

NPK Compound Fertilizer Foliar Application Impacts Productivity and Grain Quality of Rice

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ABSTRACT

A field experiment was conducted during the 2018 and 2019 rice growing seasons at The Experimental Farm of Rice Research and Training Center, Sakha, Kafrelsheikh, Egypt, to study the effect of foliar application of NPK (20:20:20) or urea combined with different nitrogen levels on grain yield and quality of Sakha 109 rice variety. Urea (46.5% N) and complex paste water-soluble NPK fertilizer (20:20:20) were used as the nutrient sources for the experimental treatments. For foliar application, NPK was used at the rate of 2 gm per liter of water and nitrogen used was at the concentration of 2% as urea. The field experiments were laid out in a Randomized Complete Block Design with four replications. The studied characteristics were chlorophyll content (SPAD value) at 55 days after transplanting, plant height at harvest, number of panicles per hill, panicle length, panicle weight, number of filled grains per panicle, unfilled grains percentage, 1000-grain weight, grain yield, straw yield and grain quality characteristics (hulling, milling and head rice percentages). N and K uptake (kg ha^{-1}) were also determined. All studied characteristics were significantly influenced by the foliar fertilizer application in the two seasons. Application of NPK or N alone twice might improve rice grain yield and quality. The economic feasibility indicated that the application of $123.75 \text{ kg N ha}^{-1}$ combined with foliar application of NPK or 2% nitrogen twice recorded the highest values of gross return and net return as well as a benefit-cost ratio.

Key words: Nitrogen, Phosphorus, Potassium, Urea fertilizer, Grain yield.

INTRODUCTION

Rice is one of the staple food crops for approximately half of the global population. Therefore, rice production should significantly increase to satisfy the requirements of the world growing population. However, challenges facing in increasing rice production include, decreased arable land area, global climate change, intensified natural disasters, the high cost of fertilizers, intensified natural disasters, and frequent occurrence of diseases and pests (Wu *et al.*, 2016)

Nitrogen is one of the most essential macronutrients for plant growth and yield. So, mineral nitrogen fertilizers are widely used in agriculture all over the world, and also in Egypt. Urea is the most common nitrogen source used in crop production particularly for rice production. This fertilizer is widely available and has a large percentage of nitrogen but relatively expensive compare to foliar fertilizers.

The foliar application increases nutrients uptake at critical growth stages and resulted in enhanced physiological activity leading to increasing yield (Kundu and Sarkar, 2009). Alam *et al.* (2010) indicated that, foliar application could be considered only as a supplement to soil application of nitrogen. Jagathjothi *et al.* (2012) reported that, foliar nutrients increased the photosynthetic rate and carbohydrate translocation and in turn increased dry matter production. They have also found that, the combined application of NPK sources with foliar spray enhanced the growth of rice. Rani *et al.* (2014) studied that, foliar fertilizers application effects on growth, yield, economics and nutrient uptake of rice. NPK 19:19:19 was used at the rate of

2.5 kg ha^{-1} at active tillering and panicle initiation stages. The results indicated that, combined application of recommended fertilizers doses with a foliar spray of NPK 19:19:19 significantly increased grain yield. Also, they found that foliar application of NPK twice at the rate of 2.5 kg ha^{-1} produced the highest values of both gross returns and net returns. Hashem (2019) studied the NPK foliar application in combination with conventional fertilizers on rice production. This study concluded that basal application of two thirds of recommended doses of urea, superphosphate, potassium sulfate, combined with foliar spray of NPK (28:28:28) either at mid tillering + panicle initiation + flowering or at mid tillering + panicle initiation, increased rice yield, compared to a traditional method. From the economic analysis results, the combination of traditional fertilizers (urea, superphosphate and potassium sulfate) with complex water-soluble fertilizer NPK (28:28:28) could be used to uplift the net return of Sakha108 cultivation.

This study aimed to decrease the use of urea fertilizer in rice fields and to substitute it with foliar fertilizers (N: P: K 20:20:20 and 2% nitrogen) as an approach to reduce costs and increasing production.

MATERIALS AND METHODS

This experiment was conducted during 2018 and 2019 summer rice growing seasons at the Experimental farm of Rice Research and Training Center, Sakha, Kafrelsheikh, Egypt ($31^{\circ}5'17''$ North and $30^{\circ}56'44''$ East at an altitude of 8 m from mean sea level). The main objective was to study the effect of foliar application of NPK (20:20:20) and urea combined with different nitrogen levels, on

grain yield of Sakha 109 rice cultivars. Some chemical properties of soil of the experimental site were presented in Table 1.

Table 1: Chemical analyses of the experimental soil before planting in the 2018 and 2019 summer seasons.

Soil chemical properties	Seasons	
	2018	2019
Soil texture	Clayey	Clayey
Clay %	55.90	56.00
Silt %	31.50	32.00
Sand %	12.60	12.00
pH(1:2.5 soil suspension)	8.05	8.20
Ec (ds.m ⁻¹)	2.00	2.05
Available ammonium (ppm)	13.50	12.60
Available Nitrate (ppm)	10.30	11.80
Available P (ppm)	14.00	12.00
Available K (ppm)	350.10	366.50
Anions (meq.L ⁻¹)		
CO ₃ ⁻	0.00	0.00
HCO ₃ ⁻	5.60	5.00
Cl ⁻	14.00	14.00
SO ₄ ⁻	2.70	2.00
Cations(meq.L ⁻¹)		
Ca ⁺⁺	7.20	6.00
Mg ⁺⁺	2.60	1.50
Na ⁺⁺	12.00	13.00
K ⁺	0.50	0.50

Treatments contain both foliar and soil application of different fertilizers. Treatments consisted of soil application of urea combined with foliar spray of NPK (20:20:20) or 2% nitrogen concentration at different growth stages. The recommended dose of nitrogen fertilizer was 165.6

kg N ha⁻¹ (urea, 46.5% N). Nitrogen fertilizer was added into splits first one was (two-third) of recommended rate as basal application and second one (one-third) was applied at 30 days after transplanting (DAT) Complex paste water-soluble fertilizer NPK (20:20:20) were used as the nutrient sources. NPK was used at the rate of 2 g/L. Solutions of 2% nitrogen, N was prepared from urea (46.5% N). The treatments schedule was as illustrated in Table 2.

Field experiments were laid out in a Randomized Complete Block Design with four replications. Plot size was 12 m² (3 X 4 m). The experimental area was plowed twice and well leveled. The nursery bed was sown on the 11th and 14th of May in both seasons, respectively. 27-day old seedlings were used at 20 X 20 cm transplanting spacing. The crop was harvested at full maturity. The border and sampling rows were harvested separately. 10 m² of each plot was harvested and the weight of grain and straw were recorded. Plant samples (five hills each) were taken randomly from each plot at 55 DAT to determine chlorophyll content (SPAD value). At harvest, plant height (cm) and the number of panicles per hill were measured. Ten panicles were collected randomly to estimate the panicle length (cm), panicle weight (g), number of filled grains per panicle, unfilled grains percentage, 1000-grain weight (g), grain and straw yield (t ha⁻¹) and grain quality characteristics (hulling, milling and head rice percentages). The nitrogen content of milled grains was measured using the Mikroieldahl method (Jackson 1967) to determine nitrogen uptake. The Potassium content of grain was determined to calculate potassium uptake using Elico CL378 Flame Photometer (RHYS international LTD, India) according to Peterpurgski (1968) scheme.

Table 2: Schedule of fertilization treatments

Treatment	Designation	Soil application (SA)	Foliar application (FA)
T1	Control	Zero nitrogen	Distilled water spray
T2	50%SA+1 NPK FA	50% of recommended N dose	NPK 2 g/L once at 20 DAT
T3	50%SA+1 N FA	50% of recommended N dose	2% N once at 20 DAT.
T4	50%SA+2 NPK FA	50% of recommended N dose	NPK 2 g/L twice at 20 &40 DAT
T5	50%SA+2 N FA	50% of recommended N dose	2% N twice at 20 &40 DAT
T6	75%SA+1 NPK FA	75% of recommended N dose	NPK 2 g/L once at 20 DAT
T7	75%SA+1 N FA	75% of recommended N dose	2% N once at 20 DAT.
T8	75%SA+2 NPK FA	75% of recommended N dose	NPK 2 g/L twice at 20 &40 DAT
T9	75%SA+2 N FA	75% of recommended N dose	N 2% twice at 20 &40 DAT
T10	100% SA	100% of recommended N dose	Without spray

*SA: N soil application

*1F and 2F: Foliar spray once or twice, respectively

*100%: N recommended dose

*DAT: Days after transplanting

Economic feasibility

An economic analysis was conducted using to measure the net return and the benefit-cost ratio for each treatment (Program et al., 1988).

Cost of cultivation (L.E. ha⁻¹):

The cost of farming for each treatment is calculated in Egyptian Pounds (L.E.). Data of inputs cost were calculated as a cost of land preparation, seeding, transportation, irrigation, fertilizers, weeding, harvesting and other expenses.

Gross return (L.E. ha⁻¹):

Gross return was estimated based on the harvested straw and grain yields (t ha⁻¹) in Egyptian pounds. One ton of straw value was 250 L.E., one ton of rice grain value was 4000 L.E. in both seasons.

Net return (L.E. ha⁻¹):

Net return was estimated as the difference between total revenue from the sale of harvested rice grains and total costs (fixed and variable cost of rice yield).

Benefit-cost ratio:

Calculated by the formula, B: C ratio = Gross return/Cost of cultivation

The collected data were subjected to statistical analysis according to the procedure described by Gomez and Gomez (1984). Treatment means were compared by Duncan's Multiple Range Test (Duncan, 1955). All statistical analyses were done using Costat Statistical Software - CoHort Software.

RESULTS AND DISCUSSION

The results of chlorophyll content in leaves at 55 days after transplanting (DAT) and plant height in the 2018 and 2019 seasons are presented in Table 3. Application of soil or foliar nutrients resulted in a significant increase in chlorophyll content and plant height compared with control treatment in both

seasons. Adding 123.75 kg N ha⁻¹ (75%SA) as soil application along with foliar spraying of NPK (20:20:20) twice at 20 and 40 DAT (T8) recorded the highest values of chlorophyll content and plant height in both seasons. There were no significant differences in chlorophyll content and plant height among the recommended dose of urea 100% SA (165 kg N ha⁻¹) as a soil application and (T8 and T9) 123.75 kg N ha⁻¹ combined with foliar application of NPK or 2 % N added once or twice. That increase might be due to balanced nutrient supply at different growth stages viz., mid tillering, panicle initiation and flowering stages. The foliar application of NPK or N at different growth stages might have increased the plant height due to the fact that the nutrients supply to rice plants at different growth stages might help cell elongation and increase photosynthetic rate. These findings are supported by the work done by Manik *et al.*, (2016) and Hashem (2019).

Number of panicles m² (Table 3), panicle length, panicle weight, number of filled grains per panicle (Table 4) and 1000-grain weight (Table 5) were significant increased by the application of any studied N source relative to the control treatment (without N) in both seasons. The opposite was true in number of unfilled grains per panicle. The plants treated by T8 (123.75 kg N ha⁻¹ + foliar spray with NPK at 20 and 40 DAT) recorded the maximum values of the mentioned traits in the two seasons. The maximum values of the after-mentioned traits were obtained from applied T8 (123.75 kg N ha⁻¹ + twice NPK foliar spray), which was parallel with T9 (123.75 kg N ha⁻¹ combined with spray of 2% N concentration at 20 and 40 DAT) and the recommended N rate (165 kg N ha⁻¹) in both seasons.

Table 3: Chlorophyll content, plant height and number of panicles m² as affected by different treatments in the 2018 and 2019 seasons.

Treatment	Chlorophyll (SPAD)		Plant height (cm)		No. of panicles m ²	
	2018	2019	2018	2019	2018	2019
(T1) Control	36.23e	36.03f	73.70f	78.00d	316.70f	308.33f
(T2) 50%SA+1 NPK FA	40.67d	41.44de	79.00e	84.30c	445.80e	443.33e
(T3) 50%SA+1 N FA	40.51d	41.17e	79.30de	85.70bc	433.30e	441.67e
(T4) 50%SA+2 NPK FA	41.99c	42.66c	84.70c	88.00abc	489.60cd	482.00cd
(T5) 50%SA+2 N FA	41.68c	42.21cd	82.70cd	86.00bc	472.90d	467.83de
(T6) 75%SA+1 NPK FA	43.16ab	44.50ab	89.70ab	89.30ab	516.70bc	535.33ab
(T7) 75%SA+1 N FA	42.67bc	43.71b	85.70bc	88.30abc	510.40bc	514.54bc
(T8) 75%SA+2 NPK FA	44.22a	45.32a	93.00a	91.70a	576.70a	568.33a
(T9) 75%SA+2 N FA	43.78a	45.13a	89.70ab	89.30ab	564.30a	554.67a
(T10) 100% SA	43.63ab	44.56ab	90.70a	90.00ab	542.30ab	539.67ab
F-test	**	*	*	**	**	**

*, ** and N.S. 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 4: Panicle length, panicle weight, No. of filled grains panicle⁻¹ and unfilled grains as affected by different treatments in the 2018 and 2019 seasons.

Treatment	Panicle length (cm)		Panicle weight (g)		No. of filled grains		Unfilled grains (%)	
	2018	2019	2018	2019	2018	2019	2018	2019
(T1) Control	17.8d	18.2c	2.7e	2.7d	89.7e	94.5e	11.0a	8.7a
(T2) 50%SA+1 NPK FA	19.4c	19.8b	2.8d	2.9c	100.2d	103.2d	7.8bc	6.4bc
(T3) 50%SA+1 N FA	18.7c	19.3b	2.8d	2.9c	99.3d	103.1d	8.4b	6.6b
(T4) 50%SA+2 NPK FA	19.2c	19.7b	2.9cd	3.0b	105.2bcd	107.5c	6.8bc	5.7bcd
(T5) 50%SA+2 N FA	19.5c	19.9b	2.9cd	3.0b	104.4 cd	107.6c	7.2bc	5.7bcd
(T6) 75%SA+1 NPK FA	22.7ab	23.4a	3.0abc	3.1a	112.7abc	116.3ab	7.3bc	5.5bcd
(T7) 75%SA+1 N FA	22.3b	22.9a	3.0abc	3.1a	111.4abc	115.6b	7.4bc	5.4bcd
(T8) 75%SA+2 NPK FA	23.5a	23.7a	3.2a	3.2a	116.5a	120.0a	6.1c	4.4d
(T9) 75%SA+2 N FA	23.2ab	23.7a	3.1ab	3.2a	115.3a	118.7ab	6.4bc	4.7cd
(T10) 100% SA	23.0ab	23.3a	3.0abc	3.1a	113.8ab	117.2ab	6.7bc	5.1bcd
F-test	**	**	**	**	*	**	*	*

*, ** and N.S. 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

These results might discriminate the fact that, foliar application of NPK at different growth stages might increase the availability of those nutrients which might increase the absorption and the translocation of nutrients to the rice grain. Therefore, photosynthesis improved, producing a great number of filled grains along with improvement in sink size. Moreover, increased total sink size because of increases in both panicles number and spikelet number panicle⁻¹. Meantime, it might be the foliar application of NPK significantly increased leaf N-content for both flag leaf and leaves besides the flag leaf. Thereby, Rubisco (Ribulose-L5- Bisphosphate Carboxylase) activity in the flag leaves was higher for the plants that received NPK. This might have increased the grain filling as well as grain weight. Similar results were obtained by Rani *et al.*, (2014), Das *et al.*, (2018) Hashem (2019) and Shrestha *et al.*, (2020)

The NPK nutrients applied as a foliar spray at different growth stages might have resulted in the rapid availability and uptake of those nutrients leading to faster crop response compared to soil application which increased significantly the number of panicles per unit area. Similar results have been reported by Jagathjothi *et al.*, (2012), Rani *et al.*, (2014) and Hashem (2019).

Data in Table 5 show that rice grain yield ha⁻¹ was significantly increased by the application of either the recommended N rate alone 100% SA (165 kg N ha⁻¹) or the other nitrogen rates (123.75 kg N ha⁻¹ (75%SA) and 82.5 kg N ha⁻¹ (50%SA) with foliar spray of NPK and N once and twice) compared with the control treatment in the two seasons. Plants treated with T8 (123.75 kg N ha⁻¹ combined with foliar application of NPK at 20 and 40 DAT) pronouncedly produced the highest grain yield followed by T9 those treated with (123.75 kg

N ha⁻¹ combined with foliar application of 2% N concentration twice) with no significant differences between the two treatments in the two seasons. Application of (123.75 kg N ha⁻¹) as a soil application among with foliar spraying with NPK (20:20:20) or 2% N twice out yielded the application of the recommended N rate alone as a soil application in the two seasons. Any increase in one or more of the yield components without a decrease in the others will lead to an increase in grain yield. Therefore, increases in grain yield due to fertilizer foliar application was a logical resultant due to the increases in yield components, i.e. number of panicles per m², filled grains percentage and the number of grain per panicle (Manik *et al.*, 2016 and Shrestha *et al.*, 2020). Moreover, the increase in grain yield associated with the utilization of NPK foliar application might be attributed to balancing NPK supply that enhanced intensive chlorophyll synthesis and sufficient translocation of assimilates to production parts. These findings are supported by the work done by Alam *et al.*, (2010), Manik *et al.*, (2016), Hervé *et al.*, (2017), Mohan *et al.*, (2017) and Hashem (2019).

The increases percentages in grain yield due to the nitrogen fertilizer combination were significant in both seasons. The highest percentage of increase in grain yield was obtained with soil application of T8 and T9 (123.75 kg N ha⁻¹ with NPK (20:20:20) foliar spray twice or 2% N). The increasing percentage was decreased by decreasing nitrogen rate to 50% SA with foliar spraying once by 2% N in the two seasons.

The N fertilizer treatments had a significant effect on rice straw yield in both seasons (Table 5).

Table 5: 1000-grain weight, grain yield and straw yield as affected by different treatments in 2018 and 2019 seasons.

Treatment	1000-grain weight (g)		Grain yield (t ha ⁻¹)		Straw yield (t ha ⁻¹)		The increase in grain yield (%)	
	2018	2019	2018	2019	2018	2019	2018	2019
(T1) Control	24.93 g	26.28 d	6.21 e	6.46 e	6.46 e	8.88 c	-	-
(T2) 50%SA+1 NPK FA	26.04 f	26.82 d	7.50 d	7.30 d	7.30 d	10.37 b	20.77 de	13.00 d
(T3) 50%SA+1 N FA	25.81 f	26.8 d	7.23 d	7.29 d	7.29 d	10.03 b	16.43 e	12.85 d
(T4) 50%SA+2 NPK FA	27.35 de	27.95 c	8.14 c	8.34 c	8.34 c	10.81 b	31.08 c	29.10 c
(T5) 50%SA+2 N FA	27.14 e	27.98 c	8.01 c	8.23 c	8.23 c	10.67 b	28.99 cd	27.40 c
(T6) 75%SA+1 NPK FA	28.29bc	29.2 ab	9.31 b	9.65 b	9.65 b	11.87 a	49.92 ab	49.38 b
(T7) 75%SA+1 N FA	27.97cd	29.01 b	9.17 b	9.54 b	9.54 b	11.80 a	47.67 b	47.68 b
(T8) 75%SA+2 NPK FA	29.28 a	30.17 a	10.23a	10.44a	10.44 a	12.58 a	64.73 a	61.61 a
(T9) 75%SA+2 N FA	28.99ab	29.83 ab	10.12a	10.07a	10.07 ab	12.77 a	62.96 a	55.88 ab
(T10) 100% SA	28.6 abc	29.47 ab	9.14 b	9.76 b	9.76 ab	12.12 a	47.18 b	51.08 b
F-test	*	**	**	**	**	**	**	**

*, ** and N.S. 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

The control treatment produced the least straw yield in both seasons. The application of (123.75 kg N ha⁻¹ as a soil application combined with foliar application of 2% N twice or 165 kg N ha⁻¹), produced similarly the highest straw yield in the two seasons. This might be due to an increase in plant height and number of tillers per unit area. Foliar NPK application might have resulted in a rapid availability and uptake of nutrients leading to faster crop response which increased the dry matter production as well as straw yields. Metwally *et al.*, (2020) indicated that, foliar application helps in the effective absorption of nutrients at critical growth stages and resulted in enhanced physiological activity leading to better growth. These results are in good harmony with that recorded by Manik *et al.*, (2016) and Mohan *et al.*, (2017).

The grain quality characteristics (hulling, milling and head rice percentages) were considered

as the most important traits that affect rice quality and consumer demand. Table (6) showed hulling, milling and head rice percentages as affected by different treatments in 2018 and 2019 seasons. Data indicated clearly that plants that received either foliar or soil fertilizers exhibited a significant increase compared to the control (without N application). Increasing nitrogen rate from (50%SA to 100% SA) 82.5 kg N ha⁻¹ to 165 kg N ha⁻¹ as a soil application along with foliar spraying of NPK or N were markedly increased hulling, milling and head rice percentages in both seasons. The best significant grain quality were obtained from (123.75 kg N ha⁻¹ combined with NPK foliar application and 2% N once or twice) and recommended dose (165 kg N ha⁻¹) in the two seasons. Okasha *et al.*, (2019) reported that, foliar spray of fertilizer at different growth stages would be recommended for improving rice quality and productivity of Giza 179.

Table 6: hulling, milling and head rice percentages as affected by different treatments in the 2018 and 2019 seasons.

Treatment	Hulling (%)		Milling (%)		Head rice (%)	
	2018	2019	2018	2019	2018	2019
(T1) Control	79.67c	76.66b	69.70b	66.67d	60.07e	64.44d
(T2) 50%SA+1 NPK FA	84.11b	81.14a	74.15a	72.78bc	65.00cd	68.87bc
(T3) 50%SA+1 N FA	84.11b	82.26a	74.18a	73.67ab	63.56d	69.03bc
(T4) 50%SA+2 NPK FA	85.11a	82.33a	74.23a	72.55bc	65.00cd	70.03ab
(T5) 50%SA+2 N FA	85.37a	82.30a	74.91a	71.44c	66.37bc	68.08c
(T6) 75%SA+1 NPK FA	86.26a	81.27a	75.41a	73.89ab	69.30a	70.57ab
(T7) 75%SA+1 N FA	85.33a	82.30a	74.98a	73.89ab	64.88cd	70.41ab
(T8) 75%SA+2 NPK FA	85.18a	82.28a	75.23a	73.89ab	69.50a	70.44ab
(T9) 75%SA+2 N FA	85.40a	82.33a	75.17a	74.77a	68.89a	71.73a
(T10) 100% SA	85.67a	81.13a	74.88a	73.59ab	67.89ab	70.04ab
F-test	*	**	**	**	**	**

*, ** and N.S. 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

Pan *et al.*, (2013) found that, foliar fertilizer application improved the rice grain quality characteristics.

Nitrogen and potassium uptakes (kg ha^{-1}) by rice yield grains at harvest were presented in Figs. 1 and 2. NPK nutrients had significant effects on N and K uptake. Application of ($123.75 \text{ kg N ha}^{-1}$ + NPK as a foliar spray twice T8) significantly recorded higher N and K uptake in grains, followed

by any of ($123.75 \text{ kg N ha}^{-1}$ + 2% N as a spray twice T9), recommended dose (165 kg N ha^{-1} T10) and ($123.75 \text{ kg N ha}^{-1}$ + NPK or 2% N as a foliar spray once T6 or T7) in both seasons. Foliar application of NPK at different growth stages increased both grain yield and the absorption of those nutrients and might have resulted in the increased uptake of N, P and K by rice grains.

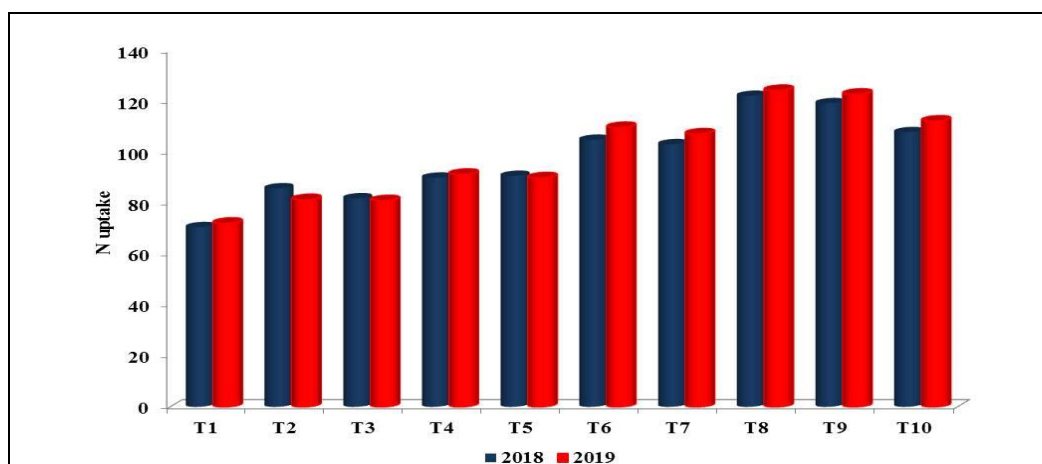


Fig 1: Nitrogen uptake (kg ha^{-1}) as affected by different treatments in 2018 and 2019 seasons.

Where is:

- T1: Control
- T2: 50%SA+1 NPK FA
- T3: 50%SA+1 N FA
- T4: 50%SA+2 NPK FA
- T5: 50%SA+2 N FA

- T6: 75%SA+1 NPK FA
- T7: 75%SA+1 N FA
- T8: 75%SA+2 NPK FA
- T9: 75%SA+2 N FA
- T10: 100% SA

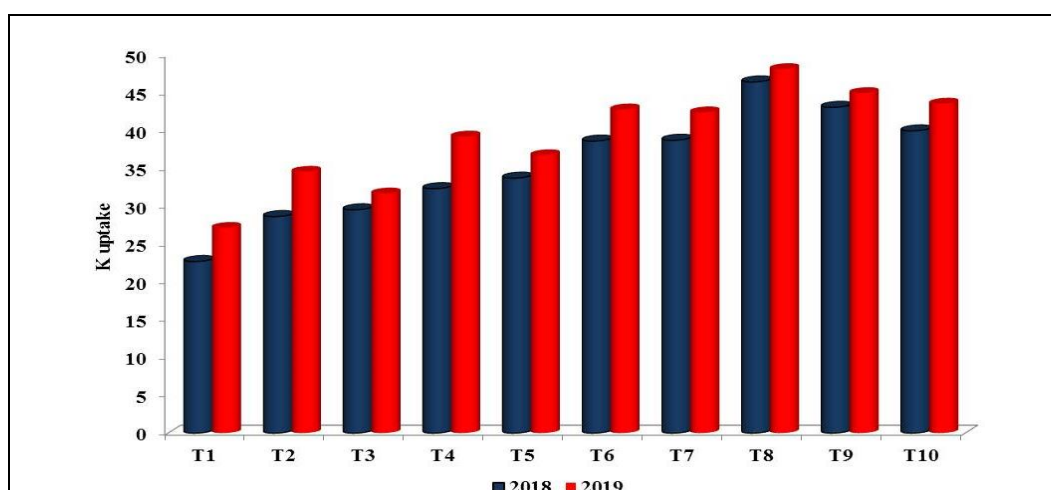


Fig 2: Potassium uptake (kg ha^{-1}) as affected by different treatments in 2018 and 2019 seasons.

Where is:

- T1: Control
- T2: 50%SA+1 NPK FA
- T3: 50%SA+1 N FA
- T4: 50%SA+2 NPK FA
- T5: 50%SA+2 N FA

- T6: 75%SA+1 NPK FA
- T7: 75%SA+1 N FA
- T8: 75%SA+2 NPK FA
- T9: 75%SA+2 N FA
- T10: 100% SA

The increase in NPK uptake with foliar application of NPK at different growth stages could be attributed also to reduce losses of nutrients and enhance fertilizer use efficiency. A similar trend was found by Jagathjothi *et al.*, (2012) and Hashem (2019).

Figures 3 and 4 illustrate the total revenue and benefits/costs of different treatments. It was

observed that the maximum variable and total costs were recorded when 100% of nitrogen recommended dose were applied. Application of (123.75 kg N ha⁻¹ combined with NPK foliar application or N two times) recorded the highest values of gross return and net return as well as benefit cost ratio.

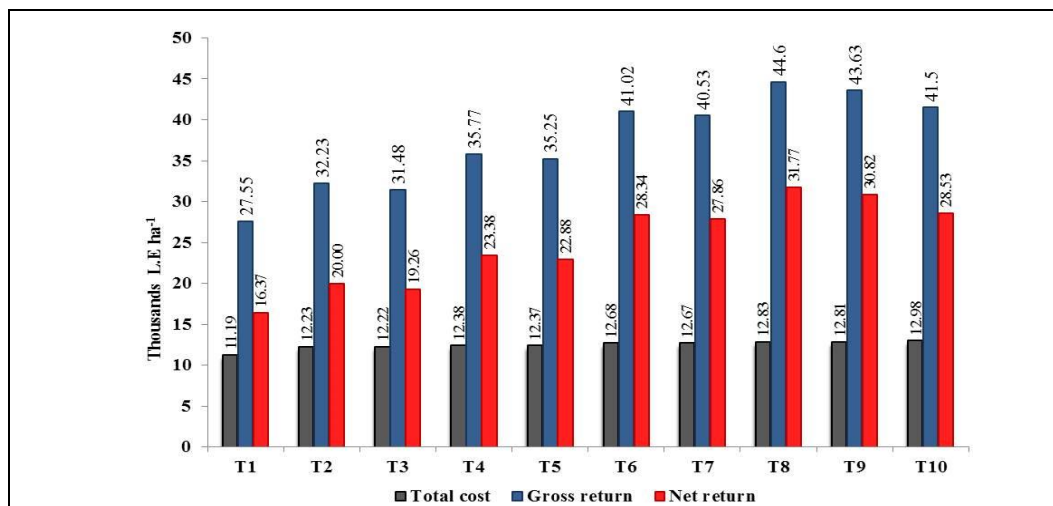


Fig 3: Total cost, gross returns and net return (L.E. ha⁻¹) as overall mean values through the two growing seasons.

Where is:

- T1: Control
- T2: 50%SA+1 NPK FA
- T3: 50%SA+1 N FA
- T4: 50%SA+2 NPK FA
- T5: 50%SA+2 N FA

- T6: 75%SA+1 NPK FA
- T7: 75%SA+1 N FA
- T8: 75%SA+2 NPK FA
- T9: 75%SA+2 N FA
- T10: 100% SA

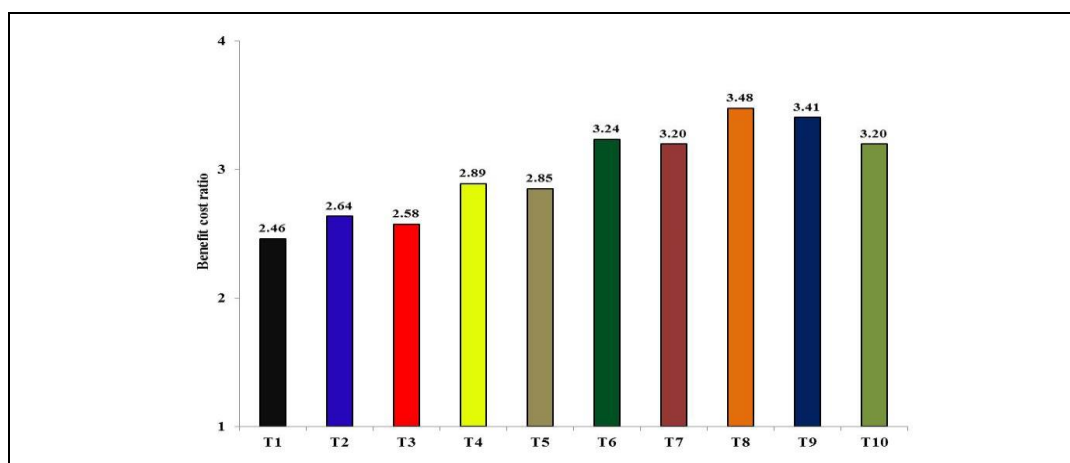


Fig 4: Benefit: cost ratio of straw and grain yield (t. ha⁻¹) as influenced by different treatments overall means value through the two growing seasons.

Where is:

- T1: Control
- T2: 50%SA+1 NPK FA
- T3: 50%SA+1 N FA
- T4: 50%SA+2 NPK FA
- T5: 50%SA+2 N FA

- T6: 75%SA+1 NPK FA
- T7: 75%SA+1 N FA
- T8: 75%SA+2 NPK FA
- T9: 75%SA+2 N FA
- T10: 100% SA

Meanwhile, there were insignificant differences in gross return, net return and benefit cost ratio among application of recommended dose and Application of (123.75 kg N ha⁻¹ combined with NPK foliar application or 2%N one application). Hashem (2019) reportet that, gross return and net returns were highest when rice plant treated by two thirds of NPK (urea, super phosphate, potassium sulphate) as basal dose + foliar spray of NPK (28:28:28) 2.5 kg ha⁻¹ compared to reoomended dose of NPK and control.

CONCLUSION

Foliar application of NPK or N may cause a significant increase in rice productivity as well as increase the benefit cost ration. Rice grain yield was significantly increased by application of either the recommended N rate alone (165 kg N ha⁻¹) or the nitrogen rates of (123.75 kg N ha⁻¹ and 82.5 kg N ha⁻¹ with NPK and N foliar spray of once and twice) compared with the control treatment. Application of (123.75 kg N ha⁻¹ combined with foliar application of NPK or N two times) recorded the highest values of gross return and net return as well as benefit cost ratio.

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الملخص العربي

تأثير الرش الورقي بالسماذ المركب النيتروجين والفسفور والبوتاسيوم علي انتاجية وجودة حبوب الأرز

عبدالفتاح صبحي غريب

مركز البحوث والتدريب في الارز - معهد بحوث المحاصيل الحقلية - مركز البحوث الزراعية - كفر الشيخ - مصر

أجريت تجربتان حقليتان بالمزرعة البحثية لمركز البحوث الزراعية - محطة البحوث الزراعية بسخا - كفر الشيخ - مصر، في موسمي ٢٠١٨ و ٢٠١٩. بهدف دراسة تأثير الرش الورقي للسماذ المركب من النيتروجين: الفسفور: البوتاسيوم (٢٠:٢٠:٢٠) والرش الورقي بمحلول النيتروجين بتركيز ٢% في مراحل نمو مختلفة تحت معدلات مختلفة من التسميد النيتروجين وتأثيره علي المحصول للصف سخا ١٠٩. واستخدمت المعاملات الاتية: معاملة المقارنة بدون اضافة نيتروجين (رش بالماء) - الكمية الموصي بها من التسميد النيتروجين (١٦٥ وحدة نيتروجين للهكتار) - الرش الورقي بمحلول النيتروجين: الفسفور: البوتاسيوم (٢٠:٢٠:٢٠) او الرش الورقي بمحلول النيتروجين بتركيز ٢% مره واحده (بعج ٢٠ يوم من الشتل) او مرتين (بعد ٢٠ و ٤٠ يوم بعد الشتل) مع ٥٠% و ٧٥% من السماذ النيتروجين الموصي به. تم تنفيذ التجربة في قطاعات كاملة العشوائية في اربع مكررات. تم قياس الصفات التالية محتوى الكلورفيل (SPAD value)، ارتفاع النبات (سم)، عدد السنابل في الجورة، طول السنبله (سم)، وزن السنبله (جم)، عدد الحبوب الممتلئة في السنبله، النسبة المئوية للحبوب الغير ممتلئة، وزن ١٠٠٠ حبة (جم)، محصول الحبوب (طن للهكتار)، محصول القش (طن للهكتار)، صفات الجودة، معدل امتصاص الحبوب لكلا من النيتروجين والبوتاسيوم بالاضافة الي التقييم الاقتصادي. اظهرت النتائج ان كل الصفات المدروسة تأثرت معنويا بالرش الورقي بالسماذ المركب من النيتروجين: الفسفور: البوتاسيوم (٢٠:٢٠:٢٠) والرش الورقي بمحلول النيتروجين بتركيز ٢% في مراحل النمو المختلفة. اظهرت النتائج ان الرش الورقي للسماذ المركب من النيتروجين: الفسفور: البوتاسيوم (٢٠:٢٠:٢٠) والرش الورقي بمحلول النيتروجين بتركيز ٢% مره واحده او مرتين ادي الي زيادة معنويه في المحصول ومكوناته. اشار التحليل الاقتصادي الي ان استخدام معدل ١٢٣,٧٥ كجم نيتروجين للهكتار مع الرش الورقي للسماذ المركب من النيتروجين: الفسفور: البوتاسيوم (٢٠:٢٠:٢٠) والرش الورقي بمحلول النيتروجين بتركيز ٢% مرتين سجلت أعلى قيم للعائد الإجمالي وصافي العائد بالإضافة إلى نسبة التكلفة للمنفعة.