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POSSIBILITY OF INCREASING THE GROWTH AND PRODUCTIVITY OF RICE VIA FOLIAR APPLICATION OF NPK FERTILIZER

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ABSTRACT

Tow field experiments were conducted during the seasons 2021 and 2022 at the field farm of the Rice Research and Training Center (RRTC), Sakha, Kafr El-Sheikh. The aim of this study was to demonstrate the effect of spraying with NPK foliar fertilizers during the vegetative growth stages on growth, yield, its components, and grain quality of Sakha 108 rice variety. Randomized complete blocks with four replicates were used in the design of this experiment. The recommended foliar spray treatments were as follows: (Urea 2%, K_2O_5 4%, P_2O_3 3%) under three rates of (50%, 75%, 100%) NPK . It was observed that the use of foliar fertilizer spraying improved the studied plant characteristics (plant height, number of branches, flag leaf area, total leaf area per plant, photosynthesis rate, flowering date, yield and its components, grain quality characteristics, number of spikes/m^2, spike weight, number of full and empty grains per spike, thousand grain weight, grain and straw yield, percentage of each of hulling, bleaching and amylose) compared to control treatments. The 75% NPK treatment in foliar spray with a mixture of (Urea2%, K_2O_5 4%, P_2O_3 3%) at panicle formation + cord stages was the most effective in improving rice grain quality, growth and productivity without significant difference with the NPK mixture in terms of improving rice grain quality. Therefore, a mixture of Urea2%, K_2O_5 4%, P_2O_3 3%of 50% and 75% NPK can be recommended to improve rice quality and productivity in Sakha 108 under North Delta conditions.

Key words***: Rice, NPK, Fertilizer, Grain yield, yield components, Grain quality*.**

INTRODUCTION

Rice is a strategic crop in the world, as it is an indispensable staple food for many people around the world. Therefore, rice production must be increased to keep pace with the steady increase in the global population. However, rice cultivation faces many problems that limit its cultivation and productivity worldwide. Rice productivity is facing a decline in the area of good agricultural land, as well as significant global climate change. There is also a sharp rise in global mineral fertilizer prices, as well as the emergence of many diseases and pests ((Krishnakumar et al 2005) and (Wu et al 2016). Nitrogen is one of the most important nutrients for plant production worldwide. Mineral fertilizers are widely used all over the world, especially in rice cultivation. Urea is one of the most important fertilizers for rice cultivation and growth, as it contains high concentrations of nitrogen. Due to its high cost when used compared to foliar fertilizers, there has been a trend towards increasing the use of foliar fertilizers during the plant growth stages. This improved plant physiological activity and increased productivity (Kondu and Sarkar 2009). Alam et al. (2010) also pointed out that the application of foliar fertilizers can only supplement nitrogen fertilization to the soil. Jagathjothi et al. (2012) reported that foliar nutrients increased the rate of photosynthesis and carbohydrate translocation and consequently increased dry matter production. They also found that application of NPK combined fertilizer along with foliar spray improved rice growth. Rani et al. (2014) found that foliar fertilizer application affected growth, yield, and nutrient uptake by rice. NPK 19:19:19 was applied at the rate of 2.5 kg/ha during the branching and panicle formation stages. The results indicated that combined application of recommended fertilizer doses with foliar spray of NPK 19:19:19 significantly increased the grain yield. They also found that foliar application of NPK twice at a rate of 2.5 kg/ha was significantly more effective than other conventional methods. Hashem (2019) also found that foliar NPK treatment with conventional fertilizers was more effective on rice production. His study concluded that the basal application of two-thirds of the recommended doses of Urea, superphosphate, and potassium sulfate, along with foliar application of (NPK 28:28:28) at mid-branch + spike initiation + flowering or mid-branch + spike initiation, resulted in an increase in rice yield, compared to the conventional method. From the economic results obtained, the combination of conventional fertilizers (Urea, superphosphate, and potassium sulfate) with a water-soluble NPK (28:28:28) fertilizer can be used to increase the net yield of Sakha109 cultivation. The objective of the present research was to improve rice growth, yield, yield characteristics and grain quality of Sakha 108 rice cultivar, under North Delta conditions using foliar spray of some chemicals at different growth stages

MATERIALS AND METHODS

Two field experiments were conducted at the experimental farm of Rice Research and Training Center (RRTC), Sakha, Kafr El-Sheikh, Governorate, Egypt. The main objective of the study was to determine the effect of foliar spraying with some of fertilizers by NPK and foliar application of saucers NPK (Urea 2%, K_2O_5 4%, P_2O_3 3%) during panicle initiation+ mid- booting stages on rice growth, yield, yield attributes and grains quality characteristics of rice cv. Sakha 108. Alfalfa was the previous crop during the two seasons. Soil samples were taken from each site at a depth of 0-30 cm from the soil surface and air-dried, then ground and mixed thoroughly. The soil was analyzed by the method of Black (1965).The results of the chemical analysis in both seasons and the chemical properties of the soil of the experimental site are shown in Table (١).

Table 1. Some mechanical and chemical analysis of the soil at the experimental sites during 2021and 2022 seasons.

Soil properties	2021	2022
Mechanical :		
Sand %	**35.0**	**27.3**
Silt %	**32.8**	**27.64**
Clay %	**32.2**	**45.06**
Texture class :	**Clayey**	**Clayey**
pH (1:2.5 soil water suspension)	**8.2**	**8.10**
Ece (soil paste extracted at 25c ds.m^{-1})	**2.5**	**2.58**
OM (organic matter) %	**1.73**	**1.65**
Available potassium (ppm)	**305**	**320**
Soluble cations, meq.l^{-1}(soil paste):		
Ca^{++}	**5.2**	**5.4**
Mg^{++}	**2.1**	**2.2**
K^{+}	**1.73**	**1.81**
Na^{+}	**11.58**	**12.49**
Soluble anions, meq.l^{-1}(soil paste):		
$CO3^{--}$	**-**	**-**
$HCO3^{--}$	**3.52**	**3.69**
Cl^{-}	**15.27**	**16.44**
$SO4^{--}$	**1.82**	**1.77**

The experimental soil was fertilized with phosphorus in form of calcium superphosphate (15.5% P_2O_5) at the rate of 50 kg P_2O_5 ha-1 before the land preparation. The experiment was performed in a randomized complete block design with four replications. Treatments were:

T1- 50 % NPK recommended.

T2 - 50 % NPK +2% spray with Urea.

T3 - 50 % NPK+ 3% spray with P_2O_5

T4- 50 % NPK+ 4% spray with K_2O.

T5 - 50 % NPK + mixture of (spray with 2% Urea + 3% P_2O_5 + 4% K_2O).

T6 - 75 % N recommended.

T7 - 75% NPK +2% spray with Urea.
T8 - 75% NPK +3% spray with P_2O_5.
T9 - 75% NPK+ 4% spray with K_2O.
T10 - 75% NPK+ mixture of (spray with 2% Urea + 3% P_2O_5 + 4% K_2O).
T11- 100% NPK recommended.

Foliar application treatments were applied during panicle initiation+ mid booting stages. Seeds at the rate of 140 kg ha^{-1} were soaked in water for 48 hr. then incubated for 24 hr to hasten early germination. Seeds were uniformly broadcasted in the nursery on 1st and 2nd May of the two seasons, respectively. Seedlings aged 30 days were carefully pulled from the nursery days old. Seedlings were manually transplanted into 10 m^2 (2 m length X 5 m wide) for each plot in 20 X 20 cm spacing apart at the rate of 2-3 seedlings/hill in ten rows. Seven days after planting, the herbicide Saturn 50% [S-(4-Chlorophenol methyl) diethyl carbamothioate] at the rate of 4.8 L $ha^{-1}$was mixed with enough sand to make it easy for homogenous distribution was applied evenly at a rate of 4.8 liters/ha, followed by flooding the soil for 2-3 weeks. Nitrogen fertilizer was added at a rate of 165 kg nitrogen/ha in the form of ammonium sulfate (20% nitrogen) in three equal doses 15, 30, and 45 days after planting. Soil application of potassium in the form of potassium sulphate (48% K_2O) at the recommended rate (60 kg K_2O ha^{-1}) was added in two equal doses at 30 and 45 days after transplanting. All other agronomic practices were followed as recommended package of rice under saline soil during the growing season. At heading stage, plants of five hills were randomly taken from each plot to estimate Heading date day^{-1}, flag leaf area in cm^2, leaf area index, and chlorophyll content. Flag leaf area and leaf area of plant samples were measured by using Portable Area Meter (Model LI– 3000A). Total chlorophyll content was determined in ten flag leaves according to Lichtenthaler and Buschmann (2001). At harvest, plant height (cm), tillers numbers $hill^{-1}$, panicle numbers $hill^{-1}$ were estimated. Ten panicles were collected randomly to estimate the panicle weight (g), panicle length (cm), number of filled grains and unfilled grains per panicle and 1000 -grain weight (g). The six inner rows of each plot were harvested, dried, threshed, and the grain and biological yields were determined based on the moisture content of 14%. The yield converted to grain yield in ton ha^{-1}.

Grain quality characters

About 150 grams of grains were taken from each treatment, mixed and sent to the grain quality laboratory of the RRTC to determine some of the grain quality characteristics according to Adair (1952), Duncan *et al* (1955), Juliano (1971) and Kush *et al* (1979).

1. Hulling percentage (%)

$$\textbf{Hulling\%} = \frac{\textbf{Weight of brown rice (g)}}{\textbf{Weight of rough rice (g)}} \times 100$$

2. Milling percentage (%)

The percentage of total milled rice was computed according to Kush *et al* (1979) as follows:

$$\textbf{Milling\%} = \frac{\textbf{Weight of milled rice (g)}}{\textbf{Weight of rough rice (g)}} \times 100$$

3. Head rice percentage (%)

$$\textbf{Head rice\%} = \frac{\textbf{Weight of whole milled rice (g)}}{\textbf{Weight of rough rice (g)}} \times 100$$

Amylose content: To 100 mg of flour sample was added 1 ml ethanol (95%) and 9 ml NaOH. The sample was heated for 10 min in boiling water bath to gelatinize starch. Sample was cooled and transferred to 100 ml volumetric flask. 5 ml of starch solution and 1 ml acetic acid were added. Two milliliters of iodine solution (0.2% of re-sublimed iodine in 2% potassium iodide) were added and volume made up to 100 ml. Flask was shaken and allowed to stand for 20 min. Percent transmittance was measured at 620 nm using an Ultra spec spectrophotometer (ultra spec Plus, model 4054, Pharmacia LICB Biochrom Ltd., England). Total amylose content of sample was determined from a previously calibrated standard amylose (Potato, Sigma) curve. The obtained data were subjected to analysis of variance according to Gomez and Gomez (1984). All statistical analyses were performed using analysis of variance technique by means of "COSTATC" computer software package.

RESULTS AND DISCUSSION

1-Growth parameters

Data in Tables 2 and 3 showed that flag leaf area (cm^2), leaf area index, net photosynthetic rate and heading date day^{-1} were significantly affected by foliar spraying with some chemical substances during panicle initiation+ mid booting stages in 2021and 2022 seasons.

Table 2. Effect of foliar spraying with some chemical substances under different NPK rates on flag leaf area in cm^2, leaf area index, and net photosynthetic rate of Sakha 108 rice variety in 2021 and 2022 seasons.

Treatments	Flag leaf area (cm^2)		Leaf area index (cm^2)		Net photosynthetic rate (mg /l)	
	2021	2022	2021	2022	2021	2022
T1-50% NPK recommended	14.58	14.58	2.86	2.71	17.5	17.7
T2-50% NPK + 2% spray with Urea	15.16	15.73	3.16	2.96f	18.8	19.1
T3-50% NPK + 3% spray with P_2O_5	15.78	15.11	3.01	2.73	17.9	18.3
T4-50% NPK + 4% spray with K_2O	15.41	15.48	3.15	2.82	18.3	18.8
T5-50% NPK + spray with 2% Urea + 3% P_2O_5+4% K_2O)	17.26	17.30	3.36	3.11	19.4	20.6
T6-75% NPK recommended	16.85	15.87	3.35	2.92	20.6	21.3
T7-75% NPK + 2% spray with Urea	18.77	19.07	3.64	3.35	22.2	22.7
T8-75% NPK +3% spray with P_2O_5	17.36	17.91	3.54	3.02	20.9	21.9
T9-75% NPK +4% spray with K_2O	18.03	18.18	3.59	3.26	21.7	22.3
T10 - 75% NPK + spray with 2% Urea + 3% P_2O_5 + 4% K_2O)	19.16	19.76	3.84	3.59	23.1	23.8
T11-100% NPK recommended	18.73	18.94	3.74	3.53	22.0	22.1
LSD 0.05	5.118	4.049	0.047	0.07	0.329	0.344

Table 3. Effect of foliar spraying with some chemical substances on heading date day^{-1}, plant height (cm) and number of tillers (hill) of sakha 108 rice variety in 2021 and 2022 seasons.

Treatments	Heading date day^{-1}		Plant height cm		Number of tillers hill^{-1}	
	2021	2022	2021	2022	2021	2022
T1-50% NPK recommended	90.3	88.7	82.20j	87.5j	14.63	15.03
T2-50% NPK + 2% spray with Urea	92.2	91.3	95.27 h	95.07 g	16.22	16.97
T3-50% NPK + 3% spray with P_2O_5	91.7	89.6	92.73 i	91.67I	15.90	15.37
T4-50% NPK + 4% spray with K_2O	92.1	90.3	93.67 h	93.37 h	15.73	16.02
T5-50% NPK + spray with 2% Urea + 3% P_2O_5+4% K_2O)	94.3	92.9	105.6 f	102.6 e	17.31	17.61
T6-75% NPK recommended	96.1	95.3	103.27g	98.13f	17.07	17.09
T7-75% NPK + 2% spray with Urea	98.3	97.9	112.83 c	111.43 c	18.84	19.16
T8-75% NPK +3% spray with P_2O_5	97.8	96.1	106.77e	102.93c	17.95	17.93
T9-75% NPK +4% spray with K_2O	98.1	97.6	109.4 d	104.3 d	18.19	18.52
T10 - 75% NPK + spray with 2% Urea + 3% P_2O_5 + 4% K_2O)	101.3	100.9	116.53 a	118.77a	19.99	20.01
T11-100% NPK recommended	99.9	99.7	114.0 b	115.27b	19.13	19.71
LSD 0.05	0.634	0.723	1.144	1.142	0.261	0.266

The tested chemical substances significantly improved the studied growth characteristics compared with control treatment. Foliar spraying with mixture of humic acid^{+} K significantly gave the highest values of flag leaf area (cm^2) and leaf area index (cm^2) without significant difference with the treatments of three application by nitrogen, phosphorus and potassium rates (50, 75 and 100%) under four foliar application with 2% Urea, 3% phosphoric acid and 4% potassium oxide during the study seasons meanwhile, foliar spray with DAP ranked the second order. The highest value of chlorophyll content was obtained by 75% NPK $^+$spray with 2% Urea+3% P_2O_5 + 4% K_2O) without statically differences with foliar spraying with 2% Urea+3% P_2O_5+4% K_2O) Moreover, no significant differences were recorded between foliar spraying with K and DAP, both of them came in the second order. As for heading date data in (Table3) indicated that foliar spray with 2% Urea+ 3% P_2O_5 + 4% K_2O significantly prolonged the days from sowing to heading without significant difference with foliar spray with mixture of 2% Urea+3% P_2O_5 + 4% K_2O under different NPK rates compared 100% NPK doses .

The second order was in favor of foliar spray with 2% Urea treatment without significant difference with SA^+ K treatment. The other treatments did not significantly differ with control in both seasons. When nutrients are applied to the leaves, the nutrient elements might penetrate into the leaves and restrict the inhibition due to the toxic effects of Na^+ and Cl^- or minimizes the salinity induced Flowers *et al* (2004). Humic acid has role as a plant growth stimulator through increasing cell division as well as optimized uptake of nutrients and water moreover, Humic acid stimulated the soil microorganisms or soil conditioner and has a positive effect on salt tolerance. These results are in agreement with those obtained by (Chan *et al* 2010), (Hayat *et al* 2010), (Kalil. *et al* 2013), (Osman *et al* 2013), Mohamed *et al* (2015) and (Okasha *et al* 2019). The beneficial influences of salicylic acid might be due to it is role as endogenous growth regulator of phenolic nature influences many physiological processes ion permeability photosynthesis and plant growth rate, salicylic acid also prevents the damaging action of various stress factors in many plant species (Afzal *et al* 2005), (Borsani *et al* 2001), (Chen *et al* 2005), (Manik *et al* 2016) and (Rafique *et al* 2011). Di-ammonium phosphate (DAP) or GA3 might be increase the nutrient content of leaves, biochemical compounds and energy compound such as ATP, increased some biochemical formation related to the growth process resulting in increasing cell division and elongation increasing mineral nutrients that play a critical role in plant stress resistance (Gavino *et al* 2008). Nitrogen is one of the most important plant nutrients and plays a vital role in plant photosynthesis and biomass production, nitrogen influences cell division and cell elongation (Laroo and Shivay 2011). As mentioned above, the substances which used in this study have a vital role inside the plant, all of this material work in harmony with the potassium which is absorbed by plant leaves under saline conditions. The improvement of studied growth characters might be due to the participation of potassium in mechanism of stomata movement, photosynthesis and osmo regulatory adaptation of plants to water stress in saline soil (Reyhaneh *et al* 2012 and Su *et al* 2018).

Yield attributes characteristics

Data in Tables 3, 4, 5 and 6 show that plant height , number of tillers per hill, number of panicle per hill, panicle weight , number of filled grains panicle^{-1}, number of unfilled grains panicles-1 and 1000-grain weight were affected by foliar spray with some substances in both seasons and panicle length in first season only. The tested chemical substances improved yield attributes compared with control (untreated treatment). The tallest plants were produced by foliar spray with humic acid $^{+}$K without statically differences with the treatments foliar spray of 2% Urea + 3% P_2O_5 + 4% K_2O. Moreover, foliar spray with DAP came in the second of order without significant differences with foliar spray of K and N+K mixture in the first season. In the second season, all tested chemical substance sprays were at the same level of_ significances with respect to plant height despite, all treatment, surpassed the control treatment (Table 3). The highest values of number of tillers hill^{-1} and number of panicle hill^{-1} panicle weight and panicle length was noticed by foliar application with 2% Urea +3%P_2O_5 + 4% K_2O without statically differences with foliar spray by 2% Urea, 3% P_2O_5 and 4% K_2O Tables (3, 4 and 5). DAP ranked the second for above-mentioned growth characters in the two seasons. Control treatment gave the lowest values of the studied growth characteristics in both seasons.

Table 4. Effect of foliar spraying with some chemical substances on number of panicles hill^{-1}, panicle weight (g) and panicles length (cm) of Sakha 108 rice variety in 2021 and 2022 seasons.

Treatments	Number of panicles (hil^{-1})		Panicle weight (g)		Panicles length (cm)	
	2021	2022	2021	2022	2021	2022
T1-50% NPK recommended	14.58	14.58	2.86	2.71	17.5	17.7
T2-50% NPK + 2% spray with Urea	15.16	15.73	3.16	2.96f	18.8	19.1
T3-50% NPK + 3% spray with P_2O_5	15.78	15.11	3.01	2.73	17.9	18.3
T4-50% NPK + 4% spray with K_2O	15.41	15.48	3.15	2.82	18.3	18.8
T5-50% NPK + spray with 2% Urea + 3% P_2O_5+4% K_2O)	17.26	17.30	3.36	3.11	19.4	20.6
T6-75% NPK recommended	16.85	15.87	3.35	2.92	20.6	21.3
T7-75% NPK + 2% spray with Urea	18.77	19.07	3.64	3.35	22.2	22.7
T8-75% NPK +3% spray with P_2O_5	17.36	17.91	3.54	3.02	20.9	21.9
T9-75% NPK +4% spray with K_2O	18.03	18.18	3.59	3.26	21.7	22.3
T10 - 75% NPK + spray with 2% Urea + 3% P_2O_5 + 4% K_2O)	19.16	19.76	3.84	3.59	23.1	23.8
T11-100% NPK recommended	18.73	18.94	3.74	3.53	22.0	22.1
LSD 0.05	5.118	4.049	0.047	0.07	0.329	0.344

Regarding to filled and unfilled grains panicle^{-1} data in Table 5 showed that foliar spray with some chemical substances had a positive impact on number of filled and unfilled grains panicle^{-1} compared with control treatment.

Table 5. Effect of foliar spraying with some substances on number of unfilled grains panicle^{-1}, number of filled grains panicle^{-1} and1000-grain weight (g) of Sakha 108 rice variety in 2021 and 2022 seasons.

Treatments	No unfilled grains		No of filled grains		1000-grain weight (g)	
	2021	2022	2021	2022	2021	2022
T1-50% NPK recommended	14.43	11.50	80.27	88.67	21.00	21.31
T2-50% NPK + 2% spray with Urea	10.13	10.83	89.24	107.10	22.17	23.20
T3-50% NPK + 3% spray with P_2O_5	11.40	10.73	87.20	101.93	22.77	21.70
T4-50% NPK + 4% spray with K_2O	8.86	9.47	93.93	106.90	22.73	24.20
T5-50% NPK + spray with 2% Urea + 3% P_2O_5+4% K_2O)	7.60	9.07	99.87	110.30	23.93	25.00
T6-75% NPK recommended	9.17	8.87	97.43	108.73	23.43	23.70
T7-75% NPK + 2% spray with Urea	5.87	7.70	115.10	115.67	25.77	26.20
T8-75% NPK +3% spray with P_2O_5	6.03	7.13	111.47	110.80	25.10	24.60
T9-75% NPK +4% spray with K_2O	6.33	6.13	116.07	116.73	26.57	27.00
T10 - 75% NPK + spray with 2% Urea + 3% P_2O_5 + 4% K_2O)	6.53	6.33	117.90	119.67	28.00	27.60
T11-100% NPK recommended	6.03	6.03	115.67	117.92	26.78	27.20
LSD 0.05	0.208	0.142	1.022	0.674	0.182	0.069

Foliar spray with mixture of 2% Urea + 3% P_2O_5 +4% K_2O significantly produced the greatest number of filled grains panicle^{-1} and the lowest value of unfilled grains panicle-1in both seasons without significant difference with the treatments of (2% Urea), (3% P_2O_5), and (4% K_2O). While DAP ranked the second order in the first season only. On the other side, potassium foliar spray ranked the second order in the second season followed by foliar spraying with 2% Urea + 3% P_2O_5 + 4% K_2O and DAP. Foliar spraying with 2% Urea significantly decreased number of unfilled grains panicle^{-1} as compared with control treatment which gave the highest number of unfilled grains panicle^{-1} during the two seasons (Table5). Data in Table 6 clarified that 1000-grain weight significantly improved with foliar spray using some chemical substances in both seasons as compared to control treatment. Foliar spraying with 2% Urea+ 4% K_2O significantly produced the heaviest 1000-grain weight in both seasons, without significant difference with the treatments of 2% Urea+ 3% P_2O_5 + 4% K_2O in both seasons and DAP in the first season only but, in the second season DAP ranked the second order. On the other hand, control treatment significantly produced the lightest 1000-grain weight in both seasons.

Table 6. Effect of foliar spraying with some substances on grain yield t ha-1 ,biological yield t ha-1 and Harvest index (%)of Sakha 108 rice variety during 2021 and 2022 seasons.

Treatments	Grain yield (t/ha)		Biological yield (t/ha)		Harvest index (%)	
	2021	2022	2021	2022	2021	2022
T1-50% NPK recommended	7.658	7.729	16.13	15.508	47.47	49.84
T2-50% NPK + 2% spray with Urea	8.469	8.239	17.675	16.927	47.92	48.67
T3-50% NPK + 3% spray with P_2O_5	7.971	7.996	16.613	16.325	47.98	48.98
T4-50% NPK + 4% spray with K_2O	8.172	8.476	17.169	17.067	47.60	49.66
T5-50% NPK + spray with 2% Urea + 3% P_2O_5+4% K_2O)	8.887	8.843	18.528	17.827	47.97	49.60
T6-75% NPK recommended	8.673	9.154	18.994	18.333	45.66	49.93
T7-75% NPK + 2% spray with Urea	10.082	9.518	20.914	19.746	48.21	48.20
T8-75% NPK +3% spray with P_2O_5	9.509	9.476	19.586	18.954	48.55	49.99
T9-75% NPK +4% spray with K_2O	9.615	8.601	20.537	18.323	46.82	46.99
T10 - 75% NPK + spray with 2% Urea + 3% P_2O_5 + 4% K_2O)	10.299	10.381	21.571	21.37	47.74	48.58
T11-100% NPK recommended	9.853	9.974	20.824	20.501	47.32	48.65
LSD 0.05	0.154	0.142	0.304	0.305	0.192	0.190

Yield

Data documented in Table 6 clarified that foliar spraying with some chemical substances had a positive impact on grain yield, but it did not affect the biological yield in the two study seasons. Chemical substances foliar application during panicle initiation+ mid booting stages resulted in higher yield as compared with control treatment. The highest value of grain yield was produced by foliar spray with 2% Urea + 3% P_2O_5 + 4% K_2O without a significant difference of (2% Urea + 3% P_2O_5 + 4% K_2O). The second rank was in favor foliar spray with DAP in both seasons. (Chan *et al* 2010) and (Shrestha *et al* 2020) demonstrated that spraying nitro- 2% Urea + 3% P2O5 + 4% K2O at the rate of 6 litters/ha at 10% days of flowering and 10 days later significantly increased rice grain yield owing to increased panicle weight, 1000 -grain weight, filled grains/panicle and reducing sterility%. The increase in grain yield with foliar application of 2% Urea + 3% P_2O_5 + 4% K_2O may be due considerable increase in early growth, which reflected on higher grain yield attributes (number of panicles hill^{-1}, panicle weight, number of filled grains panicle^{-1} and 1000-grain weight) and in turn increased grain yield. These results are confirmed with the findings of El- Ekhtyar *et al* (2014), Mohmed *et al* (2015), Zayed *et al* (2016) and Su. *et al* (2018).

Grains quality characters

Data related to hulling%, Milling%, head rice%, amylose and gelatinization of sakha108 rice variety as affected by foliar spray with some chemical substances at various growth stages in 2021and 2022 seasons are presented in Tables 7 and 8. The superiority for the treatment of increase in early growth, the mixture was clear in all studied grains quality criteria and ameliorated the harmful effect of salinity by increasing the grains quality as compared with control treatment in the two seasons. The highest value of hulling% was noticed by foliar spraying with (2% Urea + 3% P_2O_5 + 4% K_2O) without significant difference with the mixture of N + K in all grain quality but with GA3+K and K alone I some grain quality.

Table 7. Effect of foliar spraying with some substances on hulling%, milling% and head rice% of Sakha 108 rice variety during 2021 and 2022 seasons.

Treatments	Head rice%		Milling%		Hulling%	
	2021	2022	2021	2022	2021	2022
T1-50% NPK recommended	73.68	65.72	67.4	66.4	81.74	79.88
T2-50% NPK + 2% spray with Urea	73.72	67.91	68.4	67.2	82.06	80.73
T3-50% NPK + 3% spray with P_2O_5	74.07	68.31	69.4	67.9	82.15	81.51
T4-50% NPK + 4% spray with K_2O	74.91	69.22	69.8	68.2	82.77	82.73
T5-50% NPK + spray with 2% Urea + 3% P_2O_5+4% K_2O)	75.84	70.29	70.1	68.8	83.09	82.85
T6-75% NPK recommended	76.29	71.58	70.9	69.4	83.71	83.01
T7-75% NPK + 2% spray with Urea	76.92	73.01	71.9	69.9	84.69	83.77
T8-75% NPK +3% spray with P_2O_5	77.59	73.46	71.9	70.3	84.73	84.91
T9-75% NPK +4% spray with K_2O	78.11	74.28	72.9	71.8	85.07	84.97
T10 - 75% NPK + spray with 2% Urea + 3% P_2O_5 + 4% K_2O)	79.73	76.91	74.8	74.5	85.41	85.91
T11-100% NPK recommended	78.29	75.81	73.9	72.9	85.22	85.37
LSD 0.05	1.853	1.428	2.01	2.15	2.011	1.867

The treatments of N + K mixture did not appear any significant difference with (2% Urea + 3% P_2O_5 + 4% K_2O) in increasing milling% and head rice% during the two seasons. The highest values of amylose content were produced by (2% Urea + 3% P_2O_5 + 4% K_2O) without significant difference with the treatments of (Urea + P_2O_5 + K_2O), while the rest treatments ranked the second order without significant differences among them in both study seasons. Applying chemical substances showed significant improvement in rice growth and rice grains quality as it is detected particularly Urea plus potassium showed high significant positive effect in improving both growth and grains quality characteristics. Of rice especially reducing rice broken%.

Table 8. Effect of foliar spraying of some substances on amylose% and gelatinization% of Sakha 108 rice variety during 2021 and 2022 seasons.

Treatments	Amylose%		Gelatinization%	
	2021	2022	2021	2022
T1-50% NPK recommended	15.39	15.74	3.27	3.45
T2-50% NPK + 2% spray with Urea	16.22	16.44	3.59	3.84
T3-50% NPK + 3% spray with P_2O_5	15.86	15.93	3.33	3.69
T4-50% NPK + 4% spray with K_2O	16.07	16.19	3.4	3.75
T5-50% NPK + spray with 2% Urea + 3% P_2O_5+4% K_2O)	16.95	16.96	3.89	4.08
T6-75% NPK recommended	16.53	17.14	3.75	3.91
T7-75% NPK + 2% spray with Urea	17.66	17.95	4.36	4.52
T8-75% NPK +3% spray with P_2O_5	17.24	17.47	4.09	4.33
T9-75% NPK +4% spray with K_2O	17.46	17.69	4.26	4.39
T10 - 75% NPK + spray with 2% Urea + 3% P_2O_5 + 4% K_2O)	18.04	18.25	4.55	4.62
T11-100% NPK recommended	17.87	17.91	4.42	4.57
LSD 0.05	0.151	0.149	0.079	0.069

The beneficial impact of those substances including (2% Urea + 3% P_2O_5 + 4% K_2O)might be attributed to its positive effect on improving rice growth salt tolerance, rising pre-heading and current heading photosynthesis as well as net assimilation rate and its translocation to rice grain. Furthermore, improving the net assimilation rate and its translocation enhanced grain filling and starch cell of endosperm showed significant improvement in rice grain quality, particularly reducing broken rice%. High net assimilation rate, more carbohydrate translocation from current photosynthesis and pre-heading photosynthesis, the highest starch and full filling of starch cell lead more head rice grain with less broken ones, because less chalkiness% that hold true with current investigation. Above all, the adding such chemical substances at late growth stages of rice in the terms of mid booting stage. Delaying early aging and prolonging active filling period resulted in apparent improvement of grain filling reflected on very grain quality. As for, increase in early growth, without significant difference with N + K and K alone produced the highest value of gelatinization in the second season, but in the first season the chemical substances did not differ with control. Under stress conditions, plants produced grains containing aberrant starch, along with small granules and decreased levels of amylose and amylopectin, imitating a related phenotype. Globally, rice with intermediate amylose content is mostly preferred. Most importantly, the synthesis of storage carbohydrates, minerals, oils, and proteins during grain filling contribute to the nutritional value of rice. The abiotic stresses affect both rice production and quality. During the grains-filling stage, stress generates a deleterious influence on starch quality (Yamakawa *et al* 2007). The mixture of (2% Urea + 3% P_2O_5 + 4% K_2O) and/ or mixture of N + K could be recommended for improving rice quality and productivity of sakha109 under different NPK rates. Nitrogen and potassium uptakes (kg ha^{-1}) by rice yield grains at harvest were presented in table 9 NPK nutrients had significant effects on N and K uptake. Application of (123.75 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 kg N ha^{-1} + 2% N as a spray twice T9), recommended dose (165 kg N ha^{-1} T10) and (123.75 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. The increase in NPK concentration with foliar application of NPK at different growth stages could be attributed also to reducing losses of nutrients and enhancing fertilizer use efficiency. A similar trend was found by Jagathjothi *et al* (2012), Pan *et al* (2013), Herve *et al* (2017), Hashem (2019) and Metwally *et al* (2020). 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 a benefit-cost ratio.

Table 9. Effect of foliar spraying of some substances on Total photosynthetic pigments (mg/l), N%, P% and K% on flag leaf sakha 108 rice variety during 2021 and 2022 seasons.

Treatments	Total photosynthetic pigments (mg/l)		N% in flag leaf		P% in flag leaf		K% in flag leaf	
	2021	2022	2021	2022	2021	2022	2021	2022
T1-50% NPK recommended	8.807	9.354	1.287	1.301	0.375	0.379	2.313	.355
T2-50% NPK + 2% spray with Urea	9.382	9.586	1.463	1.492	0.321	0.328	2.332	2.378
T3-50% NPK + 3% spray with P_2O_5	9.113	9.363	1.329	1.466	0.384	0.424	2.336	2.577
T4-50% NPK + 4% spray with K_2O	9.474	9.658	1.349	1.368	0.334	0.338	2.421	2.455
T5-50% NPK + spray with 2% Urea + 3% P_2O_5+4% K_2O)	9.846	9.814	1.494	1.517	0.392	0.399	2.481	2.521
T6-75% NPK recommended	10.033	9.927	1.462	1.619	0.393	0.436	2.394	2.650
T7-75% NPK + 2% spray with Urea	10.302	10.076	1.658	1.832	0.366	0.404	2.421	2.656
T8-75% NPK +3% spray with P_2O_5	10.539	10.256	1.524	1.690	0.404	0.447	2.418	2.681
T9-75% NPK +4% spray with K_2O	10.667	10.329	1.545	1.715	0.380	0.422	2.536	2.514
T10 - 75% NPK + spray with 2% Urea + 3% P_2O_5 + 4% K_2O)	10.969	10.391	1.730	1.928	0.395	0.441	2.505	2.790
T11-100% NPK recommended	11.233	10.815	1.741	1.937	0.401	0.446	2.525	2.811
LSD at 0.05	2.351	2.659	0.016	0.018	0.028	0.032	0.079	0.084

CONCLUSION

Foliar application of NPK or N may cause a significant increase in rice productivity as well as increase of the benefit-cost ratio. 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 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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إمكانية زيادة نمو وإنتاجية الأرز عن طريق الإضافة الورقيه لسماد الـــ NBK الورقي.

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قسم بحوث الأرز، معهد بحوث المحاصيل الحقلية ، مركز البحوث الزراعية.

أجريت هذه الدراسة خلال موسمي ٢٠٢١ و ٢٠٢٢ في المزرعة البحثية التابعة لمركز البحوث والتدريب في الأرز بمحطة البحوث الزراعية بسخا محافظة كفر الشيخ. كان الهدف الرئيسي من الدراسة هو تحديد تأثير الرش الورقي ببعض الأسمدة بواسطة NPK والاستخدام الورقي (NPK ٢٪ Urea و ٣٪ P2O5 و ٤٪ K2O5) أثناء النمو الخضرى عند أعمار ٢٥ و ٣٥ يوم من الشتل على نمو الأرز والمحصول وصفات المحصول وخصائص جودة الحبوب فى صنف الأرز سخا ١٠٨ و تم إجراء التصميم التجريبي بتصميم القطاعات الكاملة العشوائية بأربعة مكررات. كانت معاملات الرش الورقية (٢٪ يوريا ، ٣٪ P_2O_5 و ٤٪ K_2O5) موصى بها بثلاث معدلات منNPK ٥٠% و ٧٥٪ و ١٠٠% وكانت الصفات التى تم دراستها صفات نمو النبات (طول النبات وعدد الفروع ومساحة ورقة العلم ومساحة الاوراق الكليه للنبات ومعدل التمثيل الضوئى وموعدالتزهير) والمحصول ومكوناته وخصائص جودة الحبوب (عددالسنابل/م٢ ووزن السنبله وعددالحبوب الممتلئه والفارغه بالسنبله ووزن الالف حبه ومحصول الحبوب والقش والنسبه المؤيه لكل من التقشير والتبييض والاميلوز) وأوضحت النتائج أن المعاملات المختلفة للتسميد أدت إلى اختلافات معنوية لمعظم صفات النمو والمحصول ومكوناته موضع الدراسة في جميع مراحل النمو المختلفة حيث أدت المواد المختبرة إلى تحسن معنوي في الصفات المدروسة وجودة حبوب الأرز والمحصول ومساهمات المحصول مقارنة بمعاملة الكنترول.وكان التسميد بنسبة ٧٥٪ NPK الموصى به مع الرش الورقي بمزيج من ٢٪ Urea + ٣٪P_2O_5 + ٤٪K_2O5 عند مرحلة تكوين الداليات + مراحل الحبلان كان بشكل ملحوظ هو العلاج الأكثر كفاءة في تحسين جودة حبوب الأرز والنمو والإنتاجية دون اختلاف معنوي مع خليط NPK فيما يتعلق بتحسين جودة حبوب الأرز. وعلى هذا يمكن التوصية بخليط من ٢٪ Urea + ٣٪P_2O_5 + ٤% K_2O5 من NPK ٥٠% و ٧٥٪ لتحسين جودة وإنتاجية الأرز في سخا ١٠٨ تحت ظروف شمال الدلتا.

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