POTATO YIELD AND EVAPOTRANSPIRATION DEPENDING ON PRE-IRRIGATION SOIL MOISTURE

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Abstract: *A field trial has been organized on a chernozem soil in the southern part of the Pannonian Plain, the Vojvodina Province, northern Serbia. The trial included several potato cultivars whose yields are presented at the level of general average. Sprinkler irrigation was used at three levels of pre-irrigation soil moisture: 60%, 70% and 80% of field water capacity (FWC). The control plot was not irrigated. Potato yields were highly significantly increased by irrigation. The increases were 70% in semiarid years and threefold in dry years. Highest yields were obtained with the pre-irrigation soil moisture of 70% FWC, which evidently was the lower limit of the optimum soil moisture for potatoes. The rate of water consumption for evapotranspiration of potatoes tended to increase with the increases of pre-irrigation soil moisture. Highest yields were achieved with the water consumption rate of 460 – 480 mm. This amount corresponded to the water requirement of potatoes grown under the local conditions.*

Key words**:** *evapotranspiration, potato, pre-irrigation soil moisture*

INTRODUCTION

Potato is grown on a sizeable area in the world. The potato acreage ranks fourth, after those of rice, wheat and corn. In Serbia, its area varies between 90,000 and 115,000 ha. In the chernozem zone of the Pannonian Plain (the Vojvodina Province), it is grown at 22,000 to 25,000 ha. The average yields obtained in Serbia and the Vojvodina Province are low, 8 t ha^{-1} and 13.6 t ha^{-1}, respectively. These yields are more than three times lower than those achieved in the leading potato-growing countries. The low yields are the consequence of unfavorable climatic conditions, i.e., rainfall deficit and high temperatures, especially in the chernozem zone. Better results are obtained in the mountainous parts of the country.

WRIGHT AND STARK (1990) reported that extensive studies have been conducted in various parts of the world on the production technology and irrigation of potatoes. In our country, production technology has been studied to a certain extent while the topic of irrigation of potatoes has hardly been addressed. Potato requirements for water and irrigation scheduling were studied by BOŠNJAK (1994), BOŠNJAK and PEJIĆ (1995), BOŠNJAK and PEJIĆ (1997) and BOŠNJAK et al. (2004).

The potato acreage in Serbia increases steadily, mainly on account of the introduction of new potato varieties for industrial processing (chips, French fries, dehydrated potato puree). A study was conducted to determine the effects of irrigation and different levels of pre-irrigation soil moisture on potato yield and evapotranspiration.

MATERIAL AND METHODS

The field trial was organized at Rimski Šančevi experiment field of the Institute of Field and Vegetable Crops in Novi Sad, Serbia (19º 51' E, 45º 20' N, 84 m above sea level), on the calcareous chernozem soil of the loss terrace. Sprinkling irrigation was applied. There were three irrigation; irrigation at the level of preirrigation soil moisture of 60% FWC, 70% FWC

and 80% FWC or irrigation was performed when 70%, 50% and 30% of available soil water, respectively, was consumed. Available water (Ew) is between field water capacity (FWC) and wilting moisture (Wm). Wilting moisture was determined using pressure 625 kPa.

$$Ew = FWC - Wm$$

Field water capacity to the 60 cm depth is in average 25, 1 mass %, 60 % of FWC is 15 mass %, 70% of FWC is 17,5 mass % and 80% of FWC is 20 mass %. The control plot was not irrigated. To establish the irrigation schedule, soil moisture dynamics was monitored in 10 – 20 cm layers to the depth of 60 cm. Soil samples were taken at 7 – day intervals or at shorter intervals when necessary. Moisture was determined by the thermogravimertic method, in the dryer at 105 – 110 ºC. For determination of evapotranspiration, soil moisture to depth of 2 m was measured at the beginning and the end of growing season. Evapotranspiration (ET) was calculated by the water balance method using soil moisture reserve (r), rainfall (P), perculated water (D) and irrigation requirement (Nn).

The trial included several potato varieties. These varieties are intended for household consumption and industrial processing. Yield was measured plots of 10 m^2 and expressed on a hectare basis.

RESULTS AND DISCUSSIONS

Effects of irrigation on potato yield were positive and highly significant (Table 1). On average, the yields were increased by 70 to 116%. In some years the yield of irrigated potato was increased from two to two and a half time. Similar results were obtained in our previous study (BOŠNJAK et al., 1997). In extremely dry years, however, irrigation practice increased potato yields more than three times. The yield gain obtained in the irrigated conditions in comparison with unirrigated according to BORZA et al. (2010) were very significant and ranged from 111% to 210%, which is in consistency to our results.

Table 1

Potato yield (t ha^{-1}) depending on pri-irrigation soil moisture

Year (B)	30% Ew	50% Ew	70% Ew	Ø	Average (B)
2002	36,808	40,860	32,468	16,759	31,724
2003	37,043	45,456	29,306	15,966	31,943
2004	37,800	43,800	26,620	19,220	31,860
Average	37,217	43,372	29,465	17,315	31,842

LSD	%	A	B	AB
	0,01	3,149	2,226	4,453
	0,05	4,287	3,031	6,062

A highly significant positive correlation was obtained between the achieved potato yield level and pre-irrigation soil moisture level (Fig. 1). Maximum potato yields were registered in the variant with pre-irrigation soil moisture of 70% FWC, i.e., in the variant that utilized a half of the water available in the active rhizosphere. Obviously, that moisture level is the lower limit of optimum soil moisture for potatoes grown under the local soil and climatic conditions. The higher and the lower pre-irrigation moistures caused water stress in potato plants, water excess at 80% FWC and water deficit at 60% FWC. These results fit closely with

those of THONTHON and SIECKA (1980) who had claimed that the lower limit of optimum soil moisture for potatoes is reached when 50% of available water is consumed. COSTA et al.. (1997) stated that according to some authors maximum yield can be obtained if soil moisture does not drop below 50% of crop available water in the soil. Our results differ from those of WRIGHT (1982) and KASHYAP and PANDA (2003), 65% and 45 %, respectively, which seem to be due to local conditions.

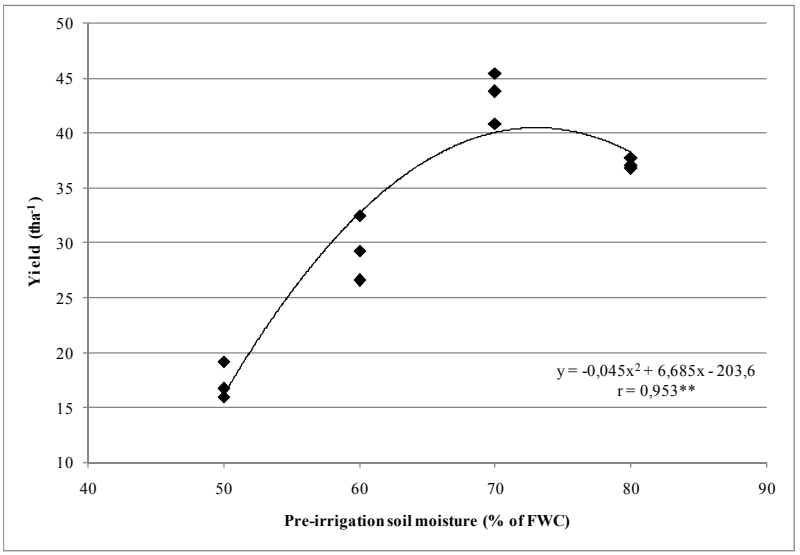

Figure 1. Potato yield depending on pre-irrigation soil moisture

Table 2

Potato evapotranspiration (mm) depending on pre-irrigation soil moisture

Year	Variant	Reserve soil moisture	Rainfall	Perculation water	Irrigation requirement	Σ
2002	80 % FWC	31,5	212,7	0,0	240,0	484,2
	70 % FWC	34,1	212,7	0,0	225,0	471,8
	60 % FWC	77,0	212,7	0,0	180,0	469,7
	Ø	168,5	212,7	0,0	0,0	381,2
2003	80 % FWC	75,3	156,1	0,0	270,0	501,4
	70 % FWC	61,2	156,1	0,0	250,0	467,3
	60 % FWC	55,4	156,1	0,0	240,0	451,5
	Ø	217,3	156,1	0,0	0,0	373,4
2004	80 % FWC	88,0	313,0	43,0	150,0	508,0
	70 % FWC	89,0	313,0	54,0	135,0	483,0
	60 % FWC	87,0	313,0	18,0	120,0	502,0
	Ø	106,0	313,0	0,0	0,0	419,0

In the variant of pre-irrigation moisture of 70% FWC, in which there was no water stress or it was negligible, the yields of potato exceeded 40 t ha^{-1}. FABERIO et al. (2001) cited several authors who had reported similar results. These authors considered such yields as satisfactory.

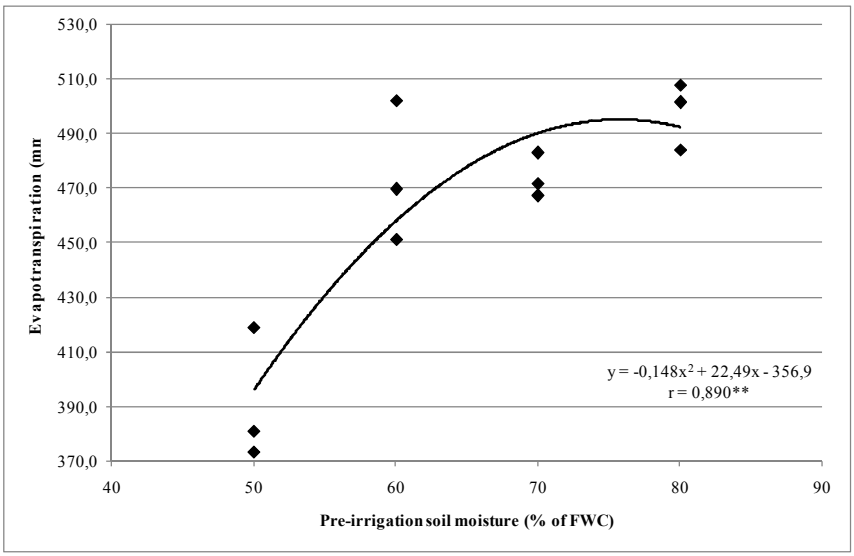

Figure 2. Potato evapotranspiration depending on pre-irrigation soil moisture

Lowest water consumption for potato evapotranspiration (Table 2) was registered in the non-irrigated control variant. Highly significant positive quadratic correlations were found between the evapotranspiration rates and the increased pre-irrigation soil moistures (Fig. 2). Two of the experiment years (2002 and 2003) were dry, while the third year (2004) had considerably higher rainfalls which, however, were unfavorably distributed. Dry and humid spells alternated. The dry spells had to be corrected by irrigation, and, after extremely heavy rainfalls that followed, excess water would percolate into deep soil layers. Highest yields of potato tubers were achieved with the evapotranspiration rate of 460 – 480 mm, in the variant of 70% FWC. These values may be considered as the water requirement of potatoes grown under the local conditions. These results are in agreement with the results of several authors cited by WRIGHT and STARK (1990). Most of these authors agreed that the water requirement of the potato does not range widely in a single region. When optimum soil moisture is provided, much larger variations occur in yield than in water consumption among the years. Yield level does not depend solely on water consumption rate. Potatoes may consume over 200 mm of water from the soil layer 0-200 cm but still produce a low yield under such conditions. This was the case in 2003, when the winter precipitation replenished the pre-vegetation reserve soil moisture but when only a scant rainfall fell during the growing season. A highly significant positive quadratic correlation was obtained (Fig. 3) between the yield of potato tubers and water consumption on evapotranspiration.

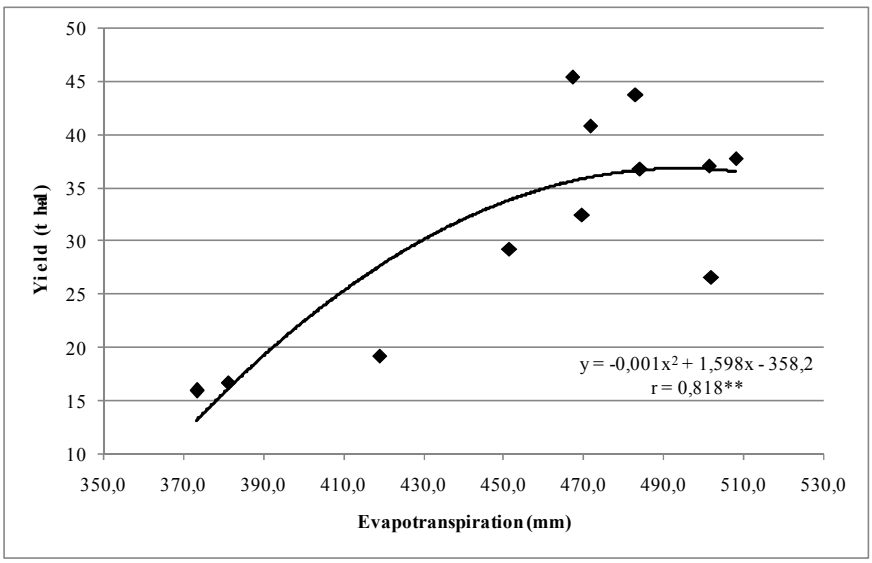

Figure 3. Potato yield depending on evapotranspiration

CONCLUSIONS

In the chernozem zone of the Pannonian Plain, northern Serbia, potato yield was highly significantly affected by irrigation. While the effects were moderate in semiarid years (70%), two- to three-fold increases occurred in extremely dry years.

Highest yields of potato were registered in the variant with pre-irrigation moisture of 70% FWC, i.e., in the variant that utilized a half of the water available in the active rhizosphere. That moisture level is obviously the lower limit of optimum soil moisture for potatoes grown on the chernozem soil, which has medium light to medium heavy mechanical composition.

The potato evapotranspiration rate increased as the pre-irrigation soil moisture was raised. The correlation between the two was positive and highly significant. Highest yields were obtained with the evapotranspiration rate of 460 – 480 mm. The yield dropped with further increases of the rate. It is evident that the evapotranspiration rate of 460 – 480 mm is the water requirement of potatoes grown under the local soil and climatic conditions. The potato may consume over 200 mm of water from the soil layer 0-200 cm, but its yield will be low. A highly significant and positive correlation was found between the obtained yields of tubers and the rate of water consumption for potato evapotranspiration.

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