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INNOVATE ASPECTS OF HANDLING OF ALFALFA SOWINGS ON FODDER USED DURING THE SECOND AND THE THIRD YEARS OF GROWTH

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The article gives the results of the study of the effects of different ways of the mechanical care on the growth, rhizogenesis, chemical composition and productivity of alfalfa on fodder used during the second and third years of growth..

Keywords: *alfalfa, tillage, harrowing, growth, dry matter, crude protein, productivity, return on investment.*

Alfalfa is one of the intensive crops of photosynthesis and assimilation of nutrients from the soil. As other crops, especially roots, potatoes, it requires good aeration of topsoil. Only under this condition growth, rhyzohenesis and activity of associative micro flora are at the appropriate level, as studies on the irrigated lands of Southern Ukraine and preliminary study of the subject by the co-author of the article Zinchenko O.I. showed [5].

Alfalfa is a perennial crop unlike annual field and forage non-perennial crops. In the process of harvesting of green mass, soil is compacted by harvesting and transport units, and watering plants on the irrigated southern lands leads to plant extinction and decrease of productivity of the crop on the second and the third years of use [6, 7, 10].

According to the literature, chornozem compaction up to 1.35 g/cm³ leads to a sharp deterioration in the re-growth of alfalfa. It reduces soil permeability [3, 4].

An important factor in improving the alfalfa vegetation conditions, due to the researches on irrigated lands of Steppe, is mellowing of the soil by its tillage [6, 7].

Deep soil mellowing on alfalfa sowings of the second or the third years of use, and its combination with fertilizer in the Forest-Steppe and in particular in the southern part are not studied enough, though by preliminary observations its effectiveness is undeniable.

The aim of the research is studying of the influence of mechanical methods of cultivation of the soil and its combination with fertilization (in autumn and in spring) on the growth and productivity of alfalfa on forage of the second-third years of use.

Methodology of the research. The researches was conducted in two stages: the first in 2008-2010 – research of the influence of mechanical handling on growth and productivity of alfalfa was conducted on the Farm "Zorya" of Holovanivsk District, Kirovograd Region and partly on the experimental field of Uman NUH; the second stage – 2011 – 2012 on the experimental field of Uman NUH. During this period the influence of combining mechanical handling with fertilization was investigated.

This article highlights only the results of the research of 2008 – 2010. Scheme of the experiment is shown in the tables of the article.

According to the aim of the research, studing of the growth and development, vegetation density, indices of biochemical composition, rhyzohenesis and productivity of

the plant depending on the terms, method and depth of tillage of chornozem were conducted.

Results of the research. Observation of the progress of alfalfa growing season showed that different methods of mechanical handling had a certain impact on vegetation phases of alfalfa. In particular, it appears that in variants with harrowing by a spike harrow and needle – BIG-3 and after autumn cultivation re-growth occurs on 2-4 days earlier compared to spring tillage. But during the subsequent growing season before the phase of vegetation it occurs only in variants with harrowing by spike harrows and BIG-3 (Table 1).

1. The impact of mechanical handling on passing the main phases of vegetation and height of alfalfa (first mowing) (2009-2010)

No. var.	Cultivation	After growth, March	Branching, May		Budding**, May-June		Flowering, June	
			Date	height, cm	date	height, cm	date	height, cm
1	Harrowing* in spring by hard spike harrow (k)	20–23	14–16	32,6	28–30	57,2	5–6	66,4
2	Cultivation BIG–3	20–23	14–16	32,2	26–28	56,4	4–5	64,3
3	Tillage by chisel up to 14–16 cm[x)] in spring	24–26	16–17	30,6	2–3	58,3	7–8	66,2
4	The same up to 18–20 cm	24–26	16–17	30,4	2–3	60,2	7–8	67,4
5	Tillage by chisel up to 14–16 cm	20–22	17–19	34,7	3–4	63,8	9–11	68,6
6	The same up to 18–20 см	20–22	17–19	36,1	3–4	64,2	10–12	70,4

* – Here and in the following tables, in variants 3 – 6 – spring harrowing.
** – In variants 3–6 budding in June.

During the subsequent vegetation, deep autumn and spring tillage has already helped to improve the vegetation of the plants and the phases of branching, budding and flowering came later, especially in variants with autumn tillage of soil, indicating, in particular, the best level of nitrogen nutrition of plants in which the occurrence of these phases is delayed. Herewith, a larger vegetative mass of plants is built up.

Observations of the growth of plants after mechanical handling showed that their height had some differences: better plant growth was on the background of autumn cultivation – especially during tillage to the depth of 18-20 cm. Spring tillage variants bi chisels on 14-16 and 18-20 cm at beginning of the growing season were close to the control, due to some moisture loss of topsoil. Cultivation by BIG-3 had no advantages over the harrowing by hard spike harrow (Table 1). It is because, along with good topsoil tillage, during the cultivation by BIG-3 soil compaction to the depth of 20 cm is observed.

During the further vegetation there is an advantage of deep loosening by chisels and in variants of spring tillage, but indices were lower here than during autumn cultivation.

The general development of plants – leafing, colour of leaves, leaf discs size, density in variants with deep loosening was significantly better compared with areas where there was harrowing by hard spike harrows or needle harrows BIG-3. Thus, on plots where they held a deep loosening, especially in autumn, plants differed by darker colour, larger leaf blades and leaf weight in total vegetative mass of herbage reached 43,8-45,4 against 42.7% in the control (cultivation by spike harrows) and 42.3% – on the background of cultivation by BIG-3.

It’s worth mentioning that during the cultivation by chisels, some plants were damaged, but only some of them got dry. It wil be compensated by the following formation of sprouts and improving root nutrition and also, as it will be shown below, by rhyzohenesis of plants.

According to our observations, loosening effect of chisel during cultivation is 3-4x of their width that is equal to 10-12 cm. Herewith, slits hold water actively.

In this regard, autumn cultivation has an advantage – promotes better digestion of autumn and winter precipitation. Also better conditions are created in the rhyzosphere zone, so that most buds recovery is laid at the root neck. They are constantly formed and enter the vegetative phase according to the scheme: bud – sprout sucker – potentially generative shoot. Depending on the conditions, some shoots remain vegetative, others develop as generative, but in general it provides herbage density and yield of alfalfa of the next mowings [1-3].

Observations showed that new buds on the root neck are already laid in the phase of branching. According to the biology of alfalfa, in this period plants activly accumulate solids, and the root system of these substances, as it is shown by Zharinov V.I. and Klyui V.S., can consume even more than stems. Similar data are found in other literature sources [11, 12, 13, 14].

We counted the number of buds on the root neck before the first mowing. It was found that most buds stock at the root neck was on the background of autumn cultivation – 5.5 and 6.0, respectively, at the depth of tillage 14-16 and 18-20 cm, and at analogous spring tillage variants – 4.4 and 4.6, during harrowing – 3.8, and cultivation by BIG 3 – 3.7 pc. Moreover, on the background of deep loosening, especially autumn root necks diameter was 1-2 mm larger; they had more buds and larger density of vegetation (Table 2).

2. The impact of deep tillage on root neck diameter, the formation of buds of stock on it and density of alfalfa (2009-2010)

Cultivation	Diameter of root neck, mm	Buds on the root neck, pc.	Stems per m^2, pc.	
			first mowing	third mowing
Harrowing by a hard spike harrow (k)	10	3,8	612	547
Cultivation BIG-3	9,0	3,7	564	514
Tillage by chisels up to 14-16 cm in spring	11	4,4	578	564
The same up to 18-20 cm	12	4,6	604	576
Tillage by chisels up to 14-16 cm in autumn	13	5,5	636	594
The same up to 18-20 cm	13	6,0	648	602
$HIP_{0,5}$	0,34	0,14	18,2	17,0

It may also be noted that the spring deep loosening of soil and cultivation by BIG-3, significant damage of root necks than during the cultivation with spike harrows was observed; therefore during the first mowing vegetation density in these variants was less than on the control. But during the subsequent vegetation, spring tillage had the advantage by the density of stems over harrowing with spike and needle harrows (Table 2).

Observations showed that deep loosening of soil is not only improves growth indices, it increases the duration of high productivity of alfalfa, as the alfalfa of the third year of usage in variants of deep loosening after the third mowing re-grew better and had more dense herbage.

Given data indicate a significant advantage of deep loosening conducted primarily in autumn, as cultivation in early spring vegetation season, especially with the absence of sufficient rainfall, leads to dryness of soil, which has a negative effect on the re-growth of plants, in spite of strong root system of alfalfa.

Mentioned benefits of deep tillage improved an increase of green mass of alfalfa during the beginning of budding phase. It lasted until the end of flowering (Table 3).

2. The growing of green mass of alfalfa depending on the techniques of mechanical handling, kg/m2 (2009-2010)

No.	Cultivation	Phase of vegetation					
		First mowing			Second moving		
		budding	beginning of flowering	end of flowering	budding	beginning of flowering	end of flowering
1	Harrowing by a hard spike harrow (k)	1,62	2,1	2,24	0,84	1,29	1,39
2	Cultivation BIG-3	1,45	2,00	2,15	0,75	1,23	1,31
3	Tillage by chisels up to 14-16 cm in spring	1,84	2,37	2,49	1,10	1,39	1,59
4	The same up to18-20 cm	2,02	2,59	2,67	1,22	1,50	1,73
5	Tillage by chisels up to 14-16 cm in autumn	2,30	2,70	2,80	1,46	1,78	2,00
6	The same up to 18-20 cm	2,48	2,94	3,10	1,59	2,03	2,19

Cultivation BIG-3 did not give positive results. As the observations showed, the harrow loosens the soil well when the top layer (4-5 cm) is already dry. When soil is just ripe and is crumbled under cultivation with spike harrows, BIG-3 loosens the soil unsatisfactory, and the bottom layer is compacted.

The second moving increased its smaller mass (to 43-47%) in response to mid-summer moisture.

These differences by variants of the experiment remained during the third mowing, but the green mass was re-grown less than during the second mowing – 1.0-1.2 kg/m2.

During the growth of green mass in plants the contents of dry substance grew. Thus, during the budding phase dry substance content in plants is 17,0-17,6%, at the beginning of flowering – 19,4-20,7%; at the end of flowering – 22.3 – 24.6%. Moreover, in areas where deep loosening was conducted, plants were watered more, therefore indicators of dry substance content decreased, coinciding with some delay of the beginning of vegetation phase. This is also observed by other authors [5, 8, 14, 15].

The second mowing had significantly higher solids content during budding, almost the same indices – at the beginning of flowering and significantly lower at the end of flowering. This can be explained by a shorter flowering period due to higher summer temperatures, when accelerates the phase beginning and their passing becomes shorter.

The increase of solids content up to a certain period is positive because it increases the energy content in the yield of green mass and productivity of the culture. But indices of solids content above 20% indicate deterioration in the quality of green mass. Thus, according to the institute of Kelner [17] (Germany), during the period of budding fibber content in solids of green mass of alfalfa during the first mowing reaches 26.1, during the second mowing it is slightly lower – 23.5%, and at the end of flowering the indices are respectively 38.3 and now 35.9%. The researches of the Department of Plant Growing of Uman NUH confirmed this [11, 12].

However, the protein content in solids due to alfalfa vegetation, reduces according to the same data of Institute of Kelner – from 22.1% in the budding phase to 19.2% at the beginning of flowering and to 15.4% at the end of flowering in the second mowing, respectively – from 25.0 to 22.0 and 17.1%. Protein content in the second mowing is higher [17, p. 84]. This is a common feature of forming not only the mass yield of alfalfa but other forage grasses [11, 12].

According to our data, the protein content in solids of green mass of alfalfa in 2009-2010 decreased from 21,6-22,8 in the budding phase to 15,7-16,3% at the end of flowering. Moreover, higher levels were in the areas with deep cultivation, where some delay in the phase of vegetation and more irrigation of plant tissues were observed (by 0.2-0.6%).

Thus, the growth and development of alfalfa inverse relationship is observed – a kind of "scissors" of accumulation of solids and protein in plants: solids content increases, and protein in solids decreases.

As alfalfa is valued primarily as a high-protein fodder crop – a powerful source of protein, we compared the gross output of protein in different phases of alfalfa growing season, using data on the dynamics of solids content and protein in plants by budding and flowering completion phases. On this basis, the gross yield of solids and crude protein in yields of green mass of alfalfa were calculated.

It was found that the yield of solids in the budding period – the end of flowering is rather rapidly increasing, but the accumulation of protein goes much slower. Thus, depending on the receiving handling, gross of solids yield of alfalfa grows up to 73,3-109,0%, while protein – only up to 21,6-45,7% (Table 4).

Alfalfa accumulates the bulk of protein in the budding phase – 74,6-80,6%. The higher rates are in the areas of tillage: spring – 76,5-77,9, autumn – 80,6-82,2%, while content of solids in this phase is only 52,0-57,8%.

The total solids yield in variants with deep autumn loosening was 66.8 and 71.9 cwt /ha in spring cultivation – 59.3 and 63.0 cwt/ha, whereas in the control – 54.4 cwt/ha. Yield of crude protein also had significant differences: in areas of autumn tillage 1070 and 1165 kg/ha, spring – 925 and 995 kg/ha, whereas in control – only 838 kg/ha. Cultivation BIG-3 provided the lowest results – 52.9 kg of solids/ha and protein – 804 kg/ha, as it is demonstrated in Table 4.

4. Comparative growth of solid material and crude protein between phases of budding and the end of flowering of alfalfa depending on the technique of receiving mechanical handling (average for 2009-2010)

No. var.	Variant of the experiment	Solid material, cwt/ha				Crude protein, kg/ha			
		budding phase	end of flowering	growth		budding phase	end of flowering	growth	
				cwt/ ha	%			kg/ha	%
1	Harrowing with a hard spike harrow (k)	28,3	54,4	26,1	92,0	625	838	213	34,0
2	Cultivation BIG-3	25,3	52,9	27,6	109,0	552	804	252	45,7
3	Tillage by chisels to 14-16 cm in spring	31,6	59,3	27,7	87,7	708	925	217	30,6
4	The same to 18-20 cm + harrowing	34,3	63,0	28,7	83,7	775	995	220	28,4
5	Tillage by chisels to 14-16 cm in autumn	38,6	66,8	28,3	73,3	880	1070	190	21,6
6	The same to 18-20 cm	41,2	71,9	30,7	74,5	939	1165	220	24,1

It shows that autumn and spring tillage with chisels has an advantage over harrowing. And the cultivation to 18-20 cm has advantages over loosening to 14-16 cm This can be explained by better absorption of rainfall and better soil air regime with increasing soil depth. However, autumn tillage had a significant advantage over the spring one. Thus, if the growth after spring deep tillage to 14-16 and 18-20 cm is 3.0 and 8.0%, which is also a great index, the autumn cultivation gives the increase of 12.6 and 16%.

After cultivation BIG-3 yield decreased, compared with the control – by 2.7% (Table 5).

Besides significant and very significant increase in the yield of air-dry weight during autumn cultivation, economic effectiveness of these methods proved to be high despite the fact that for the cultivation of hard spike harrow, 1 hectare requires only 1.6 litres of diesel (16 €/ ha for prices 2012), and for deep loosening at 14-16 and 18-20 cm harrowing – 5.1 and 6.4 l / ha (51 and 64 UAH/ha). With the price of oats 1 cwt of feed units 170 UAH, the increase is 3-12,6 kg/ha of air-dry weight (1,5-6,3 kg /ha feed units) repeatedly (in 5-17 times) covers the cost of fuel.

So deep loosening of alfalfa of the second or the third years of use is highly profitable event in technology system of growing alfalfa on fodder.

5. The impact of mechanical handling techniques on the yield of air-dry weight of alfalfa, for 3 mowings cwt/ha

Handling	Yield			Growth average for two years	
	2009	2010	average	cwt/ha	%
Harrowing with a hard spike harrow	82,0	75,2	78,6	–	–
Cultivation by BIG-3	80,4	72,6	76,5	–2,1	–27
Tillage by chisels to 14-16 cm in spring + harrowing	84,3	78,9	81,6	3,0	3,8
The same to 18-20 cm + harrowing	87,4	82,3	84,9	6,3	8,0
Tillage by chisels to 14-16 cm in autumn + spring harrowing	92,6	84,3	88,5	9,9	12,6
The same to 18-20 cm + spring harrowing	95,8	86,5	91,2	12,6	16,0
S% – accuracy of the experiment	3,51	3,31			
$HIP_{0,5}$	1,40	3,30			

The expediency of deep tillage on sowings of alfalfa of the second and subsequent years of use is indicated by several authors (H.A. Dedaev, V. Kiver, R. Malutsa, A. Pylypenko [6], O.I. Zinchenko [5], V.I. Zharinov, V.S. Klyui [3, 15] and others). But they are related to spring soil cultivation of irrigated areas in Steppe. Data on the effectiveness of autumn cultivation was not found in the literature.

There is no relevant data about comparison of the effectiveness of cultivation with spike and needle harrows. The German and Czech authors (E. Kabis, N. Michalek [9], T. Santrucek [16], it was also indicated in the magazine "Kormovyrobnytstvo" No.3, 1989, they considered it inappropriate to use a spike-tooth harrow on alfalfa due to soil compaction by wheel passes. Probably, it is connected with small acreage and narrow gripping rig. Under these conditions, the frequent passing of wheels can compact the soil and degrade the general result. However, the need for spring harrowing of alfalfa is generally accepted. This was indicated in the works of Sovetov A. with reference to the experience of Prince Kochubey in Poltava province in the works of 70-90-ies of XX

century, and some other authors: Zinchenko B.S.[4], Lupashko M.F. [8], Zinchenko O.I. [5] Zharinov V.I.[15] and others.

Our researches provide an opportunity to propose to the production innovative, more radical and effective technology of mechanical handling of alfalfa on forage of the second or third years of use – deep autumn tillage – tillage combined with the spring spike harrowing. Application of spring tillage is less efficient.

Deep tillage reduced volumetric mass of soil to 1, 12-1, 11 g/cm^3, increased leafing and height of plants, density, the number of buds of regeneration at the root neck.

It was found that very high quality shallow cultivation by needle harrow leads to soil compaction in the layer of 0-20 cm and reduces yield, even compared to cultivation by spike harrows and quite significantly (by 8-16%) than loosening by chisels. Despite the higher costs of fuel for deep loosening it is repeatedly paid back by the increase of the alfalfa crop capacity.

CONCLUSIONS

1. Deep loosening – tillage to 14-16 and 18-20 cm, improves growth and quality of alfalfa green mass of the second or third years of usage. Best results are given during autumn cultivation.

2. Solid material content in plants is actively growing in the process of formation of green mass of alfalfa – from 17,0-17,6% in the budding phase to 22,3-24,6% at the end of flowering. In parallel, solid material content of crude protein is reduced, although the gross yield of green mass increases.

3. Crop capacity of air solid mass during spring cultivation to 14-16 and 18-20 cm compared to hard spike harrow harrowing increased respectively by 3.8 and 8.0%. Autumn tillage increases these rates to 12.6 and 16%.

4. Deep tillage – economically highly-effective measure of increasing productivity of alfalfa on forage, and the increase of fuel consumption compared to traditional spring harrowing by hard spike harrows and needle (BIG-3) is repeatedly paid back by the increase of productivity of air-dry weight.

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