INDIAN JOURNAL OF *ECOLOGY*

ISSN 0304-5250

Volume 46 Issue-3 September 2019

THE INDIAN ECOLOGICAL SOCIETY

INDIAN ECOLOGICAL SOCIETY

(www.indianecologicalsociety.com)
Past resident: A.S. Atwal and G.S.Dhaliwal
(Founded 1974, Registration No.: 30588-74)

Registered Office
College of Agriculture, Punjab Agricultural University, Ludhiana – 141 004, Punjab, India
(e-mail : indianecologicalsociety@gmail.com)

The Indian Journal of Ecology is an official organ of the Indian Ecological Society and is published six-monthly in June and December. Research papers in all fields of ecology are accepted for publication from the members. The annual and life membership fee is Rs (INR) 800 and Rs 5000, respectively within India and US $ 40 and 800 for overseas. The annual subscription for institutions is Rs 5000 and US $ 150 within India and overseas, respectively. All payments should be in favour of the Indian Ecological Society payable at Ludhiana. See details at web site.

KEY LINKS WEB

site:http://indianecologicalsociety.com
Membership:http://indianecologicalsociety.com/society/memebership/
Manuscript submission:http://indianecologicalsociety.com/society/submit-manuscript/
Status of research paper:http://indianecologicalsociety.com/society/paper-status-in-journal-2/
Abstracts of research papers:http://indianecologicalsociety.com/society/indian-ecology-journals/

Indian Journal of Ecology (2019) 46(3): 594-598

Manuscript Number: 2883
NAAS Rating: 4.96

Dependence of Winter Wheat Yielding Capacity on Mineral Nutrition in Irrigation Conditions of Southern Steppe of Ukraine

Ye. Domaratskiy, O. Berdnikova, V. Bazaliy, V. Shcherbakov[1], V. Gamayunova[2], O. Larchenko, A. Domaratskiy and I. Boychuk

Kherson State Agrarian University, Stretenskaya St., 23, Kherson, 73006, Ukraine
[1]Odessa State Agrarian University, Panteleimonovskaya St., 13, Odessa, 65012, Ukraine
[2]Mykolayiv National Agrarian University, Georgiya Gongadze Str., Mykolayiv, 9, 54020, Ukraine
E-mail: jdomar1981@gmail.com

Abstract: This article is dedicated to the research of dependence of growth and development of winter wheat varieties Khersonska Awnless and Odeska 267 on conditions of moisture provision and mineral nutrition status, impact of indicated factors yielding capacity and grain quality. Years of research significantly varied in rainfall amount during growing season. According to moisture supply, 2016 was dry, 2017 was average humid and 2018 was subhumid, which had an impact on grain yield. The lowest winter wheat productivity level was f in 2016. Under supplemental watering without fertilizers the yield of the Khersonska Awnless variety was 2.07 t ha^{-1}, and of Odeska 267 variety - 1.51 t ha^{-1}. Under provision of vegetative watering, the yielding capacity increased to 3.14 and 2.94 t ha^{-1}. Fertilizers also had significant impact on production processes of plants, accumulation of over ground biomass, and area of assimilating surface that resulted in the yield increase of winter wheat. On average, the most significant factors were fertilizers (43%), irrigation (32%) and variety of winter wheat (9%).

***Keywords*:** Soft winter wheat, Varieties, Calculated fertilizer dose, Yielding capacity, Irrigation, Photosynthetic potential

In order to receive high and sustainable crop yields, it is necessary to provide favourable conditions for their growth and development throughout the whole growing season considering biological peculiarities of a crop. Soil nutrient status is one of the factors that influence these indicators. It is regulated by application of various rates of fertilizers and is the main way to interfere circulation of elements in agriculture, to increase yield of agricultural crops and to maintain soil productivity. The Southern steppe of Ukraine is classified as the zone of risky agriculture. In years with various weather conditions, it is possible to obtain high yields of field crops that are grown precisely under irrigation conditions. That's why the quality of an irrigation water which is used from the natural surface water sources (Pichura et al 2017, 2018) is an needed condition of an irrigated melioration of agricultural lands, especially in the conditions of climate change, and permanent lack of moisture (Lisetskii et al 2017). Highly intensive agricultural crop varieties, fertilizers, and other important factors and components of agrotechnical means do not prove themselves completely under moisture deficit. Evaporation from fields exceeds humidity inflow from rainfall and it breaches water balance. Drought happens every 2-3 years in the steppe area causing large damage. Winter wheat takes the largest crop sowing area in steppe zone. It is high-yielding and adapted to dry conditions effectively using autumn-winter soil moisture reserves. Soil moisture is the main source of water supply through the root system. Depending on the moisture preservation conditions the moisture content (MMC-75%) can be full and minimum for obtaining high levels of winter wheat yielding capacity in the southern Ukrainian conditions. The main feature of moisture regime of the steppe zone soil is its nonpercolative moisturization and lack of rain falls under high summer temperatures and low humidity. Water supply in Kherson region is low, but the predecessor plays an important role in the water supply of winter wheat. The purpose of the research is to study the possibilities of reducing the number of winter wheat irrigation through the use of water-saving methods of irrigation, which will save on irrigation water. Under the research program it was planned to study the possibility of reducing the number of winter wheat waterings during growing season and the value of irrigation rate due to use of water-saving watering methods.

MATERIAL AND METHODS

Field research was carried out during 2015-2018 atthe Institute of Irrigated Agriculture of the Southern Region of the National Academy of Agrarian Sciences of Ukraine, located in the southern part of the steppe zone of Ukraine. The soils of experimental areas (46 43.80688610691692,32 41.65510497081584) are dark-chestnut, medium-loamy, with a height of humus horizon 25 cm and humus content 2.2 per cent at a deep level of groundwater occurrence. Water for irrigation was taken from the basin of Inhulets irrigation system. The field experiment was based on the four times repeated three-factor scheme, where factor A was the winter wheat varieties: Khersonska Awnless and Odeska 267; factor B was irrigation regimes: supplemental watering and supplemental & vegetative watering; and factor C was various mineral nutrition statuses: unfertilized, unfertilized with feeding with microfertilizers Krystallon (2 kg ha^{-1}) and Tenso (0.6 kg ha^{-1}). The dose of fertilizers was calculated for the yield level 7.0 t ha^{-1}, the same dose of fertilizers for feeding with microfertilizers Krystallon and Tenso. Researches on the influence of alternative fertilizers and irrigation regimes on the grain productivity of winter wheat were conducted in the crop rotation link with subsequent succession of crops spring barley with alfalfa seeding-alfalfa-alfalfa-winter wheat. The predecessor of winter wheat varieties was alfalfa of three-year growing period. Doses of mineral fertilizers were calculated on the basis of the recommendations for the programmed yielding capacity level, considering subtraction of nutrient elements by crop, the NPK content in soil and coefficients of their use from soil and fertilizers (Table 1).

The dose of mineral fertilizers was determined according to the content of nutrients in soil considering subtraction of nutrient elements by preceding crop. During the years of research, nitrogen fertilizers for the basic soil treatment were introduced in an amount from 45 kg of application rate to 138 kg ha^{-1}. On average, over the years of research the dose of fertilizers for the planned yielding capacity level 7.0 t ha^{-1} was $N_{138}P_0K_0$. The tank mixture of germicides Donat – 130 g ha^{-1}, Estron - 300 g ha^{-1} and fungicide - Impact 0.5 l ha^{-1}. Irrigation has an impact on the growth of pathogens. Fungicide was used to reduce the damage of plants by patogenic microflora. Macro and micronutrient application (Krystallon + Tenso) at a rate 2 kg ha^{-1} and 0.6 kg ha^{-1} was carried out during heading phase and milky ripeness respectively. Predecessor's irrigation regime consisted of the norms and terms of watering that were adapted to climatic conditions of year on the basis of recommended crop irrigation regimes in the southern Ukrainian steppe.

Soil and crop samples were selected from two non-adjoining repetitions. The soil content of nitrate nitrogen (Grandval-Lyazh GOST 26107), labile phosphorus – in 1 per cent carbon-amniotic extract (Machihin GOST 26205-91), exchange potassium - from the same extract on a flame photometer (GOST 26205-91) were determined. Soil moisture was determined by the thermostat weight method. During growing season, biometric measurements were taken in main phases of crop development on plant height, growth of crude and dry over ground mass of winter wheat, area of leaves, the sample size was 200 typical plants in four fold. The calculations of net productivity of photosynthesis, photosynthetic potential of sowing were performed. The area of leaves was determined by the method of carving (Nychyporovych 1961). The net productivity of photosynthesis was determined according standard method (Nychyporovych 1982, Pysarenko, Kokovikhin and Hrabovskyi 2011), using the Kidd-West-Briggs formula

$$F_{n.pr.} = \frac{B_2 - B_1}{\frac{L_1 + L_2}{2} \cdot T}, \quad \text{where}$$

$F_{n.pr.}$ – the net productivity of photosynthesis, g/m^2 per day;
B_1, B_2 – the dry weight for 1 m^2 at the beginning and end of the record period, g;
L_1, L_2 – leaf surface area for 1 m^2 at the beginning and end of the record period, m^2;
T – Number of days between the first and the second determination.

Agricultural technology in the research was commonly accepted for the zone considering the issues being studied. The main treatment after alfalfa harvesting included, disking, 25-27 cm ploughing. The seeds were sown in a depth 4-5 cm. During the years of research, the sowing was carried out in the last week of September with the sowing rate 5 million grains per hectare.

RESULTS AND DISCUSSION

The leaf surface varied depending on the mineral nutrition, vegetative phase of plant and irrigation regimes (Table 2).

From tillering phase to stem elongation, the surface area

Table 1. Content of nutrient elements in soil before winter wheat sowing during years of research, mg/100g of soil

Soil layer, cm	NO^{3-}			P_2O_5			K_2O		
	2015-2016	2016-2017	2017-2018	2015-2016	2016-2017	2017-2018	2015-2016	2016-2017	2017-2018
0-30	0.80	5.98	9.65	5.65	5.95	3.68	26.5	48.0	33.0
30-50	0.75	4.18	3.09	1.75	1.05	1.47	22.0	35.0	23.0
50-70	0.35	1.13	0.87	0.37	0.70	0.24	15.5	30.0	20.5
70-100	0.35	0.25	0.52	0.41	0.75	0.50	17.0	27.0	19.0

of leaves of unfertilized plants of both studied winter wheat varieties increased two times on average within the years of study. During growing of winter wheat using fertilizers, this indicator increased 2.5 – 2.8 times in comparison with the control version without fertilizers. In further growing season, the area of leaves increased two times the most in comparison with stem elongation phase upon treatment without fertilizers and supplemental and vegetative watering over the years of research. The leaf surface of winter wheat plants varied from 18.6 – 19.1 to 29.0 – 31.5 thous. m^2 ha^{-1} in non-fertilized ground under supplemental irrigation. The calculated dose of mineral fertilizer $N_{138}P_0K_0$ was used for the planned yield of winter wheat grain 7.0 t ha^{-1}. It allows to significantly reduce the dose of fertilizers upon condition that soil is sufficiently supplied with labile soil nutrients, and due to their high content in soil it allows to avoid application of fertilizers or their varieties. Thus, the phosphoric and potassium fertilizers were not applied in sowing, as the content of labile phosphorus and exchange potassium in soil exceeded its average number (Hospodarenko 2010).

At the same time, the mixed microfertilizer Krystallon and Tenso was used in feeding during heading and kernel milk line period. This was due to the fact that winter wheat was grown in irrigated crop rotation after three years of growing of alfalfa for feeding of animals and organic fertilizers were not applied in crop rotation. Under such circumstances, the application of micro elements does not always significantly increase the crop yielding capacity, but significantly improves the quality of grown products. The nitrate content during growing of winter wheat varieties was quite high during vegetation (Table 3).

Such a high NO_3 content in the unfertilized soil is due to the fact that winter wheat was grown on an alfalfa layer, which accumulates a significant amount of root residues with high content of biological nitrogen. This fact explains quite high content of labile nitrogen in soil during the growing season of winter wheat, even without application of nitrogen fertilizer for crop in all studied layers of soil. Under conditions of using of nitrogen fertilizer, the nitrate content in soil was increasing in accordance with the dose of its introduction (Table 3). The grain yielding capacity of winter wheat, was affected by the nutrient status, had the – (43%). The factor B (irrigation) took the second place – 32 per cent, the variety composition of winter wheat (factor A) took only 9%. In addition, the research shows close interaction between irrigation and fertilizers (interaction of factors BC) at the level 7%. The interaction of other factors was less significant and ranged from 1 to 3 per cent (Fig. 1).

One of the most unfavourable conditions for winter wheat is water disbalance of soil at the beginning of its sowing and during the autumn vegetation. During sowing, the moisture content in soil is often extremely low, and winter wheat cannot germinate timely. The winter wheat seeds accumulate moisture in the autumn-winter period the most. Therefore, the most moisture content in soil is observed in early spring. In the research, the irrigation rate varied depending on the amount of rainfall in the years of growing of winter wheat varieties (Table 4).

Supplemental watering rate for all years of research was 700 m^3/ha, and vegetative irrigation rate was 500 m^3/ha. The winter wheat grain yield is influenced by many factors of cultivation. First of all, these are agrotechnical measures, biological features of variety, terms of sowing, seed quality during sowing, moisture conditions, peculiarities of weather

Table 2. Influence of the researched factors on growth dynamics of area of leaves of winter wheat plants (average for 2016-2018), thous.m^2 ha^{-1}

Nutrient status (factor C)	Irrigation regime (factor B)	Vegetative phase			
		Tillering	Stem elongation	Heading	Milky ripeness
Khersonska awnless (factor A)					
Unfertilized	Supplemental watering	9.8	18.6	31.5	32.7
	Supplemental + vegetative watering	10.1	18.6	39.7	41.3
Calculated dose $N_{138}P_0K_0$	Supplemental watering	11.3	29.6	39.7	42.0
	Supplemental + vegetative watering	11.8	31.4	44.8	46.1
Odeska 267 (factor A)					
Without fertilizers	Supplemental watering	10.0	19.1	29.0	30.2
	Supplemental + vegetative watering	9.9	19.1	37.9	39.3
Estimated dose $N_{138}P_0K_0$	Supplemental watering	11.5	26.1	38.1	39.6
	Supplemental + vegetative watering	11.7	28.9	43.4	44.7
LSD_{05}		0.21	1.12	1.87	2.03

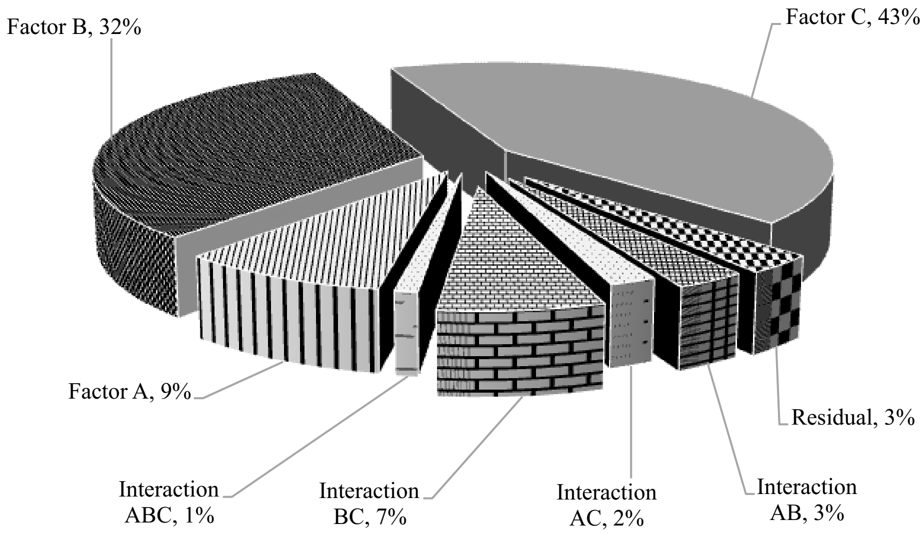

Fig. 1. Influence of researched factors on productivity of winter wheat (average for 2016 – 2018)

Table 3. Influence of mineral fertilizers and irrigation regime on nitrate content in soil during winter wheat vegetation (Average for 2016-2018)), mg 100 g^{-1} of soil

Nutrient status (factor C)	Researched soil layer, cm	Irrigation regime (factor B)							
		Supplemental watering				Supplemental + vegetative watering			
		Sowing-germination	Stem elongation	Beginning of heading	Complete grain ripeness	Sowing-germination	Stem elongation	Beginning of heading	Complete grain ripeness
Unfertilized	0-30	4.92	5.01	5.03	4.21	4.87	5.12	4.62	3.78
	0-50	2.78	2.86	3.14	2.60	2.76	2.81	2.49	2.32
	0-100	1.44	1.49	1.61	1.47	1.46	1.52	1.67	1.54
Calculated dose $N_{138}P_0K_0$	0-30	5.28	5.87	6.12	5.42	5.31	5.72	5.46	4.89
	0-50	3.02	3.81	3.88	3.47	2.99	3.74	3.38	3.12
	0-100	1.83	1.74	1.79	1.87	1.94	1.77	1.64	1.85
LSD_{05}	0-30	0.14-0.21	0.11-0.17	0.10-0.13	0.08-0.12	0.07-0.12	0.11-0.14	0.07-0.09	0.08-0.11
	0-50	0.09-0.15	0.08-0.12	0.09-0.14	0.06-0.10	0.07-0.09	0.10-0.15	0.10-0.12	0.07-0.09
	0-100	0.05-0.08	0.08-0.14	0.05-0.07	0.06-0.08	0.04-0.07	0.08-0.11	0.05-0.07	0.07-0.08

Table 4. Irrigation rate in winter wheat growing, m^3 ha^{-1}

Years of vegetation	Supplemental irrigation	Vegetative irrigation			Total irrigation rate, m^3/ha
		Number of irrigations	Watering depth	Irrigation rate	
2015-2016	700	3	500	1500	2200
2016-2017	700	1	500	500	1200
2017-2018	700	3	500	1500	2200
Average	700	2,3	500	1167	1867

Table 5. Yielding capacity of winter wheat varieties depending on fertilizers and irrigation regime (t ha^{-1})

Nutrient status (factor C)	Variety (factor A)	Irrigation regime (factor B)					
		2016		2017		2018	
		1*	2*	1	2	1	2
Unfertilized	Khersonska Awnless	2.07	3.14	4.35	5.15	3.42	4.07
	Odeska 267	1.51	2.94	4.28	4.95	3.4	3.91
Unfertilized + Krystallon + Tenso	Khersonska Awnless	2.13	3.19	4.43	5.30	3.68	4.13
	Odeska 267	1.68	3.02	4.44	5.18	3.74	3.99
Calculated dose $N_{138}P_0K_0$	Khersonska Awnless	4.02	5.25	6.56	7.34	4.42	6.61
	Odeska 267	3.63	4.78	6.12	6.93	4.32	6.39
Calculated dose $N_{138}P_0K_0$+ Krystallon + Tenso	Khersonska Awnless	3.87	5.23	6.52	7.53	4.73	6.72
	Odeska 267	3.79	5.12	6.18	7.09	4.68	6.45
LSD_{05}	Factor A	0.15		0.11		0.19	
	Factor B	0.09		0.19		0.17	
	Factor C	0.14		0.11		0.22	

1 – supplemental watering, 2 – supplemental + vegetative watering

and climate during year, use of protective means, etc. The introduction of mineral fertilizers in the calculated doses for productivity of winter wheat 7.0 t ha^{-1} increased the grain yielding capacity of the studied winter wheat varieties. It reached its maximum value under supplemental watering upon introduction of calculated dose of fertilizer $N_{138}P_0K_0$ for the yield level 7.0 t ha^{-1} and was 4.02 t ha^{-1} of the Khersonska awnless variety and 3.63 t ha^{-1} of the Odeska 267 variety. Top dressing with microelements in fertilized grounds also did not result in a significant increase of grain yielding capacity (Table 5). The top dressing with a complex mircofertilizer Krystallon$^{@}$ 2 kg ha^{-1} mixed with Tenso (0.6 kg ha^{-1} during interphase heading period and the beginning of kernel milk line period) increased winter wheat yield of both studied varieties from 0.6 to 3.0 t ha^{-1}.

CONCLUSION

In order to receive grain yielding capacity at the level 7.0 t ha^{-1} and higher under low content of nitrogen and increased content of labile phosphorus potassium in soil, it is reasonable to add mineral fertilizers as the main soil treatment at the calculated rate $N_{138}P_0K_0$ along with top dressing with a mixture of complex fertilizers Krystallon and Tenso as calculated 2.0 and 0.6 kg ha^{-1} in the interphase period between the beginning of heading and kernel milk line period.

Received 26 May, 2019; Accepted 31 July, 2019

REFERENCES

Babych VL 2005. Influence of mineral fertilizers on area of leaf surface, photosynthetic efficiency and photosynthetic potential of winter wheat. *Tavriia Scientific Bulletin* **37**: 72-77.

Hospodarenko HM 2010. Agrochemistry: Textbook. *NSC "IAE"*: 258-320.

Kudriashov IN 2001. Variety as a factor of stabilization of seed production of winter wheat. *Selection of winter wheat: Conference proceedings of scientific-practical conference "Scientific heritage of academician I.G. Kalinenko"*: 138-144.

Lisetskii FN, Stolba VF and Pichura VI 2017. Late-Holocene palaeoenvironments of Southern Crimea: Soils, soil-climate relationship and human impact. *Holocene* **27**(12): 1859-1875.

Moraru SA 1988. Winter wheat. *Kartia Moldovenske Publ*.: 400 p.

Netys IT 2003. Influence of predecessors, fertilizers and protection of plants on seed quality of winter wheat. *Tavriia Scientific Bulletin* **32**: 112-113.

Nychyporovych AA 1961. Photosynthetic activity of plants in sowing. *Academy of Science of USSR Publ*. 133 p.

Nychyporovych AA 1982. Physiology of photosynthesis and productivity of plants. *Physiology of photosynthesis* **3**: 7-33.

Peterburgskiy AV 1964. Feeding of plant roots. *Kolos Publ*. 43-48.

Pichura VI, Domaratsky YA, Yaremko YuI, Volochnyuk YG and Rybak VV 2017. Strategic ecological assessment of the state of the transboundary catchment basin of the Dnieper river under extensive agricultural. *Indian Journal of Ecology* **44**(3): 442-450.

Pichura VI, Malchykova DS, Ukrainskij PA, Shakhman IA and Bystriantseva AN 2018. Anthropogenic transformation of hydrological regime of the dnieper river. *Indian Journal of Ecology* **44**(3): 445-453.

Pysarenko PV, Kokovikhin SV, Hrabovskyi PV 2011. Influence of conditions and moisture supply and mineral nutrition status on dynamics of accumulation of wet and dry weights by winter wheat plants. *Irrigated Agriculture* **55**: 70-78.

CONTENTS