UDC 631.43: 631.8:633.16

Influence of compaction and fertilization of soil on use of nutrients and productivity of spring barley

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The purpose. To determine influence of soil compaction, as well as efficiency of action and after-action of fertilizers on use of nutrients from soil and productivity of intense and half-intense varieties of spring barley. **Methods.** Field small-plot, laboratory-analytical, mathematical-statistical. **Results**. Influence of firmness of soil and fertilizers on coefficient of use of nutrients by plants from soil and productivity of varieties of barley is determined. It is established that intense varieties of barley use on 6% more nitrogen and phosphorus, and on 11% — of potassium, than half-intensive ones. Conditions of watering have essential influence upon conditions of absorbing nutrients and formation of yield. Deficiency of moisture promotes lowering of use of nutrients from soil in 2 – 3 times in comparison to their use in excessively wet conditions. At overmoistening the greatest productivity (73,5 and 69 c/hectare of intense and half-intense varieties) have been gained at optimum firmness and at importation of $N_{45}P_{45}K_{45}$. In conditions of drought year the greatest productivity of spring barley (intense variety — 18,5, half-intense — 23,5 c/hectare) is generated on the background of after-effect of $N_{90}P_{90}K_{90}$ at optimum soil compaction. The downdrift of productivity of cultivated crop is registered at augmentation of soil compaction up to 1,4 g/cm^3. **Conclusions.** As a result of experimental researches it is established that due to importation of the heightened doses of fertilizers into combination to optimum firmness of soil it is possible to gain heavy yield of spring barley. The compacted soil negatively influences growth and development of cultivated plants, hampers use of nutrients from soil and reduces productivity of cultivated varieties of the crop.

Key words: *firmness of soil, coefficient of use of nutrients, variety, productivity.*

https://doi.org/10.31073/agrovisnyk201808-11

Significant influence of the soil density on soil water regime, soil air regime and soil nutrient regimes, as well as on the growth and development of the agricultural crops was proved by many researches [1, 2, 3]. R. James Cook notes that most often the physical properties of soil and the relief have a greater influence on the growth and absorption of nutrients by crops compared with the chemical composition of the soil [4]. According to H.N. Hospodarenko [5], the nutrients are selectively absorbed by plants from the soil, the absorption of which depends on their concentration in the nutrient medium. The application of fertilizers influences on the soil nutrient regime and, accordingly, changes the content of nutrients in plants [6]. Significant influences on the processes of metabolism, the size of the yield have varietal features of culture. Different sorts of one species of plants, that differing in their productivity, reach the highest yields at different concentrations of nutrients in the soil [7]. Currently intensive and semi-intensive sorts of barley are widely grown, which are characterized by potential yields, reaction to growing conditions and the application doses of fertilizer [8, 9].

The purpose of research. Determine the influence of soil compaction, efficiency of mineral fertilizers on the use of nutrient elements from the soil and yield of intensive and semi-intensive sorts of barley.

Materials and methods of research. Field small-plot experiment were carried out during 2016-2017 on the territory of the experimental farm "Grakivske" (NSC "Institute for Soil Science and

Agrochemistry research named after O.N. Sokolovsky") on chernozem typical leached heavy-loamy on loess (content in the arable layer: humus - 3,58 % of total nitrogen - 12,85 mg/kg of soil; of mobile phosphorus – 219,27 mg/kg of soil; of mobile potassium – 225,94 mg/kg of soil). In the experiment, it was studied two factors (table 1) - density of soil and dose of NPK, repetition was three times, the placement of variants is systematic. The size of each plot was 1 x 1 m. Variants with low (1,0 g/cm^3), optimal (1,2 g/cm^3) and high (1,4 g/cm^3) levels of soil density were artificially created. Mineral fertilizers was used: nitrogen - in the form of ammonium nitrate (34 % N), phosphorous - superphosphate of simple (20 % P_2O_5), potassium - potassium salt (40 % K_2O) in medium and high doses, respectively, 45 and 90 kg/ha of active substance. Fertilizers were used during sowing.

Table 1. Scheme and matrix of experiment planning

Factories	Levels of variation of factors		
	0	1	2
Soil density, g/sm^3 (X1)	1,0	1,2	1,4
Dose of NPK, kg/ha (X2) active substance	0	45	90

Factories	Variants								
	1	2	3	4	5	6	7	8	9
X_1	0	1	2	0	1	2	0	1	2
X_2	0	0	0	1	1	1	2	2	2

It was researched the effect of mineral fertilizers in 2016 and in 2017 it was researched after the effect of mineral fertilizers. The experimental crop is intensive (Vzirets) and semi-intensive (Zdobytok) sorts of spring barley.

The conditions of water supply were different during the research period. In 2016, there was a significant increase in rainfall during the period of growing season: the largest deviation was observed in May (by 163,7 mm) and July (by 55,7 mm) more than the average annual rainfall. In 2017, at the beginning of the growing season, the content of precipitation was almost at the level with the average annual data, but by the end of the growing season there was a decrease in the amount of precipitation in June - by 35.6 mm, in July - by 5.9 mm. Thus, the growing season in 2016 was estimated as wet, in 2017 it was as arid [10].

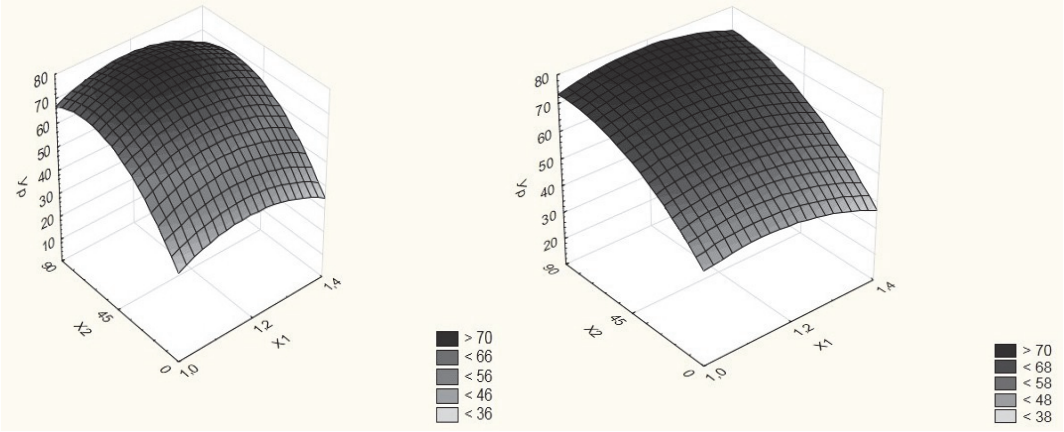
The results of research. It was proved in the scientific literature that between soil compaction and the absorption and use of nutrients by plants there is a close relationship [11, 12]. Compacted soil limit the use of nutrients owing to the reduction of pore space, slowing down the mobility of the soil solution, deterioration of the parameters of the root system of plants.

To assess the coefficient of recovery of each of the nutrients, depending on the density of the soil and fertilizer, the coefficients of their use (C.r.) were calculated. This coefficient of recovery shows the ratio of the proportion of using of each of the elements of the nutrients to the total content of its moving form in the arable layer per 1 hectare (Table 2). It was found that intensive sort of barley uses 6% more nitrogen and phosphorus, 11% - potassium in comparison with semi-intensive sort. On a sufficient moisture, the highest value of C.r. for nitrogen (40.8 and 38.6% for intensive and semi-intensive sorts) was obtained on the background by the application of $N_{45}P_{45}K_{45}$ and by at a low density of soil. By the same conditions, the highest C. r. of phosphorus was obtained - respectively, 14.4 and 15.4% for the researched sorts. The coefficient of recovery potassium were maximal in the variant by the application of $N_{90}P_{90}K_{90}$ and by optimum level of the soil density. Under conditions of insufficient humidification the use of nutrients from the soil decreased by 2-3 times compared with the wet conditions. There was a marked the tendency to decrease the C. r. of all nutrient under increasing the soil compaction to 1.4 g / cm^3

Table 2. Influence of soil density and mineral nutrition on coefficients of recovery of nutrition from the soil

Soil density, g/sm^3	Coefficients of recovery of nutrition from the soil (C. r.,%)					
	N		P_2O_5		K_2O	
	1	2	1	2	1	2
without fertilizers						
1,0	21,80 10,98	19,70 10,21	8,50 5,40	9,20 4,24	17,30 7,07	16,00 1,72
1,2	18,00 7,71	20,20 9,03	6,70 3,96	7,90 4,34	15,40 5,98	14,50 1,55
1,4	15,90 4,03	13,50 5,82	6,70 2,34	6,30 2,84	12,50 4,32	13,80 1,10
$N_{45}P_{45}K_{45}$						
1,0	40,80 9,36	38,60 8,98	14,40 4,18	15,40 4,47	28,30 6,85	22,90 1,69
1,2	24,40 8,62	26,30 9,45	10,50 3,89	12,40 5,12	24,10 6,97	21,20 1,88
1,4	24,50 3,77	16,40 3,78	8,90 1,97	8,40 2,24	21,60 4,04	15,70 1,04
$N_{90}P_{90}K_{90}$						
1,0	40,60 7,67	29,80 9,45	12,10 3,74	13,60 4,49	31,20 7,81	29,80 1,80
1,2	26,70 10,87	29,00 9,98	13,10 3,58	12,80 4,46	34,70 6,96	30,70 1,86
1,4	25,00 3,99	29,10 5,69	10,40 2,17	12,30 2,75	25,80 4,91	23,30 1,12
Note: *1-intensive sort, 2-semi-intensive sort, over the line - the effect of fertilizers, under the line - after fertilizers*						

As a result of field research, the influence of the soil density and mineral fertilizers on the productivity of spring barley sorts was determined (Fig. 1). In conditions of excessive humidification and by application of average doses of mineral fertilizers, the highest crop (73,5 and 69 centners per hectare of intensive and semi-intensive sorts) was obtained at optimum soil density. With increasing soil compaction (up to 1.4 g / cm^3) yields decreased, respectively, by 9 centners per hectare for intensive and 5,5 centners per hectare for semi-intensive sorts. Application of high-doses and at optimum soil density provided yield 75,5 and 77,5 centners per hectare of intensive and semi-intensive sorts, which in 2 and 8,5 centners per hectare greater than by application the average dose of fertilizer.

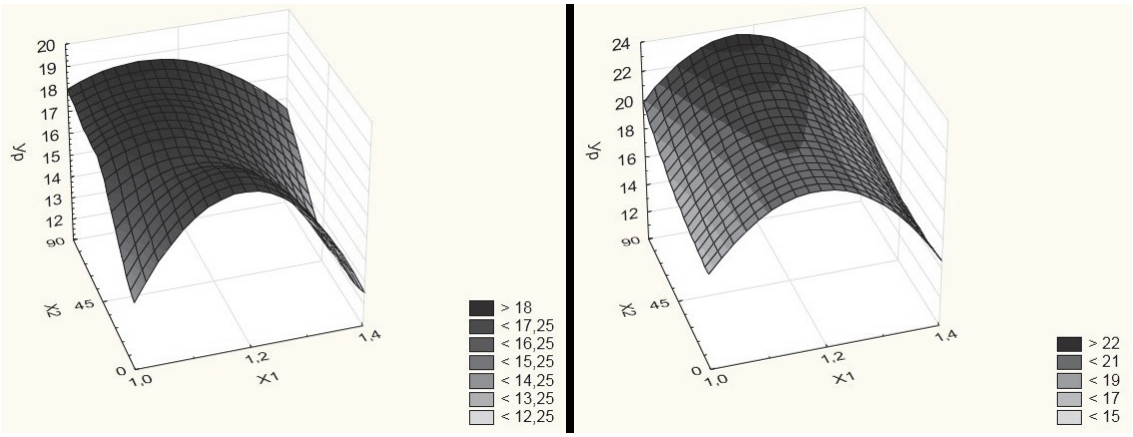


X1 – soil density, g/sm3, X2 – dose of fertilizer, kg/ha active substance

а) intensive sort (R^2 = 0,85) б) semi-intensive sort (R^2 = 0,69)

Figure 1 *Yield of barley, depending on the soil density and doses of mineral fertilizers (fertilizers research, 2016)*

Analyzing the yield data at conditions of insufficient humidification (Fig. 2), we came to the conclusion that the conditions of moisture significantly influence the conditions of absorption of nutrients and the formation of the size of the crop. The largest yield of spring barley (an intensive sort of 18.5 centners / hectare, semi-intensive - 23.5 centners / ha) was obtained on the background by application the high-doses of fertilizers and by optimal soil compaction. Under increase the soil compaction up to 1.4 g/cm3, there was a tendency to decrease the productivity of the researched sorts.



а) intensive sort (R^2 = 0,74) б) semi-intensive sort (R^2 = 0,88)

Figure 2 *Yield of barley, depending on the soil density and doses of mineral fertilizers (after fertilizers research, 2017)*

Conclusions

As a result of experimental research it was found that it is possible to obtain a high yield of spring barley by the application of higher doses of fertilizers in combination with the optimum soil density. Soil compaction negatively influence of the growth and development of cultivated plants, complicates the use of nutrients from the soil and reduces the yield of growing sorts of barley.

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