

Impact of Resource Conserving Technologies (RCT) on soil physical properties and rapeseed (*Brassica napus* L.) yield in irrigated agriculture areas of the South-Eastern Kazakhstan

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Abstract

The aim of this research was to determine the effects of Resource Conserving Technologies (RCT) system and Conventional Tillage (CT) on soil physical properties and Rapeseed (*Brassica napus* L.) yield in irrigated agriculture areas of the South-Eastern Kazakhstan. The experimental study was conducted according to a randomized block design with three replications between 2015 and 2018. The CT system had maximum anthropogenic effect and caused loosening of arable soil layer, had the lowest bulk density values (1.19 -1.21 g/cm³). The CT had a bulk density ranged between 1.13 and 1.30 g/cm³. With a RCT tillage, the bulk density during the growing season of rape was located in optimal density zone between 1.20 and 1.22 g/cm³. The RCT of rapeseed provided the greatest efficiency, where the yield of rapeseed increased by 13.3% and 22.0%. It has been revealed that with RCT of rapeseed cultivation, minimum technology (Mini-till) ensures sustainability of soil environment and its ecological condition, improves structure and raises water resistance of agroecosystem's soil aggregate. In turn the structure of soil's arable layer stabilizes with optimal soil density, which contributes to normal growth and development of rapeseed. It is proved that minimal technology of tillage is the leading agricultural practice ensuring preservation and improvement of qualitative and quantitative indicators of soil resource and productivity of oilseed rape.

Keywords: Conservation tillage, agrophysical factors, fertility, yield.

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Article Info

Received : 18.04.2018

Accepted : 05.01.2019

Introduction

At the beginning of the third millennium, humanity was faced with ecosystem's limited ecological capabilities (Carpenter et al., 2006). Particularly, this case refers to the arable lands which have been used intensively under field traffic leading to decrease not only fertility and crop yield in soil but also to reduce usage of sustainable land and soil resources (Gomiero, 2016). In addition to that, in connection with the tillage systems also have the potential not only to accelerate ecological deterioration such as soil fertility loss and soil erosion but also, to reduce economical income such as increasing financial, energy and labor costs by reducing the long-term sustainability of dryland agriculture (Telles et al., 2011). A certain sequence of multiple methods of tillage takes place under traditional technology of agricultural crops' cultivation. Between 30 and 40 % of the total cost for crop growth is tillage application (Townsend et al., 2016). In general for those main reasons, concept of conservation agriculture was developed. Conservation agriculture is a part of sustainable agriculture, aiming at optimizing yields and profits but also at protecting land resources and the environment. Therefore, it is necessary to focus on effective and environmentally friendly methods in terms of resource conserving technologies for field cultivation activities (Hobbs et al., 2008).

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e-ISSN: 2147-4249

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DOI: [10.18393/ejss.510686](https://doi.org/10.18393/ejss.510686)

In recent years, systemic measures have been taken in agriculture field in the Republic of Kazakhstan to apply highly efficient Resource Conserving Technologies (RCT). Separate elements of this (No-tillage) technology were introduced in northern Kazakhstan as a system for soil protection which contributed to slow down soil erosion processes and increased the yield of grain crops (FAO, 2013; Saparov, 2014). Moreover, in different agricultural zones of the Republic of Kazakhstan, the basic principles of resource conserving agriculture has been developed by applying mulch system with plant residues and reduction or completely non mechanical tillage. Thus, zero tillage technology is contributing to enhanced sustainability of dryland agriculture in the region by reducing erosion, and improving soil quality and soil ecosystem services (Franzuebbers, 2002; Bessam and Mrabet, 2003; Kassam et al., 2009; Palm et al., 2013; Acar et al., 2018).

Conservation agriculture involves zero or minimum soil disturbance through tillage (no-tillage, reduced tillage, mulch tillage and strip-tillage), a balanced use of fertilizers and herbicides, a permanent soil biomass cover enhancing water and soil conservation, crop rotation and integrated pest management, reduced production costs and increased farming efficiency (Mrabet et al., 2001; Kassam et al., 2009; Ruiz-Colmenero et al. 2013; Chauhan et al., 2012). As for minimal technology (Mini-till), the number of soil's mechanical treatments is also reduced, continuous action herbicides replace the systems of mechanical pre-sowing and intermediate tillage and instead of deep processing, and small flat-cutting treatment is used. The use of environmentally correct techniques of technology that fit into biochemical circulation of agroecosystem resources ensures creation of sustainable competitive agrophytocenosis (Duru et al., 2015). Therefore, the objective of this manuscript was to investigate the effects of resource conserving technology techniques on soil physical properties and rapeseed (*Brassica napus* L.) yield in irrigated agriculture areas of the South-Eastern Kazakhstan.

Material and Methods

Study site description

Experimental studies were carried out at the Turgen private farm "Agrouniversity" training and experimental farm of KazNAU found on the foot slope position of the Northern part of the Ili Alatau in the irrigated agriculture zone used under intensive agricultural activity and located at in South-Eastren part of the Kazakhstan (Figure 1). The study area is situated between 550 and 700 m elevation from sea level.



Figure 1. Location map of the study area

The climate type of study area is "Continental Climate" which can be described as low humidity, plenty of sunlight, a short but rather cold winter. The average annual air temperature is 7.7°C. The average long-term sum of precipitation for a period with temperature above 10°C is 240-350 mm with a total evaporation volume of moisture during this period (1550-1720 mm). The duration of the frost-free period is 158-175 days. Monthly average precipitation and temperature values of the study area is given Figure 2.

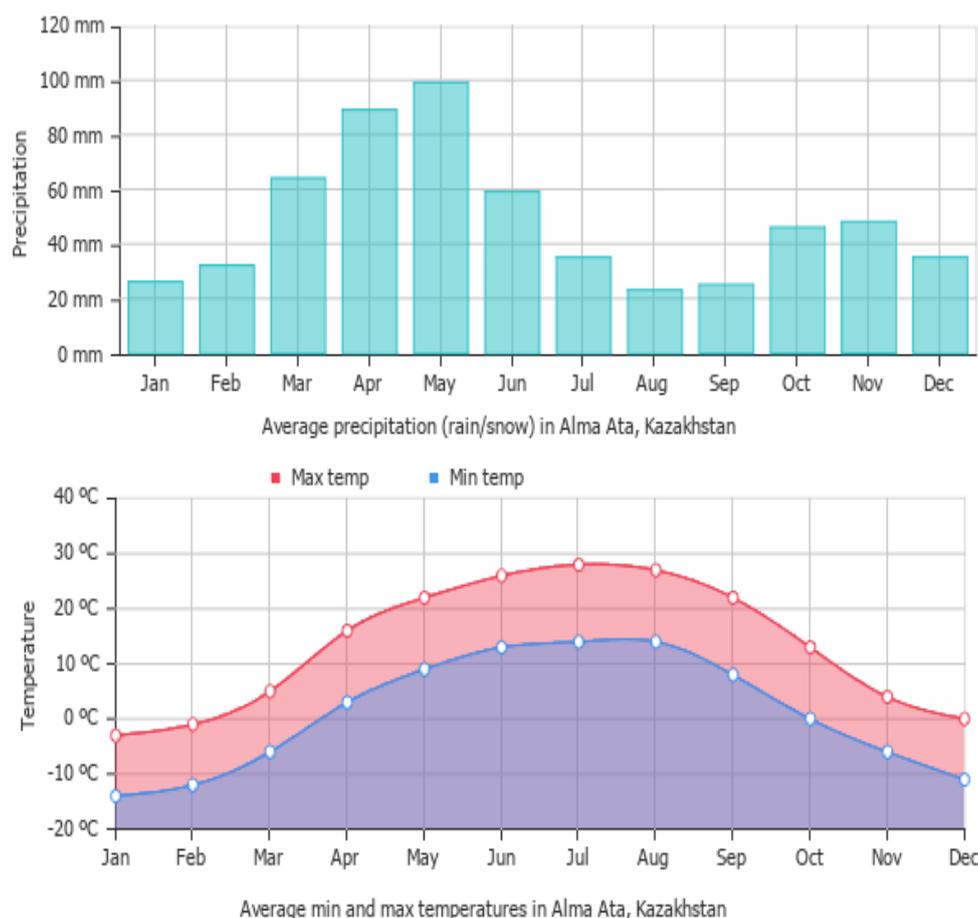


Figure 2. Monthly average precipitation and temperature values of the study area

Soil properties in study site

Before the beginning of the experiment, some properties of the soil were determined. After taking soil samples from surface depth (0-20 cm), some physico-chemical analyses were conducted on air-dried samples stored at room temperature and from which crop residues, root fragments and rock larger than 2 mm in diameter had been removed. Selected some soil chemical properties were determined by the methods of Rowell (1994) and Jones, Jr. (2001). Research area soil is slightly alkaline with 7.3 pH value in 1:1 (w/v), while amount of their average CaCO_3 is about 5.8%. In addition, organic matter content, C/N ratio and total mineral nitrogen (NH_4+NO_3), available phosphorus and available potassium of the surface soil are 4.45%, 11.8, 87 mg/kg, 435.1 mg/kg and 22 mg/kg, respectively. These ratios decreased with increasing soil depth. According to the soil classification system, soil of experimental area was classified as meadow chestnut. In addition, some soil chemical characteristic values of meadow chestnut are given in Table 1. Moreover, physical properties of meadow chestnut soil is potentially fertile and satisfies the conditions to cultivate all types of crops particularly for oilseed rape.

Table 1. Some properties of meadow chestnut soil

Depth, cm	Organic matter, %	Total nitrogen, %	C:N	Total potassium, %	Total phosphorus, %	CaCO_3 , %
0-24	4,45	0,120	21,51	2,60	0,19	5,80
24-32	4,40	0,119	21,44	2,10	0,16	5,84
32-59	1,00	0,060	9,66	1,09	0,17	5,88
59-103	0,46	0,039	6,84	1,10	0,14	7,30

Experimental design and tillage systems

In order to determine effect of different soil tillage systems on some soil physical properties such as soil aggregate stability, bulk density, and yield of Rapeseed (*Brassica napus* L.), the experimental studies were performed between 2015 and 2018. In this study, main plot treatments were the two soil tillage methods, Conventional Tillage (CT) and Resource Conserving Technology (RCT), sub-plot treatments were three primary soil tillage methods (Tillage at 20-22 cm, Flat-cut tillage at 16-18 cm and Flat-cut tillage at 12-14

cm), and sub-sub-plot treatments were three Pre-sowing soil tillage methods (Cultivation at 10-12 cm by harrowing, Loosening at 12-14 cm and Disking at 8-10 cm). Each sub-sub plot was sized as 20m x 5m (100 m²) and total plot number was 27. Each treatment was performed in three replicate plots. The plant densities of 15x10⁴ – 45x10⁴ plant ha⁻¹ and row spacings from 15–35 cm used in the study are widely used for Rapeseed production in the Almaty region. Different tillage methods used in the study were given in Table 2.

Table 2. Different tillage applications

Soil Tillage Methodology- A	Primary soil tillage-B	Soil Tillage system Pre-sowing soil tillage - C
A₁ Conventional Tillage (CT)	B₁ Tillage at 20-22 cm	C ₁ - Cultivation at 10-12 cm by harrowing
		C ₂ - Loosening at 12-14 cm
		C ₃ - Disking at 8-10 cm
A₂ Resource Conserving Technology (RCT)	B₂ Flat-cut tillage at 16-18 cm	C ₁ - Cultivation at 10-12 cm by harrowing
		C ₂ - Loosening at 12-14 cm
		C ₃ - Disking at 8-10 cm
	B₃ Flat-cut tillage at 12-14 cm	C ₁ - Cultivation at 10-12 cm by harrowing
		C ₂ - Loosening at 12-14 cm
		C ₃ - Disking at 8-10 cm

In all plot, Rapeseed (*Brassica napus* L.) seeds were placed at 2–2.5 cm depth in dry soil. Sowing of rapeseed carried out with a seeding rate of 2.5 million pieces/ha. Rapeseed was manually sown on the September. The seed density was evaluated directly after seedling emergence and adjusted for precise planting density at the five-leaf growth stage for all plots. Before sowing, Phosphorus and potassium fertilizer, as an agricultural background were applied as a basal fertilizer. Pest, disease (Cruiser -the active ingredient is Thiamethoxam, and Karate -the active ingredient is Lambda-cyhalothrin) and irrigation (two to three times at a rate of 400-420 m³/ha) were performed according to local management practices. In the fight against weeds in the sowing of rapeseed, the herbicide (Impulse) was also used in an environmentally safe dose (0.7 L/ha) in RCT plots.

Harvesting and harvest measurements

Plots were harvested when approximately 2/3 of the seed was brown. Rapeseed (*Brassica napus* L.) yield and yield components were determined by adopting the standardized Crop Cut Method (Sapkoda et al., 2016). On each plot, the following measurements and observations were made: the plant density (m²), pods per plant, seeds per plant and the 1000-seed-weight (g). Then, the remaining plants in each plot were manually harvested to measure the manually harvesting seed yield (t/ha). After the fresh weight was determined, the roots and the aboveground tissues were dried in an oven for 30 min at 105 °C to deactivate enzymes and then dried at 70 °C until a constant weight was reached for dry weight determination.

Soil sampling and analysis

Bulk soil samples were taken 2015-2018 period in undisturbed state from the experiment within each parcel at at 0-20 cm soil depth and kept in laboratory for analyses. Soil bulk density was analyzed by volume weight using the Kachinsky method (Kachinsky, 1958). Porosity and degree of aeration were determined by calculation. Aggregate size distribution was determined by the standard dry-sieving method (Savinov, 1936).

Economic analysis

A simple economic analysis was done based on total production. Production cost included rental charge of the land and input cost. The input cost was calculated by considering cost of seed, fuel, fertilizers, pesticide, hiring charges of labour. Fuel consumption was measured by filling the fuel tank twice, before and after each operation, with the re-filled volume being the actual fuel consumption. The gross income and net returns were calculated on the basis of market price for Rapeseed. Price of the product was based on local market to compute total production cost, gross return, gross margin and benefit-cost ratio. The net returns were calculated by subtracting total variable costs from the gross income.

Statistical analysis

Analysis of variance (ANOVA) was performed using Duncan's multiple range test. ANOVA and the LSD test were conducted using the KazNAU using data processing methods.

Results and Discussion

In addressing the problem of developing and introducing RCT for cultivation of oilseed crops such as rape (*Brassica napus* L.), it was identified that resupply techniques provide and enable to reveal hidden forms of stability disorders to maintain agro-ecosystem's stability. Thus, agro-ecosystem made it possible to determine the ecological situation under traditional and resource conserving cultivation technology. As a result of controlling abiotic, biotic and anthropogenic factors, the negative influence of traditional technology of rapeseed cultivation on agroecosystem's ecological situation was revealed.

Bulk density

The tillage applications did lead significant differences on bulk density in average of 3 years of the experiment (Table 3). Generally, soil bulk density was increased in RCT, while decreased in CT. Kanwar (1989) and Meek et al. (1992) reported that tillage systems have altered bulk density and porosity of soils. Decreasing the number, intensity and depth of tillage induced to obtain higher bulk density values (Table 3). The increases in bulk density of the soil with no-tillage treatments have previously been reported by Xu and Mermoud (2001). Contrasting results have been reported for the effects of soil tillage systems on bulk density. Greater bulk density values under conventional tillage systems were reported when compared to no-tillage (Dao, 1996; Roscoe and Buurman, 2003).

When compared soil bulk density in two different tillage methods (CT and RCT), it was found that under CT, which has maximum anthropogenic effect and causes loosening of arable soil layer, has the lowest values (1.19 -1.21 g/cm³) in 16-18 cm. This case can be explained that after preparing seed bed, the density of soil in arable layer was naturally decreased, thus, it created optimal condition for the initial period of growing season. On the other hand, in soil bulk density of 12-14 cm soil depth slightly increased about 1.20–1.22 g/cm³. With tillage minimization (RCT), the soil bulk density is on average 1.20 g/cm³. The data obtained by volume mass indicate the close dependence of arable soil layer's composition on the system of primary tillage. The value of the bulk mass of 0-30 cm of soil layer, with the conventional tillage indicates a loose composition with a bulk mass within range of 1.13 g/cm³ and 1.30 g/cm³ (Table 3).

The influence of main and pre-sowing treatment on soil bulk density, the day of sowing rape by horizons, average over the years of research indicates that comparing to main flat-cutting of soil to a depth of 16-18 cm, provides an increase in soil bulk density at a depth of 0-30 cm from 1.19 to 1.21 g/cm³. Against the same background, at depth of 12–14 cm of tillage in all variants of pre-sowing tillage, an increase in the soil bulk density revealed up to 1.20–1.22 g/cm³. With tillage minimization (RCT), the soil density varies within the limits of optimal addition, where the bulk density is an average of 1.20 g/cm³. The data obtained by volume mass indicated that there was the close dependence of arable soil layer's composition with the system of primary tillage. The value of the bulk mass of 0-30 cm of soil layer, with the CT indicates a loose composition with a bulk density ranged between 1.13 g/cm³ and 1.17 g / cm³ (Table 3).

Table 3. Effect of Conventional Tillage (CT) and Resource Conserving Technology (RCT) on bulk density (average of 3 years)

A	B	C	Bulk density of 0-30 cm soil layer, g/cm ³	
			Before sowing	Before harvesting
A1	B1	C1	1.14	1.27
		C2	1.17	1.28
		C3	1.13	1.30
A2	B2	C1	1.19	1.30
		C2	1.20	1.31
		C3	1.21	1.32
	B3	C1	1.20	1.31
		C2	1.20	1.32
		C3	1.22	1.32

A1: Conventional Tillage (CT), A2: Resource Conserving Technology (RCT)

When studying soil density by volume mass in dynamics, it was found that under CT system, the maximum anthropogenic effect of dump plowing manifests itself which causes loosening of arable soil layer. After preparing the field for sowing, the bulk density of arable soil layer naturally decreased, and it was optimal at the initial period of growing season and development of rape growth. The obtained results of soil's bulk mass before sowing rape showed that replacement of costly, energy-saturated traditional dump plowing with RCT with flat-cut treatments to a depth of 16-18 cm and 12-14 cm contributes to creating an optimal composition of soil's arable layer in initial period of rapeseed development.

Soil bulk density of 0-30 cm soil layer by the end of rapeseed growing season in all treatments increased from 1.20 g / cm³ to 1.27 g / cm³. Under CT with dumping plowing, the top 0-30 cm layer of soil is compacted to the maximum, the bulk density increased from 1.13 g / cm³ to 1.30 g / cm³. A sharp compaction of soil's arable layer causes a disturbance of soil's water regime due to high physical evaporation of moisture and numerous gaps in root system of plants associated with a sharp compaction of the entire root-soil layer.

On the variants of minimal tillage (RCT) during the growing season of rape, soil is compacted moderately and risks for development of plant root system are not created. Before harvesting rapeseed, the bulk density increased from 1.19 to 1.30 g/cm³ minimally under flat-cut processing for a depth of 16-18 cm, and from 1.20 g / cm³ to 1.30 g / cm³ for a depth of 12-14 cm (Figure 3).

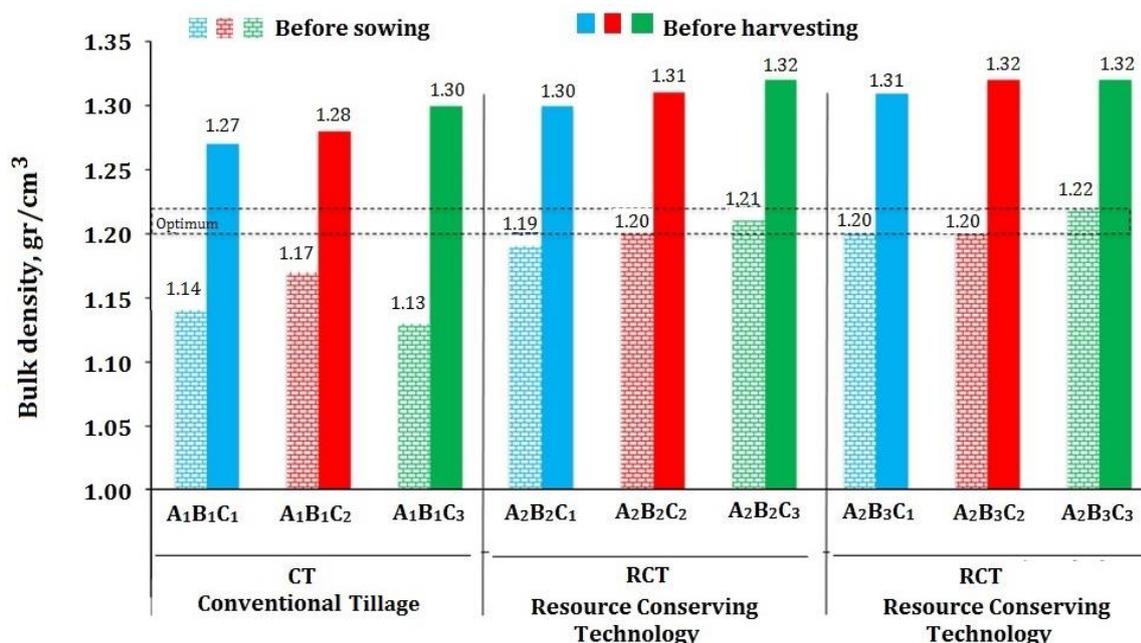


Figure 3. Effect of different tillage systems (CT and RCT) on dynamics of soil bulk density (average of 3 years)

With a RCT (implemented by flat-cut) tillage, the bulk density during the growing season of rape was located in optimal density zone between 1.20 and 1.22 g/cm³. Namely, the optimal addition of arable layer of soil takes place in variants of RCT of rapeseed cultivation with Mini-till. The soil bulk density in both studied variants of flat-cut tillage to a depth of 16-18 cm and 12-14 cm, as well as in case of RCT is within the optimum value (1.19-1.20 g/cm³) for normal growth and development of rapeseed.

Aggregate stability

The overall results of the experiment revealed a strong influence of tillage on aggregate size distribution and mean weight diameter in the average of 3 years, at the 0- 20 cm soil depth (Table 4). The quantity of fine aggregates (<0.25 mm) in RCT compared to CT. [Tisdall and Oades \(1982\)](#) also reported that the stability of macro-aggregates (>0.25 mm) was controlled by soil management (tillage, rotations, etc.), but the stability of micro-aggregates (<0.25 mm) depended on amount and stability of organic cementing agents and seemed to be independent of soil management.

Of the two tillage systems, better aggregate stability of the soil was observed in RCT, as seen by the high percentage of micro-aggregates of diameter <0.25 mm at a depth of 0 to 10 cm (range from a minimum of 42.5% to a maximum of 48.3%) with respect to that calculated in CT (28.1% to 37.0%) (Table 4). The better structure in RCT could be attributed to the effect of different agents that intervene in the aggregate stability. On the one hand, this could be due to a higher organic matter content as a consequence of the incorporation to the soil of residues coming from winter cropping and on the other hand, to that during the tillage operations, by the effect of soil turning, compacted horizons would be taken to the surface, forming stable aggregates that would arise from the compression ([Silva and Mielniczuk, 1998](#)) and not from the biological action of roots or microorganisms.

Effects of CT and RCT on water stable aggregates in average of 3 years of the experiment are given in Table 4. Generally, sum of water stable aggregates was increased in RCT, while decreased in CT. There were

differences between sum of water stable aggregates of tillage systems in all plots. The highest sum of water stable aggregates values were found for RCT (40%-42.1%), in in the average of 3 years. However, the lowest sum of water stable aggregates was reported for CT (22.3%-23.5%). These results were supported by [Arshad et al. \(1999\)](#), where no-tillage improved aggregate stability in surface soil compared to CT. Intensive tillage systems can cause the disruption of water stable aggregates and loss of organic content.

Table 4. Effects of tillage systems on sum of microaggregates and water stable aggregates as a percentage coefficient of soil structure

A	B	C	Sum of micro-aggregates (%)			Sum of water stable aggregates, %	Coefficient of soil structure
			0-10 cm	10-20 cm	0-20 cm		
A1	B1	C1	37.0	35.2	36.1±1.25	22.4±0.29	0.56±0.004
		C2	32.5	31.9	32.2±1.20	23.5±0.51	0.58±0.003
		C3	28.1	30.0	29.0±1.11	22.3±0.66	0.57±0.011
A2	B2	C1	45.8	43.2	44.5±2.12	40.0±1.75	0.91±0.012
		C2	42.5	44.1	43.3±1.51	41.1±1.97	0.83±0.011
		C3	43.5	45.5	44.5±1.56	40.8±2.25	0.87±0.010
	B3	C1	47.2	46.8	47.0±1.75	41.5±2.09	0.90±0.013
		C2	44.2	46.2	45.2±2.14	42.1±2.04	0.94±0.018
		C3	48.3	46.5	47.4±2.28	41.9±2.16	0.98±0.019

A1: Conventional Tillage (CT), A2: Resource Conserving Technology (RCT)

The analysis of soil structure during rapeseed vegetation period with minimal soil treatment, shows a satisfactory structural condition of arable layer (0-20 cm), the share of valuable macro-aggregates was between $43.3 \pm 1.51\%$ and $47.4 \pm 2.28\%$, aggregates was between $40.0 \pm 1.75\%$ and $42.1 \pm 2.04\%$. In the 0-10 cm section of arable soil layer, these indicators indicate a more visible change. After flat cutting soil to a depth of 16-18 cm, the amount of soil macro-aggregates was between 43.3 ± 1.51 and $44.5 \pm 1.56\%$, and water-resistant aggregates was between 40.0 ± 1.75 and $41.1 \pm 1, 97\%$. Flat cutting to a depth of 12-14 cm had a significant impact on these indicators, where the sum of macro-aggregates rised from $45.2 \pm 2.14\%$ to $47.4 \pm 2.28\%$ and water stable aggregates from $41.5 \pm 2.09\%$ to $42.1 \pm 2.04\%$.

In the soil management, persistency and stability of soil aggregation is associated with the size of aggregates ([Traore et al. 2000](#); [Whalen and Chang, 2002](#)). [Nyamangar et al. \(1999\)](#) indicated that there is need to root secretions in the soil for aggregates to be increased. [Martens \(2000\)](#) reported increases of water stable aggregates as a result of corn crop residues, and suggested less soil inverting methods to increase soil aggregation. [Shaver et al. \(2002\)](#) noted that no till cropping in wheat-corn rotation returned more crop residue, decreased bulk density, increased porosity and improved soil aggregation compared to wheat-fallow. [Bronik and Lal \(2005\)](#) noticed the effectiveness of organic matter and decomposition degree on the stability of aggregates. On the other hand, [Abiven et al. \(2008\)](#) determined the correlation between decomposition characters of crop residues and soil aggregates. Meanwhile [Shaver et al. \(2002\)](#) determined increase of macro aggregates and total porosity due to high aggregate stability which in turn causes in high infiltration and water use efficiency. [Kasper et al. \(2009\)](#) determined the amounts of water stable aggregates under conventional and reduced tillage treatments as 18,2 % and 18,9%, respectively, whereas it was found as 37,6% at minimum tillage practice. Besides, authors noted conventional tillage interfere more natural soil properties than reduced and minimum tillage.

Soil aggregates are a reflection of soil structure and texture. The combined group of soil particles is stronger rather than a single one. Aggregate stability is prominently a multi-parameter effect on the soil properties ([Kalhor et al., 2017](#)). Along with soil water-resistance, the effectiveness of minimal tillage was estimated by the soil structure coefficient. Under CT of rapeseed cultivation, the value of this indicator, depending on pre-sowing tillage, ranged between 0.56 ± 0.004 and 0.58 ± 0.003 , which indicated that soil structure was unsatisfactory. Under RCT, tillage minimization provided restoration of aggregate composition and soil structure, where structural coefficient increased with an average from 0.56 ± 0.004 to 0.98 ± 0.019 , which indicated good soil structure (Figure 4).

These results confirm the typical beneficial effect of the lack of disruption of the soil structure (RCT). In Rapeseed cultivation, this is consequence of the protection of the dense vegetation, without handling disturbances. According to [Eltz et al. \(1989\)](#), the larger values found for soil aggregate stability and soil structure under RCT, when compared to CT, are related to the lack of mechanical disruption of the soil and to

the protection that plant residues offer to the surface, contributing to better aggregation. The increase of the stability of aggregates in the surface layer in RCT soil is a good effect because it reduces the susceptibility of the soil to erosion and losses caused by heavy rainfall, management, and wind (Freitas et al., 1999; Hevia et al., 2007). In this present study RCT improved soil aggregation properties after continuous CT, turning them more similar to the original state under native vegetation.

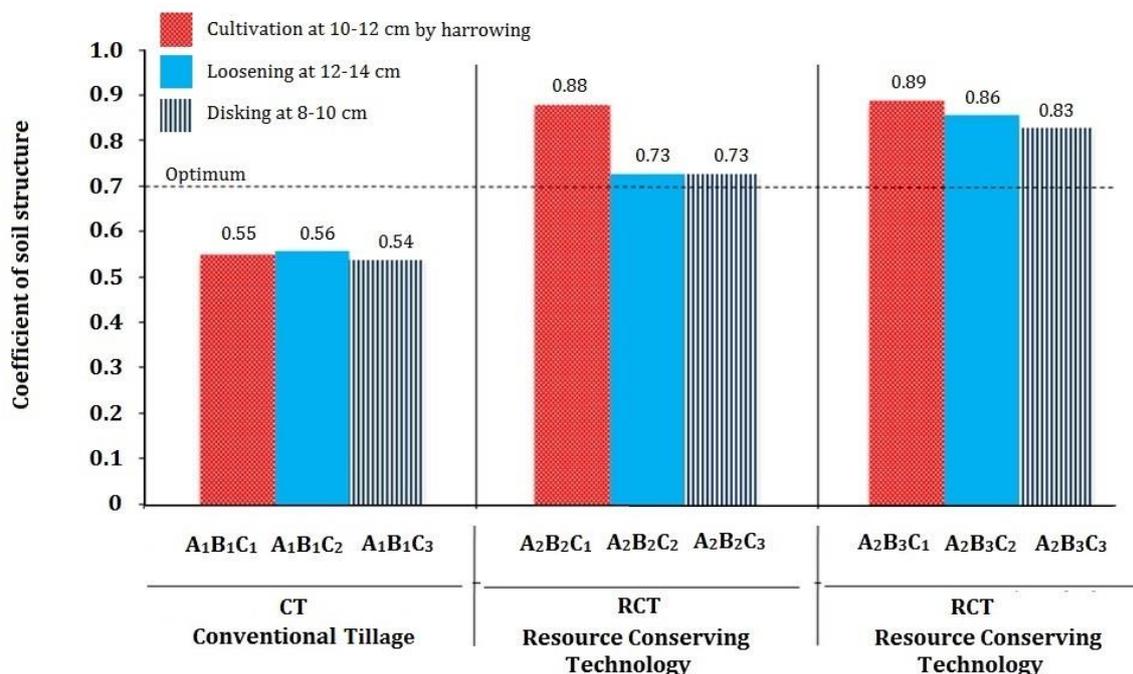


Figure 4. Effects of Conventional Tillage (CT) and Resource Conserving Technology on coefficient of soil structure

Rapeseed yield and yield components

The investigation results revealed that the rapeseed density, number of pods, number of seeds, 1000 seed weight and rapeseed yield were affected by tillage treatments as shown in Table 5. Under RCT, where flat-cut treatment (A₂B₂) was carried out to a depth of 16-18 cm, the rapeseed density was 80.1%, and with a processing depth of 12-14 cm, it was 78.6%. The density of growing rape plants depends on technology of cultivation and agrophysical indicators of soil fertility. Density of plants increases with improvement of aggregate composition and structure of soil. With a satisfactory soil structure after flat-cut treatment, due to improvement in moisture content of sowing rapeseed, the plant density increased, where the number of plants per m² was between 78.6 and 80.1%.

Table 5. Impact of tillage practices on mean values of rapeseed density, number of pods, number of seeds, 1000 seed weight and rapeseed yield

	Rapeseed density (Number/m ²)	Number of pods (pieces / plant)	Number of seeds, (pieces/plant)	1000 seed weight (gr)	Rapeseed Yield (t/ha)
A₁B₁ (CT)	69.7±2.6	12.4±0.36	297±11.5	5.8±0.06	1.73±0.059
A₂B₂ (RCT)	80.1±2.9	18.1±0.88	405±19.5	6.4±0.11	2.11±0.082
A₂B₃ (RCT)	78.6±2.1	17.8±0.61	389±13.7	6.2±0.07	1.96±0.071

One of the elements of crop structure - the number of pods on one plant, depending on primary tillage, showed that the best result was obtained on average with 17.8–18.1 pieces/plant, and the same number of seeds per plant plants 389-405. The number of seeds in one plant was 92 -108 pieces less compared to CT. The most basic indicator of crop structure is the 1000 seed weight. Under RCT of rapeseed cultivation compared to CT, the mass of 1000 seed weight averages were over the years between 5.8g and 6.2-6.4g.

The magnitude of tillage effects varies with the use of tillage implements. CT decreases the bulk density, increases the soil porosity, infiltration rate and hydraulic conductivity (Kanwar, 1989; Meek et al., 1992; Dao, 1996; Xu and Mermoud, 2001; Shaver et al., 2002; Roscoe and Buurman, 2003; Bronik and Lal, 2005). As a result, soil becomes permeable, aerated and having good physical condition for rapeseed growing. On the other hand, RCT increases the bulk density, soil resistance and mechanical impedance of soil for which poor physical condition may be developed. In our experiment, soil perhaps were more loose compared to other tillage treatments, which might have permitted the roots to enter into the deeper layer for uptaking water and mineral nutrients. Positive physiological and metabolic activities of rapeseed were indicated by higher

density, number of pods, number of seeds, 1000 seed weight. Hence, highest yield of rapeseed was obtained using RCT because of higher density, number of pods, number of seeds, 1000 seed weight. The pattern of changes in the addition of the arable layer of soil as a result of the application of the technique of RCT–Minimum (Mini-till) tillage revealed indicated an increase in the quality indicators of the soil resource and the restoration of the agro-physical factors of soil fertility.

The yield of rapeseed with the cultivation of RCT in 2016, 2017, 2018 and 3-year average yield are given in Table 6. The yield of rapeseed in the years of research with the CT was 1.73 t/ha, and with the RCT, it increased to 1.96-2.11 t / ha.

Table 6. Impact of tillage practices on rapeseed yield

Soil Tillage Methodology	Research Years			Average yield (t/ha)	Yield gain	
	2016	2017	2018		(t/ha)	%
A ₁ B ₁	1,76	1,69	1,75	1,73	St	-
A ₂ B ₂	2,16	2,04	2,14	2,11	0,38	22,0
A ₂ B ₃	1,98	1,93	1,99	1,96	0,23	13,3
Sd ₀₅ , t/ha	1,21	0,12	0,16	0,11		
S _x , %	2,43	2,43	2,87	3,04		

Yield results were processed by analysis of variance, where the lowest value of the standard deviation (Sd₀₅) between the control and the studied variants was 0.12t / ha and the accuracy of the experiment was S_x,% = 2.43%. According to the results of ANOVA, it is considered significant when the obtained difference of the studied variants exceeds the Sd₀₅. For example, in 2016, the yield difference between RCT and CT was within 0.22-0.40 t/ha. If we compare, the yield difference of the cultivation with RCT (0.40 t/ha) where Sd₀₅ = 0.12, it was proved that the RCT provided a reliable significant yield increase up to 22.7%. In all the years of studying both methods of RCT, a significant yield increase was achieved, within 0.23-0.38 t/ha. Thus, the RCT of rapeseed provided the greatest efficiency, where the yield of rapeseed increased by 13.3% and 22.0%.

Economic Evaluation

In the series, under the conditions of the foothill zone of south-east of Kazakhstan, we gave the economic efficiency of RCT techniques. Economic efficiency was calculated to assess the effectiveness of economic and natural resources in the agro-ecosystem, as well as to assess specific areas of increasing economic efficiency in the cultivation of crops, ensuring the preservation and reproduction of the natural environment and increasing yields. The economic efficiency of rapeseed cultivation technology was carried out on the basis of rapeseed cultivation technology maps, taking into account the direct costs of CT and RCT according to the standards, rates and prices existing at the farm.

The following indicators were used in the comparative assessment of the efficiency of the methods of using the RCT of rapeseed cultivation:

- Rapeseed crop yield when studying the effect of minimization (Mini-Till) of tillage,
- Production costs per 1 hectare of rapeseed (based on rapeseed cultivation maps) from 1 ha (yield multiplied by the cost of 1 ton of rapeseed),
- Net income (sales revenue minus costs of rapeseed cultivation),
- Production profitability in rapeseed cultivation (net income divided by the cost and multiplied by 100%) depending on the studied techniques of the technology.

Crop yield was the main indicator for assessing the economic efficiency of rapeseed, while evaluating the ratio of yield and production costs. Increasing the yield of a cultivated rapeseed crop implies its economic efficiency (Table 7).

Table 7. Economic efficiency of rapeseed under Conventional Tillage (CT) and Resource Conserving Technology (RCT) in foothill zone conditions of South-Eastern Kazakhstan

Economic efficiency indicators	CT	RCT
Average yield, t/ha	1,73	2,10
Cost of 1 tonna of production, \$	165,7	165,7
Sales revenue, \$/ha	286,6	347,9
Cultivating expenses, \$/ha	219,1	171,7
Relative net profit, \$/ha	67,5	176,2
Rentability of soy cultivation, %	30,8	102,6
Net profit from application of resource- saving technology, \$/ha		38,0 \$/ha

Evaluation of the economic efficiency of RCT in the foothill zone of the south-east of Kazakhstan shows that with CT of rapeseed, the yield was 1.73 tones/ha, where the direct costs of its cultivation was 219.1 \$/ha. With the sale of the harvest, revenue amounted to 286.6 \$/ha, conditionally net income – 67.5 \$/ha, which ensured the profitability of rapeseed cultivation only 30.8%.

Evaluation of the economic efficiency of RCT in the foothill zone of the south-east of Kazakhstan shows that with CT of rapeseed, the yield was 1.73 tones/ha, where the direct costs of its cultivation was 219.1 \$/ha. With the sale of the harvest, revenue amounted to 286.6 \$/ha, conditionally net income – 67.5 \$/ha, which ensured the profitability of rapeseed cultivation only 30.8%.

With the use of elements of RCT, the amount of costs was reduced due to the minimum cost of fuel and lubricants and additional funds with minimal tillage of RCT equal to 47.4 \$/ha and the cost of applying an environmentally safe dose of herbicide in the fight against debris and other types works on the cultivation of rapeseed from 219.1 to 171.7 \$/ha, where the cost of production decreased.

Comparative evaluation of economic indicators from the use of techniques of RCT shows that minimizing tillage contributed to an increase in income from 67.5 \$/ha (CT) to 176.2 \$/ha (RCT). On the basis of economic efficiency, the purity of the use of RCT of rapeseed cultivation, where the conditional net income from the use of RCT techniques (where the tillage technology pass is reduced by 2 times) rises to 176.2, \$/ha, which increases the profitability of cultivation from 30, 8% to 102.6%.

Conclusion

Thus, for the first time, the possibility of efficient use of resources and energy saving in an agroecosystem has been established. The restored parameters of the agrophysical indicators of soil fertility are determined. The decrease in total energy costs by 47.4 \$/ha, which is 21.6% due to the cost of fuel and additional funds with minimal tillage of RCT. In comparison with the waste treatment, while minimizing the cost processing is reduced. It has been established that with CT, the cost is 219.1 \$/ha, and with RCT, only 171.7 \$/ha. Where conditional net income is 67.5 to 176.2 \$/ha, additional income from each hectare of 38.0 thousand tenge is received. Indicators of the economic efficiency of the methods of RCT of rapeseed proves that the replacement of the main dump processing with small-plow cutting (Mini-till) is abundant, ensuring the effective use of soil resources and the conservation and restoration of the soil fertility agro-physical factors and the rapeseed agroecosystem energy saving in the foothill zone of South-East Kazakhstan.

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