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Different irrigation technologies on irrigation scheduling and production of onion

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Abstract

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Fields studies were conducted on the territory of the experimental field Chelopechene to IPAZR "N. Poushkarov" on leached cinnamon forest soil. They were examined variants with different irrigation technologies in an optimal and reduced irrigation regime of onion: V_1 – mikrosprinkler irrigation equipment – 100% irrigation rate; V_2 – subsurface drip irrigation – 100% irrigation rate, V_3 – subsurface drip irrigation – 50% irrigation rate; V_4 – surface drip irrigation – 100% irrigation rate; V_5 – surface drip irrigation – 50% irrigation rate; V_6 – non-irrigated option. Reduction the irrigation rates by 50% at surface and subsurface irrigated results in a reduction in yield by 23 and 7%, and can be used when have water deficit.

Keywords: technologies for irrigation; onions; irrigation regime

Introduction

The interest of onion grew production in Bulgaria and abroad has increased during the last ten years. Conducted studies and experimental results from various independent research (Bekele et al., 2007; Shoke et al., 2000; Kadayifci et al., 2005; Mitova et al., 2016; Mermoud et al., 2005; Nikolova et al., 2019) show that this culture is sensitive to water shortage and mineral fertilization in the soil during the formation of the bulb and less sensitive during the maturation phase. In recent years, due to climatic changes, it is necessary to avoid the influence of drought on the use of varieties with rapid phenological development or displacement of critical phenological periods (Naydenova & Georgieva, 2019). Many studies have been conducted on the "water-yield" link, one of them Kumar et al. (2007) have found that the application of an irregular irrigation regime with a reduction of the irrigation rate by 20 and 40% of the optimal results in a yield decrease with 14% and 38% and irrigation water shortages, respectively, can be successfully implemented. Water regime and optimal water availability to plants are also main components for agriculture (Banishka, 2008a; Banishka, 2008b; Gadjalska et al., 2017; Gadjalska et al., 2017). In the case of drip irrigation, in order to have an even distribution of the water supplied to the plants, it is necessary to correctly select the characteristics of the irrigation wings. The purpose of the hydraulic dimensioning of the PT is to determine their L_p length so that the allowable pressure difference PT is within the adjustable range of the droplets and the speeds are initially lower than the maximum allowable according to the design rules (Georgiev, 2015).

Preliminary studies of onion irrigation technology of IPAZR "N. Poushkarov" experimental field in Chelopechene have not been carried out yet.

The aim of the present study is to investigate the effect of various micro-irrigation technologies (drip irrigation and micro-stream) at onion production on cinnamon forest soil.

Materials and Methods

Field experiments were conducted on the territory of IPAZR "N. Poushkarov" experimental field in Chelopechene,

near to Sofia. The soil was Chromic Luvisols typical of the Sofia area (42.73; 23.47, 550 m above sea level), is situated of temperate continental climate zone in Europe. It was found that mechanical compositions of these soils were medium to heavy. The water-physical properties of this subtype soil are average for the layer 0 – 0.50 m depth is the following: field capacity (PPV) – 22.0% relative to the weight of the absolutely dry soil; soil volumetric weight at PPV – 1.47g/cm³.

The subject of the study: The micro-irrigation technique

Experiment betting method: Non-standard two-factor block method in four iterations.

Irrigation: Drip irrigation (surface and subsurface) and micro-sprinkler.

Meteorological factors

Crucial for crop cultivation are meteorological factors – air temperature and rainfall. Outdoor air temperature is measured yearly at 7, 14 and 21 hours. Daily average values of the indicators were calculated on the basis of measured values. Rainfall was reported on the meteorological landing territory yearly.

Fenological research begins from the beginning of the bulbs planting and takes place during the growing season: the onion development main stages are germination, increased growth, ripening of the heads.

The following options are set (Figure 1)

Variants

V1 – mikrosprinkler irrigation equipment – 100% irrigation rate

V2 – subsurface drip irrigation – 100% irrigation rate,

V3 – subsurface drip irrigation – 50% irrigation rate

V4 – surface drip irrigation – 100% irrigation rate,

V5 – surface drip irrigation – 50% irrigation rate

V6 – non-irrigated option.

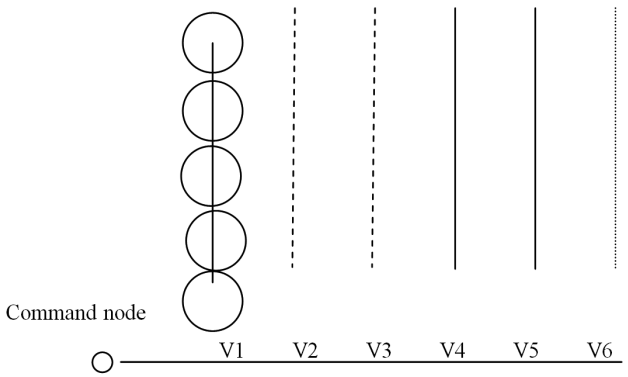

Fig. 1. Experiment placement scheme

Determination of irrigation rates. Monitoring of the soil moisture dynamics – soil samples are taken over 7 to 10 days at a depth of 50 cm through 10 cm in three replicates and processed using the classic thermostatic weight method. Obtained results on the basis of the soil humidity, the required irrigation norms are filed using the Formula 1.

Irrigation scheduling

The irrigation norm was being calculated using the formula Kostiakov:

$$m = [10H.\alpha.(\delta^{FC} - \delta^{80\%FC})].K. \quad (1)$$

where *m* – irrigation norm in mm; *a* – soil density in g/cm³; *H* – depth of the active soil layer in m (H = 0.30 m); *δ* of PPV – marginal land moisture in % relative to absolute dry weight of soil, % of soil moisture content in % relative to absolute dry weight of soil; *K* -reduction coefficient of irrigation rate by plants occupied area in 1da.

The yield was determined in four replicates for each variant in kg/da. The statistical processing of the yields was performed on the ANOVA (Analysis of variance) dispersion analysis for each experimental year.

Climatic characteristics of the experimental years 2017 – 2018

The crucial main factors of optimal yield formation are the average daily air temperature and rainfall. Rainfall is one of the limiting factors for sustainable yields (Popova et al., 2018). Because of their unevenness during the vegetation period of onion, the application of irrigation was necessity.

Regarding the climatic factors for the study period, the two experimental years differ significantly. Provision rain fall determination and average daily temperatures was done over a period of 60 years (1955 – 2017). Regarding to the amount of fallen rainfall during 2017 (Figure 2) characterized as very humid with p = 2.82% and rainfall amount 629.5 mm and medium wet 2015 year with p = 62.42% and rainfall 321mm. In Figure 3 are presented the amount of rainfall for ten days for 2017/2018. The annual average daily air temperature is proportional to soil temperature and influences the rate of flow of plant life, on the intensity of photosynthesis.

Regarding air temperature, the years 2017 and 2018 are very warm with p = 29.31% (2017) and p = 11.09% (2018) with temperature sums of 3183.2°C and 3278.2°C (Figure 2). These norms are above the average for the Sofia region with positive deviations of 3.40% and 6.40%. The hottest are the months of July and August, which coincides with the position of the laid down of the lying stems and has a favorable effect on the ripening of the bulbs.

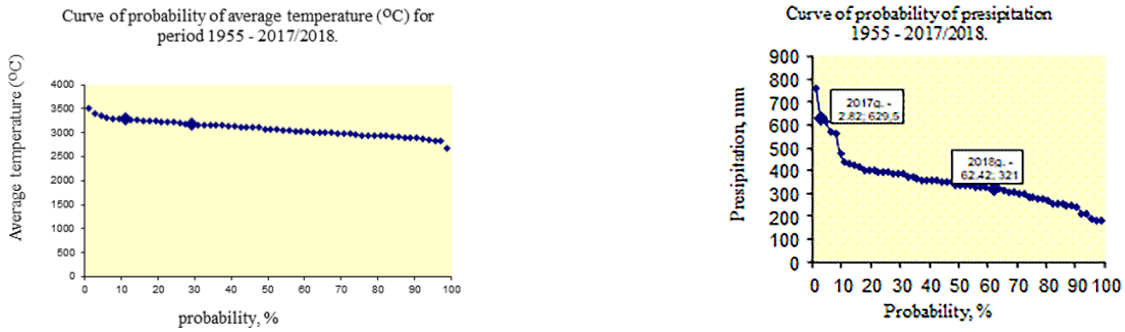

Fig. 2. Provided curves for average daily air temperatures and rainfall for the period 1955 – 2017/2018

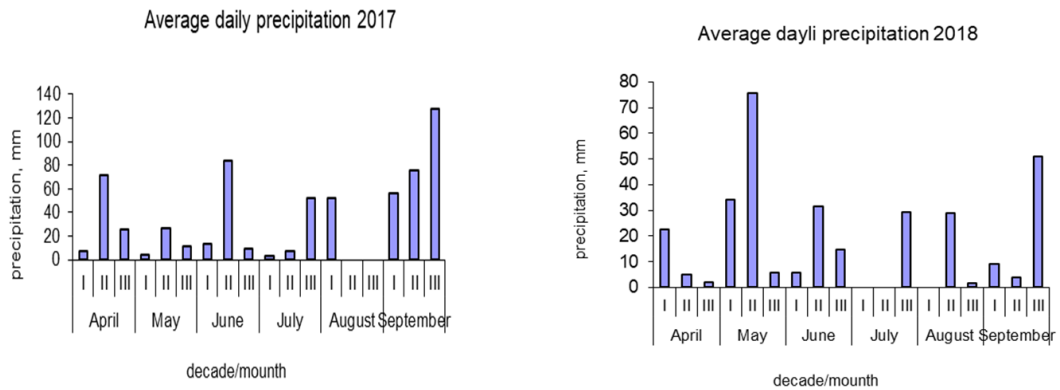

Fig. 3. Distribution of precipitation for the period April – September 2017 – 2018

Phenological research

The 2017 onion set was planted on March 26 and in 24.04.2018 was planted onion sort "Stuttgartrizen". After about two months the onion was ready for green sale. The beginning of bulb growth was about 10.06 (2017) and 25.06 (2018). The yield harvesting during the two experimental years occurred in the first ten days of August 01 – 06 .08. 2017/ 2018. In Table 1 are shown the main phases of cultural development. The seed onions planting later in 2018 had no effect on harvesting. Higher soil and air temperatures in May helped to grow faster than in 2017.

The vegetation period of onion "Stuttgartrizen" variety is 130 (2017) and 110 (2018, on average 120 days.

Irrigation scheduling

In order to ensure normal development of the seed onions to the onion- mature, it is necessary to maintain optimal soil moisture. Pre-humidity outdoor cultivation during different stages of development is different. Soil moisture and air content during germination and intense growth of onion is particularly demanding and it is necessary to maintain over 80 – 90% of PPV. During May-June, when the soil is drought, the growth of onions slows down and this leads to loss of yield. For better development of the bulb after plantings applied irrigation with irrigation rate 10m^3/da. Upon drying of the top layer 0 – 5 cm 3 – 5 days after planting, a second watering is made

Table 1. Characterization of onion phenophase – mature period 2017-2018

Year	Planting	Sprouting	Intense grow	Beginning	Ripening the bulb	
					Start of Head Chapters/ Mass position of the lying stem	Yield collecting
2017	26.03	30.03	20.04	26.05	10.06/15.05	1.08
2018	24.04	29.04	1.05	15.06	25.06/20.07	6.08
FAO56	85/114	89/119	110/121	146/135	161/135//176/201	213/218

regardless of the soil moisture in the lower layers. Better technique for watering is micro-irrigation; it causes a more uniform wetting of the soil surface. Depending on the weather conditions in 2017/2018 1/2 irrigation and 6/6 irrigation were carried out with the three irrigation techniques. In the 100% irrigation option averages over the 2017-2018 period for the vegetation period 6 count with inter-irrigation periods of 10-15 days with irrigation rate for surface drip, subsurface drip and micro-sprinkler were realized respectively 15/13 and 20 m^3/da. At subsoil drip irrigation, decrease in evaporation from the soil surface and a reduction of the irrigation rate by 15% was found compared to the surface position of the irrigation wings. Irrigation decrease variants with 50% of irrigation rate are respectively 7.4 (45) / 6.5 (39) and 20.8 (125) m^3/da (Table 2). Bulb shaping, when the licking stem begins to soften, the irrigations stop and wait 15-20 days to grow the bulb. At 3-4 sheet phases, an ammonium nitrate feed is required, at a rate of 15-20 kg/da (depending on soil chemical characteristics). When manna is observed, preparations are used, e.g. Ridomil Gold 0.25%.

Yield

The magnitude of the yields of the tested variants is irrigated by drip irrigation and micro-sprinkler different. On average for the experimental period 2017/2018 micro-sprinkler irrigation with in the 3-meter planting scheme and a distance between and in the lines of 0.30/0.10, the highest average yield was 3100 kg/da. Irrigated variants with subsurface drip irrigation at a planting scheme of 0.20/0.10 m and traces of 0.50 m 3000 kg/da is in the case of surface drip irrigation 2820 kg/da (Table 4). The irrigation rate decrease with 50% affected the yield in both years. The following average yields were 2680 kg/da in subsurface drip irrigation and 2318 kg/da in surface irrigation. When naturally wetted, a yield of 2170 kg/da was obtained.

Results of the Dispersion Analysis

The betting method in 2017/2018 in Chelopechene experimental field with different irrigation technologies on onion growing is an unconventional two-factor block method with four reps. To demonstrate the impact of the different irrigation standards on yield, the results obtained from the four iterations of the variant were subjected to a dispersion analysis. The significance of the differences obtained and the interaction of the factors was proven. The interaction between the factors of the experiment in terms of the indicators tested is demonstrated by the Fisher criterion in (Table 3).

From the statistical estimations set out in the experiment with different irrigation technologies and different water supply, it can be seen that:

Variants V_2, V_3, V_4 – are significantly different from non-polluting version V_6 – with a confidence level P = 0.1% and are marked with three plus, the difference is very well proven. Option V_5 – 50% has a simple proof (+) with confidence index P = 5%.

In all four irrigation modes, yields are higher than the non-irrigated option. The yield of 100% water supply in both the irrigation wings is high and differs from the non-irrigated variant by 43% and 30%, respectively, which proves that the onion is a moisture-loving crop and in our climatic conditions for better quality and quantity needs irrigation. Reducing irrigation rates by 50% leads to a decrease in yield by 23% (V_3 – 50%) and 7% (V_5 – 50% area).

Table 2. Irrigation scheduling elements for 2017 and 2018

Years	2017			2018			Average for the period 2017/2018		
Variants	Number of irrigation	Irrigate. Norm, m^3/da	Irrigation rate, m^3/da	Number of irrigation	Irrigat. norm, m^3/da	Irrigation rate, m^3/da	Number of irrigation	Irrigat. Norm, m^3/da	Irrigation rate, m^3/da
Subsurface drip Irrigation									
100% irrig. Norm	6	15.0	90	6	10.8	65	6	13	78
50% Irrigate. Norm	6	7.5	45	6	5.4	32.4	6	6.5	39
non-irrigation	0	0	0	0	0	0	0	0	0
Surface drip irrigation									
100 % irrigate. Norm	6	17.0	100	6	12.5	75	6	14.8	90
50 % Irrig. Norm	6	8.5	50	6	6.3	37.5	6	7.4	45
non-irrigation	0	0	0	0	0	0	0	0	0
Micro-sprinkler									
micro-irrigation	6	24.0	140	6	17.5	105	6	20.8	125

Table 3. Dispersion analysis for onion extractionof onion on different irrigation technologies in 2017-2018

Options	Yield	Differences		Proof
2017	kg/da	kg/da	%	
V2 – subs. 100%	3330	919	38	+++
V3 –subs. 50%	3017	606	25	+++
V4 – surface area 100%	3140	729	30	+++
V5 – surface area 50%	2671	260	11	++
V6 – non-irrigated	2410	St.	-	/
$GD_{5\%}$=132.40 kg/da	$GD_{1\%}$=185.63 kg/da	$GD_{0,1\%}$=226.36 kg/da		

Options	Yield	Differences		Proof
2018	kg/da	kg/da	%	
V2 -100% subs. Irrig.	2 855	924	48	+++
V3 – 50% subs. irrig.	2 342	411	21	+++
V4 – surface area 100%	2 504	573	30	+++
V5 – surface area 50%	1 964	33	2	+
V6 – non-irrigated	1 931	St.	-	/
$GD_{5\%}$=114.60 kg/da	$GD_{1\%}$=160.68 kg/da	$GD_{0,1\%}$=227.10 kg/da		

Conclusions

In the conditions of moderately humid and very dry years 2017/2018 for the optimal yield of onion, 6 number were made during the vegetation period and with the three irrigation technologies (subsurface, surface drip irrigation and micro-sprinkler) with irrigation norms 13, 15 and 20 m^3/da

Subsurface drip irrigation SDI has a better effect on the development of green onions, but in the case of micro-sprinkling irrigation in both years the productivity is higher. Its yield is 3100 kg/da, followed by 100% irrigation subsurface drip irrigation 3000 kg/da and surface drip irrigation – 2820 kg/da, in non-irrigated variant 2170 kg/da.

Lowering the irrigation rate by 50% resulted in decreased yields of 23% and 7%. In case of a water deficit, this mode can be applied.

The yield of 100% water supply in both ways of laying the irrigation wings is high and differs from the non-irrigated version by 43% and 30% respectively, which proves that the onion is a moisture-loving crop and under our climatic conditions for better quality and quantity needs irrigation.

The difference in soil moisture in the layer 0 – 30 cm in subsurface drip irrigation compared to the surface drip irrigation is in the order of 20-30%.

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