

**ADAPTIVE SYSTEM OF PRIMARY TILLAGE FOR WHITE MUSTARD (*SINAPIS ALBA*)****V. P. Kyryliuk, V. N. Krychivskyi, N. V. Kovalchuk***Khmelnytskyi State Agricultural Experimental Station of the Institute of Feed and Agriculture of Podillya of NAAS, 1, Samchyky St., Samchyky village, Starokostiantyniv district, Khmelnytskyi region, 31182, Ukraine*

*The research results of influence of the continuous application of the various systems of primary tillage and fertilization on the productivity of mustard white (*Sinapis alba*) were presented.*

*It was found that the highest yield of white mustard seeds (1.89 t/ha) on the background of  $N_{60}P_{60}K_{60}$  fertilizers was formed under moldboard plowing. Against the background of organomineral fertilization (predecessor residues and application of  $N_{30}P_{30}K_{30}$ ), the highest seed yield (1.90 t/ha) was provided by the moldboard plowing. The application of conventional fertilizer of  $N_{60}P_{60}K_{60}$  for white mustard compared to the combination of crop residues and  $N_{30}P_{30}K_{30}$  fertilizers was economically unprofitable.*

*It was found that in some years, when nonmoldboard plowing, especially minimal tillage, was performed against the background of organomineral fertilization, sparseness of white mustard plants was to 40–50 % in comparison with mineral fertilization. In general, the plant density of white mustard on the background of organomineral fertilization was 1.5–1.55 mln plants/ha, and on the mineral – 1.65–1.7 mln plants/ha, i.e. on average it was lower by 10 %.*

*Analysis of the economic efficiency of white mustard cultivation showed that the subsurface tillage on the background of organomineral fertilization (predecessor residues and the application of  $N_{30}P_{30}K_{30}$ ) can be considered as the most promising and adapted to current weather conditions. The profitability of white mustard seed production was 263 %; almost such indicators of profitability were noted under chisel tillage – 259 %. It was found that the introduction of any subsurface tillage for white mustard on the background of organomineral fertilization is more profitable.*

**Key words:** white mustard, yield, tillage, fertilizers, soil.

White mustard (*Sinapis alba*) is a crop of industrial importance due to its various uses. It is grown to obtain high-quality food oil, mustard powder and green animal feed. In addition, white mustard is widely used as a green manure crop, as there is a problem associated with reduced soil fertility and the application of mineral fertilizers. It plays an important role in the biologization of agriculture. Over the past 10 years, the demand for white mustard seeds in domestic and international markets is constantly growing. White mustard sown areas in Ukraine are increasing from year to year. With the existing indicative prices for commercial mustard seeds over \$ 350 per 1 ton, farms in market conditions have a constant and reliable source of financial income [5–10].

The global negative climate changes set scientists the task to simultaneously increase

both the yield of major crops and their resistance to adverse environmental factors [5]. The expediency to introduce technology elements for growing field crops is assessed according to crop yield. Therefore, research on the development of such elements of cultivation technology (including white mustard), which better implement the productivity potential of modern varieties under different soil and weather conditions, is becoming increasingly important.

According to domestic and foreign scientists, white mustard plants positively respond to fertilizer application, as evidenced by the increase in seed yield in the range from 25 to 50 %. Therefore, the biological potential of this crop is largely determined by the rates of mineral fertilizers [1, 3, 4, 11, 12].

It is possible to improve the productivity

**Author information:**

**Victor P. Kyryliuk**, Candidate of Agricultural Science, Senior Researcher, Head of the Laboratory for Modern Technologies in Agriculture, e-mail: [hdsgds@ukr.net](mailto:hdsgds@ukr.net), <https://orcid.org/0000-0001-5771-8142>

**Volodymyr M. Krychivskyi**, Researcher of the Laboratory for Modern Technologies in Agriculture, e-mail: [hdsgds@ukr.net](mailto:hdsgds@ukr.net), 0979053792, <https://orcid.org/0000-0002-2344-4394>

**Nelia V. Kovalchuk**, Junior Researcher of the Laboratory for Modern Technologies in Agriculture, 0680118992, e-mail: [hdsgds@ukr.net](mailto:hdsgds@ukr.net), <https://orcid.org/0000-0003-0285-2859>

of mustard by the introduction of new high-yielding varieties and hybrids and compliance with agrotechnical methods of cultivation [4].

Thus, given the economic environment and climate change, there is a need to develop adaptive cultivation technologies for specific soil and climatic conditions, which aimed to optimize the production process and to increase the mustard productivity. It is important to investigate the impact of primary tillage and fertilizer systems on the yield of this crop.

**Aim.** To identify how the different systems of primary tillage and fertilizers influence on the white mustard yield.

**Materials and Methods.** During 2009–2016, we have studied the impact of various systems of primary tillage, conventional and new fertilizer systems on crop productivity in a stationary field trial at the Khmelnytskyi State Agricultural Research Station. The studies were performed in a 4-field crop rotation with the fol-

lowing crops: soybean (*Glycine max Moench*), spring barley (*Hordeum sativum L.*), white mustard (*Sinapis alba*), winter wheat (*Triticum vulgare Best.*). Crop cultivation technology is a generally accepted in this climatic zone, with the exception of primary tillage and fertilizer application. White mustard of Podolianka variety was sown with the row spacing of 15 cm, sowing rate of 2.0 million germinable seeds/ha. Fertilizer rates for mustard are as follows: conventional (mineral) fertilizer system of N<sub>60</sub>P<sub>60</sub>K<sub>60</sub> (background 1); new (organomineral) fertilizer system – (spring barley straw + N<sub>10/t</sub> straw + N<sub>30</sub>P<sub>30</sub>K<sub>30</sub>) (background 2).

Soil was podzolic medium loam chernozem. Content of humus was 2.62–3.12 %, total nitrogen – 0.150–0.163 %, mobile phosphorus – 12.5–19.61 and exchangeable potassium 6.5–7.2 mg per 100 g of soil, pH (salt) 6.0–6.5. The scheme of the primary tillage for white mustard was as follows:

Primary tillage system for crop rotation	Method and depth of tillage for white mustard, cm	Equipment
Moldboard tillage	Plowing (25–27)	PLN(ПЛН)-3-35
Subsurface tillage	Subsurface (25–27)	KPH(КПН)-2-150
Chiseling	Chisel (25–27)	PCH(ПЧ)-2,5 + PST(ПСТ)-2,5
Disking	Disk (10–12)	BDT(БДТ)-7
Minimal tillage	Disk (6–8)	BDT(БДТ)-7

The placement of plots was systematic. The accounting area of the plot was 40 m<sup>2</sup>, the experiment replication was four times. The research was conducted according to generally accepted methods [2]. Agrometeorological conditions were characterized by significant deviations from the long-term average. The amount of precipitation, their distribution during the growing season and temperature tended to increase, but in general, the influence of the studied factors was stable.

**Results.** On average for the years of research, the highest yield of white mustard (1.89 t/ha) was obtained on the mineral background (background 1) in the case of moldboard plowing (control) (Table 1). When the system of subsurface cultivation was introduced, the mustard seed yield decreased by 0.04 t/ha or 2 % compared to the control. For all other non-moldboard cultivation, the seed yield decreased by 5–19 % compared to the control.

On the organomineral background (background 2), the highest seed yield (1.90 t/ha) was formed under the moldboard tillage. The seed yield decreased by 4–21 % compared to other tillage. In general, on the organomineral background compared to mineral one, when the moldboard, chisel and disk tillage were introduced, there was a slight increase in seed yield by 0.5; 3.0; and 2.0 %, respectively, and under subsurface and minimal – its indicators decreased by 1.0 and 3.0 %.

On both fertilizer backgrounds, the highest yield of mustard was provided with the moldboard tillage; stably the lowest seed yield was under the minimal tillage. When by-products were left a long time as fertilizer and one-time shallow disk tillage (minimal tillage) was introduced, in general, the mustard yield significantly reduced. We think that significant reduction in yield under the nonmoldboard tillage, especially minimal, compared to the

1. Influence of primary tillage and fertilizer systems on white mustard yield, t/ha (2009–2018)

Year	Mineral fertilizer (background 1)					Organomineral fertilizer (background 2)					
	Moldboard (control)	Subsurface tillage	Chiseling	Disking	Minimal tillage	Moldboard (control)	Subsurface tillage	Chiseling	Disking	Minimal tillage	
2009	3.41	3.54	3.38	3.30	2.70	3.67	3.77	3.57	3.48	2.58	
2010	1.62	1.46	1.55	1.50	1.43	1.51	1.37	1.44	1.42	1.32	
2011	2.36	2.05	2.26	2.25	2.14	2.13	2.22	2.06	2.21	2.27	
2012	2.42	2.92	1.67	2.24	1.85	2.35	1.95	1.97	2.25	1.41	
2013	2.35	2.06	1.62	2.15	1.79	2.36	1.89	1.89	2.16	1.35	
2014	1.99	1.92	1.96	1.91	1.76	1.89	1.78	1.84	1.76	1.58	
2015	0.76	0.89	0.93	0.74	0.93	0.95	0.91	1.01	1.04	1.32	
2016	1.53	1.51	1.75	1.65	0.97	1.67	1.69	1.65	1.79	1.28	
2017	0.92	0.85	1.13	0.91	0.63	1.19	1.32	1.34	0.95	0.63	
2018	1.55	1.28	1.45	1.34	1.21	1.23	1.40	1.40	1.25	1.26	
Average	1.89	1.85	1.77	1.80	1.54	1.90	1.83	1.82	1.83	1.50	
± to control	t/ha	-	-0.04	-0.12	-0.09	-0.35	-	-0.07	-0.08	-0.07	-0.4
	%	-	-2	-6	-5	-19	-	-4	-4	-4	-21
± to back-ground 1	t/ha	-	-	-	-	-	0.01	-0.02	0.05	0.03	-0.04
	%	-	-	-	-	-	0.5	-1	3	2	-3

moldboard tillage, on both fertilizer backgrounds was caused by the difference in quality and depth of soil loosening, i.e. physical properties of soil, which change indicators after primary tillage and save differences between variants for a long time. This is confirmed by the indicators of soil hardness determined with the Reviakin's penetrometer at the appearance of full sprouts.

Thus, when the moldboard tillage was applied, the hardness of 0–10 cm soil layer was 12–13 kg/cm<sup>2</sup>, nonmoldboard –14–15 kg/cm<sup>2</sup> and the minimal tillage – 15–16 kg/cm<sup>2</sup> with higher values on the mineral background. And also the mustard is highly reacted to the physical properties of the soil that was confirmed by biometric indicators of plants (Table 2).

2. Influence of primary tillage and fertilizer systems on forming yield structure elements of white mustard plants (average for 2009–2018)

Tillage systems	Fertilization	Number of branch per a plant, pcs	Number of pods per a plant, pcs	Number of seeds per a pod, pcs	Number of seeds per a plant, pcs	Seed weight per a plant, g	1000 seed weight, g	Plant height, cm
Moldboard	M*	8.2	202	3.52	712	1.25	1.76	150
	OM**	8.0	189	3.44	653	1.39	2.12	153
Subsurface	M	7.6	180	3.51	634	0.79	1.25	144
	OM	7.3	172	3.48	599	1.29	2.15	146
Chiseling	M	7.4	185	3.54	656	1.15	1.75	142
	OM	7.6	180	3.51	633	1.33	2.10	140
Disking	M	7.1	164	3.36	554	1.20	2.17	135
	OM	7.0	152	3.31	512	1.25	2.44	132
Minimal	M	5.2	150	3.32	499	0.99	1.98	131
	OM	6.2	141	2.23	324	1.10	3.39	129

\* Mineral fertilizer \*\* Organomineral fertilizer

Thus, on the mineral fertilizer background, the height of plants depending on the tillage was: moldboard tillage – 150 cm, at subsurface tillage – 144 cm (height reduced to control by 4 %), at chiseling – 142 cm (by 5 %), at disking and the minimal tillage was 135 cm (by 10 %) and 131 cm (by 13 %), respectively. In the same sequence from largest to smallest, the values of such indicators followed as the number of branches per plant, the number of pods, the number of seeds per pod and per plant, the seed weight per plant, the 1000 seed weight; accordingly, the individual productivity of plants differed.

On the organomineral fertilizer background, the above indicators were characterized by a similar trend depending on the systems of primary tillage with fluctuations in values relative to the mineral background. The difference between the backgrounds consist 1–19 % for

number of lateral shoots per a plant, the number of pods – 1–7 %, the number of seeds per a pod – 1–33 %, the number of seeds per a plant – 4–35 %, the seed weight per a plant – 4–63 %, the 1000 seed weight – 12–72 %, the plant height – 1–5 %. The maximum difference in the numerical values of these indicators depending on the systems of primary tillage (regardless of fertilization) was 37, 26, 35, 50, 37, 74, 16 %, respectively. Thus, white mustard is highly sensitive to loosening the soil and responds to this agrotechnical method more than fertilization.

According to economic analysis, the high profitability of white mustard seed production due to the organomineral background was 263 % under subsurface tillage, this indicator was slightly lower under chisel tillage (259 %), even lower – under moldboard tillage (250 %) and the lowest (206 %) – under minimal tillage (Table 3).

### 3. Influence of primary tillage and fertilizer systems on the main economic indicators of white mustard seed production (average for 2009–2018)

Tillage system	Indicator					
	production costs, UAH/ha		relative net income, UAH/ha		level of profitability, %	
	Backgrd 1*	Backgrd 2**	Backgrd 1	Backgrd 2	Backgrd 1	Backgrd 2
Moldboard	4865	3824	9145	9559	188	250
Subsurface	4776	3736	8537	9826	179	263
Chisel	4809	3769	8930	9750	186	259
Disk	4958	3685	8606	9022	174	245
Minimal	5226	3749	6267	7705	120	206

\* Mineral fertilizer \*\* Organomineral fertilizer

The profitability level under the mineral fertilizer system was lower by 62–86 % compared to the organomineral system. There is mainly explained by high prices for mineral fertilizers. Therefore, the introduction of conventional mineral fertilization with nitroammophoska at a rate of N<sub>60</sub>P<sub>60</sub>K<sub>60</sub> for white mustard, compared to the new one, when N<sub>30</sub>P<sub>30</sub>K<sub>30</sub> applied on background of leaving the predecessor straw, was economically unprofitable. On the mineral background, the production costs were increased by 93–361 UAH for disking and minimal tillage against moldboard tillage (control). This is explained by the fact that in some years (2010–2013) when these systems were introduced, the glyphosate-based herbicides were

applied after harvest.

It should be noted that in some years on the organomineral background we had observed sparseness of white mustard plants by almost 40–50 % compared to mineral fertilizer on plots with nonmoldboard tillage, especially minimal one. In general, the planting density on the organo-mineral background was 1.5–1.55 million plants/ha, and on the mineral one – 1.65–1.7 million plants/ha, i.e. decreased by an average of 10 %. The availability of significant amount of straw residues of the predecessor in the sown layer of soil on the organomineral background caused the crop sparseness. The straw residues did not decompose, and in arid weather conditions before and after sowing in April, they

caused deficit of moisture in sown layer of soil. When straw residues were deepened in soil, the effect was opposite. In that context, there may have been other factors that led to the situation, but we have not determined them.

**Conclusions.** On the background of mineral fertilizer  $N_{60}P_{60}K_{60}$ , the highest yield of white mustard seeds (1.89 t/ha) was formed in the variant with a moldboard tillage.

On the organomineral background (the predecessor straw residues and application of  $N_{30}P_{30}K_{30}$ ), the highest seed yield of white mustard (1.90 t/ha that was equal to the mineral background) was provided by the moldboard tillage. The application of conventional fertilization with nitroammophoska at a rate of  $N_{60}P_{60}K_{60}$  for white mustard was economically unprofitable compared to the new method, when  $N_{30}P_{30}K_{30}$  applied on background of leaving the

predecessor straw.

We have analysed indicators of economic efficiency of growing white mustard and established that a subsurface tillage on the organomineral background (predecessor straw residues and application of  $N_{30}P_{30}K_{30}$ ) can be considered the most perspective and adapted to current weather conditions; the next one according to these indicators was the chisel tillage. The introduction of primary tillage (nonmoldboard) for fields of white mustard on the organomineral background is more profitable than the most productive one on the mineral background.

It is required further detailed study the method when the predecessor straw is left as the fertilizer in crop rotation, especially with the introduction of various systems of primary tillage, considering the weather conditions of recent years.

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