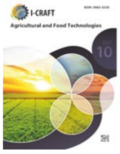

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I-CRAFT AGRICULTURAL and FOOD TECHNOLOGIES

The Effect of Mineral and Organic-Mineral Fertilizer Rates on The Productivity and Soil Fertility of Mixed Sorghum-Pea Crops in The Field

Allahverdiyev Elkhan Rajaboglu

Azerbaijan State Agrarian University, Ganja, Azerbaijan

elxan_recebli@mail.ru

Abstract. This study evaluated the effects of mineral and organic–mineral fertilizer rates on green biomass yield and soil fertility in mixed sorghum–pea intercropping under irrigated gray-meadow soils of Uchoghlan (Aghdam), Azerbaijan, during 2023–2024. Baseline soils were weakly alkaline (pH 7.2–8.1) and poorly supplied with humus (0.65–2.41%), available P (3.85–12.89 mg/kg), and exchangeable K (74.5–275.2 mg/kg), indicating a need for fertilization. Sorghum (“Stavropol Feed Hybrid”) and pea (“Nail”) were sown in the same row at 20 and 30 kg/ha, respectively, following barley harvest. Nine fertilizer variants were tested under vegetative irrigation totaling 3100 m³/ha, including mineral fertilizers (NPK) and combinations with farmyard manure (10 t/ha).

Green biomass yield increased significantly over the unfertilized control (363 s/ha), reaching 451, 540, 615, and 622 s/ha with N40P60K60, N60P90K90, N90P120K120, and N120P150K150, respectively. Although the numerically highest yield occurred at N120P150K150, statistical analysis identified N90P120K120 as the optimal mineral rate (615 s/ha; +69.42%). Organic–mineral combinations also performed strongly: manure 10 t/ha + N40P95K60 and manure 10 t/ha + N70P125K90 yielded 608 and 612 s/ha, respectively. Fertilization markedly increased stubble residue mass (from 6.1 to 10.4 s/ha with N120P150K150; to 9.4 s/ha with manure 10 t/ha + N70P125K90) and root biomass (from 24.2 to 31.8 s/ha and to 30.0 s/ha for the same treatments under three irrigations), while elevating nutrient concentrations in residues (e.g., total N from ~0.96% to 1.11%; K from ~0.98% to 1.22%). Similar trends held under five irrigations.

Findings indicate that N90P120K120 is the most efficient mineral fertilizer norm for maximizing green biomass in this system under 3100 m³/ha irrigation, with manure 10 t/ha + N40P95K60 recommended as an effective organic–mineral alternative. Enhanced residue quantity and nutrient content suggest improved soil structure, biological N contribution, and overall soil fertility, confirming sorghum–pea intercropping as a valuable precursor for subsequent crops in irrigated gray-meadow soils.

Keywords: sorghum–pea intercropping, mineral fertilizer, manure, soil fertility, residue quality, green biomass yield.

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1 Introduction

At present, the global food demand is increasing, with the total demand expected to increase by 35% to 56% by 2050. No other organic substance can replace proteins in the diet of humans and animals. As a result of the lack of proteins in the diet of animals, their productivity decreases. Thus, a lack of protein in the diet is the cause of a serious metabolic disorder. In addition to grain crops, There is a large role for legumes in increasing the supply of proteins. The importance of a high concentration of proteins in feed crops is especially high. The important aims set forward after soil reforms conducted in our republic are the cultivation of crops in scientifically bases, the increasing of soil fertility by complying with agrotechnical measures, as well as getting two yields in a year by the proper sorting of the different cereals. The limit of sowed lands in our republic makes it necessary to get two yields in a year and there’s a favorable soil-climatic condition in the region for this.

The oldest form of systemized agricultural production was based on mixed cropping. Mixed cropping involves planting two or more different crops together in the same field. Compared to monoculture, mixed cropping enhances land and light utilization, particularly when leguminous plants are grown alongside gramineous plants. Mixed cropping involves interspecific competition, where the growth of one crop can be impacted by the competition from another.
The advantage of mixed cropping is the higher number of plants per unit area and differences in pest and pathogen resistance as well as stress tolerance of different plant species and cultivars. Due to a dense plant stand, the foliage and roots cover a larger area, thus increasing the radiation, water and nutrient capture (Allahverdiyev E.R. et al 2024).
In mixed cropping, two to several different plant species or cultivars are grown at the same time in a plant stand. When planning mixed plant stands, it is important to take into account the different characteristics and features of the component species of the mixture and the mixture itself, especially the growth habit to avoid competition (Allahverdiev E. R., Ashrafov S. A. 2019; Babayev A.H. 2012).
Early in the season, plants compete mainly for water and nutrients, whereas competition for light takes over later in the season as the foliage expands. At the end of the season, the original plant stands density affects the severity of competition and thus the final number of remaining plant individuals. Environmental conditions, such as temperature and precipitation, may be more favorable to one over another species (Tahir, M. 2022).
Properly planned mixed cropping can improve sustainability, productivity, as well as yield. This should be considered especially in environments with limited nutrient availability.
The best-known and most utilized crop mixtures around the world are most likely forage. Even though mixed crops usually consist of species reaching maturity at the same time, most yield advantages are obtained from crops reaching maturity at different times.

2 Materials and Methods

The experiment was conducted in 2023 and 2024 on the gray-meadow soils of the Uchoghlan municipality in the Aghdam district, following the harvest of barley as a cereal crop. Soil samples were collected from five locations within the experimental area in a cross-sectional manner and were analyzed for their agrochemical properties. The following parameters were analyzed in the soil samples: total humus content using the I.V. Tyurin method, total nitrogen using the Kjeldahl method, total phosphorus using the Lorenz method, total potassium using the Smith method, nitrate nitrogen using the Grandval-Lajoux method, easily hydrolyzable nitrogen using the Tyurin and Kononov method, mobile phosphorus using the Machigin method, exchangeable potassium using the P.V. Protasov method, adsorbed ammonium nitrogen using the Konev method with Nessler's reagent via colorimetric analysis, soil pH in an aqueous solution measured potentiometrically (Jafarov Y.A., et al., 2014; Huseynov A.M., et al., 2018).
In order to determine the nutrient requirements of plants, the potential reserve nutrients of the soil, total humus, nitrogen, phosphorus, potassium and effective fertility of the soil should be studied first of all, the amount of nutrients that can be easily absorbed by the plant. For this, soil samples were taken from different layers from the field where the field experiments were to be conducted according to the methodology and agrochemical analyses were carried out according to the instructions.

3 Results and Discussion

The results of the agrochemical analyses of the soils taken from the experimental field were as shown in Table 1.

Table 1. Agrochemical characteristics of the soil of the experimental plot of Agdam district (Uchoglan municipality)

Depth, cm	pH, in water solution	General humus, %	Nitrogen				Phosphorus		Potassium	
			Total nitrogen	Readily hydrolysable	Absorbed ammonia	nitrate	Total, %	Mobile	Total, %	Exchangeable, mg/kg in soil
0-20	7,2	2,41	0,11	51	9,98	7,56	0,13	12,89	2,51	275,2
20-40	7,5	1,78	0,10	42	8,45	6,74	0,11	9,52	2,12	211,3
40-60	7,7	1,34	0,08	37	7,19	5,61	0,08	8,64	1,85	132,1
60-80	7,8	1,12	0,05	25	6,01	3,10	0,06	6,11	1,71	96,7
80-100	8,1	0,65	0,03	16	4,25	1,25	0,05	3,85	1,63	74,5

The results of the analyses show that the pH of the experimental soils is weakly alkaline. As can be seen from table 2, the amount of total humus varies between 0.65-2.41% in the 0-100 cm layer.

According to the gradation adopted in the republic, the soil in that area are poorly supplied with humus [168].

While the total nitrogen in the 0-20 cm layer of the soil was 0.11%, it was 0.03% in the 80-100 cm layer. The amount of nitrogen compounds absorbed by the plant in the 0-100 cm soil layer was as follows: easily hydrolyzed nitrogen 16-51 mg/kg, absorbed ammonia 9.98-4.25 mg/kg, nitrates varied between 7.56-1.25 mg/kg.

The amount of total phosphorus in the 0-100 cm soil layer in the experimental area fluctuates between 0.13-0.05%. The amount of mobile phosphorus, which plays a major role in plant life, was determined to be 12.89-3.85 mg/kg. This gives grounds to say that experimental soils are poorly supplied with phosphorus. In the soils of the region, phosphorus is found mainly in mineral form (70-80%), which constitutes 10-20% of the total amount of organic compounds. The number of mobile forms of phosphorus in the soil is very small.

During the analysis of the taken soil samples, it was found that the total potassium in the 0-100 cm soil layer is 2.51-1.63%, and exchangeable potassium is 275.2-74.5 mg/kg. Potassium in the soil is mainly in non-exchangeable form (34-40% of the total amount). Its exchangeable form accounts for 12-14% of the total amount.

Based on the results of the analyses conducted and the gradation adopted throughout the republic, we conclude that since the gray-meadow soils in the territory of the Uchoğlan municipality of the Agdam region, where we conducted the research, are poorly supplied with basic nutrients, it is advisable to apply organic and mineral fertilizers to mixed crops cultivated in the fallow in a certain norm in order to increase the effective fertility of the soils. In general, studies prove that to eliminate the deficit between the incoming and outgoing parts of nutrients, it is necessary to apply organic and mineral fertilizers to the soil every year in order to maintain soil fertility and obtain high yields.

Application of organic and mineral fertilizers in an optimal form is necessary in terms of regulating agrochemical indicators of irrigated grey-meadow soils which are under long-term cultivation, and reclamation of provision of mixed sowings with nutrients (Giannini A., et al.2017; Muniruzzaman A. 2013).

Taking into consideration the foregoing, we have practiced 9 variants in 4 variants for the purpose of studying the importance of mixed crops on gray-grass soils in the territory of Uchoghlan municipality in the Aghdam district.

For the research, the “Stavropol Feed Hybrid” sorghum variety and the "Nail" pea (Pisum L) variety were utilized. For sowing, 20 kg of sorghum and 30 kg of pea seeds per hectare were used.

Considering the above-mentioned factors, immediately after the harvest of autumn barley in the chernozem soils of Uchoghlan village in Ağdam district, the soil was plowed to a depth of 20-22 cm, followed by mixed sowing of sorghum and pea seeds after the field was leveled. Specifically, pea seeds were placed in the seed box (hopper) of the seeding machine, while sorghum seeds were placed in the fertilizer box, and both seeds were sown in the same row.

In this research, the impact of fertilizer and irrigation rates on the productivity of mixed sorghum sowing of pea in intercropping was investigated, and the findings are presented in Table 1, based on experimental replications. As shown in the table, under the vegetative irrigation conditions, the control variant without fertilizer yielded 363 s/ha of green mass. The application of different fertilizer rates resulted in a productivity increase, ranging from 451 s/ha to 628 s/ha. Specifically, with the application of mineral fertilizer at the N40P60K60 rate, 451 s/ha of green mass was obtained, while the N60P90K90 variant produced 540 s/ha, the N90P120K120 rate resulted in 615 s/ha, and the N120P150K150 rate yielded 622 s/ha of green mass.

Table 2. Effect of fertilizer rates on the green biomass yield of sorghum and pea in mixed sowing of intercropping systems

Ordinal number	Variants	3 times irrigation (3100m3)		
		Average yield	increase	
			s/ha	%
1	Fertilizer-free control	363	-	-
2	N40P60K60	451	88	24,24
3	N60P90K90	540	177	48,76
4	N90P120K120	615	252	69,42
5	N120P150K150	622	259	71,35
6	manure 10 t/ha+P35	428	65	17,90
7	manure 10t/ha+N10P65K30	523	160	40,08
8	manure 10t/ha+N40P95K60	608	245	67,49
9	manure 10t/ha+N70P125K90	612	249	68,59

E=7,99s/ha P=2,25

In the variant where manure was applied at 10 t/ha combined with P35, the yield of green mass was recorded as 428 s/ha. When manure at 10 t/ha was supplemented with N10P65K30,

the yield increased to 523 s/ha. Further, the application of manure at 10 t/ha combined with N40P95K60 resulted in a yield

of 608 s/ha, while the variant with manure at 10 t/ha and 10t/ha+N70P125K90 produced 612 s/ha of green mass. Although the highest yield was obtained with the application of

the N120P150K150 fertilizer rate, mathematical calculations indicate that the greatest yield of 615 s/ha was achieved with the N90P120K120 treatment, this corresponds to an increase of 252 s/ha, or 69.42%, compared to the control treatment.

The mathematical calculations conducted in the conclusion of the study substantiate the precision of the experiment

(Dospekhov, B.A. 1985). E, obtained through the application of fertilizers significantly surpass the s/ha indicator. Based on the findings of this research, it can be asserted that, under the regional conditions, the optimal fertilizer norm for achieving a high green biomass yield from the mixed sowing of sorghum and peas, with 3100 m³/ha of irrigation water applied, is N90P120K120. Furthermore, the application of a combination of organic and mineral fertilizers, specifically manure at a rate of 10 t/ha along with N40P95K60, is also recommended.

Biological nitrogen, in addition to improving soil fertility, is of paramount importance from both ecological and economic perspectives. In leguminous plants, the symbiotic activity of rhizobial bacteria (Rhizobium) facilitates the assimilation of atmospheric molecular nitrogen, which is subsequently mineralized and incorporated into the nutrient cycle.

Sorghum likely, climatic variation is regarded as one of the crucial challenges in terms of food security. Agriculture is meticulously influenced by climate change and food security, mostly relied on the farming division (Shegro A., et al. 2012).

Minerals like phosphorus, potassium and zinc are basically found in sorghum, the content of which actuates depending on where it is grown (Roy D. et.al 2019: Van Dijk, M. et al. 2021).

Grain and forage sorghum grow well in almost any soil, ranging from sandy to clay. It prefers soil with a pH of 4.5 – 5.5 (KCl) but can even cope with brackish soil to a certain extent.

The conservation and rational use of land is of great importance for the development of the agrarian sector. Constantly maintaining and increasing soil fertility plays an important role in ensuring the living conditions and health of the population and addressing food shortages. In order to use the soil effectively, its water, food, air and heat regimes should be established with optimal agility depending on the phenological and biological development characteristics of the agricultural crops that are properly regulated.

Organic fertilizers need to be first degraded and decomposed by microorganisms, which release the nutrients for plant uptake, whereas the nutrients in chemical fertilizers are relatively more readily available for direct uptake and use by plants.

Tillage generally accelerates crop residue decomposition and organic matter, resulting in decreased overall resource quality (Gupta, V.V. et al. 1994).

Soil health has been defined as the ability of soil to continue to function as a vital living system within ecosystem and land-use boundaries, thereby sustaining biological productivity, maintaining air and water quality, and promoting plant, animal, and human health (Allahverdiev E. R., Aliev M. T. 2013) Doran, J.W. 2002).

The health of soil is attributed to its desirable physical (texture, water holding capacity), chemical (pH, soil organic matter (SOM), and biological (microbial diversity, N mineralization, and soil respiration) properties that support healthy productive crops. Soil is considered a living and complex ecosystem harboring a wide array of both micro- and microbiota that regulate its properties.

Soil is an active storage pool of C due to its capacity to store three times more carbon than the atmosphere. One of the primary causes of soil degradation is the loss of organic carbon soil (SOC). SOC has been shown to improve soil structure, fertility, nutrient availability, aeration, water infiltration, and water-holding capacity (Robertson, F et.al. 2015).

Another way to improve soil biodiversity and SOC is to use residue as a surface mulch. There is little information available on the impact of stubble retention on the yield of subsequent crops (Tomar, V.P. et al.1992).

A variety of factors influence soil water holding capacity, including soil bulk density, infiltration rate, and crop residues. Soil aggregation, porosity, and infiltration rates can be improved by soil fauna and retaining residues on the soil surface (De Vries et.al. 2013; Lehmann, A. et. al. 2017).

Increased water infiltration combined with increased organic matter content has a positive impact on soil water storage, and mixing organic matter with soil mineral content significantly improves the water holding capacity of soil. More water can be stored, especially in topsoil, which has a higher organic matter content.

The main role in the accumulation of organic matter in the soil is the root residues and stubble residues, giving the greatest amount of phytomass. During the study, the mass of accumulated stubble residues was determined.

The norms of organic and mineral fertilizers had a profound effect on the mass of stubble residues of mixed crops of sorghum and pea. So, if in the control version without fertilizers in the mixed crops of sorghum and peas, the amount of accumulated stubble residues was 6,1 cen/hec, when applying fertilizers in the norm N120P150K150 10,4 cen/hec, in the variant in case of combined use of organic and mineral fertilizers in the norm 10 t/hec of manure + N70P125K90 - 9.4 kg/hec.

As a result of the study, it was determined that the amount of nutrients in the composition of stubble residues, i.e. total nitrogen, total phosphorus and total potassium vary depending on fertilizer rates.

Considering the above-mentioned, in the research work, the root and shoot residues were collected in the covered planting according to the methodology, and the content of nitrogen, phosphorus and potassium was determined by analysis.

So, in the control variant, if the amount of total nitrogen, total phosphorus and total potassium was 0.96%, 0.37% and 0.98%, there were no such differences when applying fertilizer in the norm of N120P150K150, i.e. when combined organic and mineral fertilizers in the norm of 10 t/hec of manure + N70P125K90 indicators amounted to total nitrogen, total phosphorus and total potassium, respectively 1.11%, 0.45% and 1.22%. And this, in turn, fundamentally affects not only the amount of nutrients accumulated in the stubble, but also the water-physical properties of the soil, the improvement of its structure, and the increase in soil fertility.

Against the background of 5 vegetation irrigation, the use of organic and mineral fertilizers in the mixed crops of sorghum and peas thoroughly affects the mass of stubble residues. So, in the control version without fertilizers in mixed crops of sorghum and peas, if stubble residues are accumulated in an amount of 6.2 cen/hec, in the variant of fertilizer application in the norm N120P150K150 10,2 cen/hec, with the combined use of organic and mineral fertilizers in the norm 10 t/hec of manure + N70P125K90 accumulated stubble residues in the amount of 9,9 cen/hec.

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As a result of the study, it became clear that in the composition of the accumulated stubble residues, the number of nutrients, i.e. total nitrogen, total phosphorus and total potassium vary depending on fertilizer rates. So, in the control variant without fertilizers, if the amounts of total nitrogen, total phosphorus and total potassium were 0.95%, 0.37% and 0.98%, respectively, there was no such difference when applying the N120P150K150 fertilizer norms, i.e. the amounts of total nitrogen, total phosphorus and total potassium were 1.09, 0.48 and 1.25%, respectively, and with the combined use of organic and mineral fertilizers in the norm of 10 t/hec of manure + N70P125K90, the indicators were 1.12, 0, respectively. 46 and 1.23%. And this, in turn, fundamentally affects not only the amount of nutrients accumulated, but also the improvement of the water-physical properties of the soil and its structure, and the increase in its fertility.

Table 2. The effect of irrigation and fertilizer norms on the mass, chemical composition and amount of nutrients of rotting residues in the co-sowing of sorghum and peas

Variants	3 times irrigation						
		Dry matter in air in %			In kg per hectare		
	of rotting remains s/ha	N	P2O5	K2O	N	P2O5	K2O
Control without fertilizer	6,1	0,96	0,37	0,98	5,76	2,22	5,88
N40P60K60	6,5	0,98	0,38	0,99	6,47	2,51	6,53
N60P90K90	7,5	1,01	0,39	1,09	7,57	2,92	8,17
N90P120K120	9,2	1,03	0,45	1,1	9,27	4,05	9,9
N120P150K150	10,4	1,08	0,48	1,23	10,8	4,8	12,3
Manure 10 t/ha+P35	6,5	0,97	0,37	0,98	6,3	2,4	6,4
Manure 10t/ha+N10P65K30	7,3	0,99	0,38	0,99	7,2	2,8	7,2
Manure 10 t/haN60P90K90	9,1	1,07	0,44	1,21	9,63	3,96	10,89
Manure 10t/ha+N70P125K90	9,4	1,11	0,45	1,22	10,4	4,2	11,46
	5 times irrigation						
		Dry matter in air in %			In kg per hectare		
	of rotting remains s/ha	N	P2O5	K2O	N	P2O5	K2O
Control without fertilizer	6,2	0,95	0,37	0,98	5,89	2,29	6,07
N40P60K60	6,9	0,99	0,39	0,99	6,83	2,69	6,83
N60P90K90	7,8	1,02	0,4	1,1	7,95	3,12	8,58
N90P120K120	9,5	1,04	0,46	1,15	9,88	5,7	10,92
N120P150K150	10,2	1,09	0,48	1,25	11,12	4,89	12,75
Manure 10 t/ha+P35	6,9	0,98	0,37	0,99	6,76	2,55	6,83
Manure 10t/ha+N10P65K30	7,7	0,99	0,38	0,98	7,62	2,92	7,54
Manure 10 t/haN60P90K90	9,5	1,07	0,44	1,22	10,16	4,21	11,59
Manure 10t/ha+N70P125K90	9,9	1,12	0,46	1,23	11,09	4,55	12,18

Table 3. The effect of mineral and organic fertilizer norms on the mass, chemical composition and amount of nutrients in the co-sowing of sorghum and peas

Variants	3 times irrigation						
	Root mass	Dry matter in air in %			In kg per hectare		
	s/ha	N	P2O5	K2O	N	P2O5	K2O
Control without fertilizer	24,2	0,86	0,2	0,73	20,64	4,8	17,52
N40P60K60	26,5	0,87	0,21	0,76	22,62	5,46	19,76

N60P90K90	28,3	0,92	0,23	0,85	25,76	6,44	23,8
N90P120K120	30,6	0,93	0,24	0,86	27,9	7,2	25,8
N120P150K150	31,8	1,02	0,26	0,98	31,62	8,06	30,38
Manure 10 t/ha+P35	26,1	0,88	0,22	0,86	22,88	5,72	22,36
Manure 10t/ha+N10P65K30	27,5	0,91	0,23	0,87	25,02	6,32	23,92
Manure 10 t/haN60P90K90	29	0,96	0,23	0,97	27,84	6,67	28,13
Manure 10t/ha+N70P125K90	30	1,07	0,27	0,99	32,11	8,6	29,7
Variants	5 times irrigation						
	Root mass	Dry matter in air in %			In kg per hectare		
	s/ha	N	P2O5	K2O	N	P2O5	K2O
Control without fertilizer	24,4	0,87	0,21	0,73	21,23	4,88	17,81
N40P60K60	26,8	0,88	0,22	0,77	23,58	5,89	20,63
N60P90K90	28,7	0,93	0,24	0,85	26,69	6,89	24,39
N90P120K120	31,1	0,93	0,25	0,86	28,92	7,77	26,74
N120P150K150	31,4	1,01	0,26	0,99	31,71	8,16	31,08
Manure 10 t/ha+P35	26,7	0,88	0,23	0,87	23,49	5,98	23,23
Manure 10t/ha+N10P65K30	28,8	0,92	0,24	0,88	26,49	6,91	25,34
Manure 10 t/haN60P90K90	29,5	0,96	0,24	0,97	28,32	7,08	28,61
Manure 10t/ha+N70P125K90	30,1	1,05	0,26	1,01	31,6	7,82	30,4

In our study, strict control was taken on the conformity of soil monolith samples to the plant nutrition area to obtain reliable information on the accumulation of root residues from mixed crops of sorghum and peas.

As can be seen from the table, if in the control version without fertilizers, when applying 3 irrigations, the root mass accumulates in the amount of 24,2 kg/hec, with the combined use of organic and mineral fertilizers in the norm of 10 t/hec of manure + N70P125K90, the root mass accumulates in the volume of 30,0t/hec. Thus, with the combined use of organic and mineral fertilizers against the background of 3 irrigation in mixed crops of sorghum and peas, the root mass increases significantly. And this, in turn, will be of great importance in the accumulation of biological nitrogen, in maintaining soil fertility because of the decomposition of ongoing microbiological processes in the soil.

As a result of the application of irrigation and fertilizer norms, the amount of total nitrogen, total phosphorus and total potassium in the composition of the root mass varies significantly depending on the norms of fertilizers. So, in the control version without fertilizers, if the amounts of total nitrogen, total phosphorus and total potassium were 0.86, 0.20 and 0.73%, respectively, when applying the N120P150K150 fertilizer standards, these indicators were 1.02, 0.26 and 0,98%, with the combined use of organic and mineral fertilizers at a rate of 10 t/hec of manure + N70P125K90, the amounts of total nitrogen, total phosphorus and total potassium were 1.07, 0.27 and 0.99%, respectively. And this, in turn, proves a thorough effect on the number of nutrients accumulated in the root mass.

If in the control case without fertilizers the root mass of plants accumulates in the amount of 24.4 cen/hec, with the combined use of organic and mineral fertilizers this amounted to a significant increase. So, when using mineral fertilizers in the norm of N120P150K150, if the yield was 31.4 kg/hec, with the combined use of organic and mineral fertilizers in the norm of 10 t/hec of manure + N70P125K90, the root mass was accumulated in the amount of 30.1 kg/hec. Thus, the use of organic and mineral fertilizers against the background of 5 irrigations of mixed crops of sorghum and peas significantly increased the root mass. And this, in turn, will be of great importance in the accumulation of biological nitrogen, in maintaining soil fertility as a result of the decomposition of ongoing microbiological processes in the soil.

The amount of total nitrogen, total phosphorus and total potassium in the composition of the root mass varies significantly depending on the norms of fertilizers. So, in the control version without fertilizers, if the content of total nitrogen, total phosphorus and total potassium was 0.87%, 0.21% and 0.73%, when applying fertilizers in the norm N120P150K150 amounted to 1.01%, 0.26% and 0.99%, and when using 10 t/hec of manure + N70P125K90 was 1.05%, 0.26% and

1.01%, respectively. And this, in turn, indicates a thorough influence on the number of nutrients accumulated in the root mass.
In general, we can say that the use of organic and mineral fertilizers in the optimal norm, in quantitative and qualitative terms, effectively affecting the root mass and stubble remnants of mixed crops, significantly increases soil fertility. This proves that sorghum and peas in mixed sowing are good precursors for subsequent sowing crops.

4 Conclusions

In conclusion, we conclude that when manure is applied as mineral and organic-mineral fertilizer at a rate of 10t/ha + N70P125K90, the green mass yield of sorghum and pea plants significantly increases. When manure is applied as mineral and organic-mineral fertilizer at a rate of 10t/ha + N70P125K90 on long-irrigated gray-grass soils, the green mass yield of sorghum and pea plants mixed in the fallow increases significantly, which increases the amount of organic biological substances in the soil. These organic biological substances have a positive effect on improving soil fertility. This gives reason to say that mixed crops cultivated in the fallow are considered good predecessors for plants that will be sown after them.
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