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Features of regimens of drip ir-rigation of cultivated crops.

The purpose. To improve and scientifically ground drip irrigation regimes of tilled crops in the steppe zone of Ukraine**.**

Methods. Field short-time experi-ments, generally accepted laboratory methods and mathematical statistics methods.

Results. Effect of the elements of drip irrigation technology on soil water regime, water consumption and productivity of tilled crops was studied; mechanisms of water regimes formation, water consumption, productivity as well as the dependence «water consumption-yield» when using drip irrigation for tilled crops were determined.

Concluslon. Optimal parameters of drip irrigation regimes for tilled crops in the steppe zone of Ukraine were scientifically proved.

Key words: technology, drip irrigation, tilled crops, irrigation regime, yield, water consumption .

Unfavorable water regime of the soil is the main limiting factor that constrains the implementation of the agro-resource potential in the steppe zone. Today there are many measures aimed at minimizing the negative effects of droughts, but the most effective, as practice shows, are irrigation melioration. During the rapid development of land reclamation (1966-1990), the area of irrigated land in Ukraine was brought to 2.62 million hectares, that is, every 5th hectare of afternoon arable land was irrigated. In the period of the economic crisis of 1990-2000, the actual area of irrigation decreased sharply to 0.58 - 0.69 million hectares, which corresponds to 1966 - 1968, in 2014 - to 0.49 million hectares (excluding the Crimea) . However, we note that this reduction concerns so-called large irrigation - spillage [11]. Instead, the area under drop irrigation increased from 4.5 thousand hectares (2000) to 75.5 thousand hectares (2014), of which 46.5 thousand hectares are under cultivating crops [12]. The advantages of drip irrigation before traditional irrigation methods (spray, surface watering) are known for a long time. It should be noted that due to the compatibility of drip irrigation technologies with two interrelated conditions for sustainable development - high economic efficiency and environmental safety - it has become widely used for the irrigation of vegetable, fruit crops and grape fields. In recent years, more and more drip irrigation has begun to be used in such crops as corn, soybean, sugar beet, sunflower, and others. [4, 5].

However, it should be noted that producers, using intensive technologies for growing dip irrigation, do not always get the desired effect.

1. Objects (geography of research) and types of agricultural crops

Установа	Місцезнаходження, ґрунтово-кліматична зона	Сільськогосподарська культура, роки досліджень
Кам'янсько-Дніпровська дослідна станція ІВПіМ НААН	м. Кам'янка-Дніпровська Запорізької обл., підзона Степова південно-центральна засушлива	Морква (2004–2006), картопля (2006–2010), перець і баклажан розсадні (2010–2013), буряк цукровий (2010–2014), кукурудза (2012–2014), соя (2010–2014)
ДП «ДГ «Брилівське» ІВПіМ НААН	с. Привітне Цюрупинського р-ну Херсонської обл., Степ Сухий	Томат розсадний (2009–2011), цибуля ріпчаста (2011–2013), кукурудза (2012–2014), буряк цукровий (2012–2014)
ДП «ДГ «Великі Клини» ПДСГДС ІВПіМ	с. Великі Клини Голопристанського р-ну Херсонської обл., Степ Сухий	Кавун (2006–2008)

The fact that drip irrigation involves radical changes in the main components of agrotechnology: irrigation regimes, fertilizer and plant protection systems, sowing schemes, as well as sowing and harvesting techniques and technology. At the moment, these elements are not yet completely exhausted and scientifically grounded for the soil-climatic conditions of the Steppe. The purpose of the research is to improve and scientifically substantiate the modes of drip irrigation of sprout crops under the conditions of the Steppe. Materials and methods of research. Field investigations were carried out in the stationary experiments of the Kamiansk-Dneprovskaya SDI IVPiM NAAN, the Brilovsky reference point of the IVPiM NAAN (on the lands of the State Enterprise "DG Brilovskoe" IVPiM NAAN) and the Southern SSGDS of the IVPiM (on the lands of the State Enterprise "Velikie Klini") in 2004 - 2014 for 10 cultivated crops (Table 1). Field studies were carried out on typical soils for a specific zone. To determine and clarify the properties and characteristics of soils on experimental sites, twice a year (in the fall and spring), samples were taken and ground sections in accordance with DSTU 4287 [15] (Table 2). Studies on the study of the water regime of the soil were of a systematic nature. They were conducted according to a single scheme: the patterns of formation of drip irrigation regimes and water consumption were established by the implementation of one-factor experiments with different levels of pre-soil moisture (RPVG). The control was a variant with natural moisture supply, the scheme then contained variants with moderate irrigation (60-70% of HB), potentially optimal variants of humidification (70-90% of HB, in particular with differentiated prefill thresholds) and variants with intense irrigation (95 - 100% HB) that potentially reflected the inhibitory (redundant) part of the response curve on a one-factor experiment.

2. Summary data of water-physical and agrochemical properties of soils of experimental areas (soil layer 0-50 cm)

Дослідна ділянка	Ґрунтова відміна	Щільність складання, т/м^3	НВ від маси	Уміст, мг/100 г ґрунту			
				гумусу,%	N л. г.	P_2O_5	K_2O
КДДС	Чорнозем звичайний середньосуглинковий	1,37	18,8	1,70	7,2	51,5	15,8
ДП «ДГ «Брилівське»	Темно-каштановий легкосуглинковий	1,47	16,5	1,44	7,0	32,3	9,3
ДП «ДГ «Великі Клини»	Чорнозем осолоділий супіщаний	1,41	13,7	1,25	7,3	19,2	7,6

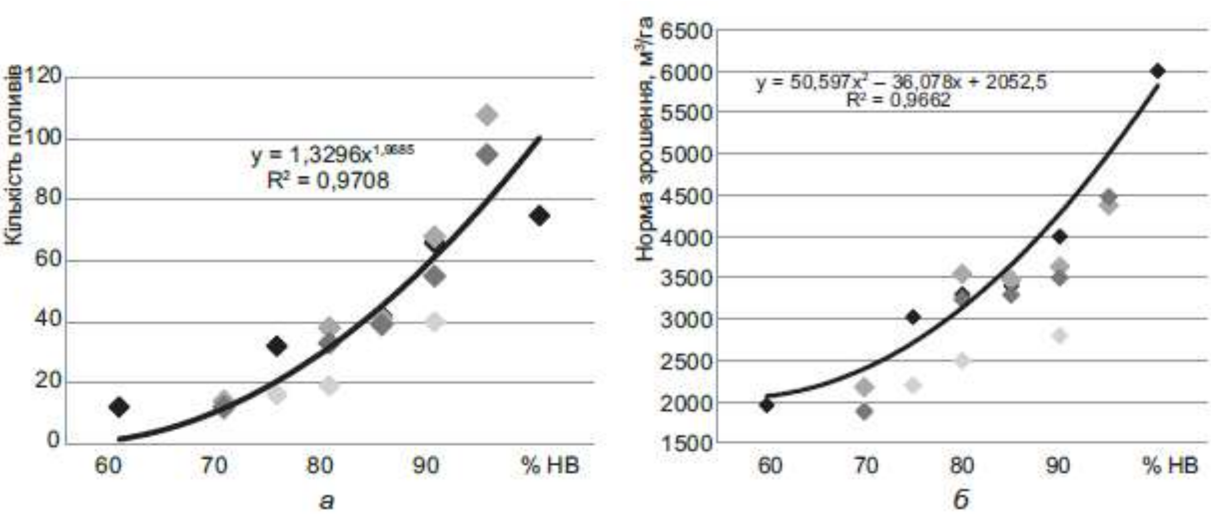

Fig. 1. Dependences of the number of vegetative irrigation (a) and the rate of drip irrigation (b) on the level of pre-soil moisture

In addition, in 2014, on the lands of the State Enterprise "DG" Brilovskoe ", the IVPiM NAAN in a corn culture conducted a search experiment aimed at comparing different methods for determining total evaporation. Placement of experimental sites - systematic, repetition - 4-time [1]. Tensiometric sensors of the VVT-I type, which were installed at different depths of the soil profile and distance from the point of water supply, were used to determine the dates of irrigation and to study water consumption (except for the experiment where this factor was studied) [13, 14]. In order to conduct surveys and observations, generally accepted [1, 3, 9] and improved [6] for conditions of drip irrigation methodology. Research results. It has been experimentally established that the greatest influence among other factors on the formation of irrigation regime was RPVG. It was recorded that with an increase in RPVG from 80 to 90% of HB, the amount of vegetative irrigation and irrigation rate respectively increase by 45% or 25 pcs. and by 42%, or 900 m3 / ha (Fig. 1). The regime of drip irrigation is closely related to the meteorological parameters that directly affect the physical evaporation and transpiration: the amount of precipitation, temperature and relative humidity of the air and wind power. However, the clearest correlation dependence "drip irrigation regime - meteorological parameters" is established only by the factor "amount of atmospheric precipitation". In particular, it was recorded that the effect of rainfall is greater, the lower the RPV: for maintaining the pre-oil threshold of 60%, the difference in the norm of irrigation (or the number of irrigation) between the years from 50% and 75% in the provision of precipitation was 42%; for 70% HB -36; 80% HB - 25; 85% HB - 22; 90% HB - 17 and HB - 7% (Fig. 2). The inflationary period is reduced also with the increase of the temperature regime. However, such a pattern is clearly traceable only during periods of abnormal heat. For example: in August, the duration of the interflood period for maintaining the RPVG of 80% HB is 3.5 to 5.5 days depending on the culture, and in periods with abnormally high daily average temperatures of 29-30 ° C (maximum - 39.0 - 40.5 ° C) Interflood period is reduced to 1 - 2 days.

An important result of the research is the established correlation between the total consumption of crops and their yield. On this basis, for the first time, the dependence of "water consumption - yield" was constructed for the first time for the conditions of drip irrigation and the most effective (optimal) variants of water use by plants were determined in relation to its costs for the formation of a product unit (Fig. 3). These dependences are the response curves for a single-factorial experiment, they consist of 3 parts: limiting, stationary (optimal) and inhibitory (superfluous). The determination coefficient R2 = 0,81-0,98 indicates a close relationship between these values. It has been established that the limiting part of the curve corresponds to the variants of the experiment with RPV 60-

75% HB and the variant without irrigation (control), stationary (optimum zone) - 75 - 90% HB, inhibitory (excess zone) - from 95% HB to the total moisture content of the soil . The established dependence of "water consumption - productivity" in relation to agrobiology is not sustainable, since there are opportunities for increasing yields for the same standards of water consumption of plants. Therefore, the main task of future studies on the study of water consumption processes is the reduction of unproductive water consumption (for physical evaporation, dumping in lower horizons of soil) while increasing the productivity of agricultural crops. The generalized experimental data on the study of drip irrigation regimes indicate that for most agricultural crops, the lower critical humidity threshold is 80% HB (Table 3). It should be noted that the optimal range of moisture of the lungs and medium loams for sprouting cultures is a rather narrow interval - 85 - 95% of HB, which provides irrigation with relatively small norms, while simultaneously reducing the abjection periods. According to analytical calculations, it is within this narrow range that the ratio of actual transpiration (T) to the potentially possible (To) approaches 1 (≈ 0.83-0.87), which characterizes the moisture supply of plants as close to optimal [7]. The obtained results are the refinement of the above-stated provisions [10], where it was noted that the optimum lower limit of moisture of heavy-soot soil is 75-80% of HB, medium and loose-bulk - 65-70% of HB and suppository - 65% HB, and confirmation of data G.A. Garyugina [2].

3. In the general parameters of drip irrigation regimes of perennial crops

Культура	Оптимальний РПВҐ, % НВ	Кількість поливів	Норма зрошення	Сумарне водоспоживання	Коефіцієнт водоспоживання, м³/т	Урожайність, т/га
			м³/га			
Томат розсадний	80–85–70	40	3450	4950	32,7	151,9
Перець солодкий	90–80	42	3655	5020	74,9	67,0
Баклажан	85	53	4085	5330	112,7	47,3
Кавун	75	15	1200	2600	48,4	45,4
Морква	80–70	20	3325	5075	72,6	69,8
Цибуля ріпчаста	90	42	3500	4610	80,4	57,3
Картопля рання	80	17	1250	2300	84,9	27,1
Кукурудза на зерно	90	29	4400	6500	357,1	18,2
Соя	80	31	5400	6900	1112,9	6,22
Буряк цукровий	90	23	3840	5400	44,5	121,4

4. Cyclic periods of moisture content of crop crops for dropping irrigation

Сільськогосподарська культура	Критична фаза або період розвитку
Томат розсадний	Бутонізація — цвітіння
Перець солодкий розсадний	Цвітіння — зав'язування плодів
Баклажан розсадний	Цвітіння — зав'язування плодів
Кавун	Цвітіння — зав'язування плодів
Картопля рання	Бутонізація — цвітіння
Кукурудза на зерно	Декада до викидання волоті — цвітіння — декада після цвітіння
Соя	Бутонізація — цвітіння

It is natural that maintenance of high humidity leads to an increase in physical evaporation and transpiration. This increases irrigation rates (Table 3), which make up 3.3 to 4.1 thousand m3 / ha of vegetables, and 3.8-5.4 thousand m3 / ha of cultivated crops. On the basis of these data, we refine the thesis on "saving of irrigation water for drop irrigation". The bottom line is that practically the same volumes of water supply for local irrigation form 1,5 to 3,5 times higher yields, this gives grounds to say only about the saving of specific water consumption for the formation of a unit of harvest. The differentiation of the RPV in the development phases has confirmed the existence of critical periods in the life of plants, during which even a slight decrease in soil moisture beyond the optimal range leads to significant losses of the crop. It has been established that the highest sensitivity to the reduction of available moisture in the soil of the plant is felt during the period of formation of the bodies of fruiting or the period preceding it (Table 4). A new scientific result is the confirmation of the hypothesis [8] that in 2-year-old plants (onions, carrots, sugar beet) in the first year of life there is no clearly expressed critical period regarding moisture content. At the same time, even in the 1 st year of life, when we grow these plants for productive organs, we observe their uneven resistance to the decrease of moisture content of the soil in different phases of development. For example, for carrots and sugar beets, such a relatively "sensitive" but not critical period is the intensive growth of root crops. The research confirms the general patterns of formation of water consumption: the minimum amount of moisture is consumed by plants in the beginning of the vegetation, it gradually increases with the development of their aboveground mass and again decreases until the end of the vegetation. Peak indicators of water consumption of plants are recorded in the hottest periods that calendar, as a rule, coincide with the second - third decades of July - I - II decades of August. The maximum daily water consumption is fixed at 9-12 mm in the conditions of the Dry Steppe and 8-11 mm for the conditions of the Southern-Central steppe. Such parameters should be oriented towards the designing institutions, since the irrigation system should technically and technologically ensure the water consumption of crops in all phases of their development. The results of the 2014 exploratory study, aimed at comparing instrumental (with the help of mortgage sensors) and estimated calculations of water consumption, indicate that the available calculation methods Penman-Monteith, AM and SM Alpatyevyh, D.A. Stoiko, MM Ivanov reflects the actual dynamics of water consumption.

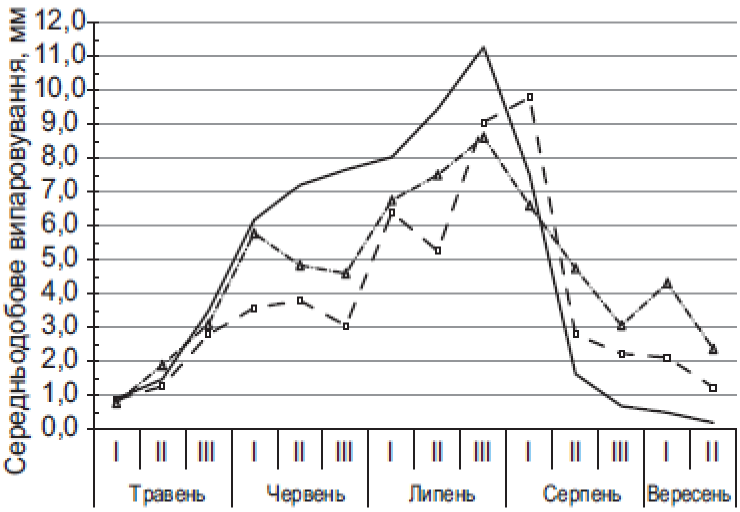

Fig. 4. The partial dynamics of the total water consumption of corn for drip irrigation, determined by calculation (by AM and SM A. lpatievyh and DA Shtekenko) and instrumentally (strain gauges): - actual; - by the method of AM and SM Alpathev - by D.A. Stoiko

However, it is established that all calculated methods underestimate the actual evaporation rates in the middle of the vegetation and somewhat overestimate them at the end of the vegetation (Fig. 4). The preliminary results obtained in this experiment require further refinement and verification. Calculated methods for determining total evaporation do not fully correspond to the characteristics of drip irrigation, therefore, need to be clarified for conditions of local humidification and specific soil-climatic conditions. The most logical method of their "adaptation" is the correction of the biological coefficients of culture based on actual experimental data on water consumption in different phases of plant development

Conclusions

The obtained dependences of "water consumption - yield" for drop irrigation are the response curves for one-factor experiment. They have the form of an asymmetric parabola, which is described by a quadratic equation. Determination coefficient R2 = 0,81-0,98 indicates a close relationship between water consumption and yield. It has been established that the optimal range of humidification of light and medium loams for sprouting cultures is a narrow interval of 85-95% of HB, which provides for irrigation with small norms, while simultaneously reducing betweenflood periods. In this case, the ratio of the actual transpiration (T) to the potentially possible (To) approaches 1 (≈ 0.83-0.87), which characterizes the moisture-supplying of the plants as close to optimal. It was recorded that the maximum values of daily water consumption of cultivated crops for drip irrigation are in the conditions of the Dry Steppe 9-12 mm, the Southern-central steppe is 8-11 mm.

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