Ecological assessment of the impact of vermicomposting on the growth and development of spring wheat in the soil and climatic conditions of the Republic of Karakalpakstan

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Abstract. The use of intensive technologies in agriculture, with the introduction of large amounts of mineral fertilizers, pesticides and a reduction in the application of organic fertilizers, has led to a shortage of humus balance in the soil. A progressive solution in this situation is the production and application of vermicomposting, which not only restores soil fertility, but also significantly increases the economic efficiency of agricultural industries. This article presents the results of a study that showed the reduction to a reasonable minimum of external anthropogenic impacts on the agro ecosystem and the activation of its own bio potential through the use of alternative fertilizers give a positive effect in maintaining soil fertility, protecting the natural environment and obtaining a sustainable harvest. The experience has shown that the degree of influence of fertilizer types turned out to be very significant in the variants where organic fertilizers and vermicomposting were applied, which clearly confirms that these types of fertilizers significantly affect the formation of plant biomass.

1 Introduction

Methods of farming in the world are the most important factors aimed at the use of high-intensity technology and the quality of the environment. Based on these principles, the task of sustainable development of agriculture and environmental protection becomes a priority.

The World Commission on Environment and Development, in its report “Our Common Future” has set the main goals for the sustainable development of agriculture, the conservation and improvement of natural resources and ecosystems, the development of economically and environmentally sound sustainable agricultural systems that should correspond to the soil and climatic characteristics of the region [7].

The basis of alternative agriculture is to reduce to a reasonable minimum the external anthropogenic impact on the agro ecosystem and maximize its own bio potential aimed at

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preserving and increasing soil fertility, it is recommended to reduce significantly the use of mineral fertilizers and pesticides and the widespread use of organic fertilizers (vermicomposting, compost, manure) [5].

Mineral fertilizers play an exceptional role in increasing food, improving the quality of products, and in general, in increasing the efficiency of agricultural production. But nevertheless, it should be noted that these same chemicals, if used incorrectly, can and do have a negative impact on the environment.

Actuality: Irrigated soils of the Republic of Karakalpakstan are the main wealth and the main breadwinner of people. The productivity of all branches of agricultural production and the economic recovery depend on the state of fertility of these soils and their rational use.

Grain growing is one of the main branches of agriculture in the economy of the Republic. However, the profitability of production in recent years leaves much to be desired. The ever-increasing doses of applied mineral fertilizers no longer give a noticeable effect. Despite the long-term use of mineral fertilizers, most of the irrigated lands of the Republic are still characterized by a low content of nitrogen and phosphorus available to plants and about 40% are low in potassium. More than half of the irrigated lands are low-provided with organic matter.

With the help of mineral fertilizers, you can control only one parameter of plant care, vary the direction of exposure, organic ones often give a general effect in many directions at once. Mineral fertilizers are more dangerous and harmful to both the consumer and the environment [4].

Taking into account the above, the practical absence of scientifically-based recommendations for the use of vermicomposting, mineral and organic fertilizers, depending on the regional characteristics of soils, was the reason for setting up field experiments aimed at studying these issues.

The purpose of the study: To give an ecological assessment of the impact of vermicomposting on the growth and development of spring wheat in the soil and climatic conditions of the Republic of Karakalpakstan.

According to this goal, the following tasks were solved:

- To study the effectiveness of the effects of various doses of vermicomposting on the growth, development and yield of spring wheat.
- To study and identify the main patterns of the influence of various fertilizers on the growth and development, formation of biomass, photosynthetic potential and productivity of spring wheat.
- To identify the optimal rates of application of vermicomposting, mineral and organic fertilizers for spring wheat, their impact on the yield of spring wheat.

In recent years, ecological fertilizers are beginning to gain more and more popularity. Vermicomposting refers to organ mineral fertilizers of natural origin. It does not carry artificial reagents, and therefore is safe for the environment and human health.

Vermicomposting is an organic fertilizer obtained as a result of processing food waste by earthworms. The worm eating organic matter (it can be various food waste from vegetables, fruits, drunk tea, coffee grounds) forms caprolites secreted from the digestive tract of the worm. The big plus of vermicomposting is that it is a completely natural organic fertilizer. It can be applied to the soil without any restrictions, starting in early spring and ending in late autumn, because it is impossible to "over-salt" the land, unlike mineral fertilizers, and the effect of its application persists for several subsequent years.

Vermicomposting is an environmentally friendly product, all substances in its composition are easily absorbed by plants, since they are in a mineralized form. The only significant disadvantage of such a fertilizer can only be called its cost, since the process of producing the substance is laborious and expensive. However, if we compare the cost and total efficiency of vermicomposting and other fertilizers, the economic benefits of its use will also be noticeableю [7].

2 Place, conditions and methodology of research

The choice of an object as a study of spring wheat is determined by the fact that spring wheat is one of those plants in which the biological characteristic is more comprehensively manifested in interaction with external environmental factors, and the functioning of the assimilation surface of the leaves and the dynamics of its changes are determined by weather and climatic conditions, types and doses of fertilizer, as well as innovative technological agricultural capabilities. The main principle of the organization of work is the development of scientific research on the ecologization of agriculture, carried out through the introduction of alternative farming systems.

The study was conducted in 2022 according to the work program at the experimental base of the scientific and production association of grain and rice in Nukus district in the village "Shortanbai" of the Republic of Karakalpakstan.

2.1 The main method of research is the field method with accompanying observations, records and laboratory analyses

Soil conditions of the research site: As studies have shown, the soil on the territory of the research object belongs to the old-irrigated meadow-alluvial, medium loamy, widespread in Karakalpakstan. The soil of the experimental site under study is medium loamy in terms of mechanical structure. The volume mass of the soil in the arable horizon before the experiment was laid was 1.31-1.33 g/cm^3, in the sub-arable horizon was 1.36-1.42 g/cm^3.

The humus content in the soil was observed to be average. In the arable horizon, its content was 0.70-1.1%, the content of gross nitrogen varied in the range of 0.08-0.05 and gross phosphorus 0.80-0.90%, potassium 1.40-1.48%. According to the content of mobile nitrogen, soils are characterized by low-availability, and by gross phosphorus to medium-availability.

Table 1. The content of nutrients in soils by contours

№	Contour number	Horizon sm	At the beginning of the growing season				At the end of the growing season			
			N mg/kg	F mg/kg	K mg/kg	Humus %	N mg/kg	F mg/kg	K mg/kg	Humus %
1	1.1	0.10	6.14	3.38	14.8	1.01	5.81	3.08	8.9	0.97
2	1.2	0.20	4.15	4.20	13.4	1.23	3.84	3.98	7.25	1.19
3	1.3	0.30	4.19	3.52	14.2	1.36	3.05	3.16	8.3	1.23
4	1.4	0.10	6.25	2.44	14.6	0.78	5.12	1.99	8.4	0.70
5	1.5	0.20	6.12	2.98	14.6	1.07	4.98	2.54	8.9	1.02
6	1.6	0.30	6.30	3.63	14.0	1.19	5.13	3.25	7.9	1.12
7	1.7	0.10	6.32	2.31	14.4	1.1	5.11	1.98	8.2	0.95
8	1.8	0.20	6.36	4.20	14.2	1.01	5.22	3.80	8.1	1.085
9	2.1	0.30	6.05	3.45	14.0	1.41	5.78	2.89	7.8	1.35
10	2.2	0.10	5.98	4.46	14.0	1.31	4.74	3.96	7.9	1.23
11	2.3	0.20	6.25	3.38	14.0	1.1	5.05	2.89	8.3	0.95
12	2.4	0.30	5.45	3.12	14.0	1.29	4.12	2.56	8.4	1.21
13	2.5	0.10	5.62	2.70	14.6	1.18	4.21	2.11	8.7	1.12
14	2.6	0.20	4.35	3.92	14.6	1.1	3.12	332	8.5	0.96
15	2.7	0.30	4.20	5.61	13.2	1.15	3.10	4.56	7.2	1.11

16	2.8	0.10	5.16	3.30	13.8	1.58	4.02	2.76	7.3	1.48
17	3.1	0.20	5.84	3.12	14.0	1.19	4.32	2.85	8.1	1.12
18	3.2	0.30	5.42	3.78	14.6	0.93	4.14	3.08	8.3	0.89
19	3.2	0.10	5.68	2.70	14.2	1.55	4.24	2.16	8.4	1.45
20	3.4	0.20	4.56	3.25	13.8	1.38	3.25	2.75	7.5	1.32
21	3.5	0.30	5.12	2.73	14.8	1.31	3.98	2.41	8.2	1.25
22	3.6	0.10	5.97	2.37	14.0	0.91	4.32	2.01	8.0	0.84
23	3.7	0.20	5.26	3.85	14.1	1.15	4.02	3.42	8.0	1.11
24	3.8	0.30	5.02	3.45	14.0	1.52	3.97	3.21	8.1	1.41

2.2 Methodology of experience bookmarking, accounting and analysis

The experiments were laid on plots with an area of 10 m^2, in threefold repetition. The predecessor is soft winter wheat. The seeding rate is 5-6 million germinating grains per hectare. Sowing and harvesting were carried out manually in the phase of full ripeness. Agro technics is generally accepted for the zone of the Republic of Karakalpakstan.

Sampling was carried out according to the main phases of plant development: full shoots, tillering, tubing, flowering, sweeping and earing. The soil of the plots was cultivated at a depth of 28-30 cm, washing with a norm of 600-700m^3.

The application of mineral, organic fertilizers and vermicomposting was carried out according to the scheme of the experiment. The rate of application of organic and mineral fertilizers: nitrogen at the rate of 200t / ha, phosphorus at the rate of 140t / ha, potassium at the rate of 100t/ha. Organic fertilizers: - 10t/ha, 20t/ha, 30t/ha. Vermicomposting: 5-t/ha, 10t/ha, 15t/ha. Three-fold repetition.

Table 2. Fertilizer application scheme

№	Variant	Name of the fertilizer	Nitrogen in grams	Phosphorus in grams	Potassium in grams
1	I-var	NPK - the traditional norm	200	140	100
2	I-var	With manure at the rate of 10t/ha	100	70	50
3	I-var	With manure at the rate of 20t/ha	100	70	50
4	I-var	With manure at the rate of 30t/ha	100	70	50
		TOTAL	0.500	0.350	0.250
5	I-var	With vermicompost at the rate of 5t/ha	100	70	50
6	I-var	With vermicompost at the rate of 10t/ha	100	70	50
7	I-var	With vermicompost at the rate of 15t/ha	100	70	50
	TOTAL: I - Repetition		0.800	0.560	0.400
	TOTAL: II - Repetition ь		0.800	0.560	0.400
	TOTAL: III - Repetition		0.800	0.560	0.400
	Total for the use of mineral fertilizers		2400 gr	1680 gr	1200 gr

The rate of application of organic fertilizers at the rate of Manure is 10 t/ha, 20 t/ha, 30t/ha, vermicompost at the rate of 5t /ha, 10t/ha, 15t/ha. three-fold repetition.

Table 3. The scheme of application of organic fertilizers (manure and vermicomposting)

№	Name of organic fertilizers	1-variant	2- variant	3- variant	Total
1	Vermicomposting				
	1-repetition	5kg per 10m2	10kg per10m2	15kg per10m2	30kg per10m2
	2- repetition	5kg per 10m2	10kg per10m2	15kg per10m2	30kg per10m2
	3- repetition	5kg per 10m2	10kg per10m2	15kg per10m2	30kg per10m2
	Total for all plots				90kg per10m2
	Manure				
2	1- repetition	10kg per10m2	20kg per10m2	30kg per10m2	60kg per10m2
	2- repetition	10kg per10m2	20kg per10m2	30kg per10m2	60kg per10m2
	3- repetition	10kg per10m2	20kg per10m2	30kg per10m2	60kg per10m2
		Total for all plots			180 kg per10m2

The rate of application of mineral and organic fertilizers. Mineral fertilizers – at the rate of 200t/ha, phosphorus – at the rate of 140t/ ha, potassium – at the rate of 100t/ha. Organic fertilizers: - 10t/ha, 20t/ha, 30t/ha. Vermicomposting: 5-t/ha, 10t/ha, 15t/ha. three-fold repetition.

Table 4. The scheme of application of mineral fertilizers

№	Variant	Name of the fertilizer	Nitrogen (gram)	Phosphorus (gram)	Potassium (gram)
1	I-var	Control without fertilizer	-	-	-
2	II-var	NPK – the established norm	200	140	100
3	III-var	Org. fertilizer – at the rate of 10t/ha	100	70	50
4	IV-var	Org. fertilizer – at the rate of 20t/ha	100	70	50
5	V-var	Org. fertilizer – at the rate of 30t/ha	100	70	50
		TOTAL	0.500	0.350	0.250
5	VI-var	Bio humus – at the rate of 5t/ha	100	70	50
6	VII-var	Bio humus – at the rate of 10t/ha	100	70	50
	VIII-var	Bio humus – at the rate of 15t/ha	100	70	50
	Total: I - repetition		0.800	0.560	0.400
	Total: II - repetition		0.800	0.560	0.400
	Total: III - repetition		0.800	0.560	0.400
	Total		2400 gr	1680 gr	1200 gr

The rate of application of organic fertilizers – at the rate of 10 t / ha, 20 t / ha, 30 t / ha, vermicompost – at the rate of 5t / ha, 10t / ha, 15t / ha. Three-fold repetition Phosphorus - 50% and potassium–100% of the annual dose were added for plowing. Every year in the spring, fertilizers were introduced at the initial stage of wheat cultivation: nitrogen – 50%, phosphorus – 30%, and at the earing stage the nitrogen rate was 50%.

The conducted field and laboratory studies, records and phenological observations were quite complex. Thus, phenological monitoring was studied during the onset of the main phases of plant development, i.e. seedlings, tillering, tube entry, earing, milk and full ripeness.

Fixation of the standing density of the plants in question, as well as biometric indicators were calculated on fixed sites of 0.25 m^2 in size at three points of the variant in each repetition. The registration of the standing phase was carried out in each phase, other parameters were calculated according to the methodology.

3 The results of the study

Thus, as can be seen from the table, the dynamics of the germination of spring wheat crops in terms of variants and repetitions do not slightly exceed the accepted norm of 5-6mn pieces per 1-ha. Seedlings were recorded on fixed plots with an area of 0.25 m^2 in 3-fold repetition in each plot. Due to the slow approach of the soil after irrigation, sowing was delayed for several days and all this affected the rate of germination of spring wheat and caused the formation of a puny grain and with a minimum weight of one grain.

Table 5. Dates of the onset of phases in the development of spring wheat (variety «Saratov», sowing 16.04.22.)

Variants	Phases of development							
	Sowing	Shoots	Tillering	Sweeps	Blossom	Milk ripeness	Waxy ripeness	Full ripeness
Without fertilizer	16-04	22-04	7-05	31-05	08-06	14-06	30-07	10-07
NPK the tradit norm	16-04	24-04	7-05	31-05	08-06	14-06	30-07	10-07
With manure 10kg	16-04	22-04	7-05	31-05	08-06	14-06	30-07	10-07
With manure – 20kg	16-04	24-04	7-05	31-05	08-06	15-06	01-07	10-07
With manure – 30kg	16-04	26-04	7-05	31-05	08-06	15-06	01-07	12-07
With biogum– 5kg	16-04	22-04	8-05	01-06	08-06	15-06	01-07	12-07
With biogum– 10kg	16-04	22-04	8-05	01-06	09-06	15-06	01-07	12-07
With biogum– 15kg	16-04	22-04	8-05	01-06	09-06	14-06	01-07	12-07

The yield of spring soft wheat, as well as other agricultural crops, largely depends on the number of plants per unit area. With the thickened standing of plants, there is a lack of nutrients, moisture, light, and the damage of plants by diseases increases. If the density of standing is too low, nutrients are not fully used, crops become overgrown with weeds. Both lead to a shortage of crops. In our experience, with the same seeding rate, the number of plants preserved for harvesting ranged from 288 to 572 pcs/m^2 and depended more on the density of seedlings than on the preservation of plants.

As can be seen from the table, the average amount of germination density varied by repetition, the maximum value was noted in the first repetition in the amount of 396 to 716 pcs, in the second repetition from 472 to 812 pcs and from 476 pcs to 584 pcs in the third repetition per 1m^2. The average value according to the experience was 572 pieces per 1m^2.

The difference in the plants preserved for harvesting by repetition was very large, more than 50%, which is due to the lack of irrigation for the entire growing season. In percentage terms, the minimum index of preserved plants was in the second repetition in 1m^2, it was 47.7% or 288 pieces of the plant, the maximum in the first repetition was 54.6%. (304 pieces), and accordingly, 48.6% or 272 pieces of the plant were preserved in the third repetition. Thus, due to various environmental factors, the average number of preserved plants according to experience was 288 pieces out of 572 pieces, or 50.3% per 1m^2.

3.1 Biomass formation and yield

As is known, the most important condition for the production process of grain yield formation is the accumulation of biomass in the plant. Since only with a well-developed vegetative mass a significant amount of assimilants is produced, which can then be formed by grain. [9].

Researchers point to a significant degree of correlation between the dry biomass of spring wheat in the earing phase and the final harvest. The intensity of the growth of the aboveground mass of plants is characterized by biometric indicators: height, plant mass (without root), leaf volume, weight and number of ears.

As can be seen from the table, the largest volume of the leaf surface of 9.7 mm^2 was formed in the second repetition in variant No. 8, where vermicomposting with a norm of 15 kg was studied, the largest raw weight in 10 plants with a weight of 40 grams was recorded in the second variant of the first repetition, where the traditional norm of mineral fertilizer "NPK" was used, and the largest plant growth was 77 see in option No. 5 of the third repetition where manure was used in the amount of 20 kg.

Thus, the results of the analysis showed that seeding rates, moisture and the type of nutrition, whether manure or vermicompost, play a significant role in the formation of biological mass, but nevertheless, when determining the crop yield, some high biometric data do not give the required results. The results obtained indicate high compensating capabilities of spring wheat. The low index of one of the yield elements is compensated by the more intensive development of other elements. Thus, a decrease in the number of plants per unit area is accompanied by an increase in productive bushiness and grain weight from the ear, which is associated with an improvement in food and water regimes, lighting and other factors of plant life. As the results of the study showed, with a decrease in the density of standing plants by 2 times (from 572 to 288 pcs. / m^2), the number of productive stems practically does not change, and the yield increases slightly due to an increase in the weight of grain from the ear. Thus, the density of standing plants had little effect on yield, that is, the number of plants that had risen had an average effect on yield, apparently the formation of the density of standing plants for harvesting and their preservation were determined by the influence of other factors (weather, cenotic, physiological, genetic, morphological, phytosanitary, etc.) that was observed during the vegetation of the plant. For example, in the first variant for 0.25 $m^2$with the number of plants of 77 pieces, the yield was 18c/ha, and in the second variant with the number of plants of 68 pieces, the yield was 19.1 c/ha, or in the 6th variant with the number of plants of 68 pieces, the yield was 11c/ha, whereas in the 7th variant with the number of on a plant of 66 pieces, the yield was 12c/ha.

The yield was determined by determining the mass of one grain multiplied by the number of stems on an area of 1m^2. The minimum yield indicators were 12c/ha, the maximum 19.1 c/ha.

3. 2 Formation of the leaf surface

One of the most important physiological characteristics of the variety is the leaf area, which in the system of assimilation apparatus makes the main contribution to the formation of the final crop.

Due to the instability of meteorological conditions during the growing season, the lack of irrigated water in the considered zone, the properties of spring wheat varieties to adapt to such conditions and form the necessary level of leaf surface for the implementation of photosynthetic activity processes at a certain level are of particular importance.

The results of our research showed that spring wheat under these conditions had significant differences in the formation of the leaf surface of the plant in the experiment between the variants both without fertilizer and with fertilizers. However, in each individual variant, the degree of influence of fertilizer types turned out to be very significant. Especially this indicator was clearly superior in the variants where organic fertilizers or vermicomposting were applied, which clearly confirms that these types of fertilizers significantly affect the formation of plant biomass. So in the eighth variant of the first repetition, where bio humus was used, the volume of the leaf surface was 7.7mg, unlike the second variant with the use of mineral fertilizer NPK with the traditional norm, it was 6.6 mg, and the raw weight of 10 plants was 37 grams versus 29.9 grams. In the eighth variant of the second repetition, where bio humus was used, the volume of the leaf surface was formed in the amount of 9.7 mg against the traditional norm of NPK-5.6 mg, which is 4.1 mg, and the raw weight of 10 plants was 35.6 grams versus 33.0 grams. The same difference was noted in the third repetition of the 8-variant where vermicomposting was used, the volume of the leaf surface was 8.9 mg against the second variant with the traditional NPK norm of mineral fertilizer, this indicator was 6.9 mg, which is 2.0 mg more, and the raw weight of 10 plants was 39.6 versus 38.4 grams.

4 Conclusions

The experience has shown that different doses of vermicomposting gave positive results, for example, in variant No. 6 with a dose of vermicomposting of 5 t/ ha, the height of the plant in the sweeping phase reached 70 cm vs. 65 cm, the volume of the leaf surface reached 9.7 mm^2vs. 5.6 mm^2, the weight of the raw mass of 10 plants 35.6 grams against the variant where it was used the traditional NPK norm.

A significant influence of vermicomposting on the formation of the aboveground part in the initial stage of development of a spring wheat plant has been established.

According to the results of the experiment, it was noted that vermicomposting is an excellent adsorbent, vermicomposting granules actively absorb moisture from the soil, and if there is not enough moisture in the soil, the soil leads to partial drying, which led to a partial slowdown in the process of the emergence of seedlings of the plant in the experiment. In this regard, before applying vermicomposting before sowing, it is desirable to control the soil moisture within the optimal level.

The leaf surface area of the plant as a whole has noticeably formed depending on the type of fertilizer and its dose, which is clearly confirmed by the responsiveness of this crop to the alternative type of fertilizer "bio humus", which significantly influenced the formation of aboveground biomass of the plant.

According to the results of the experiment, in the variants where bio humus was used, the density of plant standing in the initial phase is sharply different than in other variants in a positive way, but nevertheless in subsequent phases of development it had an average effect on the safety of the plant for harvesting, apparently they were determined by the influence of other factors (weather, cenotic, physiological, genetic, morphological, phytosanitary, etc.) that was observed during the vegetation of the plant.

The effectiveness of chemical and biological agents for the harvest of spring wheat grain was different. The largest grain increases were obtained in variants with the use of bio humus, so in the variant where bio humus was introduced within a dose of 15 t/ ha, grain yield was within 27.5 c/ha, and in the variant with 10t/ha bio humus – 15.9 c/ha. The low indicator was in the variant with the use of vermicomposting in the amount of 5k/ ha – 13.9 c/ha. In other variants where mineral fertilizers and manure were used, the grain yield index was significantly low from 9 to 11.5 c/ha. Consequently, when using vermicomposting, its valuable properties favorably affect the yield of spring wheat.

The results of the experiment showed that the seeding rate, moisture and type of nutrition, whether manure or vermicomposting, plays a significant role in the formation of biological mass, but nevertheless well-formed biometric data such as the raw mass of straw - 89.0 grams, total grain weight - 35.0 grams, plant height - 69.9 cm, the number of panicles - 98 pieces and the number of plants per $1m^2$ in the 6-variant of the second repetition, where vermicomposting was used in the amount of 5 kg / ha, was not enough to affect the crop yield. In our case, the low index of one of the yield elements is not compensated by the more intensive development of other elements. As a result of which an increase in the number of plants and growth per unit area was accompanied by a decrease in the mass of grain per ear and, accordingly, the mass of 1000 grains, apparently this is due to various environmental factors that need to be studied.

The results of the study showed that with a decrease in the density of standing plants, the number of productive stems practically does not change, and the yield increases slightly due to an increase in the amount of grain and its mass from the ear.

As a result of scientific research, the effects of various doses of vermicomposting on the growth, development and yield of spring wheat, the effects of various fertilizers on growth and development, the formation of biomass, the productivity of spring wheat were studied, optimal rates of application of vermicomposting for spring wheat were established, their effect on the yield of spring wheat. The data indicate a positive environmental assessment of the impact of vermicomposting within reasonable limits.

Thus, according to the results of the study, a priority has been determined for the sustainable development of agriculture, in which ecologization and organic farming prevail, carried out through the introduction of alternative farming systems.

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