J. of Plant Production, Mansoura Univ., Vol. 16 (11):663 - 667, 2025

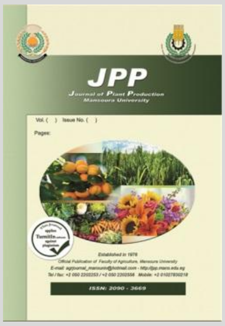
Journal of Plant Production

Journal homepage & Available online at: www.jpp.journals.ekb.eg

Synergistic Effects of Nitrogen Fertilization and Plant Growth Regulators on Rice Productivity and Nutrient Uptake under Soil Conditions of the Nile Delta Conditions

Hashem, I. M.; A. S. Gharieb* and Hasnaa A. Ghazy

Rice Research and Training Center, Field Crops Research Institute, Agricultural Research Center, 33717, Kafr El-Sheikh, Egypt.



Article Information
Received 8 / 10 / 2025
Accepted 5 / 11 / 2025

ABSTRACT

The integration of nitrogen fertilization strategies with plant growth regulators (PGRs) offers a robust framework for enhancing rice productivity under intensifying climatic changes. This study examined the combined effects of five nitrogen application rates (0, 40, 80, 120, and 160 kg N/ha) and four PGR treatments (control, cycocel, brassinosteroids BRs, and cytokinin) on the Sakha 108 rice variety over two seasons (2022 and 2023) at the Experimental Farm of Sakha Agricultural Research Station, Sakha, KafrelSheikh, Egypt. A split-plot design with four replications was employed. The nitrogen rates were applied to the main plots, while the plant growth regulator (PGR) treatments were assigned to the subplots. The study evaluated grain yield and its components, as well as nutrient uptake parameters. Results indicated that the highest nitrogen rate, combined with BRs, achieved remarkable grain yields of 13.45 t/ha and 13.68 t/ha in both seasons, respectively. BRs consistently enhanced key agronomic traits compared to other PGRs, confirming their capacity to optimize nitrogen, phosphorus, and potassium use efficiency and to mitigate trade-offs between yield components. These findings underline the potential of integrating PGRs with optimized nitrogen management as a sustainable intensification strategy for rice production under the same experimental conditions.

Keywords: Rice, nitrogen, plant growth regulators

INTRODUCTION

Rice (*Oryza sativa* L.) is a vital global crop, particularly in Egypt, where it sustains food security and rural economies within the Nile Delta. Climate change introduces abiotic stressors such as drought, salinity, and heat that threaten yield stability, necessitating adaptive agricultural strategies. Nitrogen is an essential macronutrient that plays a vital role in the physiological growth and productivity of rice. It promotes chlorophyll synthesis, enhances photosynthetic efficiency, and stimulates tillering and panicle development, leading to higher grain yield. Adequate nitrogen availability also improves nutrient uptake and grain filling by facilitating the translocation of photosynthates to the developing grains. However, its positive effects can be further enhanced through the complementary use of plant growth regulators (PGRs), which optimize physiological processes and improve nutrient use efficiency (Yoshida, 1981). These organic compounds, applied in trace amounts, regulate physiological and biochemical processes, enhancing plant vigor and resilience (Taiz and Zeiger, 2010). Over decades, PGRs such as auxins, gibberellins, cytokinins, abscisic acid, and ethylene have improved germination, photosynthetic capacity, and stress tolerance in rice (Najafi *et al.,* 2019). More recently, brassinosteroids (BRs), jasmonates, and salicylic acid have broadened this arsenal, offering precise control over developmental pathways.

Cycocel, by inhibiting gibberellin biosynthesis, limits stem elongation and redirects resources to reproductive growth, a trait valuable under environmental stress (Pirasteh Anosheh *et al.,* 2016). BRs enhance cell division, photosynthesis, and nutrient uptake, positioning them as potent yield amplifiers (Bajguz and Hayat, 2009). Cytokinins, meanwhile, delay senescence and bolster sink strength, complementing these effects (Sakakibara, 2006). This study focuses on the Sakha 108 rice variety, a regionally adapted cultivar, under varying nitrogen and PGR regimes. Conducted across 2022 and 2023, the research seeks to identify optimal treatment synergies, delivering an in-depth analysis of yield attributes and nutrient dynamics to guide sustainable rice farming in Egypt.

MATERIALS AND METHODS

The experiment was conducted at the Experimental Farm of Sakha Agricultural Research Station, Sakha, Kafr El-Sheikh, Egypt, located at 31.096° N, 30.929° E, during the 2022 and 2023 rice growing seasons. The mechanical and chemical properties of the experimental site soil were presented in Table (1).

A split-plot design with four replications was used to ensure statistical reliability. The main plot factor comprised five nitrogen levels, namely, 0, 40, 80, 120, and 160 kg N/ha in the form of Urea (46 % N), which was applied in two splits (2/3 as basal and 1/3 top dressing panicle initiation), a standard nitrogen source in rice cultivation. Sub-plots were allocated to four PGR treatments: a control (distilled water, 0 ppm), cycocel (300 ppm), brassinosteroids BRs (400 ppm), and cytokinin (30 ppm). These PGRs were delivered via foliar sprays at two pivotal stages, mid-tillering and late-booting to align with peak physiological activity.

* **Corresponding author.**
E-mail address: Abdelfatah_sobhy@yahoo.com
DOI: 10.21608/jpp.2025.419432.1504

Table 1. The mechanical and chemical analyses of the experimental soil before planting in the 2022 and 2023 summer seasons.

Soil properties	2022	2023
Mechanical:		
Clay %	55.5	55.0
Silt %	31.0	31.5
Sand %	12.1	12.3
Texture	Clayey	Clayey
Chemical:		
Organic Matter (O.M)%	1.41	1.50
pH(1:2.5 soil suspension)	8.26	8.10
Ec (ds.m^{-1})	1.53	1.36
Total N (ppm)	420.0	500.0
Available P (ppm)	7.0	10.0
Available K (ppm)	240	290
Available ammonium (ppm)	15.0	17.0
Nitrate concentration (ppm)	12.0	13.0
Soluble anions, meq.L^{-1} :		
$CO^{=}_3$	--	--
HCO^{-}_3	6.00	5.45
Cl^{-}	8.00	10.40
$SO^{=}_4$	17.86	19.05
Soluble Cations, meq.L^{-1} :		
Ca^{++}	10.10	11.40
Mg^{++}	5.10	6.30
Na^{++}	1.66	2.20
K^{+}	15.00	15.00

All plots, with an area of 12 m^2 (3 x 4 m), were each, were hosting manual transplantation of 25 day old Sakha 108 seedlings on 25 and 28 of May in the two successive seasons. A consistent 20 x 20 cm spacing was maintained, with four seedlings per hill to optimize resource allocation. Irrigation sustained a 5 cm water until two weeks before harvest, replicating traditional flooded rice conditions. Data encompassed grain yield attributes i.e. filled grains percentage, 1000-grain weight (g), panicle weight (g), panicle number per m², panicle length (cm) and grain yield (t/ha). Also, nutrient uptake (nitrogen, phosphorus, and potassium in kg/ha) were measured according to Jones and Case (1990). Nitrogen content was in paddy rice determined according to the standard micro – Kjeldahl method. The phosphorus content of paddy rice was determined using Double-Beam Spectrophotometer Specification (Hitachi High-Technologies Corporation, Japan). The grain's potassium content was measured with Elico CL 378 Flame Photometer (RHYS International LTD, India).

Statistical significance was assessed using the Least Significant Difference (LSD) test at a 5% probability level, ensuring precise differentiation of treatment effects (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Yield Components: Nitrogen and PGR Contributions

Nitrogen fertilization profoundly shaped the reproductive success of Sakha 108 across both seasons. At 160 kg N/ha, the filled grains percentage climbed to 92.31 and 92.36%, a substantial leap from 87.05 and 87.20% at 0 kg N/ha, as evidenced by the data (Table 2). This rise underscores nitrogen's role in enhancing floret fertility and carbohydrate supply, a foundational principle in rice agronomy (Yoshida, 1981). In contrast, 1000-grain weight declined from 27.57 to 24.79 g in 2022 and from 27.77 to 24.86 g in 2023 with increasing nitrogen rates (Table 2), reflecting a trade-off where greater panicle density dilutes individual grain mass (Fageria, 2007). Panicle weight, however, surged from 2.55 to 3.91 g in 2022 and from 2.67 to 3.94 g in 2023 (Table 2), highlighting nitrogen's enhancement of reproductive biomass.

Table 2. Filled grains percentage, 1000-grain weight (g), and panicle weight (g) as influenced by the studied two main factors.

Treatment	Filled grains %		1000-grain weight (g)		Panicle weight (g)	
	2022	2023	2022	2023	2022	2023
Kg N/ha						
0	87.05	87.20	27.50	27.72	2.55	2.67
40	88.32	88.37	26.83	27.04	2.70	2.72
80	90.12	90.18	26.33	26.38	3.27	3.30
120	91.43	91.51	25.73	25.81	3.75	3.78
160	92.31	92.36	24.79	24.86	3.91	3.94
LSD 0.05	0.33	0.27	0.13	0.11	0.10	0.06
PGRs						
Control	88.64	88.71	25.56	25.67	3.0	3.04
Cycocel	88.75	88.87	25.56	25.62	3.16	3.20
BRs	91.51	91.57	27.57	27.77	3.45	3.49
Cytokine	90.49	90.54	26.24	26.40	3.34	3.40
LSD 0.05	0.26	0.25	0.12	0.12	0.09	0.03

PGRs refined these dynamics further. BRs elevated filled grains percentage to 91.51% in 2022 and 91.57% in 2023, outpacing cytokinin (90.49 and 90.54%) and cycocel (88.75 and 88.87%), with the control trailing at 88.64% and 88.71% (Table 2). BRs also sustained a robust 1000-grain weight of 27.57 g in 2022, compared to 25.56 g for both control and cycocel, while panicle weight peaked at 3.45 g versus 3.0 g in the control (Table 2). These gains align with BRs' enhancement of photosynthetic capacity and assimilate allocation, as noted in prior studies (Bajguz and Hayat, 2009).

Synergistic Effects on Yield Components

The interplay of nitrogen and PGRs revealed striking synergies. At 160 kg N/ha, BRs boosted filled grains percentage to 95.43 in 2022 and 95.55% in 2023, far exceeding the control's 90.23 and 90.32% at the same nitrogen level (Table 3).

Table 3. Filled grains percentage, 1000-grain weight (g), and panicle weight (g) as influenced by the interaction between the studied two factors.

Kg N/ha	PGRs	Filled grains %		1000-grain weight (g)		Panicle weight(g)	
		2022	2023	2022	2023	2022	2023
0	Control	86.90	87.00	26.77	26.88	2.45	2.53
	Cycocel	86.77	87.10	26.90	26.90	2.53	2.60
	BRs	87.57	87.63	29.27	29.97	2.63	2.78
	Cytokine	86.97	87.07	27.07	27.15	2.60	2.78
40	Control	88.13	88.17	26.27	26.42	2.60	2.64
	Cycocel	88.17	88.22	26.03	26.10	2.68	2.68
	BRs	88.60	88.65	28.13	28.20	2.80	2.81
	Cytokine	88.37	88.43	26.90	27.44	2.72	2.75
80	Control	88.80	88.85	25.60	25.67	2.88	2.90
	Cycocel	89.02	89.10	25.73	25.73	3.13	3.16
	BRs	91.73	91.77	27.53	27.60	3.56	3.60
	Cytokine	90.93	90.98	26.43	26.53	3.50	3.53
120	Control	89.13	89.22	25.13	25.20	3.35	3.38
	Cycocel	89.60	89.67	25.03	25.20	3.65	3.68
	BRs	94.20	94.27	26.90	26.95	4.11	4.13
	Cytokine	92.80	92.88	25.83	25.88	3.91	3.93
160	Control	90.23	90.32	24.03	24.17	3.73	3.75
	Cycocel	90.20	90.25	24.12	24.15	3.83	3.86
	BRs	95.43	95.55	26.03	26.13	4.12	4.13
	Cytokine	93.37	93.33	24.97	25.00	3.96	4.00
LSD 0.05		0.57	0.53	0.26	0.25	0.19	0.08

These results unequivocally highlight BRs unparalleled capacity to maximize nitrogen yield potential a finding consistent with recent global research demonstrating BRs' roles in enhancing crop productivity by under both optimal and stress conditions (Zhu *et al.,* 2015; Khan *et al.,* 2023 and wang *et al.,* 2024). Panicle weight under this combination reached 4.12 g in 2022 and 4.13 g in 2023 (Table 3), reflecting a significant increase in reproductive sink capacity. Notably, 1000-grain weight stabilized at 26.03 and 26.13 g (Table 3), mitigating the reductions observed with nitrogen alone. This balance suggests BRs counteract the dilution effect, optimizing grain size amidst higher panicle counts (Divya *et al.,* 2015).

Panicle Development and Yield Performance

Nitrogen's influence extended to panicle proliferation and overall yield. Panicle numbers rose from 218.8 per m² at 0 kg N/ha to 608.3 at 160 kg N/ha in 2022, and from 266.7 to 639.6 in 2023, driving grain yield from 5.47 to 11.89 t/ha in 2022 and from 5.61to 12.27 t/ha in 2023 (Table 4). Panicle length increased from 14.40 to 21.88 cm in 2022 (Table 4), enhancing spikelet potential. Affirming nitrogen's role in vegetative and reproductive growth (Fageria, 2007).

BRs amplified these outcomes, yielding 470.0 panicles per m² in 2022 and 521.7 in 2023, compared to the control's 358.3 and 400.0 (Table 4). Grain yield under BRs averaged 10.02 t/ha in 2022, surpassing cycocel (8.58 t/ha) and cytokinin (8.95 t/ha) (Table 4). The combination of 160 kg N/ha with BRs produced an exceptional 13.45 t/ha in 2022 and 13.68 t/ha in 2023 (Table 5). These results highlight BRs' capacity to maximize nitrogen's yield potential, consistent with global research (Zhu *et al*., 2015). The results of this study clearly demonstrate the applying brassinosteroids (BRS) in combination with nitrogen rate (120KgN/ha) achieved higher rice yields compared to using the full nitrogen rate (160Kg N/ ha) without any plant growth regulators. Specifically, the grain yield under 120 Kg N/ha plus BRs reached 13.49 t/ha, while the yield under 160 Kg N/ha alone was limited to 11.22 t/ha. This represents a yield increase of approximately 20% despite a 25% reduction in nitrogen application. From on agronomic and environmental perspective, this findings in highly significant.

Table 4. Number of panicle per meter square, panicle length (cm), grain yield (t/ha) and biological yield (t/ha) as influenced by the studied two main factors.

Treatment	Panicle No/m2		Panicle Length (cm)		Grain yield (t/ha)	
	2022	2023	2022	2023	2022	2023
Kg N/ha						
0	218.8	266.7	14.40	14.32	5.47	5.61
40	302.1	339.6	15.68	15.90	7.22	7.34
80	395.8	458.3	18.35	18.46	8.92	8.98
120	543.7	585.4	20.45	20.51	11.08	11.16
160	608.3	639.6	21.88	21.95	11.89	12.27
LSD 0.05	37.7	19.7	0.27	0.18	0.57	0.31
PGRs						
Control	358.3	400.0	17.38	17.45	8.11	8.25
Cycocel	398.3	445.0	17.79	17.87	8.58	8.78
BRs	470.0	521.7	19.05	19.11	10.02	10.05
Cytokine	428.3	465.0	18.37	18.49	8.95	9.20
LSD 0.05	16.3	12.4	0.23	0.11	0.42	0.39

Reducing nitrogen input decrease the risk of nitrate leaching and ground water. Contamination mitigating adverse environmental inpacts commonly associated with excessive nitrogen fertilization (Peng *et al.,* 2008 and Ladha *et al.,* 2016). Economically, lowering fertilizer costs while simultaneously achieving higher yields improves farmers profitability and reduces impute dependency. This strategy not only offers an immediate economic benefit but also supports long term soil health and productivity ensuring the sustainability of rice farming system.

Table 5. number of panicle per meter square, panicle length (cm) and grain yield (t/ha) as influenced by the interaction between the studied two factors.

Kg N/ha	PGRs	Panicle No/m2		Panicle Length (cm)		Grain yield (t/ha)	
		2022	2023	2022	2023	2022	2023
0	Control	183.3	216.7	14.07	13.88	5.27	5.42
	Cycocel	225.0	266.7	14.37	14.20	5.29	5.47
	BRs	250.0	300.0	14.83	14.57	5.65	5.76
	Cytokine	216.7	283.3	14.33	14.63	5.69	5.78
40	Control	283.3	316.7	15.20	15.37	6.93	6.98
	Cycocel	300.0	341.7	15.27	15.52	6.90	7.11
	BRs	325.0	383.3	16.17	16.48	7.91	8.04
	Cytokine	300.0	316.7	16.07	16.22	7.14	7.24
80	Control	350.0	408.3	17.33	17.33	7.85	7.77
	Cycocel	391.7	458.3	18.13	18.28	8.69	8.81
	BRs	425.0	500.0	19.27	19.35	9.64	9.76
	Cytokine	416.7	466.7	18.67	18.90	9.52	9.60
120	Control	441.7	483.3	19.03	19.23	9.52	9.89
	Cycocel	475.0	541.7	19.87	19.87	10.47	10.71
	BRs	691.7	700.0	22.50	22.50	13.49	13.03
	Cytokine	566.7	616.7	20.40	20.43	10.83	11.01
160	Control	533.3	575.0	21.27	21.42	10.99	11.22
	Cycocel	600.0	616.7	21.33	21.48	11.54	11.80
	BRs	658.3	725.0	22.50	22.63	13.45	13.68
	Cytokine	641.7	641.7	22.40	22.27	11.58	12.38
LSD 0.05		46.5	29.5	0.50	0.26	0.95	0.80

Nutrient Uptake Patterns

Nutrient assimilation responded dynamically to nitrogen inputs. Nitrogen uptake escalated from 26.928 kg/ha at 0 kg N/ha to 55.134 kg/ha at 160 kg N/ha in 2022, paralleled by phosphorus uptake (6.525 to 12.211 kg/ha) and potassium uptake (16.641 to 23.733 kg/ha) (Table 6). This progression reflects heightened root activity and metabolic demand under elevated nitrogen regimes (Marschner, 2012). BRs optimized uptake further, achieving 45.751 kg/ha of nitrogen in two seasons, compared to 39.717 kg/ha for cycocel and 37.454 kg/ha for the control (Table 6). Phosphorus and potassium uptake followed suit, with BRs facilitating 9.628 and 21.569 kg/ha, respectively (Table 6). BRs could depend on BRs ability to lower the pH in the wall space by stimulating electrogenic pH extrusion. Dahse *et al.,* (1990) furthen investigated the effects of steroids on membrane potential and found evidence strongly suggesting BRs stimulated the electrogenic pump. Brs are crucial plant hormones that significantly influence nutrient uptake and homeostasis in plant (Usamani, 2025). The increase in nitrogen uptake with the combination of nitrogen with BRs maybe due to the increase in the expression of nitrogen uptake related genes and enzyme activates (Yang *et al*., 2024).

Table 6. Nitrogen, phosphorus and potassium (kg/ha) as influenced by the studied two main factors.

Treatment	N uptake (kg/ha)		P uptake (kg/ha)		K uptake (kg/ha)	
	2022	2023	2022	2023	2022	2023
Kg N/ha						
0	26.928	27.133	6.525	6.765	16.641	16.892
40	34.159	34.525	7.647	7.895	18.467	18.524
80	39.788	39.995	8.767	8.937	20.675	20.812
120	51.225	51.463	10.029	10.337	22.097	22.025
160	55.134	55.682	12.211	12.529	23.733	23.937
LSD 0.05	0.664	0.765	0.160	0.183	0.159	0.132
PGRs	37.454	37.800	8.569	8.839	19.319	19.433
Cycocel	39.717	39.965	8.915	9.073	19.926	20.149
BRs	45.751	46.069	9.628	9.908	21.569	21.653
Cytokine	42.866	43.203	9.031	9.349	20.477	20.516
LSD 0.05	0.307	0.348	0.099	0.149	0.225	0.231

The apex of nutrient efficiency occurred at 160 kg N/ha with BRs, where nitrogen uptake reached to 61.000 and 61.600 kg/ha, alongside phosphorus (13.500 and 14.100 kg/ha) and potassium (25.767 and 25.933 kg/ha), in both seasons, respectively (Table 7). This synergy underscores BRs' enhancement of nutrient transport and utilization, aligning with findings by Farooq *et al*. (2015).

Table 7. Nitrogen, phosphorus and potassium (kg/ha) as influenced by the studied two main factors.

Kg N/ha	PGRs	N uptake (kg/ha)		P uptake (kg/ha)		K uptake (kg/ha)	
		2022	2023	2022	2023	2022	2023
0	Control	26.040	26.267	6.133	6.447	15.913	16.017
	Cycocel	26.520	26.833	6.683	6.817	16.133	16.783
	BRs	27.553	27.833	6.917	7.130	17.617	17.700
	Cytokine	27.600	27.600	6.367	6.667	16.900	17.067
40	Control	32.200	32.567	7.400	7.733	17.800	17.800
	Cycocel	32.563	32.867	7.583	7.767	18.200	18.367
	BRs	36.223	36.467	7.943	8.130	19.333	19.397
	Cytokine	35.650	36.200	7.663	7.950	18.533	18.533
80	Control	34.293	34.633	8.430	8.617	19.417	19.533
	Cycocel	39.033	39.233	8.630	8.817	20.117	20.283
	BRs	42.910	42.997	9.097	9.283	21.900	22.100
	Cytokine	42.917	43.117	8.913	9.030	21.267	21.330
120	Control	44.033	44.433	9.500	9.700	21.150	21.067
	Cycocel	47.037	47.133	9.850	9.950	21.947	21.983
	BRs	61.067	61.450	10.683	10.897	23.227	23.133
	Cytokine	52.763	52.833	10.083	10.800	22.067	21.917
160	Control	50.703	51.100	11.383	11.700	22.317	22.750
	Cycocel	53.433	53.760	11.830	12.017	23.233	23.330
	BRs	61.000	61.600	13.500	14.100	25.767	25.933
	Cytokine	55.400	56.267	12.130	12.300	23.617	23.733
LSD 0.05		0.841	0.963	0.238	0.329	0.455	0.460

Interpretative Insights

The steady enhancement of yield components with nitrogen reflects its stimulation of tillering, panicle initiation, and grain filling (Yoshida, 1981). The observed decline in 1000-grain weight at higher rates suggests a shift toward panicle density, a common adaptation in high-yielding rice varieties (Peng *et al.,* 2008). BRs' exceptional performance likely stems from their regulation of photosynthetic efficiency, hormone interactions, and stress mitigation (Bajguz and Hayat, 2009). Cycocel's moderate contribution supports grain development under stress, consistent with its gibberellin-suppressing action (Pirasteh-Anosheh *et al.,* 2016). Cytokinin's influence on panicle weight and nutrient uptake reflects its role in sustaining sink-source relationships (Sakakibara, 2006).

The 160 kg N/ha and BRs combination emerges as a transformative strategy for Sakha 108, offering resilience against environmental challenges while maximizing productivity. The consistency across seasons reinforces its practical viability, though long-term soil fertility and ecological impacts merit further exploration (Ladha *et al.,* 2016). These findings resonate with broader efforts to integrate PGRs into cereal systems for climate-adapted agriculture (Rademacher, 2015).

CONCLUSION

This study establishes that combining 120 kg N/ha with BRs optimizes Sakha 108 rice performance, yielding grain outputs of 13.49–13.03 t/ha, enhanced biological yields, and superior nutrient uptake. While cycocel and cytokinin contributed positively, BRs demonstrated unparalleled efficacy, amplifying nitrogen's benefits. These results endorse a tailored nitrogen-PGR framework for rice cultivation in Egypt's Nile Delta, with potential applications in similar agroecosystems. Therefore, the synergistic use of BRs and reduce nitrogen rates provides a sustainable economically viable and environmentally friendly approach to maximizing rice productivity under current and future agricultural challenges. Future investigations should refine application protocols, assess cultivar-specific responses, and evaluate environmental sustainability to fully realize this approach's promise.

REFERENCES

Bajguz, A., and Hayat, S. (2009). Effects of brassinosteroids on the plant responses to environmental stresses. Plant Physiology and Biochemistry, 47(1), 1–8.

Dahse, I., Sack, H., Bernstein, M., Petzold, U., Müller, E., Vorbrodt, H. M., and Adam, G. (1990). Effects of (22S, 23S)-homobrassinolide and related compounds on membrane potential and transport of Egeria leaf cells. Plant physiology, 93(3), 1268-1271.

Divya, K., Sreekanth, B., and Rao, S. (2015). Effect of brassinosteroids on yield and quality of rice under field conditions. Journal of Agricultural Science, 7(3), 45–52.

Fageria, N. K. (2007). Yield physiology of rice. Journal of Plant Nutrition, 30(6), 843–879.

Farooq, M., Wahid, A., and Siddique, K. H. M. (2015). Nutrient management for improving rice productivity under stress conditions. Plant and Soil, 396(1), 1–15.

Gomez, K. A. and A. A. Gomez (1984). "Statistical procedures for agricultural research," John Wiley & Sons.

Jones Jr, J. B., and Case, V. W. (1990). Sampling, handling, and analyzing plant tissue samples. *Soil Test. Plant Anal.* 3, 389- 427.

Khan, T. A., Kappachery, S., Karumannil, S., AlHosani, M., Almansoori, N., Almansoori, H., and Gururani, M. A. (2023). Brassinosteroid signaling pathways: Insights into plant responses under abiotic stress. International journal of molecular sciences, 24(24), 17246.

Ladha, J. K., Tirol-Padre, A., and Reddy, C. K. (2016). Nitrogen management for sustainable rice production: Challenges and opportunities. Advances in Agronomy, 139, 93–132.

Marschner, H. (2012). Rhizosphere biology. In Marschner's mineral nutrition of higher plants (pp. 369-388). Academic Press.

Najafi, N., SeyedSharifi, R., and Khalilzadeh, R. (2019). Effects of cycocel and nitrogen on some physiological traits and grain yield of rice (Oryza sativa L.). Crop Physiology Journal, 11(43), 6–47.

Peng, S., Khush, G. S., and Virk, P. (2008). Rice yields decline with higher night temperature from global warming. Proceedings of the National Academy of Sciences, 105(27), 9971–9975.

Pirasteh-Anosheh, H., Emam, Y., and Khaliq, A. (2016). Response of cereals to cycocel application. Iran Agricultural Research, 35(1), 1–12.

Rademacher, W. (2015). Plant growth regulators: Backgrounds and uses in plant production. Journal of Plant Growth Regulation, 34(4), 845–872.

Sakakibara, H. (2006). Cytokinins: Activity, biosynthesis, and translocation. Annual Review of Plant Biology, 57, 431–449.

Taiz, L., and Zeiger, E. (2010). Plant Physiology (5th ed.). Sunderland, MA: Sinauer Associates, Inc.,

Usmani, L., Shakil, A., Khan, I., Alvi, T., Singh, S., and Das, D. (2025). Brassinosteroids in micronutrient homeostasis: Mechanisms and implications for plant nutrition and stress resilience. Plants, 14(4), 598.

Yang, W., Wan, G. F., Zhou, J. Q., Song, G. C., Zhao, J., Huang, F. L., and Meng, S. (2024). The Effects of Brassinosteroids on Nitrogen Utilization in Rice. Agronomy, 14(3), 604.

Yoshida, S. (1981). Fundamentals of Rice Crop Science. International Rice Research Institute, Los Baños, Philippines.

Zhu, J., Zhang, Q., and Wu, R. (2015). Plant growth regulators and nutrient uptake in cereals: A review. Agricultural Sciences, 6(8), 912–920.

التأثيرات التآزرية للتسميد بالنيتروجين ومنظمات نمو النبات على إنتاجية الأرز وامتصاص العناصر الغذائية تحت ظروف تربة دلتا النيل

إبراهيم محمد هاشم ، عبدالفتاح صبحي غريب و حسناء عبدالحميد غازي

مركز البحوث و التدريب في الأرز- معهد بحوث المحاصيل الحقلية- مركز البحوث الزراعية – كفرالشيخ - مصر

الملخص

تُعدُّ دمج استراتيجيات التسميد بالنيتروجين مع منظمات نمو النبات (PGRs) إطارًا متينًا لتعزيز إنتاجية الأرز في ظل تزايد التغيرات المناخية. هدفت هذه الدراسة إلى فحص التأثيرات المُشتركة لخمسة مستويات من السماد النيتروجين (٠، ٤٠، ٨٠، ١٢٠، و١٦٠ كجم نيتروجين/هكتار) مع أربع معاملات لمنظمات نمو النبات (كنترول، سيكوسل، البراسينوستيرويدات، والسيتوكينين) على صنف الأرز "سخا ١٠٨" خلال موسمين زراعيين (٢٠٢٢ و٢٠٢٣) فى المزرعة البحثية لمحطة البحوث الزراعية بسخا – كفرالشيخ – مصر. استخدم تصميم القطع المنشقة مرة واحدة فى اربعة مكررات حيث إحتوت القطع الرئيسية على مستويات السماد النيتروجينى و القطع الشقية على منظمات النمو. حيث تم تقييم محصول الحبوب و مكوناته وامتصاص المغذيات. أظهرت النتائج أن أعلى معدل نيتروجين (١٦٠ كجم/هكتار) مع استخدام البراسينوستيرويدات حقّق أعلى إنتاج لمحصول الحبوب وصل إلى ١٣,٤٥ طن/هكتار في ٢٠٢٢ و١٣,٦٨ طن/هكتار في ٢٠٢٣، مع تحسن كبير في كفاءة امتصاص المغذيات. كما أثبتت البراسينوستيرويدات تفوقها في تعزيز الصفات الزراعية مقارنة بالمعالجات الأخرى، مؤكدة قدرتها على تحسين كفاءة استخدام النيتروجين والفوسفور والبوتاسيوم وتقليل التعارضات بين مكونات المحصول. تبرز هذه النتائج أهمية دمج منظمات نمو النبات مع إدارة نيتروجين محسنة كاستراتيجية مستدامة لتكثيف أنظمة إنتاج الأرز في الظروف المماثلة لظروف التجربة.