

The Effect of Growth Regulators Paclobutrazol and Gibberellin and Nitrogen Fertilizer on Some Growth properties, Grain yield and Components of Wheat (*Triticum aestivum* L.)

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Abstract: A field experiment was carried out at the Agricultural Research Station, College of Agriculture, University of Basra, at latitude 30° 34' 11" N and longitude 47° 45' 05" E in winter season 2023–2024. The aim was to examine the effect of foliar application of plant growth regulators (paclobutrazol and gibberellin) and nitrogen fertilizer at different dosages on some growth traits, yield and components of wheat (*Triticum aestivum* L.). The experiment design was a randomized complete block design (RCBD) with a split-split plot arrangement in three replications. Paclobutrazol foliar application concentrations were 0, 50, and 100 mg L⁻¹, Gibberellin concentrations were 0, 100, and 200 mg L⁻¹ and Nitrogen levels were 0, 120, and 240 kg N ha⁻¹. The results showed significant differences between Paclobutrazol, Gibberellin concentrations and Nitrogen levels in most traits measured. The paclobutrazol concentration 100 mg L⁻¹ was for chlorophyll content (22.80 SPAD), number of tillers (256.2 tillers m⁻²), spike number (212.3 spikes m⁻²), number of grains per spike (55.26 grain spike⁻¹), 1000-grain weight (61.25g) and harvest index (40.26%). The Gibberellin concentration 100 mg L⁻¹ was significant for grain yield (3.59 t ha⁻¹). The Nitrogen level 240 kg N ha⁻¹ was significant for grain yield (3.70 t ha⁻¹). As for the interaction, the results showed that the interaction between Gibberellin concentration 200 mg L⁻¹ and the Nitrogen level 240 kg N ha⁻¹ produced the highest grain yield (4.88 t ha⁻¹). Whereas the interaction between Paclobutrazol concentration 100 mg L⁻¹, Gibberellin concentration 200 mg L⁻¹ and Nitrogen level 240 kg N ha⁻¹ produced the highest grain yield (5.62 t ha⁻¹). Thus, this combination was recommended for application to improve wheat grain yield at Basra, Iraq.

Keywords: Foliar Spraying, Gibberellin, Nitrogen Fertilization Levels, Paclobutrazol, Wheat.

Introduction

Wheat (*Triticum aestivum* L.) is one of the most important food crops for many countries, including Iraq (Alsulaiman & Al-Ansari,

2023). It is the second most cultivated cereal globally, and there is a continuous demand due to its high content of many nutrients; protein,

carbohydrate (each 100 grams of wheat comprises of 327 kilocalories), minerals as phosphorus, manganese, and niacin. However, fertile land for wheat cultivation is becoming limited because of many environmental causes including drought and high temperature (Qureshi *et al.*, 2023). Additionally, the constant use of fertilizers and chemicals produces disproportion of soil nutrient and its organic materials (Sarker *et al.*, 2023). The use of nitrogen levels has an effective influence on improving wheat production and yield. Nitrogen plays an essential role in the synthesis of amino acids and proteins. It affects the plant's physiological processes such as photosynthesis and chlorophyll synthesis (Abbas, 2023). Nitrogen is efficient in reducing production costs and promoting long-term environmental sustainability. Yet, when it is excessively used it may lead to environmental threats and exhaustion of mineral resources (Zhang, 2021). To overcome this critical issue, so it becomes necessary finding an alternative way instead of chemical fertilization. According to Kamran (2018), plant growth regulators such as paclobutrazol and gibberellin have recently proven effective in enhancing plant physiology. Paclobutrazol mainly acts as a growth inhibitor by reducing stem elongation, increasing vegetative density, and improving fertilizer efficiency, particularly nitrogen. In wheat, its application has been shown to increase the number of tillers and spikelet's number per unit area, which is an important objective for improving wheat yield (Bakhtiyarinejad, 2023). In contrast, gibberellin increases stem elongation and plant height and has been shown to positively affect germination and vegetative growth of wheat under various conditions (Arshad, 2022). However, uncontrolled concentrations of gibberellin can cause unwanted elongation and

lead to lodging under windy conditions. As Shah (2023) verified that, the application of gibberellin should be balanced with other factors such as nitrogen fertilization and irrigation. According to recent studies, combining nitrogen with growth regulators such as paclobutrazol and gibberellin can yield effective results. For example, Hamoda *et al.*, (2025) conducted an experiment to study the effect of nitrogen fertilization and gibberellin concentrations. The results found that the interaction significantly improved wheat vegetative growth and yield more than nitrogen alone. The aims of this study was to examine the effect of nitrogen levels, growth regulators concentrations and their interaction on some vegetative growth, yield properties of wheat under the environmental conditions of Basra.

Materials & Methods

The experiment was conducted in winter season 2023–2024 on clay loam soil at the Agricultural Research Station of the College of Agriculture, University of Basra, Iraq at latitude 30° 34' 11" N and longitude 47° 45' 05" E. The study examined the effects of plant growth regulators Paclobutrazol and Gibberellin and nitrogen fertilizer on wheat. Paclobutrazol foliar application concentrations were 0, 50, and 100 mg L⁻¹, denoted as P0, P1, and P2. Gibberellin concentrations were 0, 100, and 200 mg L⁻¹, denoted as G0, G1, and G2. Nitrogen levels were 0, 120, and 240 kg N ha⁻¹, denoted as N0, N1, and N2. The experiment followed a randomized complete block design (RCBD) with a split-split plot arrangement in three replicates. Nitrogen levels were applied to main plots, gibberellin concentrations to sub-plots, and paclobutrazol concentrations to sub-sub plots. The study was carried out in loamy silt soil. Soil samples were randomly collected at a depth of 30 cm from

different sites within the experimental area. The basic physical and chemical properties of

the samples are shown in (Table 1). The soil was prepared by plowing

Table (1): Chemical and Physical Properties of the Experimental Soil Before Sowing

Adjective	Ph	Soil	O.M	N	P	K	Clay	Silt	Sand
Unite		E. C. (dc/m)	gm kg ⁻¹	Available (mg/kg)			gm Kg ⁻¹		
Value	7.28	7.30	2.05	38.50	12.25	139.50	116.00	596.70	287.30

and leveling, then divided into experimental units of 1.5×2.5 m. Wheat cultivar Ibaa 99 was sown on November 15, 2023. Nitrogen fertilizer was applied in three stages: one week after seedling emergence, at the stem elongation stage, and at the flowering initiation stage. Superphosphate fertilizer (45% P₂O₅) was applied at 80 kg ha⁻¹. Gibberellin and paclobutrazol were sprayed twice: at the stem elongation stage and at the flowering initiation stage. Growth regulators were sprayed early in the morning using a 15-liter backpack sprayer. Tween 20 was used to reduce surface tension. Paclobutrazol was sprayed one day after gibberellin.

In order to evaluate the effect of the treatments some vegetative growth traits were studied: flag leaf area, chlorophyll content, number of tillers m⁻². In addition, yield and components like number of spikes m⁻², number of grains per spike, 1000 grain weight and harvest index. Ten randomly plants per unit area was determined to measure flag leaf area at heading stage. The equation below was used

“Flag leaf area = length (cm) × width (cm) × 0.95” (Ahmad, 2022).

Chlorophyll content of flag leaf was measured at the flowering stage using ten plants per experimental unit with a SPAD-502 Plus device (Yang, 2023).

The number of tillers per m² was counted at the end of the vegetative growth stage using ten plants from each experimental unit. The number of spikes per m² was counted directly after harvest. The number of grains per spike

was determined by averaging 10 randomly selected spikes per experimental unit. The 1000-grain weight was calculated from 1000 randomly selected grains. The grain yield (t ha⁻¹) was measured from plants harvested from 1 m². In addition, harvest index (%) was calculated by divided grain yield on biological yield.

Data were collected and analyzed statistically by using GenStat statistical software 12. Means compared with LSD at 5% ($P \leq 0.05$) probability level (Al-Rawi & Khalafallah, 2000).

Results & Discussion

Flag Leaf Area (cm²)

The results presented in (Table 2) showed that gibberellin and nitrogen fertilization significantly affected flag leaf area (cm²). The G1 treatment gave the highest flag leaf area (45.54 cm²), while G0 recorded the lowest (39.78 cm²). These results are likely due to the application of gibberellin which increased flag leaf area through increased cell elongation and improved photosynthetic efficiency, these results are consistent with (Iqbal & Ashraf, 2013; Nagar, 2021). The results also showed that the N2 treatment significantly increased flag leaf area (45.54 cm²), whereas N0 gave the lowest value (39.03 cm²). This can be attributed that nitrogen is essential for protein synthesis and cellular growth, this is consistent with (Meng *et al.*, 2021). The statistical results of the combined effect of paclobutrazol and nitrogen fertilizer significantly influenced flag leaf area. The effect of P0xN2 recorded the

highest flag area of (47.73 cm²), compared to P0xN0, which gave the lower leaf area (37.97 cm²). This can be indicated that applying

paclobutrazol to the plants leads to limiting the leaf area, while

Table (2): Effect of Paclobutrazol, Gibberellin and Nitrogen Fertilizer and their Interactions on Flag Leaf Area (cm²)

Paclobutrazol	Gibberellin	Nitrogen Fertilizer			PxG
		N0	N1	N2	
P0	G0	36.81 ^e	43.46 ^{abcde}	39.12 ^{cde}	39.80
	G1	40.03 ^{bcde}	46.58 ^{abcde}	50.88 ^{abcd}	45.83
	G2	37.08 ^e	41.06 ^{abcde}	53.19 ^{ab}	43.77
P1	G0	42.05 ^{abcde}	42.47 ^{abcde}	34.56 ^e	39.69
	G1	36.83 ^e	47.45 ^{abcde}	53.29 ^a	45.86
	G2	38.55 ^{cde}	38.26 ^{ce}	44.14 ^{abcde}	40.32
P2	G0	39.33 ^{cde}	41.92 ^{abcde}	38.28 ^{ce}	39.84
	G1	42.62 ^{abcde}	47.25 ^{abcde}	44.93 ^{abcde}	44.93
	G2	38.01 ^{de}	41.09 ^{abcde}	51.46 ^{abc}	43.52
Fertilization mean N		39.03 ^b	43.28 ^{ab}	45.54 ^a	
LSD $p \leq (0.05)$		N= 5.873	PxG= N.S	NxGxP=13.22	
Paclobutrazol	Nitrogen Fertilizer			Mean P	
	N0	N1	N2		
P0	37.97 ^b	43.70 ^{ab}	47.73 ^a	43.13	
P1	39.14 ^b	42.73 ^{ab}	43.99 ^{ab}	41.96	
P2	39.98 ^b	43.42 ^{ab}	44.89 ^{ab}	42.76	
LSD $p \leq (0.05)$		P= N.S NxP = 7.40			
Gibberellin	Nitrogen Fertilizer			Mean G	
	N0	N1	N2		
G0	39.4 ^{bc}	42.62 ^{abc}	37.32 ^c	39.78 ^b	
G1	39.83 ^{bc}	47.09 ^{ab}	49.7 ^a	45.54 ^a	
G2	37.88 ^c	40.14 ^{bc}	49.59 ^a	42.54 ^{ab}	
LSD $p \leq (0.05)$		G=5.70	NxG= 9.03		

using nitrogen fertilization increases it. Nitrogen improves the chlorophyll content in wheat leaf production leading to leaf growth. Applying the level (N2) fertilization increased leaf water resistance compared to other treatments containing lower levels of nitrogen. These results are consistent with the findings of (Ahmad *et al.*, 2021). The results also showed that the interaction of gibberellin and nitrogen fertilization significantly influenced flag leaf area. The treatment G1xN2 recorded the highest flag area (49.70 cm²), while the treatment G0xN2 recorded the lowest of (37.32 cm²). These results are due to the effect of gibberellin which increases plant uptake efficiency of nitrogen which improves the photosynthesis leading to increasing flag leaf area. These results are consistent with

(Alhaidary & Ahmed, 2017). The interaction between paclobutrazol and gibberellin and nitrogen had a significant influence on flag leaf area. The combination P1xG1xN2 produced the highest value (53.29 cm²), and the combination P0xG0xN0 produced the lowest (36.81 cm²).

Chlorophyll Content (SPAD)

Statistical results of (Table 3) revealed that all treatments significantly affected chlorophyll content. The P2 treatment achieved the highest chlorophyll content (22.80 SPAD), while P0 recorded the lowest (19.69 SPAD). Paclobutrazol enhances photosynthetic activity by reducing chlorophyll degradation and promoting chlorophyll synthesis. It is consistent with (Kamran, 2020). The treatment

G1 produced the highest chlorophyll content (23.33 SPAD), whereas G0 gave the lowest (19.48 SPAD). Gibberellin increases enzyme activity essential for chlorophyll production which is consistent with (Taiz, 2021). The treatment N2 yielded the highest chlorophyll content (23.38 SPAD), while N0 gave the lowest (19.87 SPAD). This result indicated the strong influence nitrogen on chlorophyll synthesis and photosynthetic efficiency (Skudra & Ruza, 2017). The results also revealed that the effect of the interaction of paclobutrazol and gibberellin was significant. The combination P1xG1 recorded the highest chlorophyll content (24.84 SPAD), while the combination P0xG0 recorded the lowest

chlorophyll content, reaching (16.54 SPAD). These results indicated that this interaction has a positive effect on chlorophyll synthesis and photosynthetic efficiency (Parizi *et al.*, 2024). Likewise, the interaction between paclobutrazol and nitrogen significantly affected chlorophyll content. The treatment P2xN2 recorded the highest chlorophyll content in the flag leaf (25.96 SPAD) while the lowest chlorophyll content was recorded by the treatment (P0xN1) (19.03 SPAD). This interaction has proved to be significant. Paclobutrazol regulates vegetative growth supporting the efficient chlorophyll consumption by the plant, while nitrogen

Table (3): Effect of Paclobutrazol, Gibberellin and Nitrogen Fertilizer and their Interactions on Chlorophyll Content (SPAD)

Paclobutrazol	Gibberellin	Nitrogen Fertilizer			PxG
		N0	N1	N2	
P0	G0	15.73 ^h	15.33 ^h	18.57 ^{fgh}	16.54 ^e
	G1	25.37 ^{abcd}	22.3 ^{bcdef}	21.6 ^{bcdefg}	23.09 ^{ab}
	G2	17.63 ^{gh}	19.47 ^{fgh}	21.2 ^{defg}	19.43 ^d
P1	G0	18.83 ^{fgh}	19.3 ^{fgh}	20.53 ^{efg}	19.56 ^{cd}
	G1	24.43 ^{abcde}	24.13 ^{abcde}	25.97 ^{ab}	24.84 ^a
	G2	19.17 ^{fgh}	21.77 ^{bcdefg}	24.67 ^{abcde}	21.87 ^{bcd}
P2	G0	19.3 ^{fgh}	22.5 ^{bcdef}	25.2 ^{abcd}	22.33 ^{ab}
	G1	19 ^{fgh}	21.5 ^{cdefg}	25.7 ^{abc}	22.07 ^{bc}
	G2	19.37 ^{fgh}	25.7 ^{abc}	26.97 ^a	24.01 ^{ab}
Fertilization mean N		19.87 ^b	21.33 ^b	23.38 ^a	
LSD $p \leq (0.05)$		N= 1.73 PxG= 2.62 NxGxP= 4.39			
Paclobutrazol	Nitrogen Fertilizer			Mean P	
	N0	N1	N2		
P0	19.58 ^{de}	19.03 ^e	20.46 ^{de}	19.69 ^b	
P1	20.81 ^{cde}	21.73 ^{bcd}	23.72 ^{ab}	22.09 ^a	
P2	19.22 ^e	23.23 ^{bc}	25.96 ^a	22.8 ^a	
LSD $p \leq (0.05)$		P=1.45 NxP = 2.43			
Gibberellin	Nitrogen Fertilizer			Mean G	
	N0	N1	N2		
G0	17.96 ^d	19.04 ^{cd}	21.43 ^{bc}	19.48 ^b	
G1	22.93 ^{ab}	22.64 ^{ab}	24.42 ^a	23.33 ^a	
G2	18.72 ^{cd}	22.31 ^{ab}	24.28 ^a	21.77 ^a	
LSD $p \leq (0.05)$		G= 1.77 NxG= 2.78			

helps the plant produce chlorophyll. The interaction between gibberellin and nitrogen has also proved its effectivity in increasing chlorophyll content. The treatment G1xN2

recorded the highest average chlorophyll content (24.42 SPAD), while G0xN0 recorded the lowest chlorophyll content, at (17.96 SPAD). This finding indicated the influence of this interaction on improving the plant nutrient

utilization and photosynthesis. Gibberellins work to allocate nutrients across plant tissues and increase vegetative growth, leading to increases chlorophyll content.

The results also showed the effect of the interaction between paclobutrazol and gibberellin and nitrogen was significant. P2xG2xN2 recorded the highest chlorophyll content (26.97 SPAD), and P0xG0xN1 the lowest (15.33 SPAD).

Number of Tillers m^{-2}

The results of the statistical analysis (Table 4) showed that paclobutrazol, gibberellin, and nitrogen fertilization significantly affected the number of tillers. The treatment P2 recorded the highest number of tillers (256.2 tillers m^{-2}), while P0 recorded the lowest (230.8 tillers m^{-2}). This result indicated that paclobutrazol improves carbohydrate accumulation in the stem base and promotes auxiliary bud initiation (Azarcon, 2022). Gibberellin also significantly increased the number of tillers. The treatment G1 produced the highest (257.7 tillers m^{-2}), while G0 yielded the lowest (220.9 tillers m^{-2}). Gibberellin enhances tiller formation by breaking apical dominance and encouraging auxiliary buds (Castro-Camba *et al.*, 2022). The reason behind this effect may be attributed to the fact that the foliar application of plant growth regulators (gibberellin) increases the flag leaf area and the percentage of chlorophyll (Table 3,4), which enhances plant growth and light absorption efficiency and the photosynthesis process. It is positively reflected in the increase of number of tillers. Nitrogen fertilization significantly influenced number of tillers. The treatment N2 recorded the highest (270.4 tillers m^{-2}) and N1 the lowest (226.7 tillers m^{-2}). Nitrogen is a key component of proteins and amino acids that regulate cell division and growth (AL-Hade *et*

al., 2020). As for the interaction between paclobutrazol and gibberellin, the results showed that it had a significant effect on number of tillers.

The treatment P2xG1 recorded the highest number of tillers, reaching (278.0 tillers m^{-2}), while the treatment P0xG0 recorded the lowest number of tillers (211.6 tillers m^{-2}). These results indicated that the combination of paclobutrazol and balanced levels of gibberellins improves vegetative growth in cereal crops (Assuero *et al.*, 2012). The interaction between paclobutrazol and nitrogen had a significant effect on this trait. The treatment P2xN2 recorded the highest number of tillers (289.9 tillers m^{-2}), while the treatment P0xN0 recorded the lowest number of tillers (211.8 tillers m^{-2}). The collaborative effect of paclobutrazol and nitrogen fertilization can increase the number of tillers (Li *et al.*, 2021). Likewise, the interaction of gibberellins and high nitrogen levels significantly affected number of tillers. G1xN2 recorded the highest number of tillers, reaching (281.4 tillers m^{-2}), while the treatment G0xN1 recorded the lowest number of tillers (200.3 tillers m^{-2}). This interaction increases the efficiency of nutrient use, which in turn leads to an increase in the number of tillers.

Table (4):Effect of Paclobutrazol, Gibberellin and Nitrogen Fertilizer and their Interactions on Number of Tillers (m²)

Paclobutrazol	Gibberellin	Nitrogen Fertilizer			PxG
		N0	N1	N2	
P0	G0	172.7 ⁱ	213.3 ^{ghi}	248.7 ^{bcdeg}	211.6 ^d
	G1	230 ^{degh}	232 ^{degh}	261 ^{abcdeg}	241b ^c
	G2	232.7 ^{degh}	228.7 ^{degh}	258.3 ^{abcdeg}	239.9 ^{bc}
P1	G0	240 ^{cdegh}	193.7 ^{hi}	219 ^{fghi}	217.6 ^{cd}
	G1	250.3 ^{bcdeg}	235.3 ^{degh}	277 ^{abcd}	254.2 ^{ab}
	G2	218 ^{fghi}	223.3 ^{eghi}	300.3 ^{ab}	247.2 ^b
P2	G0	215.3 ^{fghi}	194 ^{hi}	291 ^{abc}	233.4 ^{bcd}
	G1	275 ^{abcde}	252.7 ^{bcdeg}	306.3 ^a	278 ^a
	G2	231.7 ^{degh}	267.3 ^{abcdef}	272.3 ^{abcde}	257.1 ^{ab}
Fertilization mean N		229.5 ^b	226.7 ^b	270.4 ^a	
LSD $p \leq (0.05)$		N=35.28	PxG= 27.95	NxGxP=52.95	
Paclobutrazol		Nitrogen Fertilizer			Mean P
		N0	N1	N2	
P0		211.8 ^d	224.7 ^{cd}	256 ^{abc}	230.8 ^b
P1		236.1 ^{bcd}	217.4 ^d	265.4 ^{ab}	239.7 ^a
P2		240.7 ^{bcd}	238 ^{bcd}	289.9 ^a	256.2 ^a
LSD $p \leq (0.05)$		P=16.76	NxP = 37.41		
Gibberellin		Nitrogen Fertilizer			Mean G
		N0	N1	N2	
G0		209.3 ^{cd}	200.3 ^d	252.9 ^{ab}	220.9 ^b
G1		251.8 ^{ab}	240 ^{bc}	281.4 ^a	257.7 ^a
G2		227.4 ^{bcd}	239.8 ^{bc}	277 ^a	248.1 ^a
LSD $p \leq (0.05)$		G=16.38	NxG= 36.95		

The effect of the interaction of paclobutrazol and gibberellin and nitrogen proved to be significant. The P2xG1xN2 combination produced the highest number of tillers (306.3 tillers m⁻²), while the P0xG0xN0 combination the lowest (172.7 tillers m⁻²). Obviously, the effect of the interaction of foliar application of plant growth regulators (paclobutrazol and gibberellin) and nitrogen fertilizer increases the area of the flag leaf and the percentage of chlorophyll (Table 3.4), which enhances plant growth and light absorption efficiency and the photosynthesis process, which is positively reflected in increasing the number of tillers.

Number of spikes m⁻²

According to the results of the statistical analysis (Table 5), paclobutrazol, gibberellin, and nitrogen fertilizer significantly affected number of spikes (m²). The treatment P2

produced the highest number of spikes 212.3 spikes m⁻², while the treatment P0 achieved the lowest number 188.7 spikes m⁻². That is because paclobutrazol improves the growth of the reproductive parts such as spikes and flowering growth. This leads to the allocation of resources of the plant toward spike formation (Obaid, 2025). As for gibberellin spray, the treatment G1 recorded the highest number of spikes, 216.2 spikes m⁻², while the control treatment G0 recorded the lowest number, 184.0 spikes m⁻². The use of gibberellin at different concentrations increased the number of spikes compared to the G0 treatment. These results are consistent with (Islam, 2014; Iftikhar, 2019). Also, the treatment N2 produced the highest number of spikes 212.6 spikes m⁻², while the lowest number, at 189.1 spikes m⁻², was achieved by N1 level. The increase of the number of spikes

(m²) can be attributed to the positive role of nitrogen on increasing the number of spikes (Aryan et al.,2024). According to the results, the interaction between paclobutrazol and gibberellin was significant in this trait. The combination P1xG1 recorded the highest number, at 234.6 spikes m⁻², whereas the combination P0xG0 produced the lowest number, 162.7 spikes m⁻². These results are consistent with (Parizi et al., 2024). The interaction of paclobutrazol and gibberellin affects the hormonal balance of the plant and increases production. The interaction between paclobutrazol and nitrogen was significant in increasing number of spikes. The combination

P2xN2 recorded the highest spike number, 231.7 spikes m⁻², and the P0xN1 treatment produced the lowest, 185.1 spikes m⁻². The interaction of paclobutrazol and nitrogen increases the number of spikes compared to other treatments. It improves branching, spike formation, and nutrient absorption. These results are consistent with (Li et al.,2021).The significant effect of the foliar spray of

paclobutrazol P2 and the level nitrogen fertilization N2 in increasing the number of tillers (Table 5) may in turn lead to increasing the number of spikes.

Table (5): Effect of Paclobutrazol , Gibbirline and Nitrogin Fertilizer and their Interactions on Number of spike m⁻²

Paclobutrazol	Gibberellin	Nitrogen Fertilizer			PxG
		N0	N1	N2	
P0	G0	165.3 ^{fg}	156 ^g	166.7 ^{fg}	162.7 ^e
	G1	208 ^{cd}	185.7 ^{defg}	198.7 ^{def}	197.4 ^{cd}
	G2	185.7 ^{defg}	213.7 ^{bcd}	218.3 ^{bcd}	205.9 ^{bcd}
P1	G0	194.7 ^{def}	183.7 ^{defg}	197 ^{def}	191.8 ^d
	G1	237.7 ^{abc}	218 ^{bcd}	248 ^{ab}	234.6 ^a
	G2	193.3 ^{def}	187.7 ^{defg}	189.3 ^{defg}	190.1 ^d
P2	G0	207.3 ^{cd}	170 ^{efg}	215.3 ^{bcd}	197.6 ^{cd}
	G1	246 ^{ab}	186 ^{defg}	218 ^{bcd}	216.7 ^{abc}
	G2	204.7 ^{cde}	201.3 ^{cef}	261.7 ^a	222.6 ^{ab}
Fertilization	Mean N	204.7 ^{ab}	189.1 ^b	212.6 ^a	
LSD $p \leq (0.05)$		N=13.61 PxG= 21.22 NxGxP=36.55			

Paclobutrazol	Nitrogen Fertilizer			Mean P
	N0	N1	N2	
P0	186.3 ^d	185.1 ^d	194.6 ^{cd}	188.7 ^b
P1	208.6 ^{bc}	196.4 ^{cd}	211.4 ^{abc}	205.5 ^a
P2	219.3 ^{ab}	185.8 ^d	231.7 ^a	212.3 ^a
LSD $p \leq (0.05)$		P= 13.18 NxP = 21.16		

Gibberellin	Nitrogen Fertilizer			Mean G
	N0	N1	N2	
G0	189.1 ^b	169.9 ^c	193 ^b	184.0 ^b
G1	230.6 ^a	196.6 ^b	221.6 ^a	216.2 ^a
G2	194.6 ^b	200.9 ^b	223.1 ^a	206.2 ^a
LSD $p \leq (0.05)$		G=11.32 NxG= 18.74		

This is mainly due to the increase in the flag leaf area and the percentage of chlorophyll in the flag leaf (Table 3,4). It eventually enhances

plant growth and provides it with nutrients by improving the efficiency of photosynthesis in the plant. Regarding the interaction between gibberellin and nitrogen, the combination

G1xN0 recorded the highest spike number, reaching 230.6 spikes m^{-2} , while the G0xN1 recorded the lowest number, 169.9 spikes m^{-2} . The interaction between paclobutrazol and gibberellin and nitrogen also proved to be significant. The combination P2xG2xN2 recorded the highest spike number, 261.7 spikes m^{-2} , while the treatment P0xG0xN1 recorded the lowest spike number, 156.0 spikes m^{-2} .

Number of Grains Spike⁻¹

The results of the statistical analysis (Table 6) verified that paclobutrazol and gibberellin, and

nitrogen fertilization significantly affected number of grains spike⁻¹. The treatment P2 produced the highest number of grains/spike 55.26 grains spike⁻¹, compared to the control treatment P0 which recorded the lowest number, 44.06 grains spike⁻¹. As mentioned above, paclobutrazol is proved to reduce unnecessary vegetative growth and increase the growth of reproductive parts such as spikes and grains. This increases the number of grains/spike in plants including wheat by increasing nutrient uptake to improve the reproductive parts (flowers and seed formation) at the end (Zenhom et al., 2018).

Table (6): The Effect of Paclobutrazol , Gibbirline and Nitrogin Fertilizer and their Interactions on number of Grains spike⁻¹

Paclobutrazol	Gibberellin	Nitrogen Fertilizer			PxG
		N0	N1	N2	
P0	G0	33.14 ^j	37.14 ^{hij}	42.73 ^{efghij}	37.67 ^c
	G1	51.54 ^{bcdefg}	52.77 ^{bcdef}	40.62 ^{ghij}	48.31 ^b
	G2	40.77 ^{ghij}	46.88 ^{defghi}	50.94 ^{bcdefg}	46.2 ^b
P1	G0	53.7 ^{bcdef}	49.99 ^{bcdefg}	36.15 ^{ij}	46.61 ^b
	G1	51.44 ^{bcdefg}	42.5 ^{fghij}	56.79 ^{bcd}	50.24 ^b
	G2	37.77 ^{hij}	53.47 ^{bcdef}	55.53 ^{bcd}	48.92 ^b
P2	G0	53.41 ^{bcdef}	54.25 ^{bcde}	48.55 ^{cdefgh}	52.07 ^b
	G1	50.83 ^{bcdefg}	60.51 ^b	46.84 ^{defghi}	52.72 ^b
	G2	47.63 ^{defghi}	59.4b ^c	75.94 ^a	60.99a
Fertilization Mean N		46.69 ^b	50.77 ^a	50.45 ^a	
LSD $p \leq (0.05)$		N= 3.617 PxG= 7.009 NxGxP=11.636			
Paclobutrazol		Nitrogen Fertilizer			Mean P
		N0	N1	N2	
P0		41.82 ^c	45.59 ^{bc}	44.76b ^c	44.06 ^c
P1		47.64 ^{bc}	48.65 ^b	49.49 ^b	48.59 ^b
P2		50.62 ^b	58.05 ^a	57.11 ^a	55.26 ^a
LSD $p \leq (0.05)$		P= 3.978 NxP = 6.207			
Gibberellin		Nitrogen Fertilizer			Mean G
		N0	N1	N2	
G0		46.75 ^{bc}	47.13 ^{bc}	42.48 ^c	45.45 ^b
G1		51.27 ^b	51.93 ^b	48.08 ^{bc}	50.43 ^a
G2		42.06 ^c	53.25 ^b	60.8 ^a	52.04 ^a
LSD $p \leq (0.05)$		G=4.577 NxG= 6.901			

The results also showed that treatment G2 produced the highest number, 52.04 grains spike⁻¹, and the G0 treatment recorded the lowest number, 45.45 grains spike⁻¹.

Gibberellin reduces the rate of ovarian abortion, which increases the number of grains spike⁻¹. These results are consistent with (Haque et al., 2020). This effect may be

attributed to its role in increasing the flag leaf area and the percentage of chlorophyll (Table 2,3). It improves the efficiency of photosynthesis and cell divisions. It enhances the number of tillers (Table 4) and increases the percentage of fertile flowers, which is evidently leads to increasing the number of grains in the spike. As for nitrogen fertilization, the treatment N1 recorded the highest number, 50.77 grains spike⁻¹, and N0 treatment recorded the lowest number, 46.69 grains spike⁻¹. Using balanced levels of nitrogen fertilization increase spikelet growth and the number of grains spike⁻¹ at the end. In contrast, high levels decrease the number of grains because nitrogen improves vegetative results are consistent with (Zhang *et al.*, 2023). The results also verified that the effect of the interaction between paclobutrazol and gibberellin was significant on the number of grains/spike. The combination P2xG2 recorded the highest number, 60.99 grains spike⁻¹ compared to P0xG0 which recorded the lowest, 37.67 grains spike⁻¹. This interaction is proved to affect the hormonal balance of the plant. Paclobutrazol reduces stem elongation and oxidative stress, allocating nutrients to grain formation. Gibberellin improves the expression of genes responsible for cell expansion and grain formation (Nagar, 2021). The interaction between paclobutrazol and nitrogen significantly affected this trait. The combination P2xN1 treatment gave the highest grain number, 58.05 grains spike⁻¹, and the P0xN0 treatment produced the lowest, 41.82 grains spike⁻¹. Nitrogen encourages flower formation, while paclobutrazol improves seed formation by allocating nutrients to it. These results are consistent with the findings of (Obaid, 2025). As for the interaction between gibberellin and nitrogen, it also proved to be significant. The combination G2xN2 achieved the highest number, 60.80 grains spike⁻¹,

whereas the G2xN0 combination recorded the lowest, 42.06 grains spike⁻¹. These results are consistent with (Parizi *et al.*, 2024; Farad, 2025). The results of the interaction between paclobutrazol and gibberellin and nitrogen showed a significant effect on this trait. The combination P2xG2xN2 recorded the highest number, 75.94 grains spike⁻¹, while the P0xG0xN0 combination recorded the lowest, 33.14 grains spike⁻¹. These are agreed with (Parizi *et al.*, 2024). The interaction of paclobutrazol with gibberellin and balanced levels of nitrogen increases the number of grains/spike.

Weight of 1000-grain (g)

The results of the statistical analysis presented in (Table 7) showed that paclobutrazol significantly affected the weight of 1000 grains. The P2 treatment recorded the highest weight, 61.25 g per 1000 grains, while the P0 level recorded the lowest, 58.69 g per 1000 grains. These results are consistent with those of (Bakhtiarinejad, 2022; Zhang, 2024). Paclobutrazol spray improves the plant's ability of nutrient absorption and strengthens cell walls. Thus, it improves grain quality and increases grain weight. The significant effect of applying Paclobutrazol P2 in increasing the flag leaf area and chlorophyll percentage (Table 2, 3) may lead to enhance the efficiency of photosynthesis and the efficiency of transporting nutrients from the source to the flower, which in turn increases the overall weight of the seeds. The results also showed a significant effect of the interaction between paclobutrazol and gibberellin. The combination P2xG2 recorded the highest average 1000-grain weight, 61.92 g, while the P0xG1 produced the lowest, 58.03 g. The spray of paclobutrazol and gibberellin at certain concentrations obtained a significant increase in the 1000-grain weight. These

results are consistent with the findings of (Nagar, 2021). In addition, the interaction of paclobutrazol and nitrogen significantly affected this trait. The combination P2xN2 recorded the highest average 1000-grain weight, 62.34 g, while the lowest, 57.31 g, was recorded by the combination P0xN1. These results are consistent with those of (Saharsh, 2023). Furthermore, the interaction of gibberellin and nitrogen significantly affected this trait. The combination G2xN2 recorded the highest average 1000-grain weight, 62.00

g, whereas the combination G2xN0 recorded the lowest, 58.05 g. These results are consistent with those of (Farad, 2025). The use of nitrogen fertilization with gibberellin increased this trait compared to other treatments. The results of the interaction between paclobutrazol and gibberellin and nitrogen showed a significant effect on this trait. The combination P2xG1xN2 achieved the highest weight of 1000 grains, 64.43 g, while the treatment P0xG0xN1 recorded the lowest, 55.29 g per 1000 grains.

Table (7) Effect of Paclobutrazol , Gibbirline and Nitrogin Fertilizer and their Interactions on the Weight of 1000 Grain(g)

Paclobutrazol	Gibberellin	Nitrogen Fertilizer			PxG
		N0	N1	N2	
P0	G0	58.51 ^{abcde}	55.29 ^e	61.38 ^{abcd}	58.39 ^{ab}
	G1	59.31 ^{abcde}	57.8 ^{cde}	56.96 ^{de}	58.03 ^b
	G2	58.88 ^{abcde}	58.83 ^{abcde}	61.22 ^{abcde}	59.64 ^{ab}
P1	G0	60.44 ^{abcde}	63.76 ^{abc}	59.87 ^{abcde}	61.36 ^{ab}
	G1	60.94 ^{abcde}	61.83 ^{abcd}	61.11 ^{abcde}	61.29 ^{ab}
	G2	56.33 ^{de}	61.08 ^{abcde}	60.36 ^{abcde}	59.26 ^{ab}
P2	G0	63.12 ^{abc}	60.08 ^{abcde}	58.32 ^{bcd}	60.5 ^{ab}
	G1	58.93 ^{abcde}	60.61 ^{abcde}	64.43 ^a	61.32 ^{ab}
	G2	62.7 ^{abc}	58.80 ^{abcde}	64.27 ^{ab}	61.92 ^a
Fertilization Mean N		59.91	59.79	60.88	
LSD $p \leq (0.05)$		N= NS	PxG=3.663	NxGxP= 6.067	
Paclobutrazol	Nitrogen Fertilizer			Mean P	
	N0	N1	N2		
P0	58.90 ^{bc}	57.31 ^c	59.86 ^{abc}	58.69 ^b	
P1	59.24 ^{abc}	62.22 ^a	60.45 ^{abc}	60.64 ^{ab}	
P2	61.58 ^{ab}	59.83 ^{abc}	62.34 ^a	61.25 ^a	
LSD $p \leq (0.05)$		P= 2.179	NxP = 3.189		
Gibberellin	Nitrogen Fertilizer			Mean G	
	N0	N1	N2		
G0	60.55 ^{abc}	59.28 ^{abc}	61.84 ^{ab}	60.56	
G1	61.12 ^{abc}	59.90 ^{abc}	58.8 ^b	59.94	
G2	58.05 ^c	60.18 ^{abc}	62.00 ^a	60.08	
LSD $p \leq (0.05)$		G= NS	NxG=3.180		

Grain yield (t ha⁻¹)

As shown in (Table 8), the application of gibberellin and nitrogen fertilization levels had a significant effect on grain yield. The G1 treatment recorded the highest total grain yield, 3.59 t ha⁻¹, while the G0 level recorded the lowest yield, 2.98 t ha⁻¹. These results are

consistent with those of (Hamoda et al.,2025). Gibberellin spray increases the grain yield because of its effect on plant growth and metabolism. As such, it seems that the significant effect of spraying gibberellin especially at the concentration G1 on the grain yield is due to its role in increasing the flag leaf

area, percentage of chlorophyll in the flag leaf, number of tillers and number of spikes (Table 3,4,5,6). As for nitrogen fertilization, the level N2 achieved the highest grain yield, 3.70 t ha⁻¹, while the N1 fertilization level recorded the lowest, 3.16 t ha⁻¹. These results are consistent with (Belete et al.,2018). The highest grain yield is obtained when nitrogen fertilization is applied at a level of 240 kg/ha. This can be justified that nitrogen may increase the flag leaf area and the percentage of chlorophyll (Table 3.4), which enhances plant growth and increases the efficiency of photosynthesis and nutrient production and the number of grains

in the spike (Table 7). This eventually leads to an increase in the grain yield. The results of the interaction between paclobutrazol and gibberellin verified to be significant. The combination P2xG2 produced the highest total grain yield of 4.14 t ha⁻¹, while the combination P0xG0 achieved the lowest grain yield of 2.49 t ha⁻¹. Paclobutrazol works to inhibit vegetative growth and stimulate reproductive growth, while gibberellin works to increase growth and grain formation. These results are consistent with (Nagar, 2021). Moreover, the effect of paclobutrazol and nitrogen was significant.

Table (8) Effect of Paclobutrazol , Gibbirline and Nitrogin Fertilizer and their Interactions on the Grain yield (t ha⁻¹)

Paclobutrazol	Gibber ellin	Nitrogen Fertilizer			PxG
		N0	N1	N2	
P0	G0	1.65 ^h	2.48 ^{efgh}	3.34 ^{bcdefg}	2.49 ^d
	G1	4.19 ^{abc}	4.10 ^{bc}	2.98 ^{cdefgh}	3.76 ^{ab}
	G2	3.46 ^{bcdef}	2.95 ^{cdefgh}	4.43 ^{ab}	3.61 ^{ab}
P1	G0	4.37 ^{abc}	3.94 ^{bcde}	1.94 ^{gh}	3.42 ^{abc}
	G1	2.99 ^{cdefgh}	4.21 ^{abc}	3.98 ^{bcd}	3.73 ^{ab}
	G2	1.86 ^{gh}	2.00 ^{fgh}	4.60 ^{ab}	2.82 ^{cd}
P2	G0	2.57 ^{defgh}	2.58 ^{defgh}	3.93 ^{bcde}	3.03 ^{bcd}
	G1	4.08 ^{bc}	3.21 ^{bcdefg}	2.52 ^{defgh}	3.27 ^{bc}
	G2	3.86 ^{bcde}	2.93 ^{cdefgh}	5.62 ^a	4.14 ^a
Fertilization Mean N		3.23 ^b	3.16 ^b	3.70 ^a	
LSD $p \leq (0.05)$		N= 0.312	PxG= 0.759	NxGxP= 1.495	
Paclobutrazol	Nitrogen Fertilizer			Mean P	
	N0	N1	N2		
P0	3.10 ^b	3.18 ^b	3.59 ^{ab}	3.29	
P1	3.07 ^b	3.39 ^{ab}	3.51 ^{ab}	3.32	
P2	3.50 ^{ab}	2.91 ^b	4.02 ^a	3.48	
LSD $p \leq (0.05)$		P=NS NxP = 0.759			
Gibberellin	Nitrogen Fertilizer			Mean G	
	N0	N1	N2		
G0	2.86 ^c	3.00 ^{bc}	3.07 ^{bc}	2.98 ^b	
G1	3.75 ^b	3.80 ^{4b}	3.16 ^{bc}	3.59 ^a	
G2	3.06 ^{bc}	2.63 ^c	4.88 ^a	3.52 ^{ab}	
LSD $p \leq (0.05)$		G= 0.607	NxG= 0.880		

The combination P2xN2 recorded the highest grain yield of 4.02 t ha⁻¹, while the lowest grain yield, 2.91 t ha⁻¹, was obtained by the combination P2xN1. This interaction proved to be effective because nitrogen provides important nutrients for plant growth, while paclobutrazol regulates this growth,

improving grain formation. These results are consistent with the findings of (Parizi et al.,2024; Li et al.,2021). The results also showed a significant effect of the interaction between gibberellin and nitrogen. The combination G2xN2 recorded the highest grain yield, 4.88 t ha⁻¹, while the combination

G2xN1 recorded the lowest total grain yield, 2.63 t ha⁻¹. They improved the plant's ability to absorb gibberellin, which led to increased plant growth and thus increased total grain yield. These results were consistent with those of (Mahmood & Zeboon, 2019). As for the interaction between paclobutrazol and gibberellin and nitrogen, it proved to be significant. The combination P2xG2xN2 achieved the highest grain yield of 5.62 t ha⁻¹, while the control P0xG0xN0 recorded the lowest yield of 1.65 t ha⁻¹.

Harvest index (%)

The results of (Table 9) showed that paclobutrazol, gibberellin, and nitrogen fertilization significantly affected the harvest index. The treatment P2 produced the highest harvest index, reaching 40.26%, while the P0 spray level recorded the lowest, 29.74%. The reason behind increasing the harvest index can be attributed to the effect of paclobutrazol on the vegetative growth in general as number of tillers (Table 4) and yield traits as number of spikes, grains number per spike and 1000 grains weight (Table 5,6,7). These results are consistent with (Bakhtiyarnejad, 2023). The results also showed that the highest harvest index was obtained by the treatment G2 at 35.91%, while the lowest was by the G0 spray level at 32.21%. Obviously, the effect of gibberellin on grain yield (Table 8) has significantly affected the harvest index. These findings are consistent with those of (Gao & Chu., 2020; Hamoda *et al.*, 2025). As for nitrogen, the N1 treatment achieved the

highest harvest index, 35.41%, while the N0 treatment recorded the lowest, 32.53%. Subsequently, the positive impact of nitrogen fertilization on number of spikes and grains number per spike (Table 5, 6) has increased the grain yield (Table 8) and in turn the harvest index. The results obtained are consistent with those of (Zhang *et al.*, 2022). The interaction of paclobutrazol and gibberellin proved to have a significant effect on the harvest index. The combination P2xG2 recorded the highest rate, 42.30%, while combination P0xG0 recorded the lowest, 27.34%. This finding indicated that this interaction significantly affects the harvest index because they balance vegetative and reproductive growth. These results are consistent with (Parizi *et al.*, 2024). The interaction between paclobutrazol and nitrogen fertilization was also effective. The combination P2xN1 recorded the highest rate, 41.57%, and the P0xN0 recorded the lowest, 27.61%. The interaction proved to increase the harvest index by improving the nutrient distribution ability of the plant more than using nitrogen alone. The results obtained are consistent with those of (Desta & Amare, 2021). The interaction between gibberellin and nitrogen also had a significant effect on this trait. The combination G2xN0 recorded the highest rate, 38.31%, while the G0xN0 achieved the lowest, 26.31%. According to the results shown in (Table 10), the interaction between paclobutrazol and gibberellin and nitrogen had a significant effect on the harvest index. The combination P2xG2xN0 recorded the highest rate, 44.16%, and the P0xG0xN0 treatment recorded the lowest, 22.13%.

Table (9): Effect of Paclobutrazol , Gibberellin and Nitrogen Fertilizer and their Interactions on Harvest Indix (%)

Paclobutrazol	Gibberellin	Nitrogen Fertilizer			PxG
		N0	N1	N2	
P0	G0	22.13 ^h	32.32 ^{de}	27.58 ^g	27.34 ^e
	G1	28.72 ^{efg}	30.43 ^{efg}	30.73 ^{efg}	29.96 ^d
	G2	31.97 ^{ef}	31.42 ^{efg}	32.37 ^{de}	31.92 ^{cd}
P1	G0	27.79 ^{fg}	36.16 ^{cd}	32.16 ^{de}	32.03 ^{cd}
	G1	27.77 ^g	32.54 ^{de}	31.98 ^{de}	30.76 ^d
	G2	38.81 ^{bc}	31.09 ^{efg}	30.66 ^{efg}	33.52 ^c
P2	G0	28.99 ^{efg}	42.92 ^{ab}	39.8 ^{bc}	37.24 ^b
	G1	42.38 ^{ab}	41.29 ^{ab}	40.08 ^{abc}	41.25 ^a
	G2	44.16 ^a	40.5 ^{ab}	42.24 ^{ab}	42.30 ^a
Fertilization Mean N		32.53b	35.41 ^a	34.18 ^a	
LSD $p \leq (0.05)$		N= 1.653	PxG= 2.457	NxGxP= 4.182	
Paclobutrazol		Nitrogen Fertilizer			Mean P
		N0	N1	N2	
	P0	27.61 ^e	31.39 ^{cd}	30.23 ^d	29.74 ^c
	P1	31.46 ^{cd}	33.26 ^c	31.60 ^{cd}	32.11 ^b
	P2	38.51 ^b	41.57 ^a	40.71 ^{ab}	40.26 ^a
LSD $p \leq (0.05)$		P= 1.438 NxP = 2.457			
Gibberellin		Nitrogen Fertilizer			Mean G
		N0	N1	N2	
	G0	26.31 ^d	37.13 ^{ab}	33.18 ^c	32.21 ^c
	G1	32.96 ^c	34.75 ^{bc}	34.26 ^c	33.99 ^b
	G2	38.31 ^a	34.34 ^c	35.09 ^{bc}	35.91 ^a
LSD $p < (0.05)$		G= 1.518 NxG= 2.441			

Conclusions

The study concluded that gibberellin and nitrogen significantly affected the grain yield. The Gibberellin concentration 100 mg L⁻¹ gave the highest grain yield by 3.59 t ha⁻¹. The Nitrogen level 240 kg N ha⁻¹ gave the highest grain yield by 3.70 t ha⁻¹. In addition, the interaction between Gibberellin concentration 200 mg L⁻¹ and the Nitrogen level 240 kg N ha⁻¹ produced the highest grain yield 4.88 t ha⁻¹. Whereas the interaction between Paclobutrazol concentration 100 mg L⁻¹ and Gibberellin concentration 200 mg L⁻¹ and Nitrogen level 240 kg N ha⁻¹ achieved the highest grain yield 5.62 t ha⁻¹. Thus, this combination was recommended for application to improve wheat planting at Basra, Iraq.

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Contributions of authors

M.M.A: Corresponded on field experiment, data collection and analysis, lab work, writing and revision the paper.

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Conflicts of Interest

The authors declare that they have no conflict of interest.

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تأثير منظمي النمو الباكلوبوترازول والجبرلين ومستويات من التسميد النيتروجيني في بعض

صفات النمو والحاصل ومكوناتهما لمحصول الحنطة (*Triticum aestivum* L)

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المستخلص: اجريت تجربة حقلية في محطة الأبحاث الزراعية / كلية الزراعة، جامعة البصرة على خط عرض $30^{\circ} 34' 11''$ شمالاً وخط طول $47^{\circ} 45' 05''$ شرقاً خلال الموسم الشتوي 2023-2024. لدراسة تأثير الرش الورقي لمنظمات نمو النبات (باكوبوترازول وجبرلين) والسماذ النيتروجيني بمستويات مختلفة وتداخلهم على بعض صفات النمو والحاصل ومكوناتهما للحنطة (*Triticum aestivum* L). أستخدم تصميم القطاعات العشوائية الكاملة (RCBD) في التجربة ووزعت المعاملات وفقاً لأسلوب القطع المنشقة المنشقة في ثلاث مكررات. كانت تراكيز الرش الورقي للباكوبوترازول 0 و 50 و 100 ملغم لتر⁻¹، ولجبرلين 0 و 100 و 200 ملغم لتر⁻¹ وكانت مستويات النيتروجين 0 و 120 و 240 كغم هكتار⁻¹. أظهرت نتائج التجربة وجود فروق معنوية بين التراكيز المستخدمة للباكوبوترازول والجبرلين ومستويات التسميد النيتروجيني في معظم الصفات المدروسة. فقد اظهر تركيز الباكلوبوترازول 100 ملغم لتر⁻¹ تأثيراً كبيراً في صفات محتوى الكلوروفيل (SPAD 22.80) وعدد الفروع (256.2 فرع م⁻²) ومتوسط عدد السنابل (212.3 سنبل م⁻²)، وعدد الحبوب في السنبل (55.26 حبة سنبل⁻¹) ومعدل وزن 1000 حبة (61.25 غم) ودليل الحصاد بنسبة (40.26%). كما كان تأثير تركيز الجبرلين 100 ملغم لتر⁻¹ كبيراً في حاصل الحبوب الكلي حيث انتج (3.95 طن/هكتار⁻¹) بينما حقق مستوى التسميد النيتروجيني 240 كغم هكتار⁻¹ (3.70 طن هكتار⁻¹). كما أظهرت النتائج ان التداخل الثنائي بين تركيز جبرلين 200 ملغم لتر⁻¹ ومستوى التسميد النيتروجيني 240 كغم هكتار⁻¹ حقق أعلى حاصل بلغ (4.88 طن هكتار⁻¹)، بينما سجل التداخل الثلاثي بين تركيز الباكلوبوترازول 100 ملغم لتر⁻¹ وتركيز الجبرلين 200 ملغم لتر⁻¹ ومستوى التسميد النيتروجيني 240 كغم هكتار⁻¹ أعلى حاصل حبوب بلغ (5.62 طن هكتار⁻¹). وخلص البحث إلى التوصية باستخدام التوليفة الأخيرة من تراكيز منظمات النمو (الباكوبوترازول والجبرلين) ومستوى التسميد النيتروجيني لتحسين زراعة الحنطة في محافظة البصرة- العراق.

الكلمات المفتاحية: الرش الورقي، الجبرلين، مستويات التسميد النيتروجيني، باكوبوترازول، الحنطة.