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DEVELOPMENT OF TILLAGE THEORY IN NORTHERN KAZAKHSTAN

Аннотация. В последние годы в теории по обработке почвы отдается предпочтение нулевым технологиям. В статье проанализированы результаты прежних и новых исследований по обработке почвы на южном карбонатном тяжелосуглинистом черноземе. Сравнение варианта традиционной глубокой осенней обработки почвы с вариантом исключения осенней обработки почвы или с вариантом нулевой технологии показало преимущество традиционной обработки почвы в обоих случаях благодаря лучшей водопроницаемости почвы в период снеготаяния. Для сохранения плодородия почвы рекомендуется применять сокращенные обработки почвы и плодосменные севообороты, а также уменьшенные площади чистых паров.
Ключевые слова: обработка почвы, Северный Казахстан, чернозем, плодородные почвы, севообороты.

Түйіндеме. Соңғы жылдары жерді өңдеу теориясында нөлдік технологиясына басымдық көп беріледі. Мақалада оңтүстік карбонатты ауыр саз балшықты қара топырақты жерді өңдеу бойынша бұрынғы және жаңа зерттеулердің нәтижелері талданған. Жерді күзгі терең өңдеудің дәстүрлі тәсілін жерді күзгі өңдеусіз немесе нөлдік технология түрімен салыстыру барысында екі жағдайда да жерді дәстүрлі өңдеудің артықшылығы қар еру кезіндегі жерге судың жақсы сіңірілуінің арқасында болатынын байқатты. Топырақтың құнарлылығын сақтау үшін жерді өңдеудің төмендетілген түрін және ауыспалы егіс жүйесін және таза пар алқаптарын қысқартуды қолдану ұсынылады.
Түйінді сөздер: жерді өңдеу, Солтүстік Қазақстан, қара топырақ, жердің құнарлылығы, ауыспалы егіс.

Abstract. Recently, the zero technology in the theory of tillage is preferred. The paper analyzes the results of previous and new research on the treatment of the soil on the southern carbonate heavy loamy black soil. Comparison of the traditional version of late autumn tillage with exceptions option autumn tillage or zero technology showed the advantage of conventional tillage in both cases due to better soil permeability during snowmelt. To preserve the fertility of the soil is recommended to apply reduced tillage and crop rotation crop rotation and reducing the area of pure vapor.
Key words: tillage, the Northern Kazakhstan, black soil, soil fertility, crop rotation.

Introduction

Development of the bases of conservation agriculture in northern Kazakhstan began under leadership of A. Barayev during period of new land development in the mid- 1950s. First studies were conducted under strong influence of ideas on farming practices of T. Maltsev which were officially recognized during an All-Union conference on tillage conducted in 1954 [1]. The base of new theory of farming practice, suggested by an agronomist from a collective farm, was deny of existing theory of V. Williams on big role of perennial forages in soil fertility conservation. Malstev suggested that one can maintain soil fertility under annual crop growth provided you don't use moldboard plows. In fact Maltsev's theory was very similar to modern theory of No-Till. But he had no equipment for direct seeding at that time. And he suggested removing moldboards from plow or using disk for shallow tillage.

The first results of tillage studies in northern Kazakhstan were in agreement with Maltsev's conclusions. They were as follows: crop rotations with perennial forages can be replaced by grain-fallow rotations, whereas moldboard plowing can be replaced by disks [2].

The next stage of tillage studies began after Dr. A. Barayev visited Canada in 1956. The Canadian farming practices made deep influence on further development of conservation agriculture theory in Kazakhstan [3]. The decision was taken to purchase samples of Canadian equipment for testing. This machinery became prototypes of equipment for local conservation agriculture. In fact all new equipment was copies of Canadian machinery. The only original

equipment was sweep for deep tillage because Canadian farmers didn't do deep tillage using only blades. At that time tillage in the fall was not used in western Canada because all wheat was sown on summer fallow which was not tilled deep. Deep tillage in the fall was found by us and to do that type of tillage sweep was developed.

In this paper we are going to discuss development of tillage issues as one of major elements of farming systems. In northern Kazakhstan tillage systems are composed from tillage in the fall or main tillage, early spring tillage and seedbed preparation. Main tillage was studied at many research stations and main conclusion was that the moldboard plows should not be used for tillage and replaced by sweeps for deep tillage and blades for shallow tillage [4]. As a result of main tillage studies in grain- fallow rotations conducted at Shortandy on heavy clay loam chernozem soil the conclusion was that soil should be tilled in rotation with the sweeps and the blades.

Materials and methods

In 2002-2005 at Shortandy study was conducted in 5 year rotation fallow-4 year wheat. The treatments included various depth of tillage with different equipment in fallow: the moldboard plow (25-27 cm deep), the sweep (25-27 cm deep) and the blade (12-14 cm deep). The tillage in the fall on stubble land included various combinations of tillage with the sweep, the blade and no tillage. For the first crop after fallow 4 year data was obtained, for the second, third and fourth crop after fallow 3, 2 and 1 year data was obtained respectively. On all treatments of tillage in the fall early spring tillage was done using a needle harrows and sowing with a cultivator-drill.

In other study in 2002-2005 three tillage treatments were tested in 4 year rotation with fertilizers (15 kg/ha of P2O5 and 30 kg/ha of N) and without fertilizers. Treatments of tillage in the fall were deep (25-27 cm deep), shallow (12-14 cm deep) and no tillage. Across all treatments of tillage in the fall early spring harrowing and sowing with the cultivator-drill was done.

In 2009-2012 traditional tillage was compared with no-till for barley crop sown after wheat. Traditional tillage was done 25-27 cm deep, in winter snow ridging was made to collect snow, in early spring harrowing was done with the needle harrows and sowing was done

with the cultivator-drill in the second half of May. No-till plots were seeded directly without any tillage.

Results

The results of the first trial conducted in 2002-2005 have shown that tillage method and its depth significantly affected spring wheat yield (Table 1).

Table 1

Tillage method		Crop after fallow and number of years			
On fallow	On stubble	1 (4yr)	2 (3yr)	3 (2yr)	4 (1yr)
sweep	Rotating	2.41	1.98	1.81	1.68
sweep	Blade	2.31	1.96	1.81	1.71
sweep	No tillage	2.30	1.84	1.59	1.50
Blade	Blade	2.28	1.95	1.69	1.61
Blade	No tillage	2.28	1.75	1.65	1.48
Plow	Blade	2.51	2.22	1.84	1.65
Plow	No tillage	2.51	2.24	1.68	1.53

Four year data have shown that in the first year after fallow there was advantage of plowing deep in fallow year. This can be explained by improvement of nutrition regime because during several years of conservation tillage top soil becomes more fertile and placing it to deeper horizons gives positive result. Besides, intensive tillage facilitates nitrogen production from soil organic matter.

In the second year after fallow one can see advantage of deep plowing in the fallow year irrespective of tillage method on stubble. No tillage in the fall on stubble land made negative result on crop yield. The wheat yield reduction was more remarkable after shallow tillage in the fallow (10%) as compared to deep tillage in the fallow (6%).

In the third year after fallow the best treatment was shallow tillage both after sweep and plow in the fallow year. Shallow tillage conducted over three years gave yield reduction by 7% as compared with rotation of deep and shallow tillage. No tillage in the fall after plowing in the fallow year reduced yield by 9% as compared with shallow tillage. No

tillage in the fall after deep subsurface tillage by the sweep reduced wheat yield by 12%. One of the reasons of poor yields on no tillage can be explained by higher bulk density. It was 1.01-1.17 g/cm^3 after traditional tillage against 1.13-1.25 g/cm3 on no tillage. The infiltration of snowmelt water may be reduced on more compacted soil. Besides, infiltration of snowmelt water was improved remarkably when soil was tilled deep in the fall leaving big cracks in the soil. The weed infestation was also increased on no tillage plots. Tillage in the fall also improvise decomposition of nitrogen in soil organic matter.

On the fourth year after fallow also the lowest grain yields were noted when soil was left in the fall with no tillage.

Economical assessment of tillage methods has shown that lowest cost of production was when soil was shallow tilled or left with no tillage in the fall. In all, profit margins was highest in the system including plowing in the fallow year combined with no tillage on the stubble land.

In the second experiment in the same years three tillage treatments were tested in the four year crop rotation of summer fallow with wheat. In this trial soil water storage in 0-100 cm soil layer prior to sowing of spring wheat was 108 mm on no tillage compared with 119-126 mm in soil tilled in the fall. Again this data indicates on necessity of tillage in the fall for better snow melt water infiltration. This result is in conformity with previous research on southern heavy clay loam chernozem.

Analysis of nitrates content in 0-40 cm soil layer prior to sowing spring wheat has shown that on no tillage in the fall treatment reduced amount of nitrates was observed as compared with deep or shallow tillage in the fall from 82 to 38 mg/kg of soil. Thus reduction of soil moisture and nitrates caused reduction of spring wheat yield (Table 2).

In the first year after fallow there was no difference in grain yields between shallow tillage and no tillage in the fall whereas deep tillage gave lower yield both with fertilizers and no fertilizers. But on the stubble land no tillage in the fall reduced grain yield remarkably as compared with tilled soil with greater difference on non-fertilized plots. On the second and third years after fallow no tillage in the fall reduced

Table 2

Spring wheat yield as affected by tillage in the fall and fertilizer application, t/ha (average for 2002-2005)

Tillage in the fall	Year after fallow					
	first		second		third	
	fertilizer	no	fertilizer	no	fertilizer	no
Deep	1.82	1.77	1.95	1.65	1.62	1.43
Shallow	1.93	1.89	1.84	1.60	1.64	1.48
No tillage	2.00	1.92	1.70	1.33	1.37	1.18

wheat yield compared with shallow tillage by 8-17% on fertilized plots and by 17-20% on non-fertilized plots.

Later on in 2009-2012 traditional tillage was compared with no-till on barley sown after wheat. The plots were continuously tilled as traditional and no-till since 2006. Traditional tillage included deep tillage with the sweep in the fall, snow ridging in winter, early spring harrowing and seeding with the cultivator-drill while no-till plots were direct drilled continuously on tall stubble. Barley yields were in favor of traditional tillage in all years (Table 3).

Table 3

Barley yield as affected by tillage technologies, t/ha

Tillage	Year				Average
	2009	2010	2011	2012	
Traditional	4.04	1.65	4.13	2.20	3.01
No-till	3.89	1.32	4.03	1.91	2.79

This can be explained similarly as it was observed in previous research on tillage in the fall by better snowmelt water infiltration on deep tilled soil. It is especially important when snow ridging was done to collect more snow. In two years out of four advantage of traditional tillage was significant. These two years were extremely dry and

advantage in water storage prior to sowing was more critical during long drought in June and first half of July.

Discussion

Comparison of tillage in the fall methods in two trials on heavy clay loam soil has shown advantage of deep tillage. Improved snowmelt water infiltration in early spring during thawing of snow was major reason for better soil water storage prior to sowing spring wheat.

When shallow tillage in the fall was compared with no-till for two varieties of dry pea and under three seeding dates of spring wheat in 2006-2008 on average there was no significant difference in crop yields [5,6] In 2009-2012, when no-till was compared with traditional deep tillage in the fall barley yield advantage was in favor of traditional tillage especially profound in extremely dry years when difference in soil water storage prior to seeding of barley was critical. In other words advantage of deep tillage in the fall was observed both against no tillage in the fall and no-till.

In Kostanai area on sandy loam chernozem soil minimum tillage had advantage against deep tillage in the fall [7]. Later on no-till was tested and it provided higher wheat yields as compared with traditional deep tillage This can be explained by good snowmelt water infiltration on untilled light textured soil whereas soil moisture conservation was better on no-till.

Main advantage of no-till is soil fertility conservation. It is obvious that no-till leads to slower decomposition of soil organic matter. But role of no-till in conservation of soil fertility should not be overemphasized. In the studies at Shortandy (I.A. Vasko) mulching with straw was done at rates 2 and 4 t/ha during three times 4 year rotation of fallow-3 wheat. After 12 years of trial at two rates of mulching, organic matter content in 0-10 cm soil layer, increased from 3.52% up to 3.69 and 4.10% respectively, and in 10-20 cm layer from 3.30% up to 3.3 and 3.65% respectively. But nobody will transfer straw from one field to another to accumulate thick mulch layer. One should remember that average wheat yield in the region is about 1-1.2 t/ha. Thus in addition to reduced tillage one should introduce diversified crop rotations with less summer fallow area instead of wheat-fallow monoculture.

Long-term comparison of no-till with traditional tillage was carried out in the prairies of western Canada [8,9]. It should be noted that Canadian farmers never practiced deep tillage. If tillage in the fall was done heavy duty cultivators were used for this purpose. Besides, additional nitrogen fertilizer was applied on no-till plots. Under this conditions no-till had some advantage against traditional tillage in long-term trials. Widespread adoption of no-till in western Canada is associated not so with yield advantage but as the way to move away from fallow-wheat system and conserve better soil fertility.

Conclusions

1. Comparison of results of studies with no tillage in the fall with later studies with direct seeding shows many similarities in conclusions.
2. On heavy clay loam soil in most cases deep tillage in the fall is needed to facilitate snowmelt water infiltration especially when snow ridging is done for snow accumulation.
3. On sandy loam soil both no tillage in the fall and direct seeding had advantage against traditional deep tillage.
4. Reduced tillage and no-till are important for soil conservation.

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