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Innovative technologies to increase the fertility of irrigated soils and crop yield

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Abstract. The main feature of non-traditional fertilizers is that they have a complex composition. They are new-generation fertilizers that contain the nutrients plants need and are able to provide plants with mobile nutrients for a long time. The development of non-traditional fertilizers will create new resources of fertilizers from the waste products of industry, households, and agricultural sectors. With the use of non-traditional fertilizers, agricultural products of good quality are obtained; this prolongs their shelf life. The use of non-traditional fertilizers is an alternative to the negative effects of chemical fertilizers and pesticides. The article considers innovative technologies for increasing the fertility of irrigated soils and crop yields using non-traditional fertilizers produced from agricultural waste. Technology for making compost from waste and manure was developed; the influence of non-traditional fertilizers on the agrochemical properties of soil and cotton yields was revealed; the optimal rate of their application was determined.

1 Introduction

As shown by many years of experience in agriculture, along with the use of mineral and organic fertilizers, the reserves of which are insufficient for their widespread application in scientifically based doses, it is necessary to widely attract non-traditional sources of nutrients to solve this problem [1-4].

The currently existing methods for obtaining various composts based on industrial waste often do not meet veterinary and sanitary requirements. In this regard, a search for new technologies is underway to obtain non-traditional fertilizers as organic ones [5-9].

The development of technology for compost preparation from waste contributes to:
- an increase in the yield of organic fertilizers in the republic.
- an increase in soil fertility and crop yields.
- environmental protection from various pollution.

Based on the analysis of existing literary sources, the most promising for our region is compost preparation - organic-mineral fertilizers from waste [10-13]. The demand for fruits

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and vegetables grown without the use of chemical fertilizers and pesticides among the population has sharply increased worldwide. For example, in the United States, the process of biologization of agriculture is underway, associated with the introduction and use of waste-free, environmentally friendly biotechnology for manure processing using earthworms [14, 15].

Production from the waste of urban settlements began in Europe (England) in the 19th century and from the 19th century to date, 40% of the fertilizer needed by British agriculture comes from waste. The high yield of such a fertilizer was established for the first time in the world at the Rothamsted experimental station in England at the beginning of the 19th century [16].

In Uzbekistan, various types of waste accumulate in huge quantities: industrial and agricultural waste, urban waste, fresh water ooze, sawdust, fallen leaves, etc. [17-22]. These wastes in their composition contain all the nutrients necessary for plants (Table 1).

Table 1. The content of nutrients in various wastes.

Waste	%			mg/kg				
	N	P	K	B	Cu	Mo	Zn	Mn
Freshwater ooze	0.52	0.25	0.33	100.11	34.72	2.21	78.51	312.50
Cotton leaves	0.23	0.14	0.28	25.02	8.20	0.66	17.90	12.45
Cotton stalks	0.91	0.61	2.82	25.03	6.01	0.45	15.32	11.01
Manure	0.44	0.21	0.40	96.41	30.63	1.57	62.10	425.51

The use of various wastes as fertilizers for cultivated crops can be considered as an additional source of nutrients, and an effective tool for improving soil fertility and increasing crop yields. One of the additional reserves for increasing crop yields can be the use of agricultural waste as fertilizers. In this regard, the development of technology for the preparation of non-traditional fertilizers and the study of their impact on soil fertility, growth, development, and productivity of agricultural crops is an urgent task of modern agriculture.

The creation of new non-traditional types of organic fertilizers by mixing industrial, household, and agricultural waste with manure is a modern trend in agriculture. Raw materials for the preparation of such fertilizers are neither imported, nor purchased and, as a result, are cheap. Only the technology of preparation and the rate of application of non-traditional fertilizers should be developed. Non-traditional fertilizers are important local fertilizers produced by the decomposition of various organic wastes by microorganisms. Non-traditional fertilizers applied to soil form optimal conditions for the growth and development of plants [5, 19, 21, 22].

While mineral fertilizers improve the supply of nutrients to the soil, non-traditional organic fertilizers not only enrich the soil with nutrients but also increase the humus content, improving their physical, chemical, and biological properties, thereby optimizing the water, air, and nutrient regimes necessary for plants. In addition, fertilizers containing organic matter increase the CO2 concentration in the soil layer and at the same time increase the efficiency of the photosynthesis process in plants [13].

In the process of preparing non-traditional fertilizers, the amount of nutrients easily absorbed by plants (nitrogen, phosphorus, potassium, etc.) increases, the amount of fiber, hemicellulose, and pectin in organic matter decreases, pathogenic microflora and helminth eggs die, the physical properties of the fertilizer improve to appropriate (loose) states.

The use of non-traditional fertilizers in agriculture does not harm the environment, increases the production of organic fertilizers, increases the content of organic matter (humus) in soil, increases the absorption capacity of the soil, improves its composition and buffering capacity, and positively affects the physical properties of soil. Their application reduces the norms of mineral fertilizers, and increases productivity and profitability.

In terms of their properties, non-traditional fertilizers occupy a leading position among local fertilizers. Alternative fertilizers give good results in fertilizing crops, including cotton and cereals. This means that at a time when the cost of mineral fertilizers used to enrich soils with nutrients and increase crop yields increases, it is important to develop scientific solutions for the use of non-traditional organic fertilizers.

The main goal of our research is the use of agricultural waste as fertilizer to improve soil fertility and crop yields. To achieve this goal, we are faced with the task of using agricultural waste as fertilizer masses in agriculture; studying the composition of manure, freshwater ooze, cotton leaves, and stalks; developing technology for the preparation of composts from waste, setting up field experiments to study the effect of alternative fertilizers on the agrochemical properties of soil, the growth, development, and productivity of cotton and determining the norms for their use; developing recommendations on the use of this fertilizer in agriculture of the republic.

2 Materials and methods

Field and laboratory studies were conducted using methods generally accepted in agrochemistry and soil science [1, 11].

For the preparation of composts, local wastes were used: cattle manure, freshwater ooze, cotton leaves, and stalks. Non-traditional fertilizer from local waste and manure in a ratio of 1:1 was prepared by layer-by-layer composting in special pits, 1.5x1x1 meter in size. Considering the volume of raw materials for the preparation of 1 ton of organic-mineral fertilizer, it is advisable to take the dimensions of the pit from 1.0x1.0x1.0 to 2.0x1.0x1.0 meters. The process of waste decomposition is accelerated when the content of organic substances in the composition of non-traditional fertilizers is above 25% and humidity is 50-55%. Generally, the amount of the finished product is 50% of the amount of organic waste.

Organic-mineral fertilizers, as a rule, should be prepared near the field for subsequent application. Composting pits are recommended to be dug in the locations where groundwater is deep. This is because groundwater can disrupt the preparation of non-traditional fertilizers or lead to nutrient depletion.

To study the effect of composts on the agrochemical properties of soil, the growth, development, and productivity of cotton on an old-irrigated typical gray soil, a field experiment was conducted with the Namangan-77 cotton variety. The scheme of the field experiment consists of the following options: 1) control - without fertilizers; 2) N200P140K100; 3) N100P70K50 + 20 t/ha manure + straw; 4) N100P70K50 + 30 t/ha manure + cotton stalks; 5) N100P70K50 + 30 t/ha manure + cotton leaves.

3 Results and discussion

The soil of the experimental plot in the initial state contains 0.91% of humus, 0.090% of total nitrogen, 0.22% of total phosphorus, and 1.50% of total potassium; and mobile nitrogen - 29.5 mg/kg, mobile phosphorus - 35.0 mg/kg and mobile potassium -220.0 mg/kg.

Agrochemical analysis of composts made from straw, leaves, and cotton stalks showed that they are substantially enriched with nutrients (Table 2).

Table 2. The content of nutrients in composts.

Composts	%			mg/kg				
	N	P	K	B	Cu	Mo	Zn	Mn
Manure + straw	0.55	0.25	0.41	99.1	32.7	1.82	70.5	372.5

Manure + cotton leaves	0.35	0.16	0.38	62.4	19.5	1.11	40.5	201.5
Manure + cotton stalks	0.55	0.33	0.43	31.4	17.3	0.80	21.4	80.0

The effect of composts on soil properties and cotton yield was studied when they were combined with mineral fertilizers.

The results of the research showed that composts, when applied against the background of mineral fertilizers, led to significant changes in a positive direction in the agrochemical properties of soil, and an increase in the number and activity of microorganisms. At the same time, the soil air and the surface layer of atmospheric air are enriched with carbon dioxide, which in turn improves the air supply to cotton plants. Consequently, composting from waste and manure improves the conditions of root structure and air nutrition of plants.

The introduction of 20 t/ha of compost against the background of N100P70K50 contributed to an increase in the humus content in soil to 1.20-1.30%; nitrogen - 0.118-0.136%; phosphorus - 0.145-0.188% and potassium - 1.47-1.65% (Figures 1, 2).

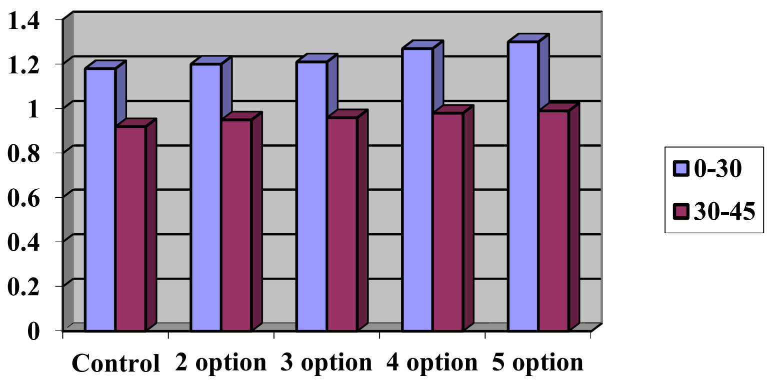

Fig. 1. Changes in the content of humus in irrigated typical gray soils under the influence of fertilizers.

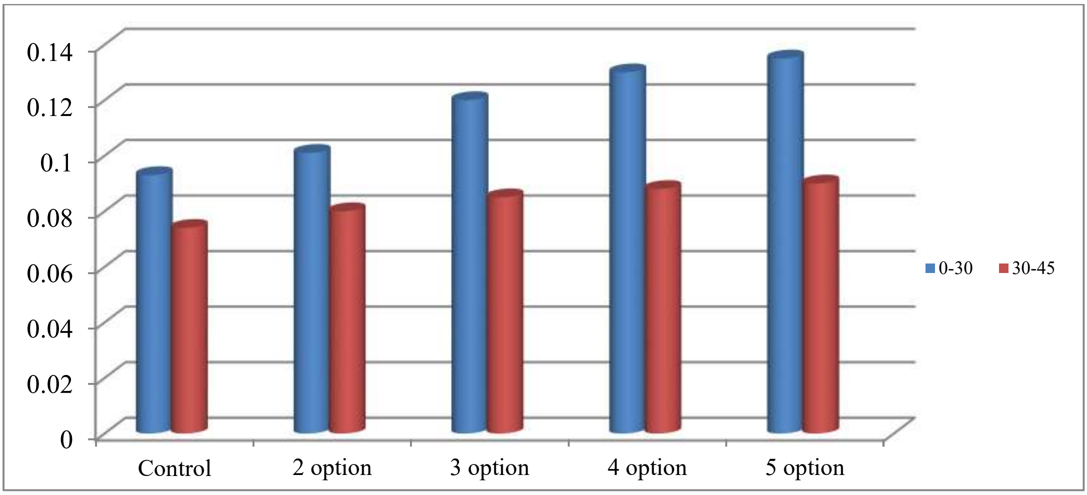

Fig. 2. Change in the total amount of nitrogen in irrigated typical gray soils under the influence of fertilizers.

The results of field experiments conducted to study the effect of non-traditional fertilizers prepared from manure and plant residues against the background of mineral fertilizers on the growth, development, and yield of the cotton show that there are clear differences in different options.

Compost has a positive effect on plants, starting with cottonseed germination. As the results of phenological observations show, 90% of cotton seedlings appeared after 5 days in the option with compost. The subsequent data of phenological observations indicate that the plants with the option of combined application of mineral fertilizers and compost were distinguished by noticeably high growth of the main stalk.

At the beginning of the growing season (May, 30), the height of the cotton stalk was the shortest (8.0 cm) in the unfertilized control option. With mineral fertilizers applied, the height of the cotton stalk was about 10.0 cm. When non-traditional fertilizers were applied to soil against the background of mineral fertilizers, cotton grew more actively and taller stalks were formed. This means that when mineral fertilizers are combined with non-traditional fertilizers, they have a strong positive effect on the growth of cotton stalks (Table 3).

Table 3. Results of phenological observations on the growth of the cotton stalk, cm.

#	Options	30 May	30 June	30 July	30 August
I	Control	8.0±0.1	18.4±0.1	53.2±0.2	54.9±0.1
II	NPK (background)	10.2±0.2	22.0±0.1	72.5±0.1	80.7±0.2
III	background +manure + straw	10.4±0.1	23.1±0.1	74.1±0.1	82.5±0.1
IV	background + manure + cotton stalks	10.5±0.1	24.2±0.2	75.9±0.2	84.0±0.2
V	Background + manure + cotton leaves	10.8±0.2	26.2±0.1	78.1±0.2	87.0 ±0.2

According to this table, after seeds are sown in May, the budding begins mainly at the end of June. The number of buds on the control option was 18.3 pcs. In the second option, where only mineral fertilizers were applied, their number was 26.6 pcs per plant, i.e. 8.3 pcs more were formed. The use of non-traditional fertilizers against the background of mineral fertilizers (options 3, 4, and 5) contributed to the formation of 29.0-31.9 buds. So even at the end of July, the positive effect of non-traditional fertilizers can be observed.

In field experiments, when cotton was sown on May 5, bolls begin to form at the end of July (Table 4). In the control option, where fertilizers were not applied, 2.2-2.3 bolls were formed on a cotton plant. In the option with mineral fertilizers, the formation of 4.2 bolls was observed on a cotton plant. In other options, i.e., when mineral fertilizers were combined with non-traditional ones, the number of bolls in a cotton plant was higher - 4.9-5.3 pcs.

Table 4. The influence of fertilizers on the formation of cotton bolls, pcs.

#	**Options**	**30 July**	**30 August**	**30 September**
I	Control	2.3±0.1	6.0±0.1	7.0±0.1
II	N P K (background)	4.2±0.2	8.0±0.2	10.3±0.2
III	Background + manure + straw	4.9±0.1	10.0±0.2	12.0±0.2
IV	Background + manure + cotton stalks	5.0±0.1	10.7±0.1	13.5±0.1
V	Background + manure + cotton leaves	5.3±0.2	10.9±0.2	14.8±0.2

By the end of the growing season, the bolls are completely formed, and one can draw an unambiguous conclusion about this process. When using non-traditional fertilizers prepared from plant residues, 12.0-14.8 bolls were formed against the background of mineral fertilizers.

One of the main elements of the crop structure is the weight of cotton per boll, which is also affected differently by fertilizers. In the unfertilized control option, the weight of cotton in one boll was 2.1-2.4 g. When applying mineral fertilizers, the weight of cotton in one boll increased to 3.2 g. When applying manure in combination with plant residues against the background of mineral fertilizers, the weight of cotton in one boll increased to 3.3–3.5 g (Table 5).

In the unfertilized option, 19.2 g of cotton was harvested from one plant, with the application of mineral fertilizers - 35.2 g/plant, and with the combined application of mineral fertilizers with non-traditional ones, the cotton yield increased to 44.6-52.5 g/plant.

Table 5. Effect of fertilizers on cotton yield.

No. of options	Number of opened bolls, pcs	Weight of cotton per boll, g	Cotton yield per plant	Number of plants, pcs	Cotton yield, c/ha
I	8±0.2	2.4±0.1	19.2±0.1	90000	17.2±0.1
II	11.0±0.1	3.2±0.1	35.2±0.3	90000	31.7±0.3
III	13.5±0.2	3.3±0.1	44.6±0.2	90000	40.1±0.2
IV	14.0±0.2	3.4±0.1	47.6±0.3	90000	42.8±0.2
V	15.0±0.2	3.5±0.1	52.5±0.2	90000	47.3±0.3

With regard to yield, the most important index is the amount of yield per hectare. To calculate it, we multiplied the cotton harvested from one plant by the number of plants per hectare. On the unfertilized control option, the yield was 17.2 c/ha. With the introduction of mineral fertilizers, the yield of cotton increased to 31.7 c/ha. The use of 20 t/ha of manure and plant residues against the background of N100 P70 K50 mineral fertilizers contributed to an increase in yield up to 40.1-47.3 c/ha.

Thus, when applying non-traditional fertilizers prepared by composting plant residues with manure in a ratio of 1: 1, soils are enriched with organic matter, nitrogen, and other nutrients, and their physical properties and water, air, nutrient, and other regimes are improved; and the cost of the cotton harvest becomes cheaper. To obtain high yields, it is necessary not only to apply mineral fertilizers but to use mineral fertilizers in combination with non-traditional ones; this gives good results. In conditions of manure deficiency, plant residues can be used as fertilizer

4 Conclusions

From the above data, it can be concluded that, at present, there are opportunities in the republic to increase the reserves of humus and nutrients in irrigated soils, to improve soil conditions and fertility. The application of recommendations developed by scientific research is crucial for this. In particular, the use of industrial waste and plant residues, household, and other local waste, as well as available agronomical ores, along with improving the soil conditions, increases the reserves of organic matter and nutrients, and the efficiency of agricultural production. The application of non-traditional fertilizers at a rate of 20 t/ha against the background of mineral fertilizers has a positive effect to coordinate the nutrient regime of soil. Against the background of mineral fertilizers N100 P70 K50, the application of non-traditional fertilizers from plant waste at a rate of 20 t/ha increases the cotton yield to 47.3 c/ha. When using waste as non-traditional fertilizers, it is necessary to conduct an environmental and economic justification for each condition.

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