

UDC 631.53.01:633.3:631.5(477.7)

DOI <https://doi.org/10.32851/2226-0099.2020.116.2.13>

WATER CONSUMPTION BY ANNUAL SWEET CLOVER PLANTS (PIVDENNY VARIETY) DEPENDING ON SOWING DATES AND RATES UNDER THE CONDITIONS OF THE SOUTHERN UKRAINIAN STEPPE

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The article presents the results of research on the influence of sowing dates and sowing rates on water consumption by the Pivdenny variety of annual sweet clover plants. It has been established that in the conditions of the Southern Ukrainian steppe on dark chestnut soils it is impossible to obtain high crop seed yield without using the adjusted sowing dates and sowing rates. Improving moisture conditions and using optimal sowing dates and seeding rates we increase yields and reduce the water consumption by clover. The observations showed that the total water consumption varies depending on the time of sowing and sowing rates. It has been established that the water consumption by sweet clover plants, Pivdenny variety, depended on precipitation and reserves of productive moisture in the soil.

On average over the years of research, total water consumption from the 0-100 cm soil layer was 3094 m³/ha when sowing in the third ten-day period of March, 3182 m³/ha when sowing in the first ten-day period of April and 3278 m³/ha when sowing in the second ten-day period of April. Under such conditions moisture was most effectively used by plants in the first ten-day period of April, when the water consumption coefficient ranged from 463 to 490 m³/c. Among the sowing dates considered, on average for the years of research, the maximum total water consumption of 3273-3283 m³/ha was on sowing in the second ten-day period of April, in this case the water consumption coefficient ranged from 502 to 670 m³/c. The lowest total water consumption was 2127 m³/ha at the optimal sowing rate of 2.5 million units/ha. Among the sowing rates only in 2015 the total water consumption by sweet clover plants was 4387 m³/ha due to productive precipitation, its total amount for the entire growing season being 3153 m³/ha, i.e. 315.3 mm.

Summarizing the above results, we can conclude that the best yield of annual sweet clover, Pivdenny variety, was obtained when sowing in the first ten-day period of April at the sowing rate of 2.5 million units/ha. Thus, on average for 2015-2017 research, the maximum yield (876.7 kg/ha) was obtained when sowing in the first ten-day period of April at sowing rates of 2.5 million units/ha. The favorable agro-climatic indicators in 2015 contributed to the annual sweet clover seed yield maximum value (1130 kg/ha) when sowing in the first ten-day period of April at sowing rates of 2.5 million units/ha.

Key words: sweet clover, variety, sowing date, sowing rate, seeds, yield.

Шапарь Л.В., Влащук А.М., Місевич О.В., Конащук О.П. Водоспоживання рослин буркуну білого однорічного сорту Південний залежно від строків сівби та норм висіву насіння в умовах Південного Степу України

У статті наведено результати досліджень впливу строків сівби та норм висіву насіння на водоспоживання рослин буркуну білого однорічного сорту Південний. Встановлено, що в умовах Південного Степу України на темно-каштанових ґрунтах не можли-

вим є отримання високої урожайності насіння культури без застосування коригованих строків сівби та норм висіву насіння. Поліпшення умов вологозабезпечення, використання оптимальних строків сівби та норм висіву сприяють підвищенню урожайності та зниженню коефіцієнту водоспоживання буркуну. Проведені спостереження показали, що сумарне водоспоживання посівів культури змінюється залежно від строку сівби та норм висіву. Встановлено, що водоспоживання рослин буркуну білого сорту Південний відбувалося за рахунок атмосферних опадів та запасів продуктивної вологи із ґрунту.

У середньому за роки досліджень на посівах рослин із шару ґрунту 0-100 см сумарне водоспоживання складало 3094 м³/га за сівби у третю декаду березня, 3182 м³/га – за сівби у першу декаду квітня і 3278 м³/га – за сівби у другу декаду квітня. В таких умовах найефективніше волога використовувалася рослинами у першу декаду квітня, коли коефіцієнт водоспоживання коливався від 463 до 490 м³/ц. Серед досліджуваних строків сівби в середньому за роки досліджень максимальний показник сумарного водоспоживання 3273-3283 м³/га було встановлено за сівби у другу декаду квітня, коефіцієнт водоспоживання при цьому коливався від 502 до 670 м³/ц. Найменше сумарне водоспоживання 2127 м³/га було за оптимальної норми висіву 2,5 млн шт./га. Серед норм висіву насіння тільки у 2015 році загальне сумарне водоспоживання рослин буркуну білого 4387 м³/га було більшим за рахунок продуктивних опадів, загальна кількість яких за весь вегетаційний період культури становила 3153 м³/га, тобто 315,3 мм.

У середньому за 2015-2017 роки проведення досліджень максимальний показник урожайності – 876,7 кг/га отримано за сівби у першу декаду квітня за норми висіву 2,5 млн шт./га. За сприятливого за агрокліматичними показниками 2015 року урожайність насіння буркуну білого однорічного набула максимального значення – 1130 кг/га за сівби у першу декаду квітня за норми висіву 2,5 млн шт./га.

Ключові слова: буркун білий, сорт, строк сівби, норма висіву, насіння, урожайність.

Problem statement. Getting high yields of both winter and spring crops in the southern steppe of Ukraine is restrained by the availability of soil water, which is vital for physiological and growth processes that intensively affect the yields [1–5].

Annual sweet clover is a crop that makes full use of the spring-summer supply of soil moisture. To establish the total water consumption by sweet clover plants during the whole growing season, the reserves of productive moisture in the soil in the periods before sowing and before harvesting were determined, and the amount of precipitation for the entire growing season was added to them. It is known that the value of total water consumption is influenced by meteorological conditions, sowing density, agricultural technology, the field moisture content. That is why the indicators of total water consumption by the same crop in different areas at different sowing dates and sowing rates differ.

Analysis of recent research and publications. The water regime of the Ukrainian steppe soils belongs to the nonleaching type, its characteristic feature being a significant deficit of moisture during the entire growing season. Under such conditions, plants suffer more from insufficient moisture or drought than from other natural factors. Lack of moisture during the plant vegetation period leads to adverse changes in physiological processes, disruption of normal metabolism. During drought period in order to survive in extreme conditions, plants use soil moisture more economically, which causes a decrease in productivity because there is a direct relationship between crop yields and soil moisture levels. Therefore, in the steppe zone moisture is one of the main factors influencing seed yields [6; 7].

Task setting. The task of the research was to study the water consumption by the *Pivdenny* variety annual sweet clover plants depending on the studied factors and their effect on seed productivity. The research was conducted in the experimental field at the Institute of Irrigated Farming, NAAS, in 2015-2017 in accordance with the requirements of generally accepted research methods complying with IPA 22 “Scientific basis of feed production, storage and use for obtaining competitive livestock products (“Feed and feed protein”)” [8; 9; 10; 11].

The experiment covers two-factors and four-time repetition, it was carried out by split sites method, the placement of variants was randomized. The accounting area is 25 m². In the experiment we used the seeds of the *Pivdenny* variety annual sweet clover, the Institute of Irrigated Farming, NAAS, being the originator. According to the experiment scheme, the seeds of the annual sweet clover were sown in the first term (the third ten-day period of March); the second term (the first ten-day period of April) and the third term (the second ten-day period of April), at the sowing rates of 1.5-2.5-3.5 million units/ha.

Presentation of the main research material. The water consumption coefficient is one of the criteria for assessing the productivity of moisture use, which shows the amount of water consumed by plants for the formation of 1 centner of white clover seeds. Improving moisture conditions and using optimal sowing dates and seeding rates increase yields and reduce the water consumption by clover. The observations showed that the total water consumption varies depending on the time of sowing and sowing rates (table 1).

Table 1

Total water consumption by sweet clover plants, *Pivdenny* variety, depending on the timing of sowing from the soil layer of 0-100 cm, m³/ha

A factor, sowing time	Year	Total water consumption, m ³ /ha	Moisture consumption, m ³ /ha			
			soil reserves		precipitation	
			m ³ /ha	%	m ³ /ha	%
Third ten-day period of March	2015	4278	1125	26	3153	74
	2016	2982	1298	43	1684	57
	2017	2021	1065	50	1065	50
	average	3094	1163	40	1967	60
First ten-day period of April	2015	4433	1280	29	3153	71
	2016	3008	1324	44	1684	56
	2017	2106	1150	50	1150	50
	average	3182	1251	40	1996	60
Second ten-day period of April	2015	4449	1296	29	3153	71
	2016	3117	1434	46	1684	54
	2017	2267	1311	50	1311	50
	average	3278	1347	40	2049	60

It has been established that the water consumption by sweet clover plants, *Pivdenny* variety, depended on precipitation and reserves of productive moisture in the soil. In the year of 2015 which was favorable for sweet clover as to the moisture reserves, the total water consumption was the greatest which subsequently resulted in the increase of seed productivity due to increased plant height, and leaf surface area. On average over the years of research, total water consumption from the 0-100 cm soil layer was 3094 m³/ha when sowing in the third ten-day period of March, 3182 m³/ha when sowing in the first ten-day period of April and 3278 m³/ha when sowing in the second ten-day period of April.

The results obtained indicate that the total water consumption by plants was 53-74% dependent on the precipitation during the growing season. Under such conditions moisture was most effectively used by plants in the first ten-day period of April, when the water consumption coefficient ranged from 463 to 490 m³/c (table 2).

Table 2

**Water consumption by the *Pivdenny* variety sweet clover crop
depending on sowing dates and sowing rates, average for 2015-2017**

A factor, sowing time	B factor, sowing rate, mln pc/ha	Productive moisture reserve at the time of germination, m ³ /ha	Productive moisture reserve at the time of harvesting, m ³ /ha	Precipitation during the vegetation period, m ³ /ha	Total water consum- ption, m ³ /ha	Water consum- ption coefficient, m ³ /c
3 rd ten-day period of March	1.5	1919	761	1931	3089	471
	2.5	1919	758	1931	3092	438
	3.5	1919	750	1931	3100	613
1 st ten-day period of April	1.5	1994	746	1931	3179	436
	2.5	1994	743	1931	3183	363
	3.5	1994	740	1931	3186	490
2 nd ten-day period of April	1.5	2089	747	1931	3273	561
	2.5	2089	743	1931	3277	502
	3.5	2089	737	1931	3283	670

Among the sowing dates considered, on average for the years of research, the maximum total water consumption of 3273-3283 m³/ha was on sowing in the second ten-day period of April, in this case the water consumption coefficient ranged from 502 to 670 m³/c. This is due to the fact that the rise of the above-zero air temperature and the availability of moisture caused an intensive growth of sweet clover plants. It was determined that on average for the 2015-2017 research, the productive soil moisture reserve was 1919-2089 m³/ha at the time of crop germination, which later resulted in obtaining high-grade shoots.

Among the sowing dates considered the moisture was most rationally used by sweet clover plants which were sown in the first ten-day period of April as evidenced by the water consumption coefficient of 363-490 m³/c. The sowing rate also influenced the total water consumption of sweet clover plants (table 3).

The lowest total water consumption was 2127 m³/ha at the optimal sowing rate of 2.5 million units/ha. Greater number of sweet clover plants increased water consumption which resulted in higher total water consumption. Among the sowing rates only in 2015 the total water consumption by sweet clover plants was 4387 m³/ha due to productive precipitation, its total amount for the entire growing season being 3153 m³/ha, i.e. 315.3 mm.

It should be noted that among the sowing rates under study, on average over the years of the research, the greatest use of productive moisture by sweet clover plants was from precipitation, its share making 44-72%. The largest differences in the efficiency of productive moisture were observed in 2016 and 2017, when sweet clover plants used productive moisture from both soil reserves and precipitation (44-56 m³/ha). The water consumption coefficient was also affected by sweet clover plant density. The lowest water consumption coefficient was with the optimal placement of plants per unit area, which contributed to the formation of the maximum sweet clover seed yield, which averaged 7.45 c/ha (745.5 kg/ha).

Summarizing the above results, we can conclude that the best yield of annual sweet clover, *Pivdenny* variety, was obtained on sowing in the first ten-day period of April at the sowing rate of 2.5 million units/ha. It should be noted that 2015 was the most favorable in terms of moisture, which ensured the subsequent highest seed productivity of sweet clover plants.

Table 3

Total water consumption by the *Pivdenny* variety sweet clover plants from the soil layer of 0-100 cm depending on various sowing rates, m³/ha

B factor, sowing rate, mln pc/ha	Year	Total water consumption, m ³ /ha	Moisture consumption, m ³ /ha			
			soil reserves		precipitation	
			m ³ /ha	%	m ³ /ha	%
1.5	2015	4387	1233	28	3153	72
	2016	3026	1342	44	1684	56
	2017	2129	1175	55	956	45
	average	3181	1250	42	1524	58
2.5	2015	4387	1233	28	3153	72
	2016	3038	1354	44	1684	56
	2017	2127	1172	55	956	45
	average	3184	1253	42	1524	58
3.5	2015	4387	1228	28	3153	72
	2016	3045	1340	44	1684	56
	2017	2138	1176	55	956	45
	average	3190	1248	42	1524	58

Thus, on average for 2015-2017 research, the maximum yield (876.7 kg/ha) was obtained when sowing in the first ten-day period of April at sowing rates of 2.5 million units/ha. The favorable agro-climatic indicators in 2015 contributed to the annual sweet clover seed yield maximum value (1130 kg/ha) when sowing in the first ten-day period of April at sowing rates of 2.5 million units/ha (table 4).

Table 4

***Pivdenny* variety annual sweet clover seed yield depending on the sowing dates and sowing rates**

A factor, sowing time	B factor, sowing rate, mln pc/ha	Yield, kg/ha				Average for factor, kg/ha	
		2015	2016	2017	Average for 2015-2017	A	B
1	2	3	4	5	6	7	8
3 rd ten-day period of March	1.5	840	790	340	656.67	623.33	656.67
	2.5	900	830	390	706.67		745.56
	3.5	630	580	310	506.67		548.89
1 st ten-day period of April	1.5	920	860	410	730.00	752.22	
	2.5	1130	1010	490	876.67		
	3.5	850	720	380	650.00		
2 nd ten-day period of April	1.5	790	670	290	583.33	575.56	
	2.5	830	810	320	653.33		
	3.5	630	570	270	490.00		
Assessment of partial differences significance							
LED05, kg/ha	A	39.08	29.41	21.05	15.40		
	B	49.13	20.52	25.16	21.30		

Table 4 (Continued)

1	2	3	4	5	6	7	8
Assessment of average main effects significance							
LED05 kg/ha	A	22.56	16.98	12.15	8.90		
	B	28.36	11.85	12.58	12.30		
Proportion of factor impact, %							
	A	41.4	32.1	95.7	44.1		
	B	49.6	64.0	2.4	51.9		
	AB	5.7	3.1	1.1	2.9		

On average, by A factor, the maximum yield of 752.2 kg/ha was achieved when sowing in the first ten-day period of April (fig. 1).

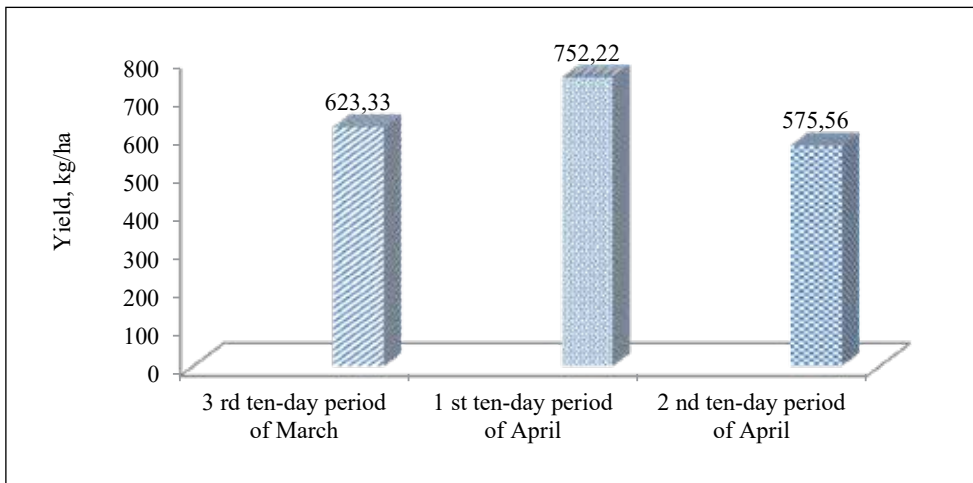


Fig. 1. Indicators of the Pivdenny variety sweet clover seed yield at different sowing dates, kg/ha (average for 2015-2017)

Among the studied sowing rates the maximum seed yield of 745.5 kg/ha was achieved at the sowing rate of 2.5 million units/ha (fig. 2).

On average, for 2015-2017 research, it was determined that, from a biological viewpoint, the best sowing time for growing sweet clover for seeds in the southern steppe of Ukraine is the first ten-day period of April at the sowing rate of 2.5 million units/ha.

Conclusions. Thus, we can conclude that under the Ukrainian southern steppe conditions on dark chestnut soils the seed productivity of annual sweet clover plants mainly depends on the meteorological conditions.

The research materials obtained show that the total water consumption by sweet clover plants depended mainly on the precipitation during the growing season (44-72%). In such conditions, most effectively the moisture was used by crops sown in the second sowing period (the first ten-day period of April) when the water consumption coefficient ranged from 363 to 490 m³/c. Therefore we can state that the Pivdenny variety sweet clover plants used soil moisture most effectively when sown in the first ten-day period of April at the sowing rate of 2.5 million units/ha. This cultivation method has prospects for its implementation on irrigated lands.

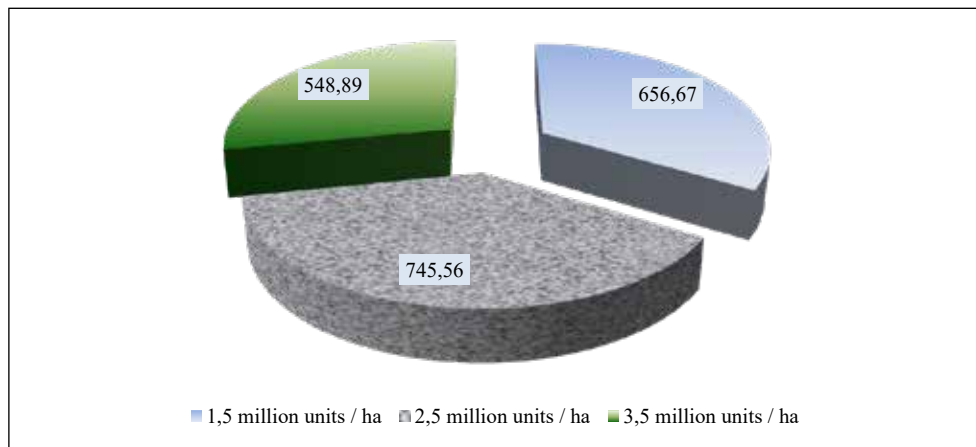


Fig. 2. Indicators of the Pivdenny variety sweet clover seed yield at different sowing rates, kg/ha (average for 2015-2017)

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