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ASSIMILATION AND RETURN OF NUTRIENT ELEMENTS BY PLANTS IN SOIL AND IMPACT OF CROP RESIDUES ON SOIL FERTILITY IN SHORT COTTON ROTATIONS

ABDUVALY IMINOV, FAZLIDDIN NAMAZOV, BAKHODIR KHALIKOV
Head of the Crop Rotation Unit Cotton Breeding, Cottonseed Production and Agrotechnologies Research Institute, Tashkent, Uzbekistan

Abstract

To develop a highly efficient the short cycled rotations which provide conservation and improvement soil fertility, of Silt Loam Calcic Xerosol (FAO, 2003) of Tashkent region and the results of the investigations recommend and inculcate to agricultural production.

The field experiment comprised six treatments of crop rotations: T1 – cotton monoculture; T2 – rotation scheme 1: 1 (1 yr cotton: 1 yr winter wheat + soybean as a summer crop); T3 – 1: 2 (1 yr winter wheat + soybean as a summer crop: 2 yr cotton); T4 – 1: 2 (1 yr winter wheat + soybean as a summer crop followed by intercropping of oats and green peas as a winter crop for green manuring: 2 yr cotton); T5 – 1: 2 (1 yr winter wheat + soybean as a summer crop followed by intercropping of oats, green peas and winter rye as a winter crop for green manuring: 2 yr cotton); T6 – 2: 1 (1 yr winter wheat + soybean as a summer crop: 1 yr winter wheat + soybean as a summer crop followed by intercropping of oat, green peas and winter rye): 1 yr cotton.

Key words: winter wheat, cotton, crop rotation, summer crop, soybean, mung bean, root, stubble, nitrogen, phosphor, potassium

After independence of Uzbekistan in 1991 a new agricultural system was introduced which had been a result of economic reforms in the country. Instead of cotton-alfalfa rotations used during soviet era there were inculcated short cotton rotations such as the cereals-cotton, cereals-cotton-fodder crops and cotton-vegetables. It led to changes in sowing structure of irrigated lands which resulted in diminishing of cotton cultivation area whereas area under irrigated winter wheat increased. Out of total irrigated area cotton is now cultivated on the area of 43 – 45% while irrigated wheat is occupied ca. 35%. The new agricultural system coincides with the requirements of market economy but soil fertility issues still are the main problem albeit the new crop rotations have been introduced in Uzbekistan's agriculture.

Crop diversification in a new cotton-winter wheat based crop rotations allows restoring, preserving and increasing content of soil organic matter and improving soil structure. Positive impact of crop rotations on soil fertility is well known. Plants residues are of organic nature and the latter one is a core of soil humus. Hence, the amount of soil humus depends on quantity of plant residues. For that reason, there is a necessity for inclusion in the crop rotations the summer and winter crops producing large amount of crop residues such as roots and stubble.

Naydin (1963) reported that for 100 kg of grain winter wheat assimilate 3.8 kg N; 4 kg P_2O_5, 2.4 kg of K_2O.

Romanov (1986) noted that soybean positively influenced on growth and development of subsequent crop in rotation which improves the soil with nitrogen from 130 to 150 kg ha^{-1} and plant residues in the amount of 3.5 to 4 t ha^{-1} causes to increasing amount of humus.

The scientific researcher of Bonn Plant Industry Research Institute, Volger (1979) found that after winter wheat and summer crop decomposition of plant a residue which accumulates from 30 to 60 kg ha^{-1} nitrogen in the topsoil is the reason to improving the main cultivated crops.

Rasulov et al. (1987) reported that winter crops residues (stubble + roots) in the amount of 3 to 4 t ha^{-1} positively influenced on growth and development of subsequent crop in rotation.

Khalikov (2007) found that crop residues of winter wheat, summer and winter crops grown in the crop rotation with 2 yr winter wheat, 2 yr mung bean as summer crop, 1 yr winter rye for green manuring and 1 yr cotton (the rotation scheme was 2: 1) were from 12.43 – 16.80 t ha^{-1}, whereas crop residues in the rotation 1: 1: 1 (winter wheat + mung bean as a summer crop + triticale for green manuring: soybean: cotton or other rotation with 1 yr winter wheat + mung bean as a summer crop: 1 yr cotton: 1 yr soybean) were from 12.09 to 16.09 t ha^{-1} and the crop residue amounts were almost similar to previously indicated quantities.

MATERIAL AND METHODS

The study was conducted from 2005 to 2009 at the Central Experiment Station of the Cotton Breeding, Seed Production and Agrotechnologies Research Institute (CES-CRI, 41°42' N, 69°49' E, 623 m elevation above mean sea level) near Tashkent. The CES-CRI is located in the northeast of the Uzbekistan cotton belt. The soil, a Silt Loam Calcic Xerosol in the FAO taxonomy (FAO, 2003), is known in the Russian taxonomy still used in Uzbekistan as an old irrigated Typical Sierozem. Its texture is uniform with depth, and it is derived from loess, either in place or in alluvial deposits. The water table is >15 m deep, ensuring an automorphic type of soil formation. Mineral nitrogen and available phosphate contents at beginning of the experiment were low but exchangeable potassium was moderate.

The experiment design utilized was a RCBD with four replicates. Each plot (4.8-m wide by 50-m long rows) comprised eight rows where crops were seeded in 0.6-m rows. Four central rows of each plot were used for sampling of stubble and roots of the crops in the rotations.

The experiment results showed that accumulation of crop residues (stubble + roots) was higher with T5 and T6 compared with other treatments (Table 2). For these treatments cumulative amounts of crop residues of winter wheat, soybean, peas, oats and rye for duration of the rotations (three years) were 10.3 and 14.4 t ha^{-1}. The plant residue amounted to 9.45 t ha^{-1} for T4 and was lesser in comparison with previous two treatments of the experiment. The lowest quantity of plant residues ranging from 4.93 to 4.96 t ha^{-1} were obtained from T2 and T3.

The first field experiment comprised three treatments of crop rotations: T1 – 1 yr winter wheat: 1 yr cotton; T2 – rotation scheme 1: 1 (1 yr winter wheat + mung bean as a summer crop); T3 – rotation scheme 1: 1 (1 yr winter wheat + soybean as a summer crop).

The second field experiment comprised six treatments of crop rotations: T1 – cotton monoculture; T2 – rotation scheme 1: 1 (1 yr cotton: 1 yr winter wheat + soybean as a summer crop); T3 – 1: 2 (1 yr winter wheat + soybean as a summer crop: 2 yr cotton); T4 – 1: 2 (1 yr winter wheat + soybean as a summer crop followed by intercropping of oats and green peas as a winter crop for green manuring: 2 yr cotton); T5 – 1: 2 (1 yr winter wheat + soybean as a summer crop followed by intercropping of oats, green peas and winter rye as a winter crop for green manuring: 2 yr cotton); T6 – 2: 1 (1 yr winter wheat + soybean as a summer crop: 1 yr winter wheat + soybean as a summer crop followed by intercropping of oat, green peas and winter rye): 1 yr cotton.

RESULTS AND DISCUSSION

The first experiment results showed that plant residues was (stubble and root) in the amount of 1.41 t ha^{-1} and 2.40 t ha^{-1} in the end of winter wheat vegetation. Mung bean as a summer crop (stubble and root) was 0.80 t ha^{-1} and 1.36 t ha^{-1}. Soybean as a summer crop (stubble and root) was 0.98 t ha^{-1} and 1.75 t ha^{-1}.

The amount of plant residues was higher with T2 (from 2.21 t ha^{-1} to 2.39 t ha^{-1} in stubble and from 3.76 t ha^{-1} to 4.15 t ha^{-1} in root), 1: 1 (1 yr winter wheat + 1 yr mung bean as a summer crop: lyr cotton) and T3, 1: 1 (1 yr winter wheat + 1 yr soy bean as a summer crop: lyr cotton). The lowest amount was with T1 (1.41 t ha^{-1} in stubble and 3.76 t ha^{-1} in root).

These results showed that after legumes-grain crops which were sown as a summer crops accumulates organic residues in the amount of 5.97 – 6.54 t ha^{-1} during a year. For that reason, it positively influenced the water-physical properties of soil and increasing the amount of humus and soil macro- microstructure.

During the experiments determined the amount of nitrogen, phosphorus and potassium in vegetative organ of winter wheat, mung bean and soybean.

According to the results the amount of nitrogen was 0.3% in 100 g of dry winter wheat stalks, 0.4% in the leaves, and 1.1% in the ear of wheat, 2.13% in the grain, moreover the amount of phosphorus was 0.25% in 100 g of dry winter wheat stalks, 0.14% in the leaves, and 0.50% in the ear of wheat, 0.95% in grain, apart from that the amount of potassium was 1.40% in 100 g of dry wheat stalks, 1.0% in the leaves, and 0.95% in the ear of wheat, 1.23% in grain.

After winter wheat as a summer crop the amount of nitrogen was 0.4% in the mung bean stalks, 0.6% in the harvest branches, 0.7% in the legumes, 1.08% in the cereal, the amount of phosphorus was 0.20%, 0.25%, 0.16% and 0.70% respectively, moreover the amount of potassium was 1.0%, 0.55%, 0.70% and 1.30% respectively.

As a summer crop soybean the amount of nitrogen was 0.7% 0 in soybean stalks, 0.95% in the leaves, 0.5% in the harvest branches, 0.75% in the beans, 1.20% in the cereal, the amount of phosphorus was 0.20%, 0.20%, 0.20%, 0.22% and 0.63% respectively, moreover the amount of potassium was respectively 0.7%, 0.85%, 0.55%, 0.25% and 0.55% respectively.

The experiment showed that during the vegetation each winter wheat crop assimilates in the amount of 0.047 g nitrogen, 0.022 g phosphorus, 0.056 g potassium. If these facts multiply to the number of plants in per hectare, in that case, above-ground part of the plant assimilates 150.6 kg ha^{-1} of nitrogen, 70.5 kg ha^{-1} of phosphorus, 179.4 kg ha^{-1} potassium elements from the soil over the period from the beginning of sowing to harvest.

After winter wheat as a summer crop mung bean assimilates in the amount of 0.66 g nitrogen, 0.42 g phosphorus, 0.93 g potassium. In turn the amounts of nitrogen, phosphorus, potassium were 71.6 kg, 45.6 kg 100.9 kg in per hectare. Furthermore soybean as a summer crop during the vegetation assimilates 0.48 g nitrogen, 0.064 g phosphorus, 0.30 g potassium elements. In that case it assimilates 94.4 kg nitrogen, 12.6 kg phosphorus, 59 kg potassium in per hectare.

The research results showed that winter wheat assimilates 150 kg N, 70 kg P_2O_5 and 179.4 kg

Table 1. Crop residue (stubble + roots) amounts accumulated in the 0 – 50 cm soil layer by different crops during the crop rotations (t ha^{-1})

Treatments	Crop rotation schemes	Winter wheat (stubble + roots)	Summer crop mung bean (stubble + roots)	Summer crop soybean (stubble + roots)	Amount of crop residues (stubble + roots)
1	1: 1 (1 yr winter wheat: lyr cotton)	3.81	-	-	3.81
2	1: 1 (1 yr winter wheat + 1 yr mung bean as a summer crop: lyr cotton)	3.81	2.16	-	5.97
3	1: 1 (1 yr winter wheat + 1 yr soybean as a summer crop: lyr cotton)	3.81	-	2.73	6.54

T1 – cotton monoculture; T2 – rotation scheme 1: 1 (1 yr cotton: 1 yr winter wheat + soybean as a summer crop);
T3 – 1: 2 (1 yr winter wheat + soybean as a summer crop: 2 yr cotton).

Table 2. Crop residue (stubble + roots) amounts accumulated in the 0 – 50 cm soil layer by different crops during the crop rotations (t ha^{-1})

Treat-ments	Crop rotation schemes	Winter wheat		Summer crop (soybean)		Winter crops (peas, oats, rye)		Amount of crop residues (stubble + roots)
		roots	stubble	roots	stubble	roots	stubble	
1	Control	-	-	-	-	-	-	-
2	1: 1	2.54	0.97	1.18	0.24	-	-	4.93
3	1: 2	2.67	0.83	1.24	0.22	-	-	4.96
4	1: 2	2.65	0.96	1.20	0.25	3.14	1.25	9.45
5	1: 2	2.73	0.88	1.23	0.25	3.54	1.67	10.30
6	2: 1	4.55	1.76	2.43	0.45	3.50	1.74	14.43

K_2O in 1: 1 scheme of crop rotation (1 yr cotton: 1 yr winter wheat: 1 yr). In this scheme after winter wheat which is sawn mung bean as a summer crop the amount of NPK were 222.2 – 116.1 – 208.3 kg or 1 yr cotton: 1 yr winter wheat + soybean as a summer crop the amount of NPK 245 – 83.1 – 238.4 kg respectively.

The second experiment results showed that accumulation of crop residues (stubble + roots) was higher with T5 and T6 compared with other treatments (Table 2). For these treatments cumulative amounts of crop residues of winter wheat, soybean, peas, oats and rye for duration of the rotations (three years) were 10.3 and 14.4 t ha^{-1}. The plant residue amounted to 9.45 t ha^{-1} for T4 and was lesser in comparison with previous two treatments of the experiment. The lowest quantity of plant residues ranging from 4.93 to 4.96 t ha^{-1} were obtained from T2 and T3.

CONCLUSIONS

We concluded that amount of plant residues such as crop's stubble and roots which are to be plowed in soil much depends of crop species grown in crop rotations. In our experiment the crop residue amount of winter wheat and soybean grown as a summer crop during one cropping season was from 4.0 to 5.0 t ha^{-1}. The plant residue of intercropped winter crops such as the peas, oats and rye was 9.5 – 14.5 t ha^{-1} during the autumn-winter season. Nitrogen, phosphate and potassium of the plant residue serve as a source of nutrients after its decomposition with input to soil organic matter.

The above results showed that winter wheat assimilates 40 – 50% more than cereals-grain. The requirement of potassium element was more than phosphorus element in all crops. Therefore, the main reason of growing legume-grain crops in Typical Sierozem Soil is using nitrogen fertilizer, phosphorus fertilizer and potassium fertilizer in the norm of 1 (nitrogen); 0.7 (potassium); 0.5 (phosphorus).

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