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The Effectiveness of Novel Growth Regulator and Fertilizer to Improve Quality and Yield of Spring Wheat

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Abstract: Reducing the use of chemical fertilizers is possible by implementing environmentally friendly smart farming technology like growth regulators and foliar fertilizer interactions. The experiment was entitled "Effectiveness of novel growth regulator and fertilizer to improve spring wheat quality and yield production." The field was conducted at Barybino, Moscow Region in 2023. The experiment comprised 16 treatment combinations in Randomized Complete Block Design (RCBD) viz plant growth regulators (PGR) Centrino-1 (GR1), Centrino-2 (GR2), Centrino-3 (GR3), and Terrasay Fertilizer-1 (F1), Terrasay Fertilizer-2 (F2) and Terrasay-3 (F3) and Control (Co). The purpose of the research work was, to examine the effects of a new formulation of foliar fertilizer and PGR on the quality and productivity of spring wheat, and to determine the best way and right dosage levels of growth regulators and fertilizers to increase crop resistance, nutrient uptake efficiency of the crop. The results showed GR3F2 need-based led to the highest plant height (69.8cm) and leaf area (7.63 cm^2). GR2F1 attained the highest number of tillers, root length, biological yield, grain yield, and gluten with a mean value of 3 tiller $plant^{-1}$, 10.7cm, 11118 kg ha^{-1}, 5042kg ha^{-1} and 12.30 respectively. GR1F3 and GR2F2 recorded the highest in protein, and carbohydrate with a mean value of 9.63%, and 89% respectively. In conclusion, proficient handling of plant growth regulators (PGR) and fertilizers (F) can be considered as a crop management strategy to boost yield and quality by improving chemical fertilization, utilization efficiency, and reducing environmental pollution.

Keyword: Fertilizer, Growth regulator, Quality, Wheat, Yield.

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Introduction

Wheat (*Triticum aestivum* L.) is cultivated in most nations and makes up a sizeable portion of the global food supply. Globally, wheat is the largest cultivated with an estimated area of 220.19 million hectares (Pleskachiov *et al.,* 2022). In terms of both overall production volume and grain acreage, it is the second-largest grain globally. The global production volume came to about over 778 million metric tons in the marketing year of 2021/22. This was an increase of about four million tons compared to the previous year and is also forecast to increase to about 286 million metric tons worldwide by 2022/2023. As the most important crop in Europe, West Asia, and North Africa, and one of the first plants to be domesticated, wheat is still one of the most important crops farmed worldwide (Almayyah & Al-Atab, 2024).

Spring wheat is more common in the Russian Federation and Canada while, winter wheat is more common in Europe and the US. Many farmers are switching from fall to spring planting of annual crops due to challenges with weed species and changing planting dates (de Oliveira Amatussi *et al.,* 2023). Many farmers apply excessive amounts of mineral fertilizers willfully to increase production in response to the market's rising demand. Global warming's trend is becoming more obvious. Surface sun radiation is diminishing significantly in many places as global temperatures rise (Klofac *et al.,* 2023). Wheat is a high source (20% or more of the Daily Value, DV) of numerous vital nutrients, including protein, dietary fiber, manganese, phosphorus, and niacin. One hundred grams of wheat contains 1,368 kilojoules (327 kilocalories) of food energy. However, harmful environmental factors including drought, fertilizer, heavy metals, low temperature, pests (weeds), and diseases frequently have an impact on the quality of wheat (Qureshi *et al*., 2023).

An increasing number of agricultural problems are a result of long-term use of pesticides, fertilizers, and other chemicals. According to Sarker *et al.* (2023) Al, not only contaminates agricultural products but also leads to an imbalance in the proportions of different nutrients, the decomposition of organic matter in the soil, and a decrease in the structural integrity and properties of aggregates, which in turn causes soil compaction, salinization, and the aggravation of disease. It will be difficult to overcome some of these variables in the near future, such as the carbonate mineral content (Almayyah & Al-Atab, 2024). Genetic stability of various genotypes of *Triticum aestivum* or bread wheat, growing in nitrogen-rich environments. The results published by Abbas (2023) indicated that the influence of nitrogen levels (N) differed significantly for every attribute. For every attribute, the relationship between nitrogen level (G x N) and genotype (G) was highly significant. On the other hand, the problems associated with the overuse of chemical fertilizers include increased production costs, groundwater pollution, energy consumption, environmental dangers, depletion of mineral resources, and degradation of soil structure. Fertilizers are used so extensively; their production elasticity has a low positive value (0.002). A 1% increase in fertilizers leads to a 0.002% increase in wheat yield. About pesticides, the production elasticity was (0.014), meaning that a one percent increase in pesticide quantity would result in a 0.014% increase in production (Mahmood et al., 2022). Annually, a significant amount of nitrogen (N) based fertilizer is sprayed on agricultural land in the area to achieve high crop yields (Gupta, R. *et al.,* 2022).

Intensive farming methods have the potential to cause soil degradation and have a variety of negative effects on the quality, health, and ecosystem services provided by the soil. By 2030, sustainable food production methods will need to restore degraded land and soil, stop desertification, and gradually increase soil quality (Sarker *et al.,* 2023; Wang *et al.,* 2023). The beneficial effects of PGR (plant growth-promoting rhizobacteria) / AMF (arbuscular mycorrhizal fungi) on plants led them to be considered as an alternative to chemical fertilizers. Due to this innovative agricultural practice, to change the microbial community composition by (1) influencing the physical and chemical parameters of soil and (2) changing rhizospheric synergistic/ antagonistic interaction between plants and microbes, which eventually impacts plant productivity. These PGRs are an economical and environmentally friendly way to increase the productivity of grain crops, enabling the full realization of plants' potential. According to de Oliveira Amatussi *et al.* (2023), such management approaches improve N rates and regulate PGR lodging, which eventually increases wheat production. PGRs boost plants' antioxidant content, reduce their intake of heavy metals and radioactive elements, and raise their resistance to the harmful effects of pesticides and the cations of heavy metals (Wang *et al.,* 2023). In this report indicated that, Innovative Fertilizer application, have an advantage in weed management strategy and optimization of the resource utility. Food production for the expanding world population has required the development and application of new technology and an intensification of management to produce more food technology and intensified production often a greater need for commercial fertilizer nutrients to avoid nutrient depletion and increase crop productivity.

To fully evaluate how PGRs affect plant secondary metabolites (PSM), a thorough understanding of plants' is required. Silicon is a constituent of PGR may help in the recovery of wheat from lodging and make the leave erect (Mishra *et al.,* 2021). Because of that growth retardants often function by changing their metabolism and are antagonistic to lodging prevents (also known as plant height retardants) are also frequently referred to as anti-gibberellin. Numerous studies have looked at how different PGR types affect the growth and productivity of wheat, but this study concentrated on how different foliar fertilizer dosages interact with growth regulators influenced on wheat. Keeping in mind this problem-focused experiment, the objectives of this research endeavor were as follows:

- ✓ To examine the effects of a new formulation of foliar fertilizers and PGR on the quality and productivity of spring wheat by increasing pigment concentration, increasing tillering number, and reducing lodging issues.
- ✓ To determine the best way to apply growth regulators and fertilizers at the right dosage levels to increase crop yield, through maximize nutrient uptake, and Efficiency.

Materials & Methods

Location description and climate

The investigation was carried out in 2023 in sod-podzolic heavy loamy soil in the Research Institute of Agrochemistry in Barybino, Domodedovo Microdistrict, Moscow Region, at latitude 55° 15' 52.6248" N and longitude 37° 53' 13.1712" E. The experiment comprised of 16 treatments viz plant growth regulators (PGR) Centrino-1 (GR1), Centrino-2 (GR2), Centrino-3 (GR3), and Terrasay Fertilizer Micro Brand, Terrasay Fertilizer -1 (F1), Terrasay Fertilizer -2 (F2) and Terrasay Fertilizer -3 (F3) and Control (Co). As an active component of chlormequat chloride with 750 g per l, Centrino is a member of the quaternary ammonium compound chemical family. It is a water-soluble concentrate that works by contact and was sprayed once, at rates of 0, 1.0, 1.25, and 1.5 ml per ha, which are represented as Co, GR1, GR2, and GR3, respectively, with a working fluid flow rate of 300 l per ha, during the phase of entering the tube/tillering phase. Terrasay Fertilizer contains a set of vital vitamins for plant growth, strength, and development, and it is Granular fertilizer with the following recommended composition are more practical to use nutrients available for plants (%): N-20; P-9; K-10; Mg-2.0; Fe-0.15; Mn-0.08; B-0.02; Cu-0.01; Zn-0.02, was applied as a foliar treatment twice during the tillering and earing phase at rates of 0, 0.5, 1, and 2 ml per hectare were represented as Co, F1, F2 and F3 respectively. GenStat software was used to evaluate all parametric measurements collected during the experiment.

Experimental design and layout

The area will be plowed using a disc harrow and disc plough. For the field experiment, a randomized complete block design (RCBD) with four replications was employed. Each replication consisted of 16 plots of 5 m by 2.5 m, with 16 cm separating rows, 12 cm separating plants within rows, and 2 m separating blocks. During the growing season crops were harvested, at August 19–August 21.

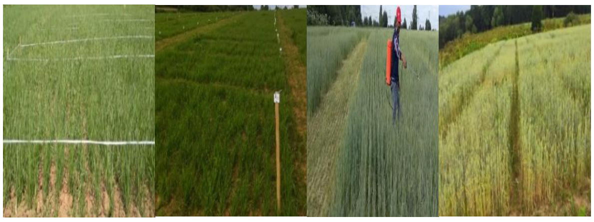


Fig. (1): Diagrammatic representation of a PGR and their combinations with foliar fertilizers on the quantitative and qualitative traits of a spring wheat.

Crop Analysis

Leaf sample (0.4g) was taken, then the juice extracted, to determine the pigment content of chlorophyll a, b, and carotenoid using a spectrophotometer with a wavelength range of 400nm–700nm. To determine the quality of spring wheat seed analyses, 4000 mg of seeds from each plot were taken, and Grainsense A-2 - Portable Infrared Express Grain and Oilseed Analyzer was used (Flak, 2020).

Statistical analysis

Analysis of variance (ANOVA) and post hoc least significant difference (LSD) analysis were carried out. The means comparison analysis was conducted using IBM SPSS statistical package version 20 and GENSTAT software (4th edition) with the treatment means compared with LSD at 5% (P<0.05) probability levels.

Result & Discussion

Interaction effects of Growth Regulator and foliar Fertilizer on Growth parameters of Spring Wheat

The results of interaction effect of growth regulator and chemical fertilizers are presented in (Table 1). A cursory glance at the research work on growth studies were significantly influenced by all treatments. Means comparison analysis, showed that the highest and lowest means of the growth parameters related to the control and different PGR and fertilizer treatments. According to the research results, using a growth regulator with retardant properties provided a significant reduction in plant height and an increase in leaf area, tillering number, and root length. On average, the use of growth regulators at the end of the tillering exit into the tube phase reduced the height of plants by an average of 10 cm, 15 cm compared to the control, where the height of plants averaged 65.706 cm (58cm maximum and 73cm minimum). The leaf area, tillering number and root length were significantly increased with the mean values of 1.51cm^2, 1.23 and 3.08 cm respectively as compared to without application of PGR. The data on the effect of Fertilizer doses on Plant height, leaf area, Number of tillers and root length presented in (Table 1), indicated that fertilizer application showed a significantly influence. The highest plant height, leaf area, tillering number and root length were obtained in F1, F2 and F2 respectively. The report of Pleskachiov *et al.* (2022) revealed that plant height, leaf area, and number of tillers were significantly affected by the application of the various Fertilizer treatments. Inline to these results which shows significant variations in the regression coefficients, particularly for the traits of plant height, show that various genotypes respond differently to environmental changes (Abbas, 2023).

Stalk lodging was positively correlated with plant height, the center of gravity height and internode length, but negatively correlated with basal internode diameter (Gupta *et al*., 2022). PGR are important in this regard as they can increase the root growth and nutrient uptake of plants (Gupta *et al.,* 2023). It is also consistent with the findings of (Klofac *et al*., 2023).

The data on the interaction effect of PGR and Fertilizer showed significantly different on plant height, leaf area, number of tillers and root length (Table 1). The results of this research work reported that GR3F2 need-based led to the highest Plant height (69.8cm) and leaf area (7.63 cm^2). However, the highest number tillering and Root length were recorded with GR2F1 treatment interaction with a mean value of 3 and 10.7cm respectively. The results of treatment interaction reported GR3F2 need-based led to the highest Plant height (69.8cm) and leaf area (7.63 cm^2). GR2F1 attained the highest number of tillering and root lengths with a mean value of 3 and 10.7cm respectively. The same trend was observed with the application of B2 (growth retardant) significantly reduced plant height and internode length compared with the control (Peng *et al.,* 2023.

Table (1): Interaction effects of growth regulator and chemical fertilizers on growth parameters of spring wheat.

Treatments	Plant height (cm)	Leaf Area (cm2)	Tillers number /plant	Root length (cm)
C0	73 ±7.3a	5.20±0.52g	1.07±0.10m	6.53±0.65l
F1	65.33±6.53f	7.88±0.78a	1.63±0.16j	8.17±0.81n
F2	72±7.2b	7.14±0.714c	1.53±0.15j	8.67±0.86j
F3	70±7.0c	6.4±f0.64g	1.7±0.17i	8.9±0.89h
GR1	68±6.8e	6.61±0.66fg	2.2±0.22f	9.61±0.96d
GR2	63±6.3i	6.93±6.93f	2.3±0.23d	9±0.9g
GR3	65±6.5f	6.71±0.67f	2.1±0.21g	9.5±0.95e
GR1F1	64.8±6.48g	6.97±0.69f	2±0.2h	8.72±0.87i
GR1F2	65.5±6.55f	6.56±f0.65g	2.5±0.25c	8.77±0.87i
GR1F3	65±6.5f	6.47±0.64fg	2.5±0.25c	8±0.8o
GR2F1	61.66±6.17j	7.06±0.70cd	3±0.3a	10.7±1.0a
GR2F2	62.7±6.27i	7±0.7df	2±0.2h	10.07±1.0b
GR2F3	59±5.9k	6.11±0.61fg	2.5±0.25c	8.63±0.86k
GR3F1	58±5.8l	7.22±0.72bc	2.2±0.22f	8.45±0.84m
GR3F2	69.8±6.98d	7.63±0.76a	2.67±0.26b	9.9±0.99c
GR3F3	64±6.4h	7.29±0.72b	1.6±0.16k	9.41±0.94f
Mean	65.42	6.85	2.09	8.94
F	33,2	3.76	1.38	4.67
P	<.001*	NS	<.001*	<.001*
SED	0.65	1.4	0.024	0.028
CV	0.7	7.42	1.4	0.4
LSD 5%	1.284	2.82	0.04828	0.05706

Effects of applied growth regulator and their combinations with foliar fertilizer on yield and quality of spring wheat

The results of the combined effect of applied growth regulator and their combination with foliar fertilizer on the yield components of the spring wheat cultivar are shown in (Table 2). The effect of growth regulator on biological yield (BY), grain yield (GY), protein, gluten, and carbohydrate were statistically significant at a 5% probability level. GY, BY, protein, gluten and carbohydrate were significantly (P<0.05) affected due to interactive outcomes of different doses of growth regulators and fertilizer (Table 2). Results revealed that GR2F1 treatment interaction shows significantly the highest biological yield and grain yield with a mean value of 11118kg.ha^{-1} and 5042kg ha^{-1} respectively.

According to the result obtained in this experiment, the trend presented in (Table 2) shows that an increase growth for the regulator applied resulted in a respective increase in yield characters. This is evident in the average yields as compared to the addition of nitrogen fertilizer and growth retardant which improve the yield components as a result it is positively influenced the BY and GY. A similar trend was observed for GY as the highest means were obtained by the application of the GR2 and F1 with a mean value of 4220 kg/ha and 4303 kg/ha respectively, and the lowest was obtained in control. It is also consistent with the findings (Isaychev *et al.,* 2020), that the increase in yields by 0.17–0.40 t/ha, with the application of the growth regulator Energia provides the greatest increase about the control group (22.3%). According to the results reported by (Pleskachiov *et al.,* 2022). The topdressing with N32 kg.ha^{-1} fertilizer during the wheat tillering stage in autumn afforded more than 13 kg grain.kg^{-1} of nitrogen fertilizer used. Optimal use of PGRs with proper field rates in combination with N fertilizer is considered one of the most effective practices for increasing crop yields through improved growth regulation and the development of plants. Among all treatments significantly the highest proteins and gluten were observed in GR2F2 followed by GR2F1 treatment interaction. GR1F3 and GR2F3 were significant at par and the highest in carbohydrate was recorded. In contradiction, the output of the experiment obtained shows the highest in protein and gluten content was observed with lowest in carbohydrate and vis versa with the application of PGR and fertilized treatments interaction. The use of growth regulators in the technology of cultivation of spring wheat has a positive effect on the formation of grain quality indicators, which determine the technological and baking properties of products, such as the content of protein and starch, and the quantity and quality of gluten. The regulation of plant growth and development with the help of physiologically active substances allows one to influence the individual stages of ontogenesis to mobilize the genetic potential of the plant organism and, ultimately, to increase the productive capacity and quality of crops. The grain protein content was increased by 0.63 %, 0.47 % and 49 % through the integrated application of GR2F2 need-based PGR and chemical fertilizers. One of the most important indicators of grain quality, which largely determines its technological properties is the protein content. In agreement with this finding, the quality of wheat grain is a factor in intensifying agricultural production; therefore, the improvement of biochemical indicators of production is of key importance in farming and crop growth (Isaychev *et al*., 2022). In agreement to this result the top three widely disseminated wheat varieties shown significant gains in both grain and straw yield averages between 2015 and 2022 when compared to the control variety. Farmers produced 490 tons of straw and 340 tons of quality seeds between 2014 and 2022 (Hamdan *et al*., 2024). In the conducted studies, with the action of growth regulators, the starch content increased compared to the control group by 2.01–5.08%, depending on the variant.

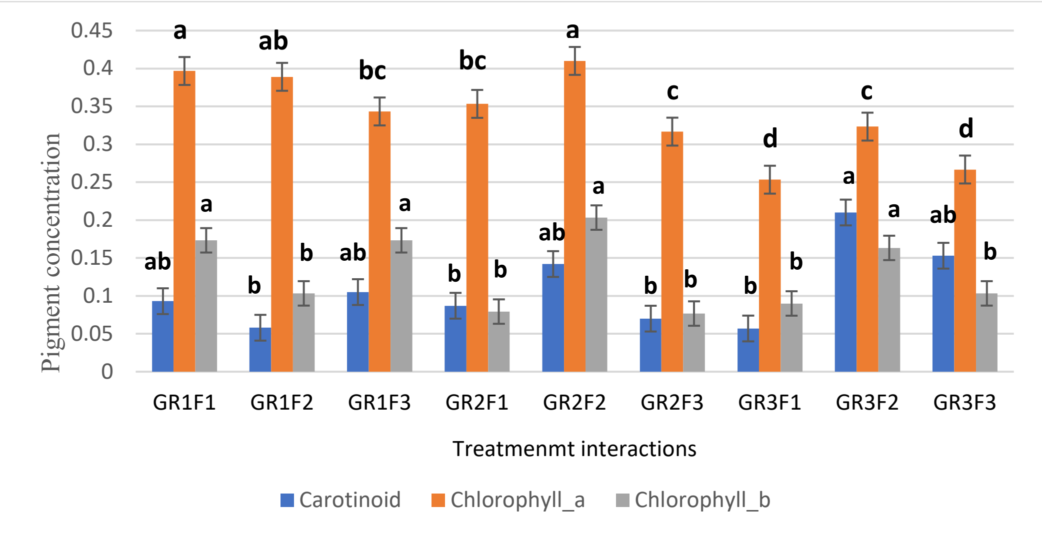
Table. (2). Effects of applied growth regulator and their combinations with chemical fertilizers on yield and quality of spring wheat.

Treatments	Biological Yield kg/ha	Grain Yield kg/ha	Protein (%)	Gluten (%)	Carbohydrate (%)
C0	8739±873.9^{de}	3391±339.1^{d}	9.27±0.927e	11.38±1.1138^{h}	88.69±8.869^{f}
F1	10199±1019.9^{b}	4303±4303.^{b}	9.42±0.942c	11.79±1.179^{d}	88.55±8.855^{g}
F2	8980±898.0^{d}	4199±419.9^{b}	9.47±0.947^{b}	11.91±1.191^{c}	88.75±8.875^{df}
F3	9072±907.2^{cd}	3653±365.3^{c}	9.28±0.928^{e}	11.42±1.142^{h}	88.86±8.886^{c}
GR1	9360±936.0^{cd}	3491±349.1^{d}	9.14±0.914^{g}	11.08±1.108^{i}	89.14±8.914^{a}
GR2	9568±956.8^{cd}	4220±422.0^{b}	9.49±0.949^{b}	11.97±1.197^{b}	88.78±8.878^{d}
GR3	8446±844.6^{e}	3943±394.3^{bc}	9.42±0.942^{c}	11.83±1.183^{d}	88.95±8.895^{b}
GR1F1	8818±881.8^{de}	4303±430.3^{b}	9.23±0.923^{f}	11.37±1.137^{h}	88.76±8.876^{d}
GR1F2	9722±972.2^{bc}	4199±419.9^{b}	9.40±0.940^{c}	11.93±1.193^{c}	88.85±8.885^{c}
GR1F3	8810±881.0^{de}	3653±365.3^{c}	9.00±0.900^{h}	10.67±1.067^{j}	89.15±8.915^{i}
GR2F1	11118±1111.8^{a}	5042±504.2^{a}	9.50±0.950^{b}	12.30±1.230^{a}	88.75±8.875^{df}
GR2F2	8154±815.4.^{de}	3857±385.7^{bc}	9.63±0.963^{a}	12.27±1.227^{a}	88.25±8.825^{h}
GR2F3	9681±968.1^{c}	4257±425.7^{b}	9.41±0.941^{c}	11.97±1.197^{b}	89.15±8.915^{a}
GR3F1	7834±783.4^{e}	3734±373.4^{bc}	9.44±0.944^{bc}	11.77±1.177^{f}	88.75±8.875^{df}
GR3F2	9036±903.6^{cd}	4207±420.7^{b}	.9.42±0.942^{c}	11.80±1.180^{d}	88.95±8.895^{b}
GR3F3	8318±831.8^{de}	3604±3604^{c}	9.33±0.933^{d}	11.50±1.150^{g}	88.79±8.879^{d}
Means	9115.94	4003.5	9.36	11.69	88.82
F	3.81	2.27	3.12	27.52	20.36
P	0.003*	0.045*	0.009*	<.001*	<0.001*
SED	901.6	432.4	0.03	0.05	0.02
CV %	13.2	12.1	0.40	0.70	0.10
LSD 5%	1841.4	883.1	0.06	0.14	0.04

Effects of a new formulation of growth regulators and their Combinations with

foliar fertilizers on the pigment content of spring wheat leaf

The interaction effect of the growth regulator and foliar fertilizer was significantly the highest during the investigated pigment content of the spring wheat leaf presented in (Fig. 2). Means comparison analysis, showed that the highest and lowest means of the chlorophyll content parameters related to the control and different PGR and fertilizer dose treatments. According to these results, the use of growth regulators interacted with fertilizer, GR2F2 followed by GR1F1 and GR1F3 recorded significantly the highest in chlorophyll a and chlorophyll b. These results were attributed to the presence of F2 enriches the pigment content particularly chlorophyll a. With retardant properties provided a significant reduction in all pigment content was observed on GR3F1 treatment interaction level. The highest carotenoid pigment content was obtained on GR3F2 followed by GR3F3 treatments interacted as compared in all other treatment interactions. In agreement with this study under the influence of retardants, the leaf surface area of plants increases significantly (on average by 25-40%) and the content of chlorophyll increases (on average by 10-35%) (Pleskachiov *et al.,* 2022).



	Chlorophyll a	Chlorophyll b	Carotenoid
LSD 5%	0.05	0.06	0.11
CV%	8.8	19	20.2

Fig. (2): Effects of new formulation of Growth regulators and their Combinations with foliar Fertilizers on the quality of spring wheat.

Conclusion

A field study was conducted to assess the effects of different dosages of PGR and their combinations with foliar chemical fertilizers on the Growth yield and quality characteristics of spring wheat.

According to the results reported, Control need-based led to the highest Plant height (73 cm) and with GR3F2 attained leaf area (7.63 cm^2) and carbohydrate content (88.95 %). GR2F1 attained the highest tillering number and root lengths with a mean value of 3 and 10.7cm respectively.

The highest yields were obtained on GR2F1 with a mean value of 11118 kg/ha biological yield, 5042 $kg.ha^{-1}$ grain yield and 12.30 % gluten content.

Among all treatments a significantly the highest proteins and chlorophyll a and chlorophyll b were obtained by GR2F2 treatment interaction during this research

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Contributions of Authors

S.G.O.: Principal investigator of proposal of the article, Field work, Laboratory techniques for collecting parameters, conceptual, wrote and revised the manuscript.

M.A; revised the manuscript, identification of the properties.

E.N.P.: Suggestion the proposal of the article, revised the manuscript, identification of the properties.

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Conflicts of interest

The authors declare no conflict of interest.

Ethical approval

All ethical guidelines related to field work of Agrochemical farm and care issued by national and international organizations were implemented in this report.

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فعالية منظمات النمو والأسمدة في تحسين جودة وإنتاجية القمح الربيعي.

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المستخلص: مكن تقليل استخدام الأسمدة الكيماوية من خلال تنفيذ تكنولوجيا الزراعة الذكية الصديقة للبيئة مثل منظمات النمو وتفاعلات الأسمدة الورقية. كان الهدف من التجربة دراسة فعالية منظم النمو الجديد والرش بالاسمدة الورقية وتداخلاتهما لتحسين جودة الحنطة الربيعية وحاصل الحبوب. أجريت التجربة في باريبينو، منطقة موسكو في عام 2023. وتضمنت التجربة 16 معاملة مركبة باستخدام تصميم القطاعاتالعشوائية الكاملة (RCBD). وهي كالتالي: منظمات نمو النبات (Centrino-1 (GR1 و(Centrino-2 (GR2 و(Centrino-3 (GR3 وسماد (Terrasay-1 (F1 وسماد (Terrasay-2 (F2 و(Terrasay-3 (F3 والتحكم (Co). كان الغرض من العمل البحثي هو دراسة تأثير تركيبة جديدة من الأسمدة الورقية وPGR على جودة وإنتاجية القمح الربيعي، وتحديد أفضل طريقة ومستويات منظمات النمو والأسمدة لزيادة مقاومة المحاصيل وكفاءة امتصاص المحصول للمغذيات. أظهرت النتائج أن GR3F2 القائم على الاحتياجات اعطى أعلى ارتفاع للنبات بلغ (69.8 سم) ومساحة ورقة (7.63 سم 2). حقق GR2F1 أعلى عدد من السيقان وطول الجذر والحاصل البايلوجي وحاصل الحبوب والكلوتين بلغ 3 سيقان نبات$^{-1}$، 10.7 سم، 11118 كغم هكتار$^{-1}$، 5042 كغم.هكتار $^{-1}$ و 12.30 على التوالي. سجل GR1F3 و GR2F2 أعلى نسبة في البروتين والكربوهيدرات بقيمة متوسطة 9.63٪ و 89٪ على التوالي. وفي الختام، يمكن اعتبار التعامل الماهر مع منظمات نمو النبات (PGR) والأسمدة (F) بمثابة استراتيجية لإدارة المحاصيل لتعزيز الغلة والجودة من خلال تحسين التسميد الكيميائي وكفاءة الاستخدام والحد من التلوث البيئي.

الكلمات المفتاحية: الأسمدة، منظمات النمو، الجودة، القمح، الحاصل.