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Rice Soil Properties and Nutrients Uptake as Affected by Compost and Antioxidant Application

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Abstract: A field experiment was carried out at the Experimental Farm of Rice Research Training Center, Sakha, Kafr El-Sheikh, Egypt in 2012 and 2013 seasons, to investigate and the effects of antioxidant (control and foliar spraying with ascobien two and three times), compost (0, 3.5 and 7 tons ha^{-1}) and nitrogen (0, 55, 110 and 165 kg N ha^{-1}) application on soil properties and nutrients uptake of Sakha106 Egyptian rice cultivar. The availability of N P K at 55 days after transplanting (DAT) and harvest were significantly increased by increasing nitrogen and compost rate. Foliar application of ascobien resulted in significant decrease in the availability of these nutrients compared with control treatment. Organic matter percentage in soil at 55 DAT and harvest was significantly increased by application of compost only. Nitrogen, compost and ascobien application resulted in significant increase in nitrogen, phosphorus and potassium uptake (kg ha^{-1}) in grain and straw compared with control treatments. Combinations of 110 kg N ha^{-1}, 7 t compost ha^{-1} and three sprays with ascobien produced the highest values of nitrogen, phosphorus and potassium uptake (kg ha^{-1}) in grain. It can be concluded that application of compost improved yield, soil properties and nutrients availability.
Key words: rice, compost, antioxidant, soil properties, nutrients uptake.

Introduction

Rice (*Oryza sativa* L.) is one of the most important cereal crops of the world, grown in wide range of climatic zones, to nourish the mankind. Increasing productivity per unit land area is a native goal to meet the consistent demands from this crop. Rice occupies a conspicuous position in the predominately agricultural economy of Egypt, this attention is required to improve its yield, quality characters and quality of elements nutrition.

Rice straw is unique relative to other cereal straws in being low in lignin and high in nitrogen, potassium and silica. Unlike other cereal straws rice straw tend to be leafy while the leaves are less digested than stems. This may contribute to higher straw value with rice yield. Rice straw compost is an organic fertilizer that can be made on the farm at very low cost[1]. Incorporation of organic sources into paddy soil markedly improved root morphological characteristics of rice plant[1]. Incorporation of organic manure significantly increased P uptake by rice plants and facilitated the allocation and transfer of nutrient elements, especially P to rice ears and grain. The integration between organic and inorganic fertilizer showed significant effect on the concentrations of rice grain and straw N, P, K, S. The levels of organic matter and nutrient concentration were increased in the post-harvest soils due to added manure plus inorganic fertilizer[2]. The accumulative amounts of nitrogen, phosphorus and potassium in rice plants across all growth stages tended to increase with the application of organic manure in combination with mineral nitrogen[3].

Ascobien contains 13% citric acid, 25% ascorbic acid plus 62% organic materials. Ascorbic acid had different effects on many physiological processes including the regulation of growth and metabolism of plants[4]. Ascorbic acid is the most abundant antioxidant, which protects plant cells, ascorbic acid is currently considered to be a regulator on cell division and differentiation and added that ascorbic acid is involved in a wide range of important functions as antioxidant defense, photo protection and regulation of photosynthesis and growth[5]. Foliar application of ascobien resulted in a significant increase in N uptake by rice plant compared with other simulative compounds (humate potassium, amino acid, organic nitrogen, k_2O)[6]. The effect of foliar application of humic and fulvic acids was studied by several investigators[7,8]. Foliar application of humic and fulvic acids together led to significant increases N, P & K content of grain and straw as well as NO_2 and NO_3 of grain and straw[7]. Foliar application of humic and fulvic acids together led to significant increases of grain, straw rice yield and N, P & K content of grain and straw as well as NO_2 and NO_3 of grain and straw[8]. NH_4 and NO_3 concentrations in rice soil after harvest decreased significantly with foliar application of each humic or fulvic acids or both[8]. **The main objective of this study is** to study the effect of compost rice straw and antioxidant application on soil properties and nutrients uptake in paddy field.

Experimental

This experiment was conducted during 2012 and 2013 rice growing seasons at the Experimental Farm of Rice Research and Training Center, Sakha, Kafr El-Sheikh, Egypt to study the effect of ascobein and compost application under different nitrogen levels on soil properties and nutrients uptake by Egyptian rice cultivar Sakha 106 . The previous crop was barley in the two seasons. Some chemical and physical properties of the soil of the experimental site are presented in Table 1.

The experiment was laid out in split-split design plots based on RCBD in four replications, where main plots were assigned to nitrogen levels (0, 55, 110 and 165 kg N ha^{-1}) in the form of urea (46% N) and sub-plots were allocated to compost rates (0, 3.5 and 7 tons ha^{-1}), while the sub-sub-plots were assigned to ascobein treatments (control, spraying with ascobein two times at 15 and 30 days after transplanting (DAT), spraying with ascobein three times at 15, 30 and 45 DAT). Ascobein (13% citric acid, 25% ascorbic acid plus 62% organic materials) was applied at the concentration of 1.5 g $litre^{-1}$ as a foliar application. The organic fertilizer (rice straw compost) was applied as a basal application into the dry soil before transplanting by two weeks and was well turned into the soil. Chemical analysis of the used compost is presented in Table 2.

The nursery seedbed was well ploughed and carefully levelled**.** Seed was soaked in water for 24 hours at the rate of 90 kg ha^{-1}, and then incubated for 48 hours to hasten early germination. Pre-germinated seed was uniformly broadcasted in the nursery on 10th and 12th of May in 2012 and 2013 seasons, respectively. The permanent field was well prepared. Seedlings were carefully pulled from the nursery after 30 days from sowing and distributed through the plots. Seedlings were manually transplanted into 15 m^2 sub-plots in 15X 15 cm transplanting spacing at therateof2-3seedlings $hill^{-1}$. Allagronomic practices were followed as recommended.

Soil samples were collected from the surface layer of (0-30 cm) twice from each plot, once at 55 DAT and after rice harvesting in each season. The samples were dried for constant weight, then ground before conducting some soil analysis. Available ammonium, nitrate, phosphorus and potassium (ppm) were determined. Soil organic matter percentage was measured[9].

After harvest, rice straw and grains (milled) were ground after drying to a constant weight to be ready for chemical analyses. Half gram of these samples was digested[10], and then chemical analyses were carried out to evaluate NPK concentrations in rice grains and straw. Then, NPK uptakes were calculated.

The obtained data were subjected to analyses of variance[11] .Treatment means were compared by Duncan's Multiple Range Test[12]**.** All statistical analysis was performed using "MSTATC" computer software package.

Table 1: Some physical and chemical properties of the experimental soil before planting in 2012 and 2013 summer seasons

Soil properties	2012	2013
Mechanical:		
Clay %	55.9	56.0
Silt %	31.5	32.0
Sand %	12.6	12.0
Texture	Clayey	Clayey
Chemical:		
Organic Matter (O.M)%	1.45	1.50
pH(1:2.5 soil suspension)	8.35	8.44
Ec ($ds.m^{-1}$)	3.12	3.34
Total N (ppm)	477.00	430.50
Available P (ppm)	14.00	12.00
Available K (ppm)	460	432
Available ammonium (ppm)	18.0	17.2
Nitrate concentration (ppm)	14.0	13.2
Soluble anions, $meq.L^{-1}$:		
CO^{--}_3	--	--
HCO^-_3	5.30	6.20
Cl^-	8.50	9.10
SO^{--}_4	17.40	18.00
Soluble Cations, $meq.L^{-1}$:		
Ca^{++}	11.70	10.70
Mg^{++}	3.50	5.00
Na^{++}	1.60	2.00
K^+	14.40	15.60
Availabe micronutrients (ppm)		
Fe^{++}	5.00	5.80
Mn^{++}	3.04	3.20
Zn^{++}	1.00	0.95

Table 2. Chemical analyses of the compost in 2012 and 2013 summer seasons.

Season	C %	N%	C:N Ratio	P%	K%	Fe ppm	Mn ppm	Zn ppm
2012	35	1.75	20.00	0.44	0.63	480	190	38
2013	30	1.80	16.67	0.59	0.81	580	290	68

Results and Discussion

I. Nutrients availability in the soil:

I.1. Available ammonium and nitrate (ppm):

Available ammonium (NH_4^+) and nitrate (NO_3^-) in the soil at 55 DAT and at harvest were affected significantly by nitrogen fertilizer application during 2012 and 2013 as presented in Table 3. NH_4^+ and NO_3^- concentrations in soil at 55 DAT were higher than at harvest. This phenomenon might be due to that nitrogen uptake increased with the advancement of plant age and it will reflect directly in nitrogen concentration in the soil[13,14]. Available ammonium and nitrate were significantly increased with each increment of nitrogen fertilizer. These findings could be as result of the mineralization of nitrogen from native and N-sources[15].

Table 3: Available ammonium and nitrate (ppm) in the soil as affected by nitrogen rate, compost rate and foliar application of ascobien in 2012 and 2013 seasons.

Factor	Available ammonium (ppm)				Available nitrate (ppm)			
	2012		2013		2012		2013	
	55 DAT	At harves	55 DAT	At harves	55 DAT	At harves	55 DAT	At harves
kg N ha^{-1}(N)								
0	26.83 d	16.19 d	28.52 d	19.22 d	6.41 d	3.05 d	5.61 d	4.29 d
55	28.79 c	20.79 c	30.93 c	21.79 c	7.90 c	3.59 c	7.45 c	4.98 c
110	32.37 b	25.01 b	33.80 b	24.86 b	8.88 b	4.14 b	10.45 b	6.12 b
165	37.75 a	27.13 a	36.56 a	26.8 a	11.21 a	5.16 a	12.92 a	7.25 a
F-test	**	**	**	**	**	**	**	**
t compost ha^{-1}(C)								
0	27.95 c	20.61 c	27.59 c	20.24 c	7.35 c	3.32 c	7.56 c	4.41 c
3.5	31.42 b	21.91 b	33.69 b	23.58 b	8.36 b	3.94 b	9.1 b	5.81 b
7	34.94 a	24.31 a	36.08 a	25.68 a	10.08 a	4.7 a	10.66 a	6.76 a
F-test	**	**	**	**	**	**	**	**
Ascobein spray No. (A)								
0	32.31 a	23.1 a	33.61 a	24.14 a	9.38 a	4.48 a	9.93 a	6.26 a
2	31.26 b	22.29 b	32.56 b	23.28 b	8.54 b	3.92 b	9.11 b	5.65 b
3	30.74 c	21.44 c	31.19 c	22.08 c	7.87 c	3.56 c	8.27 c	5.07 c
F-test	**	**	**	**	**	**	**	**
Interaction								
NxC	**	**	**	**	**	**	**	**
NxA	**	**	**	**	**	**	**	**
CxA	**	**	**	**	**	**	**	**
NxCxA	**	**	**	**	**	**	**	**

*** and** indicate p< 0.05, p<0.01 and not significant, respectively. Means of each factor designated by the same letter are not significantly different at 5% level using Duncan's multiple range test.**

Available ammonium and nitrate (ppm) in the soil were gradually increased by increasing compost rate form 0 up to 7 t ha^{-1} at 55 DAT and harvest. Release of N (also called mineralization) from compost is due to conversion of organic forms of N to inorganic N (as ammonium N-NH_4). Compost application leads to enhanced enrichment of organic nitrogen in the soil[16]. Other investigator reported that rice straw incorporation or organic manure application increased significantly NH_4 concentration in rice soil[17].

Foliar spraying with the solution of ascobein resulted in significant decrease in available ammonium and nitrate (ppm) in the soil compared with control treatment at 55 DAT and harvest. The highest available ammonium and nitrate in soil were found when ascobien was not applied, while the lowest ones were obtained with spray of ascobien three times. Other investigators found that NH_4^+ and NO_3^- concentration in rice soils after harvest decreased significantly with foliar application of each humic or fulvic acids or both[7,8].

Data in Table 4 showed that available ammonium and nitrate (ppm) in the soil at 55 DAT and harvest affected significantly by the interaction among nitrogen fertilizer rate, compost rate and ascobien foliar application in the two seasons. Application of nitrogen fertilizer and compost without ascobien resulted in significant increase in available ammonium and nitrate compared with other treatments in the two seasons. Adding 7 t compost ha^{-1} and 165 kg N ha^{-1} without ascobien recorded the highest values of these treats at 55 DAT and harvest. The lowest available ammonium and nitrate were found when ascobien was applied three times without nitrogen and compost application.

I.2. Available phosphorus and potassium (ppm):

Data in Table 5 showed that nitrogen fertilizer rate affected significantly available phosphorus and potassium (ppm) in soil at 55 DAT and harvest in the two seasons. Available phosphorus and potassium tended to increase as nitrogen levels increased. Plots which received the highest level of nitrogen 165 kg N ha^{-1} showed more available phosphorus and potassium than other plots. Under NH_4-N nutrition, interlayer K can be replaced by NH^+_4 ions which are similar in ionic size[16]. NH_4^+ could be fixed by clays in a manner similar to that of K^+, it is presence will be after both the fixation of added similar potassium and the release of fixed potassium[15,16].

Table 4: Available ammonium and nitrate in the soil (ppm) as affected by the interaction among nitrogen rate, compost rate and foliar application of ascobien in 2012 and 2013 seasons.

kg N ha^{-1}	t compost ha^{-1}	Ascobein spray	Available ammonium (ppm)				Available nitrate (ppm)			
			2012		2013		2012		2013	
			55 DAT	At harvest	55 DAT	At harvest	55 DAT	At harvest	55 DAT	At harvest
0	0	0	23.23 s	15.12 xy	22.24 r	16.68 m	5.1 t	2.8 r	4.11 qr	3.45 op
		2	22.82 st	14.98 xy	21.48 r	15.37 n	5.08 t	2.59 rs	3.97 r	3.16 pq
		3	22.21 t	14.46 y	20.14 s	15.04 n	4.37 u	2.22 t	3.79 r	2.88 q
	3.5	0	27.92 op	17.08 tu	31.1 lm	20.3 j	7.06 p	3.47 no	6.56 m	4.96 ij
		2	27.72 p	16.2 vw	30.44 mn	18.74 kl	6.14 rs	2.82 qr	5.01 op	4.71 jk
		3	27.7 p	15.6 wx	30.12 no	18.27 kl	5.91 s	2.8 r	4.55 pq	3.88 mn
	7	0	31.47 kl	18.94 qr	34.32 ghi	23.41 fg	8.2 klm	4.22 ij	8.67 j	5.7 h
		2	29.12 mn	16.8 uv	33.64 ij	22.76 gh	7.94 lmn	3.41 no	7.68 kl	5.09 ij
		3	29.28 mn	16.52 uv	33.16 jk	22.41 h	7.87 mn	3.14 p	6.13 mn	4.78 j
55	0	0	25.95 q	18.24 rs	27.44 p	19.07 k	7.42 op	3.27 op	6.6 m	4.4 kl
		2	25.42 qr	17.96 s	25.14 q	18.18 l	7.17 p	2.69 r	5.81 n	3.71 no
		3	25.06 r	17.64 st	24.42 q	17.2 m	6.35 qr	2.41 st	5.27 o	3.2 pq
	3.5	0	29.4 mn	20.6 p	33.72 ij	23.87 f	8.76 hi	3.61 mn	7.93 k	5.25 i
		2	28.62 no	19.36 q	32.8 k	23.07 fgh	7.89 mn	3.39 no	7.4 kl	4.86 j
		3	27.95 op	18.48 rs	31.7 l	21.42 i	6.63 q	3.23 op	7.32 l	4.83 j
	7	0	32.72 hi	25.64 hij	36.04 d	25.18 de	9.75 ef	5.43 c	9.85 i	6.63 e
		2	32.2 ijk	24.68 kl	35.2 def	25.07 de	8.65 hij	4.43 hi	8.96 j	6.15 g
		3	31.8 jkl	24.48 lm	31.92 l	23.08 fgh	8.49 ijk	3.83 lm	7.93 k	5.76 h
110	0	0	29.56 m	24.84 jkl	30.56 mn	23.44 fg	8.96 h	3.89 kl	9.08 j	5.71 h
		2	29.01 mn	23.64 n	30.15 no	22.92 gh	7.65 no	3.13 p	9.04 j	4.95 ij
		3	28.84 mn	22.4 o	29.4 o	20.75 ij	7.58 no	3.04 pq	8.66 j	4.07 lm
	3.5	0	33.82 g	25.32 h-l	35.78 de	26.77 c	9.46 fg	4.82 g	11.84 f	6.73 e
		2	32.38 ij	25.08 ijkl	35.46 def	25.54 de	8.3 jkl	4.13 j	10.58 h	6.25 fg
		3	31.08 l	23.84 mn	33.4 jk	24.72 e	7.14 p	3.71 lm	9.86 i	5.75 h
	7	0	36.23 e	27.64 cd	37.56 c	27.1 c	10.96 c	5.49 c	12.19 ef	7.84 c
		2	35.28 f	26.8 def	37.08 c	26.93 c	10.5 d	4.99 efg	11.71 f	7.29 d
		3	35.16 f	25.56 hij	34.78 fgh	25.58 de	9.33 g	4.08 jk	11.05 gh	6.52 ef
165	0	0	35.88 ef	26.52 efg	34.88 fg	25.74 d	10.59 cd	5.08 ef	12.5 e	6.86 e
		2	33.94 g	26.08 fgh	33.98 hij	24.94 de	9.75 ef	4.56 h	11.95 f	5.71 h
		3	33.44 gh	25.48 hijk	31.2 lm	23.58 fg	8.13 klm	4.22 ij	9.89 i	4.78 j
	3.5	0	38.56 d	28.2 bc	38.56 b	27.41 c	12.53 b	5.38 cd	13.91 bc	8.2 b
		2	36.6 e	27.32 de	36.04 d	27.22 c	10.62 cd	5.03 efg	13.08 d	7.5 cd
		3	35.36 f	25.88 ghi	35.16 ef	25.62 d	9.92 e	4.87 fg	11.21 g	6.85 e
	7	0	43.04 a	29.08 a	41.08 a	30.74 a	13.8 a	6.31 a	15.99 a	9.41 a
		2	41.96 b	28.62 ab	39.32 b	28.67 b	12.83 b	5.85 b	14.18 b	8.43 b
		3	40.98 c	26.96 de	38.82 b	27.28 c	12.68 b	5.17 de	13.61 c	7.52 cd

Means of each column designated by the same letter are not significantly different at 5% level using Duncan's multiple range test.

There were significant increases in available phosphorus and potassium in soil at 55 DAT and harvest with increasing compost level from zero to 7 t compost ha^{-1} in the two seasons (Table5). The lowest values of P&K-available were observed with control (without compost). This may be due to releasing of phosphorus and potassium from composted rice straw[16]**.** This could be attributed to that soil solution K^+ is higher in the compost straw treatments; another reason could be the higher increase in the soil solution Fe_3^+ and Mn_2^+ caused by rice straw compost which release K from exchange complexes[18]. The addition of compost to soil can affect soil fertility by modifying the physical, chemical and biological properties of the soil. The chemical changes include enhancement nutrients content of the soil[16].

Foliar application of ascobien caused a significant decrease in P&K-available compared with control at 55 DAT and harvest in the two seasons (Table 5). The highest values of P&K-available were obtained when ascobien was not applied. Moreover, the lowest values were recorded when ascobien was applied three times in the two seasons[7,8].

The interaction among nitrogen fertilizer rate, compost rate and ascobien foliar application had significant effects on available phosphorus and potassium (ppm) in the soil in the two seasons, except available phosphorus at 55 DAT in the second season only (Table 6). Application of nitrogen fertilizer and compost alone or together without ascobien foliar application resulted in significant increases in available phosphorus and potassium. Adding 7 t compost ha^{-1} and 165 kg N ha^{-1} without ascobien recorded significantly higher available phosphorus and potassium in soil than all other combinations. The lowest values of available phosphorus and potassium were found when ascobien was applied three times without nitrogen and compost.

Table 5: Available phosphorus and potassium (ppm) in the soil as affected by nitrogen rate, compost rate and foliar application of ascobien in 2012 and 2013 seasons.

Factor	Available phosphorus (ppm)				Available potassium (ppm)			
	2012		2013		2012		2013	
	55 DAT	At harvest	55 DAT	At harvest	55 DAT	At harvest	55 DAT	At harvest
kg N ha^{-1} (N)								
0	23.04 c	16.48 c	26.29 c	17.02 c	384 d	394 d	384 c	408 d
55	24.4 b	17.28 b	27.11 b	17.4 b	403 c	409 c	403 b	416 c
110	25.39 b	17.85 ab	27.72 b	18.22 a	423 b	424 b	418 b	426 b
165	26.46 a	18.31 a	30.28 a	18.77 a	446 a	441 a	435 a	444 a
F-test	*	**	*	**	**	**	**	**
t compost ha^{-1} (C)								
0	22.83 c	15.45 c	25.78 c	17.02 c	358 c	339 c	356 c	345 c
3.5	24.49 b	17.94 b	27.84 b	17.67 b	414 b	426 b	403 b	445 b
7	27.15 a	19.05 a	29.92 a	18.87 a	471 a	485 a	472 a	480 a
F-test	*	**	*	**	**	**	**	**
Ascobein spray No. (A)								
0	25.92 a	18.12 a	28.56 a	18.35 a	433 a	436 a	429 a	438 a
2	24.76 b	17.55 b	27.84 b	17.83 b	412 b	417 b	410 b	421 b
3	23.79 c	16.76 c	27.15 c	17.38 c	398 c	397 c	392 c	411 c
F-test	*	**	*	**	**	**	**	**
Interaction								
NxC	**	**	**	NS	NS	NS	NS	NS
NxA	**	**	NS	**	**	*	NS	**
CxA	**	**	NS	**	**	**	NS	**
NxCxA	**	**	NS	**	**	**	**	**

***, ** and NS indicate $p < 0.05$, $p < 0.01$ and not significant, respectively. Means of each factor designated by the same letter are not significantly different at 5% level using Duncan's multiple range test.**

I.3. Soil organic matter percentage:

Organic matter content at 55 DAT and harvest were found to be significantly affected by the compost rate only in the two seasons (Table 7). Increasing compost rate up to 7 t ha^{-1} increased organic matter percentage. The lowest organic matter was found when no compost was applied. The application of compost enhances the organic matter of the soil[16].

Figure 1 and Table 1 showed that the percentage of organic matter in soil decreased with no compost fertilizer application compared to the value of organic matter before rice transplanting, but application of 3.5 and 7 t compost increased the percentage of organic matter at 55 DAT and harvest. Figures illustrated that OM % was gradually decreased from soil preparation until harvest when compost of rice straw was not applied. However, application of compost increased OM % in soil with increasing age of rice plant from transplanting to harvest. The increase in OM content in soil was higher at application of 7 t compost than 3.5 t. Under the two compost rates, OM % were greater at harvest than at 55 DAT as well as before transplanting. The reduction of organic matter with control may be due to the decomposition of organic matter of the soil[16,19,20].

II. NPK uptake by rice grain and straw:

Nitrogen, phosphorus and potassium uptake (kg ha^{-1}) by rice plant at harvest as affected by nitrogen fertilizer rate, compost rate and ascobien foliar application is presented in Tables 8 and 9. Data showed that NPK uptake in grain was higher than in straw. This mainly may be due to the translocation of nutrients (NPK) from straw to grains. The absorbed nitrogen at the vegetative stage is transported to the panicles at advanced developmental stages[3,21]. Therefore, the total amount of nitrogen in the straw decreased, while the panicles N contents increased with progressive development. Consequently, the nitrogen uptake by grain was higher than by the straw[3,21].

Table 6: Available phosphorus and potassium (ppm) in the soil as affected by the interaction among nitrogen rate, compost rate and foliar application of ascobien in 2012 and 2013 seasons.

kg N ha^{-1}	t compost ha^{-1}	Ascobein spray	Available phosphorus (ppm)			Available potassium (ppm)			
			2012		2013		2012	2013	
			55 DAT	At harvest	At harvest	55 DAT	At harvest	55 DAT	At harvest
0	0	0	21.08 s	15.05 pqr	16.44 qr	347 s	335 tu	342 r	335 p
		2	20.58 s	14.93 qr	16.25 rs	328 u	322 v	323 t	317 r
		3	19.77 t	14.74 r	16.13 s	316 v	310 w	313 u	364 n
	3.5	0	23.44 no	17.12 kl	17.19 mn	402 mn	423 m	402 kl	439 jk
		2	23.25 nop	16.49 mn	16.63 pq	384 op	398 o	378 o	421 l
		3	22.35 qr	16.11 no	16.32 rs	367 q	385 p	361 pq	419 l
	7	0	26.07 fgh	18.24 hi	18.44 fg	469 f	484 ef	464 ef	471 de
		2	25.57 ghij	17.92 ij	18.04 hij	433 j	461 h	447 g	461 f
		3	25.32 ij	17.67 j	17.75 jk	406 lm	424 m	430 i	444 ij
55	0	0	23.73 mn	15.35 p	16.88 op	356 r	347 s	366 p	349 o
		2	22.39 qr	15.11 pqr	16.49 qr	342 st	329 u	356 q	334 pq
		3	21.77 r	14.8 qr	16.22 rs	340 t	318 v	334 s	329 q
	3.5	0	24.94 jk	18.74 efg	17.88 ij	415 k	434 kl	413 j	454 g
		2	24.59 k	17.99 ij	17.01 no	409 l	425 m	393 mn	436 k
		3	22.8 opq	16.8 lm	16.77 op	397 n	409 n	376 o	424 l
	7	0	28 bc	19.49 c	19.13 c	491 d	496 d	486 c	489 c
		2	25.88 fghi	18.86 ef	18.44 fg	453 h	482 f	468 e	476 d
		3	25.53 ghij	18.42 gh	17.84 ij	429 j	439 jk	441 h	449 ghi
110	0	0	24.49 kl	16.1 no	17.82 ij	384 op	361 r	389 n	358 n
		2	22.7 pq	15.8 o	17.51 kl	361 qr	343 s	365 p	343 o
		3	22.17 qr	15.19 pq	16.94 no	356 r	331 u	341 r	329 q
	3.5	0	26.44 ef	19.14 cde	18.76 de	430 j	441 j	426 i	464 f
		2	25.43 hij	18.99 def	18.23 gh	417 k	429 lm	409 j	451 gh
		3	23.38 no	17.24 k	17.75 jk	408 lm	414 n	399 lm	439 jk
	7	0	29.38 b	20.18 b	19.62 b	516 b	529 b	497 b	504 b
		2	27.69 bc	19.3 cd	19.14 c	483 e	494 d	480 cd	484 c
		3	26.82 de	18.68 fg	18.23 gh	456 gh	471 g	460 f	464 f
165	0	0	26.16 fg	16.65 m	18.26 gh	397 n	371 q	398 lm	379 m
		2	25.28 ij	16.24 n	17.89 ij	389 o	355 r	380 o	359 n
		3	23.89 lmn	15.43 p	17.44 lm	381 p	341 st	362 p	345 o
	3.5	0	27.44 cd	19.86 b	18.94 cd	460 g	474 g	448 g	484 c
		2	25.6 ghij	18.99 def	18.56 ef	442 i	449 i	426 i	466 ef
		3	24.31 klm	17.8 j	18.07 hi	433 j	435 jkl	407 jk	445 hij
	7	0	29.87 a	21.55 a	20.88 a	527 a	538 a	517 a	526 a
		2	28.19 b	19.99 b	19.75 b	505 c	514 c	494 b	504 b
		3	27.44 cd	18.24 hi	19.17 c	483 e	490 de	479 d	486 c

Means of each column designated by the same letter are not significantly different at 5% level using Duncan's multiple range test.

Data showed also that nitrogen, phosphorus and potassium uptake by grain and straw significantly increased with the increase in the rate of nitrogen up to 165 kg N ha^{-1}. This may be due to the role of nitrogen in improving nutrients absorption[14]. There is evidence that nitrogen promotes phosphorus uptake by plant increasing top and root growth, altering plant metabolism, increasing solubility and availability of phosphorus[3,18,22].

Data in Tables 8 and 9 showed that application of compost fertilizer resulted in significant increase in nitrogen, phosphorus and potassium uptake by grain and straw compared with control (without compost) in both seasons. The significant increase in nitrogen, phosphorus and potassium uptake by grain and straw was accompanied with each increment of compost in the two seasons. This may be due to the increase in N, P and K availability resulting from the compost decomposition during the season beside the increase of the dry matter. Also, the compost accelerated the development of active rice roots that carry out nutrient absorption[19,20,21,23,24].

Table 7: Soil organic matter (%) as affected by nitrogen rate, compost rate and foliar application of ascobien in 2012 and 2013 seasons.

Factor	2012 season		213 season	
	55 DAT	At harvest	55 DAT	At harvest
kg N ha^{-1} (N)				
0	1.48	1.50	1.54	1.51
55	1.50	1.52	1.55	1.53
110	1.51	1.53	1.56	1.54
165	1.52	1.55	1.57	1.56
F-test	NS	NS	NS	NS
t compost ha^{-1}(C)				
0	1.43 c	1.41 c	1.46 c	1.40 c
3.5	1.51 b	1.55 b	1.56 b	1.57 b
7	1.57 a	1.63 a	1.64 a	1.65 a
F-test	**	**	**	**
Ascobein spray No. (A)				
0	1.51	1.54	1.56	1.55
2	1.50	1.53	1.55	1.54
3	1.49	1.52	1.54	1.53
F-test	NS	NS	NS	NS
Interaction				
NxC	NS	NS	NS	NS
NxA	NS	NS	NS	NS
CxA	NS	NS	NS	NS
NxCxA	NS	NS	NS	NS

***, ** and NS indicate p< 0.05, p<0.01 and not significant, respectively. Means of each factor designated by the same letter are not significantly different at 5% level using Duncan's multiple range test.**

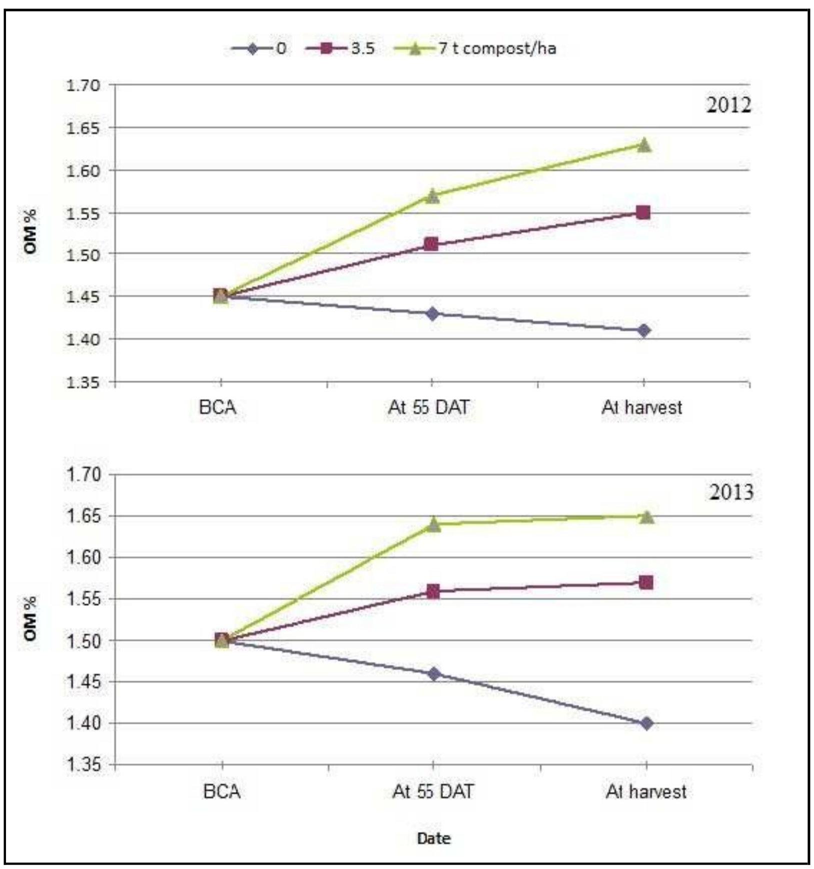

Figure 1: Soil organic matter percentage (OM%) before soil preparation or before compost application (BCA), at 55 DAT and at harvest as affected by compost rate.

Table 8: NPK uptake in grain of rice cv. Sakha 106 as affected by nitrogen rate, compost rate and foliar application of ascobien in 2012 and 2013 seasons.

Factor	N uptake (kg N ha^{-1})		P uptake (kg P ha^{-1})		K uptake (kg K ha^{-1})	
	2012	2013	2012	2013	2012	2013
kg N ha^{-1} (N)						
0	76.82 d	84.38 c	14.64 c	15.9 c	27.13 d	25.78 c
55	89.18 c	99.43 b	17.64 b	19.05 b	31.26 c	30.8 b
110	110.36 b	112.16 a	22.14 a	21.94 a	37.92 b	35.19 a
165	113.73 a	112.77 a	22.96 a	22.56 a	41.1 a	35.75 a
F-test	**	*	**	*	**	*
t compost ha^{-1}(C)						
0	82.02 c	88.8 c	17.05 c	16.47 c	30.49 c	25.38 c
3.5	100.85 b	106.18 b	19.63 b	20.35 b	34.26 b	32.39 b
7	109.70 a	111.57 a	21.35 a	22.76 a	38.31 a	37.87 a
F-test	**	*	**	*	**	*
Ascobein spray No. (A)						
0	88.19 c	93.67 c	17.37 c	17.79 c	31.36 c	28.18 c
2	100.44 b	104.99 b	19.90 b	20.35 b	35.09 b	32.81 b
3	103.94 a	107.90 a	20.77 a	21.45 a	36.60 a	34.65 a
F-test	**	*	**	*	**	**
Interaction						
NxC	**	**	**	**	*	**
NxA	*	**	**	**	**	**
CxA	**	**	**	**	**	**
NxCxA	**	**	**	**	**	**

***, ** and NS indicate p< 0.05, p<0.01 and not significant, respectively. Means of each factor designated by the same letter are not significantly different at 5% level using Duncan's multiple range test.**

Table 9: NPK uptake in straw of rice cv. Sakha 106 as affected by nitrogen rate, compost rate and foliar application of ascobien in 2012 and 2013 seasons.

Factor	N uptake (kg N ha^{-1})		P uptake (kg P ha^{-1})		K uptake (kg K ha^{-1})	
	2012	2013	2012	2013	2012	2013
kg N ha^{-1} (N)						
0	43.86 d	36.92 d	11.40 d	10.52 d	145.81 d	123.91 d
55	55.64 c	47.80 c	14.56 c	13.34 c	178.80 c	153.82 c
110	70.66 b	57.92 b	18.68 b	16.42 b	228.95 b	181.35 b
165	77.89 a	63.79 a	20.85 a	18.17 a	243.07 a	195.66 a
F-test	**	**	**	**	**	*
t compost ha^{-1}(C)						
0	48.78 c	39.75 c	13.59 c	11.07 c	163.98 c	129.59 c
3.5	62.85 b	51.46 b	16.57 b	14.94 b	200.13 b	167.51 b
7	74.41 a	63.62 a	18.95 a	17.83 a	233.36 a	193.94 a
F-test	**	**	**	**	*	*
Ascobein spray No. (A)						
0	53.67 c	45.31 c	14.1 c	12.54 c	174.45 c	144.83 c
2	64.08 b	53.14 b	16.97 b	15.09 b	205.43 b	169.02 b
3	68.29 a	56.37 a	18.04 a	16.21 a	217.59 a	177.2 a
F-test	**	**	**	**	**	**
Interaction						
NxC	*	**	**	**	**	**
NxA	**	**	**	**	*	**
CxA	**	*	**	**	**	**
NxCxA	**	**	**	*	**	**

***, ** and NS indicate p< 0.05, p<0.01 and not significant, respectively. Means of each factor designated by the same letter are not significantly different at 5% level using Duncan's multiple range test.**

Foliar spraying with solution of ascobein substantially increased nitrogen, phosphorus and potassium uptake by grain and straw compared with unsprayed treatment in both seasons. Increasing number of foliar sprays with ascobein from 0 to 3 times gradually increased nitrogen, phosphorus and potassium uptake by grain and straw**.** This may be due to the considerable increase in grain and straw yield by foliar application of ascobien[6,7,8].

Nitrogen , phosphorus and potassium uptake by grain and straw was affected significantly by the second order interaction (Tables 10 and 11). Data in Table 30 showed that application of nitrogen and compost without or with ascobien foliar application resulted in significant increase in nitrogen uptake by grains and straw compared with control treatment (untreated) in the two seasons. The relative ranking of the interaction among nitrogen, compost and ascobien compound for N, P and K uptake by grain was inconsistent in both seasons.

Table 10: NPK uptake in grain of rice cv. Sakha 106 as affected by the interaction among nitrogen rate, compost rate and foliar application of ascobien in 2012 and 2013 seasons.

Kg N ha^{-1}	t compost ha^{-1}	Ascobein spray No.	N uptake (kg N ha^{-1})		P uptake (kg P ha^{-1})		K uptake (kg K ha^{-1})	
			2012	2013	2012	2013	2012	2013
0	0	0	49.54 s	55.78 r	10.19 m	9.610 q	19.43 m	14.67 p
		2	55.80 rs	71.41 q	11.35 lm	12.80 p	21.77 l	19.92 o
		3	60.19 r	74.87 pq	12.29 klm	14.01 op	23.36 kl	21.32 no
	3.5	0	79.12 opq	78.84 opq	14.31 jkl	14.46 op	25.39 k	22.96 n
		2	86.20 m-p	91.49 lm	15.66 ijk	16.84 mn	28.20 j	27.03 m
		3	89.80 l-o	96.17 jkl	17.17 g-j	18.11 klm	30.77 hi	29.15 l
	7	0	83.96 n-q	84.61 mno	15.64 ijk	16.15 mno	28.99 ij	27.25 m
		2	93.11 k-n	101.6 ijk	17.38 f-j	19.87 ijk	32.78 gh	33.59 h
		3	93.67 k-n	104.7 g-j	17.75 f-j	21.21 f-j	33.50 g	36.14 g
55	0	0	59.34 rs	72.75 pq	13.64 j-m	12.87 p	24.07 kl	19.60 o
		2	64.42 r	80.92 nop	14.33 jkl	14.63 op	25.27 k	23.08 n
		3	74.20 q	89.76 lmn	15.85 ijk	17.04 m	27.85 j	26.21 m
	3.5	0	85.07 m-p	92.72 klm	15.97 ijk	17.18 lm	27.93 j	27.22 m
		2	88.39 l-p	105.7 g-j	16.81 hij	19.65 jk	29.50 ij	31.53 ij
		3	97.87 ijkl	110.8 c-i	18.75 e-i	20.90 g-j	33.34 gh	33.80 h
	7	0	89.98 l-o	100.8 ijk	16.99 hij	19.32 jk	31.54 ghi	32.51 hi
		2	122.8 bcd	120.5 a-d	23.31 a-d	24.52 a-d	40.81 a-e	40.92 bc
		3	120.5 b-e	120.8 abc	23.13 a-d	25.36 abc	41.02 a-e	42.30 ab
110	0	0	77.78 pq	82.15 nop	16.64 hij	14.80 nop	29.53 ij	22.30 n
		2	101.8 h-k	103.1 hij	21.18 d-g	19.23 jkl	37.35 f	29.89 jkl
		3	106.0 ghi	106.5 ghi	21.95 b-e	20.40 hij	38.41 ef	31.40 ijk
	3.5	0	95.22 j-m	108.8 f-i	18.61 e-i	21.00 g-j	32.16 gh	32.47 hi
		2	113.7 d-g	117.6 a-f	22.33 b-e	22.48 d-h	38.97 def	36.13 g
		3	119.3 cde	122.1 ab	23.74 a-d	23.76 b-e	40.54 b-e	38.68 de
	7	0	114.2 d-g	118.3 a-f	22.22 b-e	23.34 c-f	40.75 b-e	38.37 def
		2	130.7 ab	126.1 a	25.72 ab	25.86 ab	41.48 a-d	43.47 a
		3	134.5 a	124.9 a	26.89 a	26.62 a	42.06 abc	44.02 a
165	0	0	105.0 g-j	105.4 g-j	20.45 d-h	19.41 jk	36.95 f	29.57 kl
		2	114.1 d-g	110.1 e-i	23.17 a-d	20.81 g-j	40.15 cde	32.43 hi
		3	115.9 c-g	113.0 b-h	23.60 a-d	22.05 e-i	41.74 abc	34.14 h
	3.5	0	111.8 d-h	113.3 b-g	22.49 b-e	22.42 d-h	38.75 ef	34.21 h
		2	118.3 c-f	117.6 a-f	24.17 a-d	23.46 cde	42.37 abc	36.58 fg
		3	125.4 abc	119.1 a-e	25.57 abc	24.01 b-e	43.15 ab	38.96 d
	7	0	107.3 f-i	110.6 d-i	21.33 c-f	22.92 d-g	40.87 a-e	37.01 efg
		2	115.9 c-g	113.7 b-g	23.35 a-d	24.06 b-e	42.43 abc	39.16 cd
		3	109.8 e-h	112.2 b-h	22.49 b-e	23.94 b-e	43.50 a	39.67 cd

Means of each column designated by the same letter are not significantly different at 5% level using Duncan's multiple range test.

Combinations of (110 kg N ha^{-1} + 7 t compost ha^{-1} + two or three sprays of ascobein) or (165 kg N ha^{-1} + 3.5 t compost ha^{-1} + three times sprays of ascobein) produced high N, P and K uptake by grain compared with application of the recommended N rate alone (165 kg N ha^{-1}) in the two seasons. On the other hand, the relative ranking of the interaction among nitrogen, compost and ascobien compound for N, P and K uptake by straw was inconsistent in both seasons. Combinations of (165 kg N ha^{-1} + 7 t compost ha^{-1} + spraying of ascobien two or three times) or (110kg N ha^{-1} + 7 t compost ha^{-1} + three time sprays of ascobien) produced higher NPK uptake by straw than application of the recommended N rate alone in the two seasons. This may be due to the fact that nutrient uptake is influenced by nutrient available in the soil as well as biomass production[6,7,8,16].

Table 11: NPK uptake in straw of rice cv. Sakha 106 as affected by the interaction among nitrogen rate, compost rate and foliar application of ascobien in 2012 and 2013 seasons.

Kg N ha^{-1}	t compost ha^{-1}	Ascobein spray no.	uptake (kg N ha^{-1})		uptake (kg P ha^{-1})		K uptake (kg K ha^{-1})	
			2012	2013	2012	2013	2012	2013
0	0	0	27.90 p	19.81 r	7.580 n	5.163 v	102.1 s	69.72 s
		2	31.41 o	26.87 q	8.493 mn	7.330 u	111.7 rs	95.16 r
		3	33.60 no	30.95 opq	9.153 m	8.313 tu	118.6 qrs	102.1 qr
	3.5	0	41.29 lm	31.67 opq	10.61 kl	8.830 st	138.3 opq	108.1 pq
		2	46.19 jk	39.26 lmn	11.58 jk	11.41 r	151.0 nop	132.6 n
		3	50.35 hi	42.47 kl	12.68 ij	12.42 q	163.2 mn	144.0 m
	7	0	46.51 jk	38.93 lmn	11.56 jk	11.15 r	153.0 nop	128.7 n
		2	57.46 fg	49.13 j	14.98 gh	14.38 m-p	184.1 jkl	162.8 jk
		3	60.04 fg	53.20 hij	15.92 fg	15.65 kl	190.4 jk	172.1 hi
55	0	0	35.32 n	28.82 pq	9.267 lm	7.540 u	122.8 qrs	97.11 r
		2	38.55 m	33.85 nop	10.63 kl	9.277 st	132.4 pqr	112.4 op
		3	44.14 kl	39.59 lmn	12.32 j	11.05 r	148.9 nop	130.6 n
	3.5	0	47.82 ij	40.63 lm	12.33 j	11.41 r	155.6 no	135.4 n
		2	52.46 h	48.16 jk	13.87 hi	14.02 nop	168.2 lmn	159.8 jkl
		3	60.75 f	52.78 ij	16.20 fg	15.34 klm	192.6 jk	175.7 ghi
	7	0	56.68 g	52.38 ij	13.82 hi	14.32 m-p	177.5 klm	162.5 jk
		2	81.73 b	66.02 de	20.94 abc	18.06 gh	254.0 def	203.0 d
		3	83.31 b	67.99 de	21.68 ab	19.03 d-g	257.2 c-f	207.8 cd
110	0	0	44.70 jk	35.79 mno	12.27 j	9.630 s	150.9 nop	117.9 o
		2	60.41 f	46.98 jk	16.79 f	13.39 p	201.2 ij	152.2 l
		3	65.36 e	50.15 j	18.45 e	14.59 mno	214.8 hi	160.5 jkl
	3.5	0	59.08 fg	52.38 ij	15.38 fg	14.67 lmn	189.3 jk	168.2 ij
		2	73.70 cd	59.80 fg	20.03 cd	17.36 hi	235.0 fgh	193.6 e
		3	80.25 b	63.58 ef	21.71 ab	19.19 def	247.4 d-g	205.5 d
	7	0	76.41 c	66.58 de	19.26 de	18.26 fgh	238.8 efg	202.5 d
		2	86.75 a	71.67 bcd	21.81 ab	20.01 cd	282.3 ab	214.1 bc
		3	89.28 a	74.38 abc	22.37 a	20.71 bc	300.9 a	217.6 ab
165	0	0	58.68 fg	48.74 j	16.77 f	13.57 op	195.8 ijk	156.8 kl
		2	71.35 d	56.66 ghi	20.15 cd	16.02 jk	231.3 gh	178.1 fgh
		3	73.92 cd	58.80 fgh	21.19 abc	16.93 ij	237.4 fg	182.5 fg
	3.5	0	72.77 d	58.88 fgh	19.95 cd	16.67 ij	230.6 gh	184.7 f
		2	81.13 b	63.04 ef	22.13 a	18.61 efg	254.1 def	200.5 de
		3	88.47 a	64.83 ef	22.35 a	19.34 de	276.2 bc	202.0 d
	7	0	76.90 c	69.11 cde	20.38 bcd	19.25 def	238.8 efg	206.3 cd
		2	87.87 a	76.31 ab	22.27 a	21.16 ab	259.9 cde	224.0 a
		3	89.96 a	77.74 a	22.44 a	21.98 a	263.5 bcd	225.9 a

Means of each column designated by the same letter are not significantly different at 5% level using Duncan's multiple range test.

III- Grain and straw yield (t ha^{-1}):

Straw and grain yields of sakha106 rice cultivar as affected by the application of nitrogen, compost and ascobien in 2012 and 2013 rice growing seasons are presented in Table12. Data indicated that increasing nitrogen level up to 165 kg N ha^{-1} significantly increased straw yield. While, there was no significant difference between 110 and 165 kg N ha^{-1} on straw yield. This mainly due to the fact that nitrogen application increased leaf area index, dry matter and number of tillers per unit area[3,6]. Data indicated also that there were significant differences in grain yield due to different treatments. Significant grain yield increases were observed from the application of nitrogen levels. Increasing nitrogen levels from 0 up to 165 kg N ha^{-1} increased grain yield in the two seasons. There was no significant difference between 110 and 165 kg N ha^{-1}. Grain yield, in fact, is the out-product of its main components. Any increase in one or more of such components without decrease in the others will lead to an increase in grain yield. Therefore, the increase in grain yield due to applying nitrogen was the logical resultant due to the achieving increased in its components, i.e. the number of panicles per m^2, filled grains percentage and the number of grain per panicle[1,3,6].

Straw and grain yield were significantly affected by compost application. Increasing compost level up to 7 t ha^{-1} significantly increased grain and straw yield. While, there was no significant difference between 3.5 and 7 t ha^{-1} on grain yield. The increase in grain yield was due to the increase in most of yield components. The increase in the straw yield mainly due to the fact that compost application increased the accumulation of more assimilates and vigorous growth of rice plant[1,16].

Data showed also that significant increase in straw and grain yields as ascobien was applied in the first and second seasons. The differences in straw and grain yield between two and three times foliar application were not significant. This may be due to the considerable increase in early growth which reflected in higher grain yield attributes (number of panicles $hill^{-1}$, panicle weight, number of filled grains $panicle^{-1}$ and 1000- grains weight) and in turn increased grain yield[6,7].

Table12: Straw yield and grain yield of rice cv. Sakha 106 as affected by nitrogen rate, compost rate and foliar application of ascobien in 2012 and 2013 seasons.

Factor	Straw yield (t ha^{-1})		Grain yield (t ha^{-1})	
	2012	2013	2012	2013
kg N ha^{-1}(N)				
0	9.175c	8.600c	7.071c	7.306c
55	10.751b	10.584b	8.122b	8.543b
110	13.126a	12.426a	9.806a	9.575a
165	13.913a	13.348a	9.847a	9.594a
F-test	**	**	**	**
t compost ha^{-1}(C)				
0	10.177c	9.397c	8.054b	7.901b
3.5	11.753b	11.473b	8.839a	9.027a
7	13.294a	12.850a	9.242a	9.336a
F-test	**	**	**	*
Ascobien spray (A)				
0	10.519b	10.037b	7.972b	8.059b
2times	12.033a	11.598a	8.960a	9.001a
3times	12.672a	12.085a	9.202a	9.204a
F-test	**	**	**	**

***, ** and NS indicate $p< 0.05$, $p<0.01$ and not significant, respectively. Means of each factor designated by the same letter are not significantly different at 5% level using Duncan's multiple range test.**

Conclusion

The availability of ammonium, nitrate and phosphorus (ppm) in the soil decreased with progressive plant age from 55 DAT to harvest. However, the inverse was true in the availability of potassium. The availability of all the mentioned nutrients in the soil at 55 DAT and harvest were significantly increased by increasing nitrogen and compost rate. Foliar application of ascobien resulted in significant decrease in the availability of ammonium, nitrate, phosphorus and potassium (ppm) in the soil compared with control treatment. Organic matter percentage in soil at 55 DAT and harvest was significantly increased by application of compost. Nitrogen, compost and ascobien application resulted in significant increase in nitrogen, phosphorus and potassium uptake (kg ha^{-1}) in grain and straw. Combinations of 110 kg N ha^{-1}, 7 t compost ha^{-1} and three sprays with ascobien produced the highest values of nitrogen, phosphorus and potassium uptake (kg ha^{-1}) in grain. It can be concluded that application of compost and ascobein improved yield, soil properties and nutrients availability.

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