17.53%) and irrigated (17.37%) cultivation. The starch content of Rioja variety was higher than the starch content of Desirée, Lorett, Kondor and Hópehely varieties ($LSD_{5\%}$=2.98%).

Irrigation increased the starch content each 3 years, but significant difference was found only in 2006, when the precipitation was low. The starch content of Rioja, White Lady and Kuroda varieties was higher than 15% in every year. The starch content of Kánkán, Hópehely and Desirée varieties increased as a result of irrigation in every year, their quality can be improved by even water supply. The starch content of Lorett variety was low, but it was higher with 2% than in 2004 and 2006 in consequence of the relatively good weather conditions. There was positive correlation between the starch and the protein content (2004: 0.603**, 2006: 0.360*). There was negative correlation between the starch content and the index of frying colour (2004:-0.645**, 2006: -0.385*).

3.4. The effect of irrigation on protein content

In 2004, under irrigation the protein content of every examined variety was higher than 2.00%. The protein content was 2.38% under non-irrigated and 2.28% under irrigated conditions. The protein content of the Rioja (non-irrigated:2.78%, irrigated: 2.77%) and Kuroda (non-irrigated: 2.55%, irrigated: 2.56%) varieties was the highest. The starch content was higher in the case of these varieties as well (table 4).

In 2005, without irrigation the average protein content of the varieties was 1.90%. Irrigation increased the average protein content to 2.06%, respectively (LSD5%=0.13%). Irrigation increased the protein content in case of 7 varieties. The protein content of Kánkán, Rioja (non-irrigated: 1.99%, irrigated: 2.28%), Kuroda (non-irrigated: 1.95%, irrigated: 2.08%) and Desirée (non-irrigated: 1.94%, irrigated: 2.35%) varieties was favourable. Without irrigation the protein content of Góliát (1.78%), White Lady (1.76%) and Kondor (1.72%) varieties was low. The protein content of White Lady (1.92%), Hópehely (1.76%) and Kondor (1.74%) varieties was lower than 2.00% under irrigation as well.

In 2006, the protein content was lower than in the precedent years. In 2006 the average protein content was 1.85% under non-irrigated cultivation and 1.87% under irrigation. The protein content of Rioja (non-irrigated: 2.38%, irrigated: 2.09%) and Kuroda (non-irrigated: 2.30%, irrigated: 2.14%) varieties was the highest in 2006 as well. Under irrigation the protein content of Lorett (1.48%) and Kánkán (1.45%) varieties was very low.

Table 8) The effect of irrigation on the protein content of potato varieties (%). Debrecen-Látókép, 2004-2006.

	2004		2005		2006	
	Irrigated	Non-irrigated	Irrigated	Non-irrigated	Irrigated	Non-irrigated
Rioja	2.77	2.78	2.28	1.99	2.09	2.36
Góliát	1.94	2.17	2.15	1.78	2.10	1.76
White Lady	2.16	2.54	1.92	1.76	1.82	1.62
Kánkán	2.52	2.34	2.13	2.22	1.45	1.63
Hópehely	2.38	2.12	1.76	1.87	1.81	1.67
Desirée	2.33	2.43	2.35	1.94	2.12	1.64
Kondor	2.00	2.43	1.74	1.72	1.83	1.65
Kuroda	2.56	2.55	2.08	1.95	2.14	2.30
Lorett	1.86	2.05	2.14	1.86	1.48	2.03
Average	2.28	2.38	2.06	1.90	1.87	1.85
$LSD_{5\%}$	Varieties: 0.81 Irrigation: 0.17 Interaction: 0.50		Varieties: 0.52 Irrigation: 0.13 Interaction: 0.39		Varieties: 0.94 Irrigation: 0.20 Interaction: 0.59	

The highest protein contents were measured in 2004, without irrigation the protein content of all varieties was higher than 2%. The varieties with higher protein content (Rioja, Kuroda) had higher starch content as well, which shows the positive correlation between these two factors. The shortage of precipitation during the summer is disadvantageous in the point of view of protein content of potato tubers; the lowest protein content was measured in 2006 in the case of most of the varieties. The amount of precipitation in July influences the protein content in a large measure (0.524). There was positive correlation between the protein- and the starch content in every year during the experiment. The protein content is in correlation with the frying quality. There was negative correlation between the protein content and the index of frying colour in 2004 (-0.653**) and 2006 (-0.410*).

3.5. The effect of irrigation on index of frying colour

The index of frying colour is result of a subjective method. The lower if index of frying colour is more favourable. For the food industry the value under 3 is very good, between 3 and 4 is acceptable.

The index of frying colour was the lowest in 2005 and the highest in 2006 which proves that the relatively favourable year effect and the even water supply have favourable effect on the frying quality of potato as well (table 5). The index of frying colour depends on the variety in the first place; there was significant difference between the indexes of the varieties in every year. The index of frying colour of Rioja variety was under value 2.00 in every year, and the index of Lorett

variety changed about value 3 in every year. There was significant difference between the indexes of frying colour of the varieties in the average of the years as well; the average colour of frying index of Rioja variety was lower than the index of the other varieties, respectively. The colour of frying colour of Lorett variety was higher than the indexes of Rioja, Desirée, Kuroda, Hópehely and Kondor varieties (LSD5%=0.78).

Table 9) The effect of irrigation on the colour of frying index of potato varieties. Debrecen-Látókép, 2004-2006.

	2004		2005		2006	
	Irrigated	Non-irrigated	Irrigated	Non-irrigated	Irrigated	Non-irrigated
Rioja	1,05	1,10	1,80	1,25	1,90	1,60
Góliát	2,93	3,00	3,23	2,46	2,25	2,40
White Lady	2,98	2,40	2,58	2,60	2,80	3,05
Kánkán	2,65	2,60	2,50	2,43	2,85	2,80
Hópehely	2,30	2,40	2,25	2,55	2,50	3,15
Desirée	2,53	2,60	2,28	1,85	2,20	2,50
Kondor	2,75	2,33	2,39	2,88	2,50	2,65
Kuroda	2,48	2,40	2,38	2,40	2,35	2,60
Lorett	3,00	3,53	3,63	3,25	3,55	3,33
Average	2,52	2,48	2,56	2,41	2,54	2,68
LSD5%	Varieties: 0.77 Irrigation:0.19 Interaction: 0.57		Varieties: 1.38 Irrigation: 0.20 Interaction: 0.61		Varieties: 0.90 Irrigation: 0.21 Interaction: 0.63	

Conclusions

On the base of the results of our experiment it can be stated, that irrigation and even water supply increased the yield in the average of the examined varieties respectively, and the quality also improved as a result of irrigation.

The protein content of the potato tubers depends on the year effect primarily. The protein content was higher in those years (2004 and 2005) when the summer was rainy during the development of the tubers. In 2006, there was lower precipitation during the summer than in 2004 and 2005, and the protein content was 1.85% under irrigated and 1.87% under non-irrigated cultivations. The difference between the varieties is distinct. The varieties with higher protein content (Rioja, Kuroda) had higher starch content as well, which shows the positive correlation between these two factors (2004: 0.645**, 2006: -0.385*).The protein content is in correlation with the frying quality. The varieties with higher protein content have more favourable frying quality (Kuroda, Rioja varieties).

R E F E R E N C E S

[1] SÁRVÁRI, M. (2001): *A termesztési tényezők hatása a burgonya termésére.* In: Burgonyatermesztés, 2001. augusztus. 21.p.

[2] MÉSZÁROS F. (1979): *A burgonya termesztése*. Mezőgazdasági Kiadó Budapest.;

[3] A KHEDHER, B. – EWING, E. E. (1985) *Growth analyses of eleven potato cultivars grown in the greenhouse under long photoperiods with and without heat stress*. American potato journal 62. 537-554.p;

[4] MARUTANI, M. - CRUZ, F. (1989): *Influence of supplemental irrigation on development of potatoes in the tropics*. HortScience 24 6 (1989), pp. 920–9-23;

[5] KRUPPA, J. – GYŐRI, Z. – SÁRVÁRI, M.: 2003. *A burgonya minőségét, piacosságát befolyásoló ökológiai és agrotechnikai tényezők*. Burgonyatermesztés. 2003. augusztus. 7-14.p.

[6] KRUPPA, J. – ZSOM, E. (2001): *The effect of potassium fertilization on potato yield quality and quantity*. In: Fertilizers in context with resource management in agriculture; volume II. p. 664-670.

[7] HORVÁTH, S. (2002): *Analysis of the present status of Hungarian potato production with special regard of its expected competitiveness in the EU*. In: 50 éves az Acta Agronomica Hungarica. 155-160.p.