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AVAILABILITY AND UPTAKE OF NITROGEN AND POTASSIUM AS AFFECTED BY INORGANIC FERTILIZERS IN FLOODED RICE SOILS

El-Hamdi, Kh. H.*; S. A. Ghanem and I. M. Hashem****

*** Soils Dept., Fac. Agric., Mansoura Univ., Egypt.**

**** Rice Research and Training Center, Sakha, Kafr El-Sheikh**

ABSTRACT

Effect of nitrogen (N) and potassium (K) fertilizers application on the uptake and availability of nitrogen and potassium was studied at the Farm of Rice Research and Training Center *at Sakha Kafr El-sheikh* during 2007 and 2008 seasons. The highest values of available NH_4-N in the soil were recorded at 30 DAT under 92 kg N fed^{-1} with application full dose of potassium before transplanting (50 Kg potassium sulphate .fed^{-1}). Data showed also that highest values of available soil K were obtained at 30 DAT when rice plants were fertilized with 92 kg N fed^{-1} *combined* with application of full dose of potassium before transplanting in 2007 and 2008 seasons, respectively. The highest values of nitrogen and potassium uptake were recorded at 30 days after transplanting (DAT) when rice plants were fertilized with 92kg N fed^{-1}combined with application of potassium full dose (50kg potassium sulphate fed^{-1}) before flooding at both seasons of study. Data showed also that maximum nitrogen uptake values were found when 92kg N fed^{-1} was combined with application of potassium (half dose before transplanting + spray with 2% K_2O (4kg potassium sulphate) at panicle initiation stage + spray with 2% *K2O (4kg potassium sulphate)* at flowering stages). The N uptake *increased significantly* at 50, 70 and 95 days after transplanting (DAT) in both seasons of study. Data showed also that application of nitrogen at the rate of 92 kg N fed^{-1} in combined with application half dose of recommended amount potassium before transplanting + spray with 2% K_2O at panicle initiation and flowering stages gave the highest grain yield in 2007 and 2008 seasons, respectively.

Keywords: Availability, uptake, nitrogen, potassium and rice flooded soil.

INTRODUCTION

The crop is generally fertilized by farmers either with nitrogen or with nitrogen and phosphorus only, through potassium is equally important as it stabilizes yield and it's a quality nutrient. Nitrogen is considered the limiting factor for rice growth. Secondary minerals may affect the availability of K irreversibly fixed in the interlayer and wedge sites of soil clay and is rendered unavailable to growing plants (Arshad and Akram, 1999). During weathering, physical disintegration of mica into clay size fractions resulted in replacement and release of interlayer K by more hydrated cations (Ca^{2+}, Mg^{2+}, or Na^{+}). Evidence of particle size reduction has been found in alluvial soils of Gujranwala, Lyallpur, and Burhan series (Akhtar, 1989).

The amount of *fixed* K in soil increases with added K, whereas the present K fixed relative to total added K decreases *(Bouabid et al., 1991)*. Fixation of K fertilizers may affects its recovery by crops. Application of potassium along with nitrogen has become very necessary due to intensified agriculture with high yielding varieties. Introduction of hybrid rice is an important step towards augmentation of rice yield. Hybrid rice is highly fertilizer responsive, but there is a shortage in hybrid rice nutrition. So, adequate fertilization and combination at real time in a proper manner is essential to achieve potentially yield of hybrid rice.

The present work was designed to evaluate the combined effects of different levels of N and different methods of K application on:

1- Availability of ammonium and potassium in flooded rice soils.
2- Uptake of nitrogen and potassium in rice.
3- Grain yield of hybrid rice

MATERIALS AND METHODS

A field experiment was carried out on the transplanted rice system at the Experimental Farm of the Rice Research and Training Center (RRTC), Sakha, Kafr El-Sheikh, Egypt, during the two growing summer seasons of 2007 and 2008 to investigate the effect of nitrogen levels and different methods of potassium application on the nutrient uptake, availability of some nutrients and grain yield of hybrid rice.

Soil Analyses:

Soil sample was taken before cultivation crushed then grinned to pass through 2mm sieve, some physical and chemical analysis were determined according to Cottenie *et al*, (1982) and Page *et al*, (1982). The results are presented in Table 1.

Experimental Design:

Experimental design was laid out in a split plot design with four replications. The main plots were devoted to the three nitrogen levels in urea form;

1) Zero nitrogen (N_1).
2) 69 kg N fed^{-1} (N_2).
3) 92 kg N fed^{-1} (N_3).

Where the sub plots occupied by the eight methods of potassium application at the rate of 24 kg K_2O (fed^{-1}) in potassium sulphate form (50 kg fed^{-1}),

1) Zero potassium (K_1).
2) All amount was applied as basal (B) incorporated into the soil surface (K_2).
3) Half dose of potassium fertilizer was applied as basal and incorporated into the soil surface + spray with 2% K_2O (4kg potassium sulphate) was applied at panicle initiation (P I (K_3).
4) Half dose of potassium fertilizer was applied as basal and incorporated into the soil surface + spray with 2% K_2O (4kg potassium sulphate) was applied at flowering (F) (K_4).
5) Half dose of potassium fertilizer was applied as basal and incorporated into the soil surface + spray with 2% K_2O was applied at panicle initiation (PI) and flowering (F) (K_5).
6) Spray with 2% K2O (4kg potassium sulphate) was applied at panicle initiation (PI) (K_6).
7) Spray with 2% K2O (4kg potassium sulphate) was applied at flowering (F) (K_7).
8) Spray with 2% K2O (4kg potassium sulphate) was applied at panicle initiation (PI) and flowering (F) (K_8).

Table 1: Some physical and chemical analysis of soil used

Soil properties	2007	2008
- Clay%	55.9	56.0
- Silt%	31.5	32.0
- Sand%	12.6	12.0
- Texture	Clayey	Clayey
- Total nitrogen, mg kg^{-1}	520	600
- Available P, mg kg^{-1} (0.5 M $NaHCO_3$)	13.0	16.0
- Available ammonium (mg kg^{-1})	17.2	18.8
- Nitrate concentration (mg kg^{-1})	13.0	14.1
- Available Potassium (mg kg^{-1})	310	325
- pH (1:2.5 soil suspension)	8.1	8.2
- EC $dS.m^{-1}$ (soil paste)	2.1	2.3
- **Soluble cations, meq.L^{-1}(soil paste):**		
- Ca^{++}	5.2	5.4
- Mg^{++}	2.0	2.1
- K^{+}	0.5	0.4
- Na^{+}	12.1	12.3
- **Soluble anions, meq.l^{-1}:**		
- $CO^{=}_3$	0.00	0.00
- HCO^{-}_3	3.6	3.9
- Cl^{-}	14.9	15.1
- $SO^{=}_4$	1.30	1.2
- **Available micronutrients mg kg^{-1}**		
- Fe^{++}	6.0	6.2
- Zn^{++}	0.9	1.1
- Mn^{++}	3.5	3.6

Plant samples:

During the growth stage, plant samples were taken at 30, 50, 70 and 95 days after transplanting (DAT). All plant samples were placed in paper bags and oven dry at 70^0C for 48 hours. Dried samples were ground to powder and digested according to the method of Chapman and Pratt (1961), prior to chemical analysis as follows.

Plant analysis:

- Nitrogen content was determined using Orange-G dye colorimetric method according to Hafez and Mikkelson (1981).
- Potassium was determined by the flame photometer as described by Jackson (1967).

- Soil sampling:

Soil samples were collected from each treatment (0 – 20 Cm depth) four times at 30, 50, 70 and 95 days after transplanting (DAT). The soil samples were homogenized and frozen directly after collection to prevent microbial activity. After thawing samples were immediately extracted to determine the nutrient elements. Available ammonium and potassium in the soil sample were determined according to Cottenie *et al.*, (1982).

RESULTS AND DISCUSSION

1- Effect of nitrogen and potassium fertilization on nutrients availability:

1.1- Ammonium availability:

Available NH_4-N at different periods throughout rice growing seasons as affected by nitrogen levels and methods of potassium application are presented in Tables 2 and 3.

Data show that available NH^+_4 sharply increased after flooding reached its high peak at 30 DAT in 2007 and 2008 seasons, and then declined to the minimum by 95 DAT. De Datta (1981) stated that the greater part of N mineralized during rice season appears as ammonium with in two weeks after submergence. It is worthy to mention that the other doses of N fertilizer at mid tillering, panicle initiation and flowering stages did not increase the mean values of NH_4. This could be attributed to the rapid absorption of this ion by rice roots for tillers production and initiation of panicles. These results in agreement with those reported by Young *et al.* (2005).

Table 2: NH_4 availability in soil (mg kg^{-1}) as affected by nitrogen levels and potassium application during 2007 seasons.

N Treatments	K- Treatments								
	30 DAT								
	K1	K2	K3	K4	K5	K6	K7	K8	Mean
N1	8.51	40.10	34.85	35.75	35.82	27.70	26.90	28.95	32.32
N2	41.90	51.65	45.85	46.20	46.05	40.57	40.45	40.15	44.09
N3	60.65	67.70	63.50	63.20	63.00	60.00	61.05	61.20	62.50
Mean	43.68	53.15	48.06	48.38	48.29	42.75	42.76	43.43	46.30
	50 DAT								
N1	20.45	30.45	25.40	26.09	25.15	20.00	21.10	20.49	23.64
N2	33.60	40.00	35.90	36.23	35.00	33.00	32.90	33.85	35.06
N3	43.95	50.40	47.95	47.10	46.30	43.55	43.00	44.05	45.78
Mean	32.66	40.28	36.41	36.47	35.48	32.18	32.33	32.79	34.82
	70 DAT								
N1	17.35	24.00	21.30	21.60	20.80	16.95	17.05	17.25	19.53
N2	26.00	30.40	30.00	29.15	29.50	27.00	26.30	26.90	28.15
N3	32.70	39.99	37.50	36.95	37.00	33.00	32.80	33.60	35.44
Mean	25.35	31.46	29.60	29.23	29.10	25.65	25.38	25.91	27.70
	95 DAT								
N1	14.00	17.70	16.66	16.95	15.80	14.90	15.00	14.60	15.72
N2	20.10	23.30	24.00	24.50	23.00	20.00	20.80	19.90	21.95
N3	24.00	29.50	30.20	31.10	29.00	26.25	25.65	25.00	27.58
Mean	19.60	23.50	23.62	24.18	22.60	20.38	20.48	19.83	21.75

Where: DAT: days after transplanting, N_1: 0kg N fed-1., N_2: 69kg N fed-1, N_3: 92kg N fed-1., K_1: Zero potassium., K_2: 50kg as basal., K_3: 25kg as basal + 2% at P.I, K_4: 25kg as basal + 2% at F, K_5: 25kg as basal + 2% at P.I and F., K_6: 2% at P.I., K_7: 2% at F., K_8: 2% at P.I and F.

Table 3: NH_4 availability in soil (mg kg^{-1}) as affected by nitrogen levels and potassium application during 2008 seasons.

N Treatments	K- Treatments								
	30 DAT								
	K1	K2	K3	K4	K5	K6	K7	K8	Mean
N1	32.20	43.33	39.00	38.00	38.50	32.80	33.00	33.15	36.24
N2	45.23	54.90	50.10	50.00	51.00	44.10	45.00	45.20	48.19
N3	61.40	69.00	65.00	65.30	65.60	60.34	61.00	61.90	63.56
Mean	46.27	55.74	51.36	50.76	51.70	45.74	46.33	46.75	49.33
	50 DAT								
N1	24.95	32.50	28.75	29.15	28.45	24.60	23.70	24.00	27.01
N2	35.33	42.45	38.82	38.00	39.06	34.30	33.99	34.90	37.10
N3	50.10	58.13	55.20	56.00	55.90	51.80	50.60	51.00	53.59
Mean	36.79	44.36	40.36	40.92	41.05	41.13	36.90	36.09	39.23
	70 DAT								
N1	20.15	26.30	24.30	24.70	24.00	19.36	20.00	19.30	22.26
N2	27.40	33.10	31.50	32.20	32.60	27.80	27.90	26.40	29.86
N3	34.90	40.60	39.80	39.99	40.00	32.18	33.40	34.00	36.85
Mean	27.48	32.35	31.86	32.29	32.20	26.44	27.10	26.56	29.65
	95 DAT								
N1	16.33	22.00	22.80	22.60	22.05	17.00	17.35	17.80	19.74
N2	24.60	27.20	27.60	27.95	26.90	23.20	23.36	23.00	25.47
N3	28.45	33.00	33.15	33.70	32.70	27.50	27.60	26.90	30.37
Mean	23.12	27.53	27.85	28.08	27.21	22.60	22.77	22.56	25.19

Data indicate that in the first season at 30, 50, 70 and 95 DAT available NH_4-N tended to increase as N levels increased. Plots which received high level of N fertilizer (92 kg N fed^{-1}) showed more available NH_4-N than plots, which received low N levels. Data show also that the highest values of available NH^{+}_4-N were obtained at 30 DAT with the application of 92 kg N fed^{-1} while, the lowest values of NH_4-N were obtained at 95 DAT with untreated soil. This view could be in harmony with those found by De Datta (1981), Suresh *et al.* (1995) and Sikdar *et al.* (2008) who stated that increasing level of nitrogen application up to 73 kg N fed^{-1} increased the availability of NH^{+}_4 in soil. The same trend was found in the second season.

Regarding the affect of potassium application methods, data show that in the first season at different periods of sampling application of potassium fertilizer at transplanting increased available NH_4–N compared with treatments having no potassium application at transplanting. This mainly due to the convergence radius of both the NH^{+}_4, K^+ and radius of six fold gap for minerals of clay 2:1 which would lead to fixation of potassium on exchangeable sites releasing the NH_4 to the soil solution. The same trend was found in the second season.

It is worthy to note that the highest values of available NH_4–N in the soil were recorded at 30 DAT under 92kg N fed^{-1} with application full dose of potassium before transplanting (50kg potassium sulphate), while the lowest values of soil NH_4 –N available were observed in plots which did not receive any fertilizer at 95 DAT.

1.2- Available potassium in soil:

Available soil potassium throughout the growth of rice plants as affected by nitrogen levels and methods of potassium application in Tables 4 and 5.

Table 4: Available potassium in soil (mg kg^{-1}) as affected by nitrogen levels and potassium application during 2007 season.

N- Treatments	K- Treatments								
	30 DAT								
	K1	K2	K3	K4	K5	K6	K7	K8	Mean
N1	446	500	489	485	492	439	440	450	468
N2	490	570	550	543	555	480	495	499	523
N3	553	636	610	620	625	560	548	556	588
Mean	496	569	550	549	557	493	494	501	505.3
	50 DAT								
N1	415	470	465	460	468	410	416	420	440
N2	450	540	536	520	538	469	460	480	499
N3	530	600	584	570	599	535	528	540	599
Mean	465	536	528	516	535	471	468	480	512
	70 DAT								
N1	350	400	390	408	412	360	375	383	385
N2	402	460	450	445	470	415	410	425	435
N3	460	503	485	479	500	465	461	470	479
Mean	404	454.3	441	444	460	413	415	426	432.2
	95 DAT								
N1	300	325	310	312	305	295	305	300	306
N2	320	390	380	378	389	330	328	337	356
N3	370	409	395	389	400	380	383	375	387
Mean	330	373	361	360	364	335	338	337	349

Data in Tables 4 and 5 show that the highest amount of available K were obtained at 30 DAT in 2007 and 2008 seasons, then decreased continuously with crop growth, reaching the lowest values at 95 DAT (harvest time) in 2007 and 2008 seasons. The decrease in the available soil K under continuous flooding mainly attributed to that K uptake by rice plant and losses by leaching. Hammad (1995) stated that the availability of K decreased with continuous flooding and development of plant growth.

Data in Tables 4 and 5 show the effect of N levels on available K in soil was clear at early growth stage. Since in both seasons, at 30 DAT available K tended to increase with N level increasing. The highest mean values were obtained with application of 92 kg N fed^{-1}, while the lowest mean values were obtained with control in 2007 and 2008 seasons, after 30 DAT. Available K as affected by N levels have unclear trend up to 95 DAT. Wihardjaka *et al.* (1999) proposed that mobilization of non-exchangeable K in flooded rice root induced through acidification, coupled with K removed from the soil solution by the roots, under NH_4-N nutrition, interlayer K can also be replaced by NH_4^+ ions which are similar in ionic size. Tisdale *et al.* (1985) reported that NH_4^+ could be fixed by clays in a manner similar to that of K^+. Slaton *et al.* (2004) stated that soil water K concentrations peak about on two week after flooding.

Decline rapidly until 4 to 5 weeks after flooding and then reach a consistently low concentration for the duration of the seasons. Both soil K pools, exchangeable and solution reach low K concentration near the time of panicle differentiation and persist until the water is drained for harvest.

Data also show that in the first season at all growth periods, application of potassium before transplanting increased available K^+ compared with treatments having no potassium application before transplanting. Data show also that the maximum mean values of available K were obtained at 30 DAT with application of potassium full dose at transplanting (50kg potassium sulphate), while the lowest values of available K were observed at 95 DAT with untreated control. Thippeswamy *et al.* (2000) reported that water soluble K and available K^+ increased with increase in potassium doses up to 80 kg K_2O ha^{-1}, but decreased with growth stages of crop from tillering to harvesting. The same trend was found in the second seasons.

Concerning the interaction effect, data in Tables 4 and 5, show that highest values of soil K available in soil (636 and 660 mg kg^{-1}) were obtained at 30 DAT when rice plants were fertilized with 92 kg N fed^{-1} and application full dose of potassium before transplanting, in 2007 and 2008 seasons, respectively. While the lowest values of soil K available (300 and 299 mg kg^{-1} in 2007 and 2008, respectively) were observed at (95 DAT) in both seasons of study.

Table 5: Available potassium in soil (mg kg^{-1}) as affected by nitrogen levels and potassium application during 2008 seasons.

N- Treatments	K- Treatments								
	30 DAT								
	K1	K2	K3	K4	K5	K6	K7	K8	Mean
N1	459	515	496	499	505	445	452	458	478
N2	520	595	568	560	566	518	510	522	545
N3	580	660	626	620	630	583	585	577	608
Mean	520	590	563	559	567	515	516	519	543
	50 DAT								
N1	420	478	463	462	466	415	413	418	442
N2	452	546	538	523	537	463	459	470	498
N3	536	609	590	578	592	536	530	535	563
Mean	469	544	530	521	532	471	476	474	501
	70 DAT								
N1	351	405	393	395	414	363	366	370	333
N2	406	465	451	450	469	417	415	420	386
N3	463	519	490	483	511	466	460	469	482
Mean	407	463	445	442	465	415	414	419	434.13
	95 DAT								
N1	299	326	319	323	325	299	300	302	312
N2	329	395	385	382	396	331	330	334	360
N3	374	409	399	392	410	381	380	379	390
Mean	336	376	368	366	377	337	336	338	354

2- Effect of nitrogen and potassium fertilization on nutrients uptake:

Nitrogen uptake in hybrid rice at different growth periods as affected by different nitrogen levels and methods of potassium application during 2007 and 2008 seasons.

The results in Tables 6 and 7 show that increase N levels up to 92 kg N fed^{-1} increased N uptake at all studied growth periods in 2007 and 2008 seasons. It might be owing to fact that hybrid rice absorbs N continuously up to maturity and the delayed N application at flowering stage expectedly results in relatively higher N accumulation in foliage including lower leaves. This probably contributing to higher growth leading to lager cytokinine production which causing more dry matter production to adequately meet the needs arising on account of larger sink in hybrids this undoubtedly would increase the uptake of nitrogen by plant, (Krishankumar *et al.* 2005). These results are in harmony with those obtained by Meena *et al.* (2002) and Zhang Hong *et al.* (2003).

Addition of K as full dose before transplanting (50 kg potassium sulphate) increased significantly nitrogen uptake at 30 days after transplanting (DAT) in both seasons, Table 6 and 7.

Data also show that application of potassium (half dose before transplanting (25 kg potassium sulphate) + spray with 2% K_2O (4kg potassium sulphate) at panicle initiation stage + spray with 2% K2O (4kg potassium sulphate) at flowering stages) increased significantly the nitrogen uptake at 30, 50 and 95 DAT in both seasons. This might be to the continuous supply of K to the crop during growth period which is more beneficial and increased dry matter accumulation and fertilizer use efficiency resulted higher N uptake. These findings are in close conformity with those of Thakur *et al.* (1999).

Table 6: Nitrogen uptake (Kg fed^{-1}) at different growth periods (30, 50, 70, 95 DAT) as affected by different nitrogen levels and methods of potassium application during 2007 season.

Treatment	30 DAT	50 DAT	70 DAT	95 DAT	
				Grain	Straw
N- treatments					
N_1	21.91 c	41.45 c	56.49 c	34.37 c	24.88c
N_2	53.84 b	79.85 b	100.45 b	54.07 b	33.68b
N_3	77.61 a	113.05 a	123.64 a	63.82 a	43.0a
K- treatments					
K_1	43.12 c	64.37 c	80.91 h	43.39 e	30.05c
K_2	62.11 a	88.21 a	103.68 b	55.61 b	35.16b
K_3	57.63 b	88.30 a	98.22 c	54.12 c	34.86ab
K_4	57.81 b	77.44 b	93.22 d	53.06 c	33.99b
K_5	58.08 b	89.33 a	106.00 a	59.12 a	36.03a
K_6	43.72 c	76.52 b	89..49 f	46.88 d	33.55b
K_7	43.12 c	64.51 c	84.65 g	46.17 d	33.43b
K_8	43.03 c	76.28 b	91.83 e	47.67 d	33.76b

Table 7: Nitrogen uptake (Kg fed^{-1}) at different growth periods as affected by different nitrogen levels and methods of potassium application during 2008 season.

Treatment	30 DAT	50 DAT	70 DAT	95 DAT	
				Grain	Straw
N- treatments					
N_1	22.44c	41.23c	58.05c	35.44c	25.25c
N_2	54.74b	80.85b	102.62b	56.00b	35.16b
N_3	78.82a	115.30a	125.26a	65.33a	43.72a
K- treatments					
K_1	44.58d	66.01d	82.63g	44.86e	31.00d
K_2	62.78a	89.67a	104.59b	57.50b	36.58ab
K_3	59.40b	88.58a	100.06c	55.60c	35.22bc
K_4	57.58c	79.22b	94.68d	55.01c	34.32c
K_5	59.35b	88.65a	108.26a	60.57a	37.76a
K_6	44.93d	76.20c	91.43e	48.44d	34.93bc
K_7	43.43d	66.56d	87.0f	47.35d	33.66c
K_8	43.96d	78.11bc	82.63g	48.75d	34.21c

Data listed in Tables 8 and 9 show that highly significantly interaction differences were recorded between nitrogen levels and methods of potassium application at growth periods in both seasons of study. The highest values of nitrogen uptake (90 and 91 kg N.fed-1) were recorded when rice plants were fertilized with 92kg N fed^{-1} in combined with application of potassium full dose before transplanting (K_2) at 30 DAT in 2007 and 2008 seasons, respectively . Data show also that maximum nitrogen uptake values were found when 92 kg N fed^{-1} was combined with application of potassium (half dose before transplanting (25 kg potassium sulphate) + spray with 2% (4 kg potassium sulphate) at panicle initiation stage + spray with 2% (4 kg potassium sulphate) at flowering stages), which increase significantly the N uptake at 50, 70 and 95 DAT in both seasons of study. This might be owing to the continuous supply of potassium to the crop growth period which is more beneficial and increase nitrogen transport amount and percentage after anthesis, as well as, nitrogen accumulation in different rice organs. (Wang *et al.*2004). These results are in congruent with that the increase of nitrogen uptake could be attributed to the role of nitrogen and potassium metabolism in rice plant.

Table 8: Nitrogen uptake (Kg fed^{-1}) at different growth periods (30, 50, 70 and 95 DAT) as affected by interaction between different nitrogen levels and methods of potassium application during 2007 and 2008 seasons.

	K-treatments	N- treatments					
		2007			2008		
		N_1	N_2	N_3	N_1	N_2	N_3
30 DAT	K_1	15.98g	45.24e	68.14c	17.51j	46.34g	69.89cd
	K_2	30.51f	65.83cd	90.00a	31.07h	66.26e	91.02a
	K_3	27.21f	61.52d	84.46b	27.00i	65.46e	85.75b
	K_4	26.49f	62.09d	84.86b	26.60i	59.59f	86.48b
	K_5	26.97f	62.17d	84.96b	27.15i	65.34e	85.56b
	K_6	15.97g	45.40e	69.80c	16.64j	45.71g	72.43c
	K_7	16.39g	44.48e	69.39c	16.56j	43.67g	70.06cd
	K_8	15.79g	44.02e	69.27c	16.90j	45.59g	69.39d
	K-treatments	N- Treatments					
		2007			2008		
		N_1	N_2	N_3	N_1	N_2	N_3
50 DAT	K_1	33.56j	62.08e	97.46c	32.76k	64.77g	100.50d
	K_2	47.56f	92.20a	124.87a	46.30h	95.74e	126.76a
	K_3	46.28fg	93.26a	125.36a	45.16hi	93.30e	127.30a
	K_4	43.54fg	75.36b	113.42b	42.53ij	79.30f	115.83b
	K_5	45.33fgh	97.49a	125.17a	45.56hi	93.60e	126.80a
	K_6	41.25gh	78.65b	109.66b	40.30j	77.00f	111.30c
	K_7	33.82i	62.53c	97.19c	34.50k	65.00g	100.20d
	K_8	40.26h	77.29d	111.28b	42.74h-j	78.10f	113.50bc
	K-treatments	N- treatments					
		2007			2008		
		N_1	N_2	N_3	N_1	N_2	N_3
70 DAT	K_1	50.05p	82.06L	110.63gh	51.20n	83.10j	113.60ef
	K_2	62.43m	112.66fg	135.96b	64.15k	114.83e	134.80b
	K_3	60.22m	109.0h	126.00c	61.22kl	110.96f	128.00c
	K_4	58.00n	96.73j	124.16c	58.25lm	98.60h	127.20c
	K_5	62.21m	113.6ef	142.16a	64.90k	115.60e	144.20a
	K_6	54.30o	98.65j	115.53e	55.90m	100.9gh	117.50de
	K_7	50.51p	88.53k	114.93ef	51.50n	92.50l	117.00de
	K_8	50.05p	102.28i	118.96d	57.30m	104.40g	119.80d

Table 9: Nitrogen uptake (Kg fed^{-1}) at 95 DAT (grain and straw) as affected by interaction between different nitrogen levels and methods of potassium application during 2007 and 2008 seasons.

	K-treatments	N- treatments					
		2007			2008		
		N_1	N_2	N_3	N_1	N_2	N_3
Grain	K_1	26.28k	45.00g	58.90de	27.60n	48.00j	59.00g
	K_2	40.68h	59.36de	66.80b	41.20k	61.00efg	70.10b
	K_3	38.28i	58.8de	65.30b	39.50l	60.00fg	67.30c
	K_4	37.60i	57.5e	64.10bc	38.85l	60.40fg	65.80cd
	K_5	41.66h	61.90cd	73.80a	42.90k	65.00d	73.81a
	K_6	30.50j	50.16f	60.00de	31.72m	51.60hi	62.00ef
	K_7	29.18j	49.00f	60.35de	30.36m	50.00i	61.70ef
	K_8	30.80j	50.90f	61.33d	31.25m	52.00h	63.00e
	K-treatments	N- treatments					
		2007			2008		
		N_1	N_2	N_3	N_1	N_2	N_3
Straw	K_1	20.50h	30.66e	39.00c	21.00j	32.00g	40.00cd
	K_2	26.60fg	34.80d	44.10ab	27.90h	36.25ef	45.60ab
	K_3	26.45fg	34.35d	43.80ab	26.00hi	34.66fg	45.00ab
	K_4	24.98fg	34.00d	43.00ab	23.66ij	35.50efg	43.80ab
	K_5	27.50f	35.00d	45.60a	28.00h	38.50de	46.80a
	K_6	24.55g	33.50d	42.60b	25.80hi	36.00ef	43.00bc
	K_7	24.40g	33.00de	42.90ab	25.00hi	34.00fg	42.00bc
	K_8	24.09g	34.20d	43.00ab	24.66hi	34.36fg	43.60ab

2.2. Potassium uptake:

Potassium uptake (kg fed^{-1}) by hybrid rice at different growth periods as affected by different nitrogen levels and methods of potassium application during 2007 and 2008 are presented in Tables 10,11,12 and 13.

Data in tables 10 and 11 reveal that potassium uptake by hybrid rice in both years of study, nitrogen fertilization significantly increased potassium uptake at all growth periods (30, 50, 70 and 95 DAT). Each successive increment of nitrogen resulted in a significant increase in potassium uptake over the preceding level, the highest potassium uptake was recorded at 92 kg N fed^{-1}. These increases in potassium uptake by hybrid rice plants may be due to the role of nitrogen in improving nutrients absorption. These results are in agreement with those of Meena *et al.* (2002), Maiti *et al.* (2003) and Dwivedi *et al* (2006).

Data in Tables 10 and 11 indicate that potassium uptake was significant affect by a method of potassium application which observed at 30 DAT by applying full dose of potassium before transplanting. On the other hand low potassium uptake was found in plots which did not receive potassium fertilizer at transplanting. As regarded application of potassium half dose at transplanting (25 kg potassium sulphate) + spray with 2% (4 kg potassium sulphate) at panicle initiation stage + spray with 2% (4 kg potassium sulphate) at flowering stages increased significantly the potassium uptake at 50, 70 and 95 DAT in both seasons.

Table 10: Potassium uptake (Kg fed^{-1}) at different growth periods as affected by different nitrogen levels and methods of potassium application during 2007 season.

Treatment	30 DAT	50 DAT	70 DAT	95 DAT	
				Grain	Straw
N treatments					
N_1	29.26c	57.57c	86.63c	12.82c	74.89c
N_2	57.13b	84.79b	121.34b	19.06b	102.10b
N_3	87.48a	119.24a	158.10a	23.47a	112.56a
K treatments					
K_1	45.93c	68.61d	102.10g	14.04e	85.83f
K_2	73.97a	101.83a	135.00b	20.34ab	101.05b
K_3	68.32b	101.17a	129.33c	19.21bc	99.33c
K_4	69.10b	91.16b	124.61d	18.72bc	96.66d
K_5	69.20b	101.16a	139.60a	21.60a	104.90a
K_6	46.07c	81.22c	114.25e	18.06cd	94.40e
K_7	46.00c	69.22d	108.86f	16.88d	94.13e
K_8	45.07c	82.31c	122.46d	18.76bc	95.83d

Table 11: Potassium uptake (Kg fed^{-1}) at different growth periods as affected by different nitrogen levels and methods of potassium application during 2008 season.

Treatment	30 DAT	50 DAT	70 DAT	95 DAT	
				Grain	Straw
N- treatments					
N_1	31.77c	58.56c	87.41c	13.14c	76.48c
N_2	58.96b	86.73b	123.27b	19.79b	104.98b
N_3	88.55a	120.04a	157.27a	23.49a	116.63a
K- treatments					
K_1	47.43c	69.26e	102.74h	14.55d	87.83f
K_2	75.56a	102.06a	136.01b	20.56b	104.67b
K_3	70.45b	101.06a	129.88c	19.35bc	100.83c
K_4	70.82b	92.80b	125.43d	19.17bc	100.01cd
K_5	70.78b	103.27a	140.60a	22.27a	107.31a
K_6	47.31c	82.81d	114.86f	18.08c	98.43d
K_7	47.75c	70.48e	109.36g	17.66c	95.94e
K_8	47.97c	85.31c	122.33e	18.82bc	99.90cd

The increase of potassium uptake of hybrid rice owing to potassium fertilizer application at recommended rate having three times of application (half before transplanting (25 kg potassium sulphate) + spray with 2% (4 kg potassium sulphate) at panicle initiation stage + spray with 2% (4 kg potassium sulphate) at flowering stages were attributed directly to continuous supply which was proved more beneficial and increased dry matter resulted higher potassium uptake Thakur *et al.*(1999) and Ali *et al.*(2005) and Pattanayak *et al.*(2008).

Highly significant interaction differences between nitrogen levels and methods of potassium application in regarded to the potassium uptake (kg fed^{-1}) by hybrid rice in both seasons as listed in Tables 12 and 13. Multiple range tests partly indicated that the best combination which produced the highest potassium uptake by hybrid rice at 30 DAT was 92 kg N fed^{-1} with application of potassium full dose at transplanting (50 kg potassium sulphate) in both seasons. On the other hand low potassium uptake was found in plots which did not receive nitrogen or potassium fertilizer in both seasons of study. At 50, 70 and 95 DAT the best combination which produced the highest potassium uptake by hybrid rice was 92 kg N fed^{-1} with application of potassium half dose before transplanting (25 kg potassium sulphate) + spray with 2%(4 kg potassium sulphate) at panicle initiation stage + spray with 2% (4 kg potassium sulphate) at flowering stages. Devendra *et al.* (1999) reported that application of nitrogen and potassium caused an increase in uptake of potassium in hybrid rice. Arivazhagan and Ravichandran (2005) found that application of potassium and nitrogen in split doses resulted in higher potassium uptake.

Table 12: Potassium uptake (Kg fed^{-1}) at different growth periods as affected by interaction between different nitrogen levels and methods of potassium application during 2007 and 2008 seasons.

		N treatments					
		2007			2008		
	K-treatments	N_1	N_2	N_3	N_1	N_2	N_3
30 DAT	K_1	21.13f	71.65d	71.65c	24.00f	46.50d	71.80c
	K_2	41.81de	108.69c	108.69a	43.80d	73.00c	109.90a
	K_3	36.59e	69.11c	99.26b	38.30e	71.26c	101.81b
	K_4	36.03e	69.94c	101.33b	38.96e	70.50c	103.00b
	K_5	36.16e	69.06c	102.37b	37.35e	72.00c	103.00b
	K_6	21.70f	44.54d	71.97c	23.40f	45.92d	72.60c
	K_7	21.52f	44.11d	72.38c	23.90f	46.33d	73.00c
	K_8	19.12f	43.87d	72.23c	24.40f	46.22d	73.30c
		N- treatments					
	K-treatments	2007			2008		
		N_1	N_2	N_3	N_1	N_2	N_3
50 DAT	K_1	45.15j	60.90h	99.80d	46.25k	61.32i	100.21d
	K_2	68.50g	101.00d	136.00a	69.10g	102.12d	136.50a
	K_3	66.60g	100.00d	136.91a	67.20gh	101.00d	135.00a
	K_4	59.10h	90.00e	125.00b	60.40i	91.70e	126.30b
	K_5	67.30g	101.20d	136.06a	69.33g	103.60d	136.90a
	K_6	54.30i	81.30f	110.25c	55.10j	82.00f	111.33c
	K_7	46.00j	61.66h	100.02d	46.15k	63.20hi	102.10d
	K_8	53.66i	82.26f	111.00c	55.00j	88.95e	112.00c
		N - treatments					
	K-treatments	2007			2008		
		N_1	N_2	N_3	N_1	N_2	N_3
70 DAT	K_1	72.30p	99.00k	135.00f	73.80r	100.43m	134.01hi
	K_2	98.00k	136.00f	171.00b	99.03m	138.00gh	171.00b
	K_3	90.80l	129.20g	168.00bc	91.06n	131.50l	167.10bc
	K_4	87.30lm	121.25h	165.30cd	88.21no	123.10j	165.00c
	K_5	99.40k	141.32e	178.10a	100.90m	143.00ef	177.90a
	K_6	81.60no	116.00i	145.15e	82.40pq	118.20k	144.00e
	K_7	78.50o	108.00j	140.10ef	78.90q	110.00L	139.20fg
	K_8	85.20mn	120.00hi	162.00d	85.00op	112.00jk	160.00d

Table 13: Potassium uptake (Kg fed^{-1}) at 95 DAT (grain and straw) as affected by interaction between different nitrogen levels and methods of potassium application during 2007 and 2008 seasons.

	K-treatments	N- treatments					
		2007			2008		
		N_1	N_2	N_3	N_1	N_2	N_3
Grain	K_1	8.05j	14.09hi	20.00	8.50l	14.66ijk	20.50d-h
	K_2	14.59hi	20.83def	25.62	15.80 ij	21.00c-h	24.90b
	K_3	13.63hi	20.00efg	24.00	14.00ijk	20.40e-h	23.66bc
	K_4	13.25hi	19.90efg	23.03	13.06k	21.09c-h	23.36bc
	K_5	15.40h	21.80cde	27.60	16.00i	22.90be	27.92a
	K_6	12.80hi	18.50fg	22.90	12.50k	19.30gh	22.46bf
	K_7	12.00i	18.00g	20.66	12.00k	18.99h	22.00c-g
	K_8	12.90hi	19.40efg	24.00	13.30jk	20.30fgh	23.15bcd
	K-treatments	N- treatments (kg.fed^{-1})					
		2007			2008		
		N_1	N_2	N_3	N_1	N_2	N_3
Straw	K_1	62.60m	90.00i	104.90ef	64.00n	93.00j	107.75g
	K_2	79.95jk	106.00e	117.20b	82.50k	110.33f	121.20b
	K_3	78.00k	103.50ef	116.50b	76.25lm	106.25gh	120.00b
	K_4	75.00l	103.00fg	112.00c	75.00m	107.75g	116.80c
	K_5	81.50j	111.20cd	122.00a	83.15k	114.00de	124.80a
	K_6	73.60l	100.60gh	109.00d	76.30lm	104.00h	115.00cde
	K_7	73.50l	100.00h	108.90d	75.50m	99.33i	113.00e
	K_8	75.00l	102.50fg	110.00cd	78.70l	105.00h	116.00c

3. Effect of nitrogen and potassium fertilization on grain yield

3- Grain Yield:

Grain yield of hybrid rice as affected by the application of nitrogen levels and methods of potassium application in 2007 and 2008 seasons are presented in Tables 14 and 15.

Data indicate that there was a significant difference in grain yield due to nitrogen fertilizer application. Data show that significant increase in grain yield as nitrogen levels increased from 0 up to 92 Kg N fed^{-1} in both seasons of study. The increased grain yield owing to N fertilization was attributed directly by significantly improvement in the yield attributed like number of panicles per m^2, panicle weight and filled grains percentage. The results confirm the findings of Badasubramanian (2002), Samrathlal *et al.* (2003), Singh *et al.* (2004), Zaheen *et al.* (2006) and Sikdar *et al.* (2008).

Table14: Grain yield (t fed^{-1}) as affected by different nitrogen levels and methods of potassium application.

Treatment	Grain	
	2007	2008
N - treatments		
N_1	3.044c	3.085c
N_2	4.805b	4.952b
N_3	5.290a	5.378a
K - treatments		
K_1	3.752e	3.908f
K_2	4.661b	4.737b
K_3	4.517c	4.555c
K_4	4.442c	4.437d
K_5	4.925a	5.137a
K_6	4.215d	4.340de
K_7	4.167d	4.250e
K_8	4.360c	4.412d

Where: DAT: days after transplanting, N_1: 0 kg N fed-1., N_2: 69 kg N fed-1, N_3: 92 kg N fed-1., K_1: Zero potassium., K_2: 50 kg as basal., K_3: 25 kg as basal + 2% at P.I, K_4: 25 kg as basal + 2% at F, K_5: 25 kg as basal + 2% at P.I and F., K_6: 2% at P.I., K_7: 2% at F., K_8: 2% at P.I and F.

Grain yield of hybrid rice as affected by the methods of potassium in both seasons are presented in Table 14. Data indicate that grain yield was significantly affected by method of potassium application in both seasons. Half dose of potassium before transplanting (25 kg potassium sulphate) + spray with 2% K_2O (4 kg potassium sulphate) at panicle initiation stage + spray with 2% K_2O (4 kg potassium sulphate) at flowering stage produced significantly higher grain yield compared with the other treatments. This might be owing to the continuous supply of potassium to the crop during crop-growth period which is more beneficial and increased translocation of carbohydrates form stems, leaf sheathes and other storage organs to grains, leading to high sink capacity and, subsequently, higher grain yield. Similar trend was obtained by Janardan *et al.* (2000) and Zaratin *et al.* (2004).

Data document in Table 15 reveal that the interaction between nitrogen levels and methods of potassium application had a significant effect on grain yield in 2007 and 2008 seasons. Application of nitrogen at the rate of 92 Kg N fed^{-1} in combined with application half dose of recommended amount potassium before transplanting (25 kg potassium sulphate) + spray with 2% K_2O (4 kg potassium sulphate) at panicle initiation stage + spray with 2% K_2O (4 kg potassium sulphate) at flowering stage were superior to other treatments While, the minimum values were obtained when nitrogen and potassium did not applied. The increase in grain yield is attributed mainly to the increase in most yield components, i.e. number of panicle per m^2, filled grains percentage and 1000-grain weight. Similar trend was obtained by Manivannan *et al.* (2005), Dwived *et al.* (2006) and Bahmaniar and Ranjbar (2007).

Table 15: Grain yield (t fed^{-1}) as affected by the interaction between nitrogen levels and methodsof potassium application during 2007 and 2008 seasons.

	K-treatments	N treatments					
		2007			2008		
		N_1	N_2	N_3	N_1	N_2	N_3
Grain Yield	K_1	2.190m	4.386e	4.680ef	2.290o	4.593j	4.843g-i
	K_2	3.396hi	5.030d	5.556b	3.396kl	5.193de	5.623b
	K_3	3.190i-k	4.923de	5.440b	3.203lm	4.943f-h	5.520bc
	K_4	3.056j-l	4.923de	5.346bc	2.946n	5.01efg	5.356cd
	K_5	3.496h	5.130cd	6.150a	3.560k	5.626b	6.226a
	K_6	2.963kl	4.680ef	5.003d	3.066mn	4.776h-j	5.176de
	K_7	2.820kl	4.646f	5.036d	2.943n	4.686ij	5.120ef
	K_8	3.240ij	4.726ef	5.113cd	3.280l	4.793h-j	5.163de

Where: DAT: days after transplanting, N_1: 0 kg N fed-1., N_2: 69 kg N fed-1, N_3: 92 kg N fed-1., K_1: Zero potassium., K_2: 50 kg as basal., K_3: 25 kg as basal + 2% at P.I, K_4: 25 kg as basal + 2% at F, K_5: 25 kg as basal + 2% at P.I and F., K_6: 2% at P.I., K_7: 2% at F., K_8: 2% at P.I and F.

CONCLUSION

From this study, data obtained could be recommended that applying of nitrogen fertilizer at the rate of 92 Kg N fed^{-1} along with potassium at basal application as a half dose (25 kg potassium sulphate) + spray with 2% K_2O (4 kg potassium sulphate) at panicle initiation and flowering growth stages produced the peak values of both availability and uptake of nitrogen and potassium at growth periods as well as grain rice yield.

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تيسر وامتصاص النيتروجين والبوتاسيوم تحت التسميد بالأسمدة الغير عضوية فى أراضى الأرز المغمورة

خالد حسن الحامدى* ، صبحى عبدالحليم غانم** و إبراهيم محمد هاشم**
* قسم الأراضي – كلية الزراعة – جامعة المنصورة
** مركز البحوث والتدريب فى الأرز سخا– كفرالشيخ

أجريت تجربتان حقليتان فى مزرعة مركز البحوث والتدريب فى الأرز– سخا كفرالشيخ خلال موسمى ٢٠٠٧ ، ٢٠٠٨ وذلك لدراسة أثر استخدام مستويات مختلفة من السماد النيتروجينى ومستوى واحد من السماد البوتاسى مع طرق إضافة مختلفة من السماد البوتاسى على امتصاص كل من النيتروجين والبوتاسوم بواسطة نبات الأرز وتيسر هذه العناصر فى التربة. أوضحت النتائج ان إضافة السماد النيتروجينى بمعدل ٩٢ كجم للفدان مع إستخدام المعدل الموصى به من السماد البوتاسى (٥٠ كجم سلفات بوتاسيوم) قبل الغمر أدى الى زيادة الكمية الميسرة للنبات من النيتروجين والبوتاسيوم عند ٣٠ يوم بعد الشتل فى عامى الدراسة.

كما أوضحت النتائج أنة عند إستخدام ٩٢ كجم نيتروجين للفدان مع إضافة نصف كمية البوتاسيوم الموصى بها (٢٥ كجم سلفات بوتاسيوم) قبل الغمر مع الرش بتركيز ٢% (٤ كجم سلفات بوتاسيوم) فى مرحلتى تكوين السنابل والتزهير أدى إلى زيادة الممتص من النيتروجين والبوتاسيوم عند ٥٠ ، ٧٠ ، ٩٥ يوم من الشتل فى عامى الدراسة.

أظهرت النتائج أن أعلى قيمة لمحصول الحبوب قد ظهرت عند إستخدام التسميد النيتروجينى بمعدل ٩٢ وحدة نيتروجين للفدان مع إضافة نصف كمية السماد البوتاسى الموصى بة (٢٥ كجم سلفات بوتاسيوم) للتربة قبل الغمر والرش بتركيز ٢% بوتاسيوم (٤كجم سلفات بوتاسيوم) فى مرحلتى تكوين السنابل والتزهير.

قام بتحكيم البحث

أ.د / أحمد عبد القادر طه	كلية الزراعة – جامعة المنصورة
أ.د / عيد مرسى خالد	كلية الزراعة – جامعة عين شمس