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Effects of composts application with inorganic fertilizers on soil organic carbon and productivity of irrigated cotton (*Gossypium hirsutum* L.) in Uzbekistan

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ABSTRACT : The organic amendments (FYM, farmyard manure; CP, chicken poultry; TL, tree leaves of *Platanus orientalis* L.) added inorganic fertilizer as nitrate calcium phosphate: (5%) N, (10%) Ca, (16%) P_2O_5) were composted in 2009 for 120 days at Cotton Breeding, Seed Production and Agro Technologies Research Institute (CBSPARI), near Tashkent, Uzbekistan. Prepared the composts (Compost 1: FYM + TL + NPK-fertilizer; Compost 2: FYM + CP + TL + NPK fertilizer) were applied in the cotton field in autumn 2009 to assess the direct and residual effects on soil organic carbon (SOC) and irrigated cotton productivity. The experiment with irrigated cotton having randomized complete block design with 3 replications was carried out in 2010 to 2011 at the Central Experiment Station (CES-CBSPARI). Compared to compost free treatment an influence of compost application on plant height and sympodial branches/plant was significantly higher accordingly at GS55 and GS75 cotton growth stages in both the study years. Composts significantly increased the boll/plant as compared to control at both GS75 and GS84 stages. Seed lint yield increase under direct and residual effects of composts was significant and ranged from 0.23 to 0.26 Mg/ha. In 2 years after compost application the SOC in compost amended soil was significantly higher for 0.61 g/kg (13%) and 0.68 g/kg (15%), respectively in comparison with no compost application treatment.

Key words : Compost, cotton growth, seed lint yield, soil organic carbon

Most of irrigated soils of the Republic of Uzbekistan are characterized by medium and low amounts of soil organic matter (SOM, 10 to 15 g/kg and 5 to 10 g/kg accordingly in the 0-30 cm depth) (Tashkuziev, 2012). SOM sharply decreases with depth owing to dry climate, high temperatures, irrigation and tillage practices, which enhance fast decomposition in plowing layer (0-30 cm). As the inherent fertility of soils in Uzbekistan is rather low there is need of improving organic carbon status of soil using mineral and organic fertilizers (Bairov and Khamdamov, 2013).

Application of inorganic fertilizers increases cotton yield for 50 per cent and more. However unbalanced and excessive application of inorganic fertilizer decreases SOM and creates environmental problems. Balanced application of inorganic and organic fertilizers could overcome the problem because organic fertilizers and composts play an important role in improving soil fertility and increasing crop productivity. Research results suggest annual application of organic fertilizer with rate of 10-12 t/ha to restore and sustain SOM content in irrigated soils of Uzbekistan. Amount of organic fertilizers produced annually in the country for application at the rate of 10 t/ha covers only 1.0 million ha of irrigated land. Hence there is need to increase organic fertilizer production in

Uzbekistan using various sources of organic wastes (Ibragimov and Niyazaliev, 2016).

Composts are rather inexpensive in comparison with chemical fertilizers, properly collected and composted organic materials pose lesser risk to the environment. Different sources of organic fertilizers (FYM and chicken poultry) along with wastes such as lignin, bentonitic and glauconitic clay, municipal waste and coal production waste, crop residues (tree leaves, grinded hay, stubble, etc.) are available in Uzbekistan. Hence the waste must be utilized for improving soil health and reducing doses of inorganic fertilizers (Niyazaliev, 2016).

Applications in cotton field different organic composts made of FYM added lignin, bentonit, municipal waste and coal production waste increased soil organic matter, improved soil physical properties, microbial biomass and other soil properties and crop yields (Nazarov and Boltaev, 2016; Niyazaliev, 2016; Bairov and Khamdamov, 2013).

Despite of ample evidence existing on influence of organic fertilizers on soil properties and crop yields there is less information available on composting of farmyard manure with addition chicken poultry and tree leaves, and the composts use in the irrigated croplands of Central Asia. The objectives of this study were to examine direct and residual effects of the composts application on SOC and irrigated cotton productivity.

MATERIALS AND METHODS

Preparation of compost : The composts were prepared before conducting the field experiment from the available wastes locality. The FYM and poultry litter were collected from the local farmers and leaves of *Platanus orientalis* L. were collected from the trees widely grown around the area near Institute. Compost 1 was prepared using 1500 kg of each FYM and tree leaves along with 45 kg of nitrate calcium phosphate fertilizer while compost 2 was prepared by using 1250 of each FYM and tree leaves and 500 kg poultry litter along with 45 kg of nitrate calcium phosphate fertilizer. Organic wastes and chemical fertilizer were mixed thoroughly using spade and composted for 120 days in 3 replications by maintaining about 70 per cent moisture content throughout the composting period. The chemical composition of organic wastes is presented in Table 1.

Table 1. Composition of farmyard manure, poultry litter and tree leaves before compost preparation

Parameters	Farmyard manure	Poultry litter	Tree leaves (*Platanus orientalis* L.)
Moisture (g/kg)	625.8	601.7	479.6
Dry matter (g/kg)	374.2	398.3	520.4
Ash (g/kg DM)	117.9	133.0	283.8
ÎM (g/kg DM)	256.1	210.0	225.2
Total N (g/kg DM)	7.2	26.6	11.7
Total P (g/kg DM)	3.7	19.9	5.4
Total K (g/kg DM)	8.6	18.3	12.9
Cu (mg/kg DM)	23.0	27.0	34.0
Pb (mg/kg DM)	18.0	29.0	29.0
Ni (mg/kg DM)	10.6	18.2	30.6
ðH$_{1:5}$	6.9	6.8	6.9
EC (dS/m)	4.0	4.6	6.2

Experimental setup : A field experiment was conducted during 2010 and 2011 at Central Experimental Station of CBSPARI. The soil samples (0-30 cm) were collected before compost application in soil and analyzed for available and total nutrient content of soil by using standard procedures. The experimental soil was silt loam calcic xerosol as per FAO taxonomy having water table > 15 m deep. The soil had total N content of 0.68 g/kg, total P of 1.34 g/kg, nitrate N of 16.2

mg/kg, available P of 24.4 mg/kg and exchangeable K of 196 mg/kg before cotton planting.

The experiment comprised of 2 fertilization treatments with composts ($N_{200}P_{140}K_{100}$+ compost) and a compost-free control treatment with $N_{200}P_{140}K_{100}$ kg/ha fertilizers for comparison was conducted in randomized complete block design with 3 replications. The composts were applied at the rate of 10 Mg DW/ ha which is a common application rate in Uzbekistan. Phosphorus and potassium fertilizers ($P_{100}K_{50}$ kg/ha) together with composts as the base application were incorporated into soil before plough. Nitrogen was split into 3 applications: 50-75-75 kg N/ha correspondingly at 3 leaves (GS13), budding (GS55) and flowering (GS61) stages of cotton. Remaining portion of the PK fertilizers (P_{40} and K_{50} kg/ha) was incorporated onto soil together with N fertilizer correspondingly at budding and flowering stages of cotton. Direct and residual effects of composts application on SOC and cotton productivity were assessed in 2010 and 2011, respectively.

Cotton was irrigated 5 times during the vegetation season with irrigation rate from 800 to 1000 m^3/ha for each irrigation event, and seasonal irrigation rate ranged from 4300 to 4600 m^3/ha.

Analysis of organic amendments and soil *:* Representative samples of the organic materials were dried in an oven at 105°C for 24 h for determination of moisture and calculation of DM. Separately collected samples of the organic materials were dried in an oven at 70°C for 24 h, grounded to a powder and analyzed for determination of chemical composition. Moisture, dry matter, ash, total nitrogen, total phosphorus, total potassium contents in the organic amendments before composts preparation and in the composts during composting were determined according to the GOST 26712-85-GOST 26718-85. Micronutrient Cu and heavy metals (Pb and Ni) contents in the organic amendments were analyzed with the Atomic Absorption Spectrometer, Perkin Elmer. SOC (%) was determined according to Tyurin which is a modified Walkley Black method.

Statistical analysis : All data were checked for normality. Analysis of variance (ANOVA) of the cotton seed lint yield was performed using the general linear model (GLM) procedure. The same was true for the phenological data, which were analyzed with the repeated measures option. An LSD Post Hoc test compared individual treatment means where the ANOVA test indicated significant (P < 0.05) treatment effects. All statistical analyses were performed using SAS software.

RESULTS AND DISCUSSION

Growth and seed lint yield of cotton : The plant height significantly increased with development of growth stage under all the treatments in both years (Table 2).

Effect of compost application on plant height was significantly higher at GS55 stage in both the years. Similarly sympodial branches/ plant significantly increased with advancement of plant growth in both the study years and effect of compost application was significant only at GS75 stage as compared to control during both the study years. Compost application significantly increased the boll/plant as compared to control at both GS75 and GS84 growth stages and boll was highest at GS84 growth stage. Performance of compost 2 was slightly better than compost 1 in case of growth parameters (Table 2). *Treatment* effect was

Table 2. Influence of composts application on plant height, sympodial branches and bolls of cotton plant

Treatment	Plant height (cm)			Sympodial branches/plant		Bolls/plant	
	GS13†	GS55	GS75	GS55	GS75	GS75	GS84
Year of 2010							
NPK (Control)	12.0A‡	30.6C	62.4A	4.6B	9.6C	4.2B	8.6B
NPK + Compost 1	12.2A	31.5B	63.4A	4.8B	10.2B	4.3BA	9.2A
NPK + Compost 2	12.4A	32.2A	64.5A	5.2A	10.7A	4.6A	9.6A
Treatment	*<.0001*	*<.0001*	*<.0001*				
Treatment x Time	*0.9549*	*0.0881*	*0.1388*				
Year of 2011							
NPK (Control)	12.3A	29.9B	70.3C	4.4A	10.6C	5.6B	8.7B
NPK + Compost 1	13.0A	30.8A	71.6B	4.6A	11.0B	6.1A	9.4A
NPK + Compost 2	13.7A	31.4A	72.6A	4.5A	11.3A	6.0A	9.7A
Treatment	*<.0001*	*<.0001*	*<.0001*				
Treatment x Time	*0.8893*	*0.0003*	*0.0876*				

†GS, Growth stages according to the BBCH scale [11].
‡Treatment-means in a column for each parameter, growth stage and year followed by the same letter are not significantly different at $P < 0.05$ according to the Repeated Measures test.

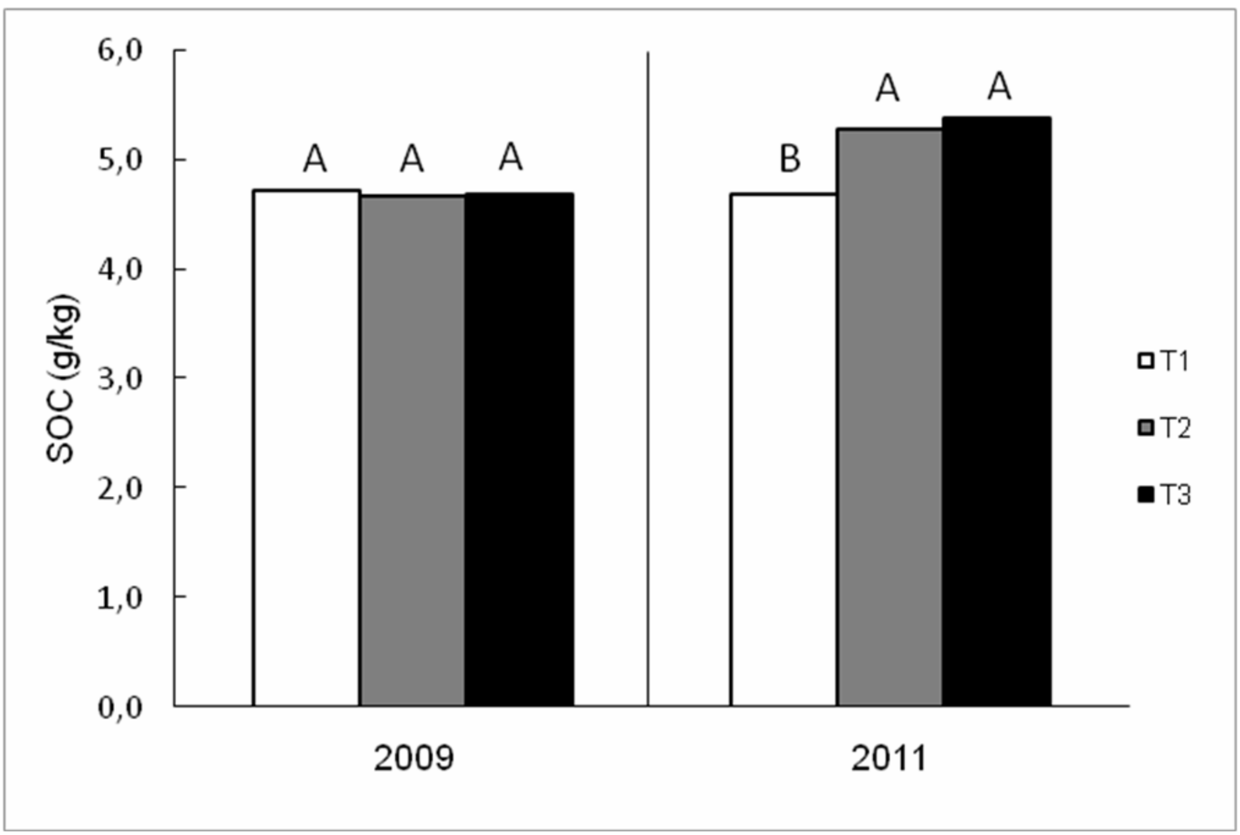

Fig. 1. SOC content of top 0-30 cm soil before (autumn 2009) and after compost application (autumn 2011). Values of column each year followed by the same letter are not significantly different at $P < 0.05$ according to the Proc GLM comparison test.

significant in both study years while *treatment x time* effect was not significant for the parameters measured except bolls in 2011.

Seed lint yield in both study years was affected by the composts application (Table 3). Compared to the control treatment, composts application significantly increased seed lint yield of cotton for 0.22 to 0.24 Mg/ha in 2010. Yield increase from compost application was ranging from 0.23 to 0.26 Mg/ha in 2011. However, no significant difference was between compost 1 and compost 2 in both years. Besides, direct and residual effects of the compost on seed-lint yield were identical and the differences were not significant. Positive effect of compost application on seed yield yield of cotton was due to enhanced carbon sequestration in soil and other improved soil properties (Nazarov and Boltaev, 2010).

Preliminary and post harvest soil organic carbon content of soil : Addition of organic materials to agricultural soil is important for replenishing the annual SOC losses and for improving the chemical and other soil properties (Brar *et al.,* 2015; Arthur *et al.,* 2012). Application of compost significantly enhanced carbon sequestration in soil (Fig. 1). Before the composts application in 2009, SOC content of 0-30 cm top soil across all treatment was ranging from 4.67 to 4.72 g/kg with no difference among treatments (p=0.0992). In 2 years after amending soil with compost 1 and compost 2, SOC content of soil was 5.29 and 5.36 g/kg accordingly while control treatment SOC was 4.68 g/kg (Fig. 1). Organic carbon of compost amended soil was significantly higher for 0.61 g/kg (13%) and 0.68 g/kg (15%), respectively in comparison with no compost application treatment.

Table 3. Effects of composts application on seed-lint yield of cotton

#	Treatment	Seed lint yield (Mg/ha)	
		2010	2011
1	NPK (Control)	2.86Ba‡	2.90Ba
2	NPK + compost 1	3.08Aa	3.13Aa
3	NPK + compost 2	3.10Aa	3.16Aa

‡Treatment-means in a column for each year followed by the same uppercase letter and treatment-means in a row for each treatment followed by the same lowercase letter are not significantly different at $P < 0.05$ according to the Proc GLM comparison test.

Organic matter content in both compost 1 and compost 2 was higher than 200 g/kg DM, and this is the reason for the higher SOC observed with composts application treatments compared to compost free treatment. This is in agreement with the results of Vo and Wang (2015) and Arthur *et al.,* (2012), who reported an increase in SOC following compost application.

CONCLUSION

This study assessed the direct and residual effects of composts application on SOC, plant development and seed lint yield of irrigated cotton. The results demonstrated that SOC, cotton plant development and yield were significantly affected by composts application. The organic amendments increased SOC, sympodial branches and bolls on cotton plant. Consequently, the seed lint yield significantly increased with application of composts. The results from our study imply that balanced application of organic amendments with chemical fertilizers stimulates carbon sequestration in soil and formation of cotton fruit branches and increases seed lint yield.

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