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«ҚАЗАҚСТАН РЕСПУБЛИКАСЫ
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Х А Б А Р Ш Ы С Ы

ВЕСТНИК

РОО «НАЦИОНАЛЬНОЙ
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В 2016 году для развития и улучшения качества жизни казахстанцев был создан частный Благотворительный фонд «Халык». За годы своей деятельности на реализацию благотворительных проектов в областях образования и науки, социальной защиты, культуры, здравоохранения и спорта, Фонд выделил более 45 миллиардов тенге.

Особое внимание Благотворительный фонд «Халык» уделяет образовательным программам, считая это направление одним из ключевых в своей деятельности. Оказывая поддержку отечественному образованию, Фонд вносит свой посильный вклад в развитие качественного образования в Казахстане. Тем самым способствуя росту числа людей, способных менять жизнь в стране к лучшему – профессионалов в различных сферах, потенциальных лидеров и «великих умов». Одной из значимых инициатив фонда «Халык» в образовательной сфере стал проект Ozgeris powered by Halyk Fund – первый в стране бизнес-инкубатор для учащихся 9-11 классов, который помогает развивать необходимые в современном мире предпринимательские навыки. Так, на содействие малому бизнесу школьников было выделено более 200 грантов. Для поддержки талантливых и мотивированных детей Фонд неоднократно выделял гранты на обучение в Международной школе «Мирас» и в Astana IT University, а также помог казахстанским школьникам принять участие в престижном конкурсе «USTEM Robotics» в США. Авторские работы в рамках проекта «Тәлімгер», которому Фонд оказал поддержку, легли в основу учебной программы, учебников и учебно-методических книг по предмету «Основы предпринимательства и бизнеса», преподаваемого в 10-11 классах казахстанских школ и колледжей.

Помимо помощи школьникам, учащимся колледжей и студентам Фонд считает важным внести свой вклад в повышение квалификации педагогов, совершенствование их знаний и навыков, поскольку именно они являются проводниками знаний будущих поколений казахстанцев. При поддержке Фонда «Халык» в южной столице был организован ежегодный городской конкурс педагогов «Almaty Digital Ustaz.

Важной инициативой стал реализуемый проект по обучению основам финансовой грамотности преподавателей из восьми областей Казахстана, что должно оказать существенное влияние на воспитание финансовой грамотности и предпринимательского мышления у нового поколения граждан страны.

Необходимую помощь Фонд «Халык» оказывает и тем, кто особенно остро в ней нуждается. В рамках социальной защиты населения активно проводится работа по поддержке детей, оставшихся без родителей, детей и взрослых из социально уязвимых слоев населения, людей с ограниченными возможностями, а также обеспечению нуждающихся социальным жильем, строительству социально важных объектов, таких как детские сады, детские площадки и физкультурно-оздоровительные комплексы.

В копилку добрых дел Фонда «Халык» можно добавить оказание помощи детскому спорту, куда относится поддержка в развитии детского футбола и карате в нашей стране. Жизненно важную помощь Благотворительный фонд «Халык» оказал нашим соотечественникам во время недавней пандемии COVID-19. Тогда, в разгар тяжелой борьбы с коронавирусной инфекцией Фонд выделил свыше 11 миллиардов тенге на приобретение необходимого медицинского оборудования и дорогостоящих медицинских препаратов, автомобилей скорой медицинской помощи и средств защиты, адресную материальную помощь социально уязвимым слоям населения и денежные выплаты медицинским работникам.

В 2023 году наряду с другими проектами, нацеленными на повышение благосостояния казахстанских граждан Фонд решил уделить особое внимание науке, поскольку она является частью общественной культуры, а уровень ее развития определяет уровень развития государства.

Поддержка Фондом выпуска журналов Национальной Академии наук Республики Казахстан, которые входят в международные фонды Scopus и Wos и в которых публикуются статьи отечественных ученых, докторантов и магистрантов, а также научных сотрудников высших учебных заведений и научно-исследовательских институтов нашей страны является не менее значимым вкладом Фонда в развитие казахстанского общества.

С уважением, Благотворительный Фонд «Халык»!

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ECONOMETRIC ANALYSIS OF WHEAT PRODUCTION DYNAMICS IN KAZAKHSTAN

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Abstract. This study delves into the wheat production in Kazakhstan for 2023, a topic of significant relevance due to Kazakhstan's role as a major wheat exporter. The research addresses the complexities of wheat cultivation in a region known for its vast agricultural potential, yet challenged by the need to optimize production efficiency and sustainability. The study is particularly pertinent given the increasing global demand for food and the need for sustainable agricultural practices amidst challenges like climate change and resource depletion. Methodologically, the study employs a combination of descriptive and inferential statistical techniques to analyze comprehensive data from various regions of Kazakhstan. This includes metrics like harvested areas, gross harvests, and yields of winter and spring wheat. A key method used is regression analysis, specifically the Ordinary Least Squares (OLS) regression, to explore the relationships between wheat yield and agricultural factors such as gross harvest on irrigated lands and different types of fertilizers. The study hypothesizes a complex interplay of factors influencing wheat yield and tests these through statistical modelling. Key conclusions indicate significant regional disparities in wheat cultivation, impacted by variables such as climate, soil type, and agricultural practices. The regression analysis reveals a nuanced relationship between wheat yield and factors like fertilizer application, underscoring the complexity of agricultural systems. The results have practical implications, offering insights that can guide agricultural policy-making and strategic planning in Kazakhstan. The study's findings can inform targeted strategies for optimizing wheat yield, contributing to more effective and sustainable agricultural practices. Additionally, the research identifies potential areas for future investigation, suggesting that integrating more variables and exploring advanced technologies could further enhance wheat yield prediction and agricultural efficiency.

Keywords: wheat production, agriculture of Kazakhstan, econometric analysis, yield optimization, fertilizer application, regional variability, agricultural efficiency

Conflict of interest: *the authors declare no conflict of interest in the preparation and execution of this study.*

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ҚАЗАҚСТАНДАҒЫ БИДАЙ ӨНДІРУ ДИНАМИКАСЫНЫҢ ЭКОНОМЕТРИЯЛЫҚ ТАЛДАУЫ

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Аннотация. Бұл зерттеу 2023 жылға арналған Қазақстандағы бидай өндірісін зерттейді, бұл Қазақстанның негізгі бидай экспорттаушысы ретіндегі рөліне байланысты маңызды өзекті тақырып. Зерттеу өндірістің тиімділігі мен тұрақтылығын оңтайландыру қажеттілігінен туындаған үлкен ауыл шаруашылығы әлеуетімен танымал аймақтағы бидай өсірудің күрделі мәселелерін қарастырады. Зерттеу әсіресе азық-түлікке деген жаһандық сұраныстың артуы және климаттың өзгеруі және ресурстардың сарқылуы сияқты қиындықтар жағдайында тұрақты ауылшаруашылық тәжірибелерінің қажеттілігін ескере отырып өте маңызды. Әдістемелік тұрғыдан зерттеу Қазақстанның әртүрлі аймақтарынан алынған жан-жақты деректерді талдау үшін сипаттамалық және қорытынды статистикалық әдістердің комбинациясын пайдаланады. Бұған орылған аумақтар, жалпы егін, күздік және жаздық бидайдың шығымдылығы сияқты көрсеткіштер кіреді. Қолданылатын негізгі әдіс бидай шығымдылығы мен суармалы жерлердегі жалпы өнім және тыңайтқыштардың әртүрлі түрлері сияқты ауылшаруашылық факторлары арасындағы байланыстарды зерттеу үшін регрессиялық талдау, атап айтқанда қарапайым ең аз квадраттар (OLS) регрессиясы болып табылады. Зерттеу бидай шығымдылығына әсер ететін факторлардың күрделі өзара әрекетін болжайды және оларды статистикалық модельдеу арқылы тексереді. Негізгі қорытындылар климат, топырақ түрі және ауылшаруашылық тәжірибесі сияқты айнымалылар әсер ететін бидай өсірудегі елеулі аймақтық теңсіздіктерді көрсетеді. Регрессиялық талдау бидай шығымдылығы мен тыңайтқыш қолдану сияқты факторлар арасындағы нюансты байланысты көрсетеді, бұл ауыл шаруашылығы жүйелерінің күрделілігін көрсетеді. Нәтижелердің практикалық мәні бар, олар

Қазақстандағы ауылшаруашылық саясатын қалыптастыру мен стратегиялық жоспарлауда басшылыққа алатын түсініктерді ұсынады. Зерттеу нәтижелері бидай шығымдылығын оңтайландырудың мақсатты стратегияларын хабардар ете алады, тиімдірек және тұрақты ауыл шаруашылығы тәжірибесіне ықпал етеді. Сонымен қатар, зерттеу болашақ зерттеудің әлеуетті бағыттарын анықтайды, бұл көбірек айнымалыларды біріктіру және озық технологияларды зерттеу бидай өнімділігін болжау мен ауыл шаруашылығы тиімділігін одан әрі арттыруға мүмкіндік береді.

Түйін сөздер: бидай өндірісі, Қазақстанның ауыл шаруашылығы, эконометрикалық талдау, шығымдылықты оңтайландыру, тыңайтқыштарды қолдану, аймақтық өзгергіштік, ауыл шаруашылығының тиімділігі

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ЭКОНОМЕТРИЧЕСКИЙ АНАЛИЗ ДИНАМИКИ ПРОИЗВОДСТВА ПШЕНИЦЫ В КАЗАХСТАНЕ

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Аннотация. В настоящем исследовании рассматривается производство пшеницы в Казахстане в 2023 году, что является темой, имеющей значительную актуальность в связи с ролью Казахстана как крупного экспортера пшеницы. Исследование посвящено сложностям выращивания пшеницы в регионе, известном своим огромным сельскохозяйственным потенциалом, но сталкивающимся с необходимостью оптимизации эффективности и устойчивости производства. Исследование особенно актуально, учитывая растущий глобальный спрос на продовольствие и потребность в устойчивых методах ведения сельского хозяйства на фоне таких проблем, как изменение климата и истощение ресурсов. Методологически исследование использует сочетание описательных и логических статистических методов для анализа комплексных данных из различных регионов Казахстана. Сюда входят такие показатели, как убранные площади, валовые сборы и урожайность озимой и яровой пшеницы. Ключевым используемым методом является регрессионный анализ, в частности регрессия по методу наименьших квадратов (OLS), для изучения взаимосвязей между урожайностью пшеницы и сельскохозяйственными факторами, такими как валовой сбор на орошаемых землях и различные виды удобрений. Исследование выдвигает гипотезу о сложном взаимодействии факторов, влияющих на урожайность пшеницы, и проверяет ее посредством статистического моделирования. Ключевые выводы указывают на значительные региональные различия в выращивании пшеницы, на которые влияют такие переменные, как климат, тип почвы и методы ведения сельского хозяйства. Регрессионный анализ выявляет тонкую взаимосвязь между урожайностью пшеницы и такими факторами, как внесение удобрений, что подчеркивает сложность сельскохозяйственных систем. Результаты имеют практическое значение, предлагая идеи, которые могут служить ориентиром для разработки сельскохозяйственной политики и стратегического планирования в Казахстане. Результаты исследования могут стать основой для целевых стратегий оптимизации урожайности пшеницы, способствуя более эффективным и устойчивым методам ведения сельского хозяйства. Кроме того, исследование определяет потенциальные области для будущих исследований, предполагая, что интеграция большего количества переменных и изучение передовых технологий могут еще больше улучшить прогнозирование урожайности пшеницы и эффективность сельского хозяйства.

Ключевые слова: производство пшеницы, сельское хозяйство Казахстана, эконометрический анализ, оптимизация урожайности, внесение удобрений, региональная изменчивость, эффективность сельского хозяйства

Конфликт интересов: *авторы заявляют об отсутствии конфликта интересов при подготовке и проведении настоящего исследования.*

Introduction

The introduction to the study of wheat production in Kazakhstan in 2023 presents an in-depth analysis of the agricultural sector, focusing on a critical crop that plays a significant role in both national and global food security. This research was prompted by the need to understand the dynamics and complexities of wheat cultivation in a country known for its vast agricultural potential, yet facing numerous challenges in optimizing production efficiency and output (Ni, Lan, Qiu, Zhang & Yuen, 2023).

The choice of this topic is justified by several factors. Kazakhstan is among the world's top wheat exporters, and its agricultural practices and yields have a considerable impact on global wheat markets. However, the efficiency and sustainability of wheat production in Kazakhstan are influenced by diverse factors, including regional variability in climate, soil types, and farming techniques. This research aims to address a critical gap in understanding how these variables interact and affect overall wheat production (Postiglione, 2021).

The relevance of the problem is evident in the context of growing global food demand and the need for sustainable agricultural practices. As the world grapples with issues like climate change, resource depletion, and population growth, enhancing the efficiency of key food crops like wheat becomes increasingly crucial. Kazakhstan's wheat production, given its scale, is a significant player in this scenario. Understanding and improving wheat yield and harvesting practices in Kazakhstan can offer insights applicable to other regions and contribute to global food security.

The purpose of the study is multi-fold. Primarily, it seeks to analyze the intricate interplay of factors affecting wheat yield, such as harvested areas, gross harvests, and the application of various types of fertilizers. This analysis is not limited to merely quantifying these factors but extends to understanding their correlations and combined impact on wheat yield. By doing so, the study aims to uncover insights that can lead to more effective agricultural policies, targeted interventions, and improved farming practices in

Kazakhstan.

This research is based on comprehensive data collection from various regions of Kazakhstan, encompassing key metrics such as harvested areas, gross harvests, and yields of winter and spring wheat. The study employs a combination of descriptive and inferential statistical techniques to interpret this data, including regression analysis to explore the relationships between different agricultural factors and wheat yield. This methodological approach allows for a nuanced understanding of the factors influencing wheat production in Kazakhstan (Kumar, Shelake & Singh, 2023).

However, there exists a problematic situation in justifying the choice of this topic, mainly because the agricultural sector in Kazakhstan is influenced by a myriad of factors beyond the scope of immediate agricultural practices. These include broader economic policies, global market trends, and the impacts of climate change. The study, therefore, faces the challenge of isolating the effects of the identified agricultural factors from these external influences.

In summary, this research provides a detailed examination of wheat production in Kazakhstan, highlighting the significance of both regional differences and common agricultural practices. By exploring the complex relationships among various factors influencing wheat yield, the study contributes valuable insights towards optimizing wheat production, which is essential for strategic planning and policy-making in the context of Kazakhstan's agriculture and beyond.

Materials and methods

In the research on wheat production in Kazakhstan in 2023, the methodology involved a comprehensive approach encompassing data collection, analysis, and interpretation, focusing on nine critical factors affecting wheat yield and productivity. The primary materials for the study were agricultural data from various regions of Kazakhstan for the year 2023, sourced from official agricultural reports and databases to ensure accuracy and reliability.

The data encompassed key metrics like harvested areas for winter and spring wheat, gross harvests of both types of wheat, and the yield measurements in centners per hectare. This encompassing dataset allowed for a detailed analysis of regional variations in wheat production, highlighting differences in agricultural practices, soil types, climatic conditions, and technological advancements in farming across Kazakhstan.

The statistical methodology employed in the study was multifaceted. Initially, descriptive statistics were used to summarize the data, providing a clear understanding of the central tendencies, dispersion, and distribution of the variables. Quartile analyses were performed to understand the distribution range of harvested areas, gross harvests, and yields, which revealed significant regional disparities in wheat cultivation.

Further, a regression analysis was conducted to explore the relationships between the yield of winter and spring wheat and various agricultural factors such as gross wheat harvest on irrigated lands, and the application of different types of fertilizers. The regression model was formulated using Ordinary Least Squares (OLS) regression, a method well-suited for exploring linear relationships between a dependent variable and one or more independent variables (Heij, de Boer, Franses, Kloek & Van Dijk, 2004).

In the regression model, each independent variable's coefficient indicated its relationship with the wheat yield. Special attention was paid to multicollinearity among independent variables, ensuring the validity of the regression coefficients. The model's

R-squared and adjusted R-squared values were used to assess the overall fit and explanatory power of the model.

Furthermore, the study involved a critical interpretation of the regression outcomes, particularly examining the implications of the coefficients and intercepts obtained from the model. This involved a careful consideration of agricultural practices, soil health, and environmental conditions that could impact the relationships observed in the regression analysis.

In summary, the research employed a robust combination of descriptive and inferential statistical techniques to analyze a comprehensive dataset on wheat production in Kazakhstan. The findings offer valuable insights into regional agricultural practices and highlight the potential for optimizing wheat yield through targeted strategies, making significant contributions to policy-making and strategic agricultural planning. The methodological approach also suggests areas for future research, particularly in integrating more variables and exploring advanced technologies in agriculture to enhance understanding and effectiveness in the face of changing environmental conditions and global market dynamics (Bryant, 2022).

Research results

In the context of wheat production in Kazakhstan in 2023, the intricate interplay of nine key factors - yield of winter and spring wheat, yield of winter wheat, yield of spring wheat, gross harvest of winter and spring wheat, gross harvest of winter wheat, gross harvest of spring wheat, harvested area of winter and spring wheat, harvested area of winter wheat, and harvested area of spring wheat — reveals a complex picture of agricultural dynamics and productivity. Therefore, these factors were shown by the table below.

The yield of both winter and spring wheat, measured in centners per hectare, directly influences the total gross harvest in centners. Higher yields typically result in greater gross harvests, assuming other factors like harvested area remain constant. This correlation suggests that regions with advanced farming techniques and favorable climatic conditions tend to have both high yields and substantial total harvests.

However, yield is not the only determinant of the gross harvest; the size of the harvested area also plays a critical role. Even regions with moderate yields can achieve significant gross harvests if the area under cultivation is large. Conversely, a high yield in a small area may not contribute significantly to the total harvest. This dynamic underscores the importance of balancing yield improvements with expansions in the area under cultivation.

The distinction between winter and spring wheat is also critical. Different regions may favor one over the other due to climatic conditions, soil types, and farming practices. The yields of winter and spring wheat can vary significantly within a region, reflecting these differing agricultural conditions and crop preferences.

Examining the harvested areas for winter and spring wheat separately reveals further insights. Some regions may have a large area devoted to one type of wheat but not the other, which can be attributed to regional climatic suitability and historical farming practices. The harvested area, in conjunction with yield data, can provide a comprehensive understanding of a region's agricultural focus and capacity.

The relationship between the harvested area and the yield of a specific type of wheat (winter or spring) is also noteworthy. A region may have a large harvested area for a particular type of wheat but a lower yield, or vice versa. This could indicate potential areas for improvement, either by increasing yield through better farming practices and technology or by optimizing the allocation of land to different types of wheat based on their suitability and market demand.

The interplay of these factors also reveals broader trends and commonalities across the agricultural sector in Kazakhstan. Regions with well-developed agricultural infrastructure and technology tend to have higher yields and gross harvests, demonstrating the impact of investment and innovation in agriculture. In contrast, regions with less developed agricultural sectors might have lower yields, indicating potential areas for development and growth.

The correlations and relationships among these nine factors are also influenced by external variables such as climate change, economic policies, and global market trends. For instance, shifts in global wheat demand can influence the focus on either winter or spring wheat cultivation. Similarly, climate change can alter regional growing conditions, thereby impacting yields and the choice of crop type.

Therefore, the analysis of these nine factors provides a multi-dimensional view of wheat agriculture in Kazakhstan. It highlights the importance of considering both yield and area under cultivation, the significance of distinguishing between winter and spring wheat, and the role of regional conditions and practices in shaping agricultural outputs. Understanding these interrelationships is crucial for policy-making, strategic planning, and the advancement of agricultural practices in Kazakhstan, aiming to optimize wheat production in response to both domestic needs and global market demands.

Table 1 – Harvested area, gross harvest and yield of grain in the Republic of Kazakhstan in 2023 (Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan, 2024a, 2024b, 2024c)

Regions of Kazakhstan	Harvested area of winter and spring wheat, ha	Harvested area of winter wheat, ha	Harvested area of spring wheat, ha	Gross harvest of winter and spring wheat, centners	Gross harvest of winter wheat, centners	Gross harvest of spring wheat, centners	Yield of winter and spring wheat, centners per ha	Yield of winter wheat, centners per ha	Yield of spring wheat, centners per ha
Abai	241419.4	9430.7	231988.7	2480339.6	114788.8	2365550.8	10.3	12.2	10.2
Akmola	4031170.5	72.0	4031098.5	27651130.4	1330.6	27649799.8	6.9	18.5	6.9
Aktobe	304724.5	10676.0	294048.5	3014924.2	93662.0	2921262.2	9.9	8.8	9.9

Almaty	39438.1	26637.3	12800.8	577998.3	417502.8	160495.5	14.7	15.7	12.5
West Kazakhstan	204582.8	71030.3	133552.5	2350900.5	1075367.5	1275533.0	11.5	15.1	9.6
Zhambyl	170865.3	170516.3	349.0	1701531.0	1697587.3	3943.7	10.0	10.0	11.3
Zhetysu	99578.8	70363.1	29215.7	1691917.6	1191892.0	500025.6	17.0	16.9	17.1
Karaganda	771891.1	-	771891.1	5250289.7	-	5250289.7	6.8	-	6.8
Kostanay	3603830.8	662.0	3603168.8	38001684.7	7541.0	37994,143.7	10.5	11.4	10.5
Kyzylorda	9026.5	4595.5	4431.0	95955.0	64533.0	31422.0	10.6	14.0	7.1
Pavlodar	647287.9	647	646640.9	2678408.4	3166.0	2675242.4	4.1	4.9	4.1
North Kazakhstan	2575277.6	7674.0	2567603.6	29314524.5	66667.6	29247856.9	11.4	8.7	11.4
Turkestan	215625.4	199106.6	16518.8	3782026.0	3500610.3	281415.7	17.5	17.6	17.0
Ulytau	21330.0	900.0	20430.0	180781.0	7700.0	173081.0	8.5	8.6	8.5

East Kazakhstan	183136.8	7334.9	175801.9	2233046.3	112810.2	2120236.1	12.2	15.4	12.1
City of Astana	626	-	626	3467.0	-	3467.0	5.5	-	5.5
City of Shymkent	10025.9	9239.9	786.0	100204.0	90,827.0	9377.0	10.0	9.8	11.9
Total for Kazakhstan	13129837.2	588885.6	12540951.6	121109128.2	8445986.1	112663142.1	9.2	14.3	9.0

In the Republic of Kazakhstan in 2023 as shown in Table 1, the harvested areas of winter and spring wheat varied significantly across different regions. The Akmola region had the largest combined harvested area of winter and spring wheat, covering a vast 4,031,170.5 hectares. In stark contrast, the City of Astana had the smallest area, with only 626 hectares dedicated to wheat cultivation. Analyzing the quartiles, the lower quartile (Q1) indicates that at least 25 % of the regions have a harvested area less than 21330.0 hectares. The median (Q2), which divides the data into two equal halves, shows that half of the regions have less than 183136.8 hectares. The upper quartile (Q3) reveals that 75 % of the regions have a harvested area below 771891.1 hectares, leaving the top 25 % with larger areas.

Focusing specifically on the harvested area of winter wheat, Zhambyl region tops the chart with 170,516.3 hectares, while the Akmola region, despite its overall dominance, has a surprisingly low winter wheat area of only 72.0 hectares. Quartile-wise, the lower quartile (Q1) is at 662.0 hectares, suggesting that 25 % of the regions have winter wheat areas smaller than this. The median (Q2) is 7,674.0 hectares, meaning half of the regions have less than this area under winter wheat cultivation. The upper quartile (Q3) is at 9,430.7 hectares, indicating that 75 % of the regions have harvested areas of winter wheat less than this figure.

The harvested area of spring wheat shows North Kazakhstan region as the leader with 2,567,603.6 hectares, which is significantly higher than other regions. On the other end, the City of Astana has the smallest spring wheat area, with only 626 hectares. The lower quartile (Q1) for spring wheat is at 12,800.8 hectares, the median (Q2) is at 175,801.9 hectares, and the upper quartile (Q3) is considerably higher at 646,640.9 hectares.

In summary, the data from Kazakhstan in 2023 presents a diverse picture of wheat cultivation. Akmola region, while having the largest combined area for winter and spring wheat, has one of the smallest areas dedicated specifically to winter wheat. In contrast, regions like North Kazakhstan region and Zhambyl region show significant skew towards either spring or winter wheat cultivation. These differences in regional cultivation patterns could be influenced by a variety of factors including climate, soil type, and agricultural practices specific to each region.

In the Republic of Kazakhstan in 2023, the gross harvest of winter and spring wheat, as well as the separate categories of winter wheat and spring wheat, displayed notable variations across different regions.

The Kostanay region reported the highest gross harvest of winter and spring wheat combined, with a staggering 38,001,684.7 centners. Conversely, the City of Astana had the smallest gross harvest in this category, with just 3,467.0 centners. When analyzing the quartiles, the lower quartile (Q1) for the gross harvest of winter and spring wheat is 180,781.0 centners, indicating that at least 25% of the regions have a harvest smaller than this figure. The median (Q2) is at 2,235,046.3 centners, showing that half of the regions have a gross harvest below this amount. The upper quartile (Q3) is much higher at 5,250,289.7 centners, suggesting that the top 25% of regions have a significantly larger harvest.

In the specific category of winter wheat, the Zhambyl region leads with a gross harvest of 1,697,587.3 centners. This is in stark contrast to the Akmola region, which, despite its large total wheat harvest, has a relatively small gross harvest of winter wheat at only 1,330.6 centners. The lower quartile (Q1) for the gross harvest of winter wheat is 7,700.0 centners, the median (Q2) is 11,2810.2 centners, and the upper quartile (Q3) is at 114,788.8 centners.

For spring wheat, the North Kazakhstan region tops the list with a gross harvest of 29,247,856.9 centners, while the City of Astana, similar to its overall wheat harvest, has the smallest harvest in this category with 3,467.0 centners. The lower quartile (Q1) for the gross harvest of spring wheat is at 17,3081.0 centners, the median (Q2) at 2,120,236.1 centners, and the upper quartile (Q3) at 5,252,428.9 centners.

This data demonstrates the vast differences in wheat harvests across Kazakhstan's regions in 2023. Regions like Kostanay and North Kazakhstan significantly contribute to the country's total wheat production, particularly in the spring wheat category. The varied figures across regions could be attributed to factors such as regional climate conditions, soil fertility, agricultural practices, and the specific types of wheat grown. These differences underscore the importance of regional agricultural strategies in optimizing wheat production in Kazakhstan.

In Kazakhstan during 2023, the yield of winter and spring wheat, as well as the yields for winter wheat and spring wheat separately, exhibited significant regional variations.

The highest yield for combined winter and spring wheat was found in the Turkestan region, boasting 17.5 centners per hectare. In contrast, the Pavlodar region had the lowest yield, with only 4.1 centners per hectare. When examining the quartile distribution, the lower quartile (Q1) for combined winter and spring wheat yield is 8.5 centners per hectare, indicating that 25% of the regions have a yield lower than this. The median yield (Q2) is 10.5 centners per hectare, suggesting that half of the regions have a yield below this level. The upper quartile (Q3) is at 12.2 centners per hectare, showing that 75% of regions have yields less than this figure.

In the specific category of winter wheat yield, the highest is found in the Akmola region with 18.5 centners per hectare, while the lowest is in the Pavlodar region with only 4.9 centners per hectare. The lower quartile (Q1) for winter wheat yield is 8.6 centners per hectare, the median (Q2) is 12.2 centners per hectare, and the upper quartile (Q3) is 15.1 centners per hectare.

For spring wheat yield, Turkestan again leads with a yield of 17.0 centners per hectare, while the lowest yield is in the Kyzylorda region with 7.1 centners per hectare. The lower quartile (Q1) for spring wheat yield is 6.9 centners per hectare, the median (Q2) is 10.2 centners per hectare, and the upper quartile (Q3) is 12.1 centners per hectare.

These variations in yield across different regions of Kazakhstan reflect the diversity in agricultural conditions, such as soil quality, climate, and farming practices. Regions like Turkestan demonstrate high productivity in both winter and spring wheat, whereas areas like Pavlodar show comparatively lower yields. Understanding these regional differences is crucial for developing targeted agricultural policies and practices to enhance wheat production efficiency in Kazakhstan.

In Kazakhstan's agricultural landscape, the yield of winter and spring wheat collectively stands as a crucial indicator of efficiency, more so than the growth of harvest area and gross harvest. This preference for yield as a metric is rooted in its direct reflection of the efficiency of agricultural practices, as opposed to mere expansion in cultivation or total production.

Yield, measured in centners per hectare, encapsulates how effectively the land is utilized and the productivity achieved per unit area. This is in stark contrast to increasing the harvested area, which might lead to a higher gross harvest but doesn't necessarily indicate improved efficiency. Expanding the harvest area can often be a less feasible approach due to limitations in available land and the additional resources required. In contrast, enhancing yield through better farming practices and technology is a more sustainable approach towards intensifying agriculture.

Focusing on the collective yield of winter and spring wheat is particularly relevant in Kazakhstan due to the comprehensive nature of the available data. While data for gross wheat harvest on irrigated lands, application of mineral fertilizers, nitrogen, phosphorus, potassium mineral fertilizers, and microfertilizers is available for wheat in general, and not separated for winter and spring wheat, it makes sense to consider the combined yield. This approach allows for a holistic understanding of wheat production efficiency, incorporating both types of wheat and aligning with the data on fertilizer application, which is crucial for yield enhancement.

The application of mineral fertilizers and specific nutrients like nitrogen, phosphorus, potassium, and microfertilizers is one of the primary factors within the control of Kazakhstani farmers to improve grain yield (Lewu, Volova, Thomas, & Rakhimol, 2020). These fertilizers play a pivotal role in supplying essential nutrients to the soil, thereby enhancing its fertility and productivity. Nitrogen is critical for plant growth and development, directly influencing crop yield. Phosphorus contributes to the development of roots, flowers, and seeds, while potassium is vital for the overall health of the plant. Microfertilizers provide trace elements necessary for various physiological processes in plants.

Kazakhstan's diverse climatic and soil conditions mean that the effective use of fertilizers can vary significantly across regions. Understanding regional soil composition and climate patterns is crucial in determining the right type and amount of fertilizer to use. Overuse of fertilizers can lead to soil degradation and environmental issues, whereas underuse can result in suboptimal yields.

The interplay between yield and fertilizer use is also influenced by other factors like irrigation practices, seed quality, pest control, and climate change. Innovations in farming techniques, such as precision agriculture, can help optimize fertilizer use, thereby enhancing yield without adverse environmental impacts (Annosi, Appio, & Brunetta, 2023).

In conclusion, while harvested area and gross harvest are important metrics, they do not provide a complete picture of agricultural efficiency in Kazakhstan. Yield, especially the combined yield of winter and spring wheat, serves as a more telling indicator of how effectively resources are being used and how productive the agricultural practices are. The application of fertilizers, tailored to regional needs and environmental considerations, stands as a key controllable factor for Kazakhstani farmers in their quest to improve wheat yields. This approach, focusing on yield optimization through efficient resource use, aligns well with sustainable agricultural practices, ensuring long-term productivity and environmental health.

Table 2 – Application of various fertilizers and gross harvest from irrigated lands for wheat in the Republic of Kazakhstan in 2023 (Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan, 2024a, 2024b, 2024c).

Regions of Kazakhstan	Gross wheat harvest on irrigated lands, centners	Application of mineral fertilizers for wheat in terms of 100 % nutrients, centners	Application of nitrogen mineral fertilizers for wheat in terms of 100 % nutrients, centners	Application of phosphorus mineral fertilizers for wheat in terms of 100 % nutrients, centners	Application of potassium mineral fertilizers for wheat in terms of 100 % nutrients, centners	Application of micro-fertilizers for wheat in terms of 100 % nutrients, centners
Abai	4000.0	535.5	78.2	457.4	-	-
Akmola	1876.0	153668.9	56,530.9	90157.9	2814.2	4165.8
Aktobe	18194.0	482.2	133.3	235.0	74.7	39.1
Almaty	106484.1	380.7	271.6	109.1	-	-
West Kazakhstan	-	4293.2	4129.7	140.0	-	23.5
Zhambyl	11154.0	730.7	580.6	150.1	-	-
Zhetysu	24603.0	1315.9	1315.9	-	-	-
Karaganda	162286.6	36400.6	13089.7	23111.8	194.7	4.4
Kostanay	39078.0	71908.8	33596.4	37518.9	96.3	697.3
Kyzylorda	2300.7	442.2	422.0	20.3	-	-
Pavlodar	95955.0	4014.1	1029.7	2984.4	-	-
North Kazakhstan	28562.0	222712.5	106592.2	112599.1	2892.3	629.0
Turkestan	17550.0	24484.9	23266.1	1218.8	-	-
Ulytau	210125.9	-	-	-	-	-
East Kazakhstan	1363.0	33086.6	26182.1	6719.0	179.4	6.2
City of Astana	-	-	-	-	-	-
City of Shymkent	435.0	61.9	61.9	-	-	-
Total for Kazakhstan	723967.2	554518.9	267280.4	275421.8	6251.5	5565.2

Table 2 in the document showcases the gross wheat harvest on irrigated lands across different regions of Kazakhstan in 2023. The Karaganda region recorded the highest gross wheat harvest on irrigated lands, with an impressive 162,286.6 centners. In sharp contrast, the City of Shymkent had the lowest harvest in this category, yielding only 435.0

centners. When analyzing the quartile distribution, the lower quartile (Q1) for the gross wheat harvest on irrigated lands is approximately 2,300.7 centners, indicating that 25% of the regions have a harvest smaller than this figure. The median (Q2), which is the midpoint of the dataset, is at 11,154.0 centners, showing that half of the regions have a gross harvest below this amount. The upper quartile (Q3) is significantly higher at 24,603.0 centners, suggesting that 75 % of the regions have a gross harvest of less than this, leaving the top 25 % with larger harvests.

In Kazakhstan in 2023, the application of various fertilizers for wheat cultivation, as detailed in Table 2 of the document, reveals significant regional differences and highlights the diverse agricultural practices across the country.

The use of mineral fertilizers, vital for providing essential nutrients to wheat crops, varied widely among regions. The highest application was recorded in the Akmola region (153668.9 centners), signifying a robust approach to fertilizer use, potentially driven by larger agricultural areas or a focus on intensive wheat production. In contrast, regions with lower application rates might have smaller agricultural sectors or rely more on organic farming practices or less nutrient-demanding crops. The distribution of mineral fertilizer application across regions, from highest to lowest, also reflects regional disparities in agricultural infrastructure, soil fertility needs, and access to agricultural inputs.

Nitrogen, a key component for plant growth and yield, saw its highest application in the North Kazakhstan region (106592.2 centners). This aligns with the region's likely focus on maximizing wheat yields, as nitrogen is essential for vegetative growth and is a common limiting factor in crop production (Barker, 2010). The varying application rates of nitrogen across regions can be linked to differing soil nitrogen levels, crop rotation practices, and local farming strategies aimed at balancing crop nutrition with environmental considerations.

Phosphorus fertilizer application, essential for root development and seed formation, was also unevenly distributed, with the Akmola region (90157.9 centners) again leading. Phosphorus application is often influenced by soil test results and specific crop requirements (Barker, 2010). Regions applying less phosphorus might have soils naturally rich in phosphorus or employ crop rotations that help maintain soil phosphorus levels.

Potassium, crucial for plant health and resistance to diseases and stress, had its highest application in the North Kazakhstan region (2892.3 centners). Potassium application strategies vary based on soil potassium levels, crop needs, and historical yield data. Regions with lower potassium application might have adequate natural potassium in their soils or focus on crops that are less demanding in potassium (Barker, 2010).

The application of microfertilizers, which provide trace elements needed in smaller quantities but are nonetheless critical for plant health and productivity, showed significant variations (Prasad & Zhang, 2022). The highest application in the Akmola region (4165.8) indicates a focus on comprehensive crop nutrition management, ensuring that all nutrient needs of the wheat are met. Lower application rates in other regions could be due to limited availability, cost considerations, or lack of awareness about the benefits of microfertilizers.

This wide range in fertilizer application across Kazakhstan's regions highlights several key points. Firstly, it reflects the diverse soil types and climatic conditions in Kazakhstan, necessitating tailored fertilizer strategies. Secondly, it suggests varying levels of agricultural development and resource availability, with some regions possibly having more access to agricultural inputs and knowledge. Thirdly, it points to the potential for improving wheat yields through optimized fertilizer use, especially in regions where application rates are lower. Lastly, the data underscores the importance of soil testing and crop-specific nutrient management to ensure that fertilizer application is both efficient and environmentally sustainable.

In summary, the application of various fertilizers in Kazakhstan's wheat cultivation presents a complex picture of regional differences, resource allocation, and agricultural strategies. Understanding these variations is crucial for developing targeted interventions to enhance wheat production, optimize resource use, and ensure the sustainable development of the agricultural sector in Kazakhstan.

Discussion

The regression equation defining the yield of winter and spring wheat in Kazakhstan can be formed using the coefficients obtained from the model:

$$Y = 10.5494 - 9.247 \times 10^{-6} \times GH + 3.8466 \times MF - 3.8463 \times NF - 3.8468 \times PHF - -3.8464 \times POF - 3.8461 \times MIF \quad (1)$$

In this equation:

1. Y - yield of winter and spring wheat, centners per ha.
2. GH - gross wheat harvest on irrigated lands, centners.
3. MF - application of mineral fertilizers for wheat in terms of 100 % nutrients, centners.
4. NF - application of nitrogen mineral fertilizers for wheat in terms of 100 % nutrients, centners.
5. PHF - application of phosphorus mineral fertilizers for wheat in terms of 100 % nutrients, centners.
6. POF - application of potassium mineral fertilizers for wheat in terms of 100 % nutrients, centners.
7. MIF - application of microfertilizers for wheat in terms of 100 % nutrients, centners.
8. The coefficients (like 10.5494, -9.247×10^{-6}, etc.) represent the estimated impact of each variable on the wheat yield.

The regression equation you provided allows us to interpret the relationship between the yield of winter and spring wheat in Kazakhstan (Y) and the various agricultural factors (GH, MF, NF, PHF, POF, MIF) based on their coefficients:

1. Yield (Y) and gross wheat harvest on irrigated lands (GH): the coefficient for GH is "-9.247×10^{-6}", indicating a very slight negative relationship. This suggests that as the gross wheat harvest on irrigated lands increases, the yield of winter and spring wheat decreases marginally. However, the impact is minimal due to the small size of the coefficient.

2. Yield (Y) and application of fertilizers (MF, NF, PHF, POF, MIF): the coefficients for the application of mineral fertilizers (MF), nitrogen fertilizers (NF), phosphorus fertilizers (PHF), potassium fertilizers (POF), and microfertilizers (MIF) are all negative ("-3.8466", "-3.8463", "-3.8468", "-3.8464", and "-3.8461", respectively). These negative coefficients suggest that an increase in the application of these fertilizers is associated with a decrease in yield. This might seem counterintuitive, as fertilizers are generally used to increase yield. However, these results could be due to over-fertilization, imbalances in nutrient application, or other unmeasured factors impacting the yield.

3. Intercept (10.5494): The intercept value of 10.5494 in the equation is signifi-

cant. It represents the expected yield of winter and spring wheat (in centners per hectare) when all the independent variables (GH, MF, NF, PHF, POF, MIF) are zero. Essentially, this is the baseline yield without considering the effects of these specific factors. This baseline is particularly useful in understanding the underlying yield in the absence of the specific influences measured in this study.

Overall, the relationships indicated by the coefficients should be interpreted with caution (Zaman, 2023). The negative coefficients for fertilizer applications, in particular, may seem counterintuitive and could indicate issues such as overuse of fertilizers, other unaccounted variables affecting yield, or complex interactions in the agricultural system not fully captured by the model. This highlights the importance of considering the broader context, including agricultural practices, soil health, and environmental conditions, in understanding and applying these results.

The regression analysis examining the influence of various agricultural factors on the yield of winter and spring wheat in Kazakhstan reveals a nuanced and complex relationship. The model's R-squared value is 0.380, indicating that about 38% of the variability in wheat yield is explained by the independent variables included. However, the adjusted R-squared, which accounts for the number of predictors, drops to 0.041, suggesting the model's explanatory power is relatively low when the number of variables is considered (Westfall & Arias, 2020).

Each of the independent variables - gross wheat harvest on irrigated lands, application of mineral, nitrogen, phosphorus, potassium, and microfertilizers - shows a specific coefficient in the model. However, the coefficients' standard errors and the corresponding t-values and P-values suggest that the individual contributions of these variables to the yield are not statistically significant within this model. This outcome could be due to the complex nature of agricultural systems where multiple interacting factors influence yield, and the limited dataset might not capture all relevant variables or nuances.

Moreover, the condition number being large indicates potential multicollinearity, where independent variables are highly correlated with each other. This correlation can distort the individual coefficients' interpretation, suggesting that the variables might not be providing unique information about the dependent variable.

Despite these statistical challenges, the model provides valuable insights. The fact that 38% of the yield variability is explained by these factors highlights their importance in wheat production. However, the low adjusted R-squared value and the lack of statistical significance of individual factors suggest that wheat yield is influenced by a complex interplay of many variables, some of which might not have been included in the model.

Factors like soil quality, weather conditions, irrigation practices, and even socio-economic factors like market access and farming technology could also play crucial roles in determining yield and are not captured in this model. This analysis underscores the complexity of agricultural production and the need for comprehensive approaches that consider a wide range of factors to understand and improve crop yields.

In summary, while the regression model provides some understanding of the factors influencing wheat yield in Kazakhstan, it also highlights the complexity and multifaceted nature of agricultural systems. The results suggest that a more detailed model or additional data might be necessary to fully capture the dynamics affecting wheat yield in the region.

Conclusion

The extensive research analysis of wheat production in Kazakhstan in 2023 not only provide a deeper understanding of the current agricultural dynamics but also suggest avenues for practical application and future research.

1. Regional variability and its implications: the research data reveals a pronounced variability in wheat production across different regions of Kazakhstan. This variability is evident in the harvested areas, yields, and gross harvests of both winter and spring wheat. Such regional differences underscore the need for region-specific agricultural policies and practices (Haj-Amor, Kim & Bouri, 2024). Understanding and addressing the unique challenges and opportunities in each region, such as climate, soil type, and resource availability, could lead to more efficient and sustainable agricultural practices. This approach can enhance overall productivity and support regional agricultural development.

2. Grain yield optimization versus harvested area expansion: the research analysis highlights that yield (centners per hectare) is a more critical indicator of agricultural efficiency than merely increasing the harvested area. Focusing on yield optimization through advanced farming techniques and technology can lead to more sustainable agricultural growth. This strategy is especially relevant in scenarios where expanding the harvest area is limited due to land availability or environmental concerns. Investments in agricultural research, development, and extension services that focus on yield improvement can thus be a key driver for enhancing wheat production in Kazakhstan.

3. Role of fertilizer application in yield: the regression equation and its coefficients indicate a complex relationship between fertilizer application and wheat yield. While intuitively fertilizers are expected to enhance yield, the analysis suggests a potential issue of over-fertilization or imbalances in nutrient application. This finding calls for a more nuanced approach to fertilizer use, emphasizing the importance of balanced and judicious fertilizer application tailored to regional soil and crop requirements. Soil testing, precision agriculture, and farmer education could play significant roles in optimizing fertilizer use for sustainable yield improvement.

4. Potential for future research and development: the research highlights several areas for future investigation. The complex interplay of factors influencing wheat yield, as evidenced by the regression analysis, suggests that additional variables, possibly unaccounted for in the current model, could significantly impact wheat production. Future research could focus on integrating more variables, such as specific farming practices, climate change impacts, water use efficiency, and socio-economic factors, to develop a more holistic model of wheat yield prediction. Additionally, the exploration of advanced technologies in precision agriculture, crop breeding, and resource management could provide new insights into improving wheat production in Kazakhstan.

In conclusion, the study of wheat production in Kazakhstan offers valuable insights into agricultural practices and efficiency. The findings have practical applications in guiding policy-making, strategic agricultural planning, and resource allocation. Moreover, the identified gaps and challenges present opportunities for further research, aiming to enhance the understanding and effectiveness of agricultural practices in the context of changing environmental conditions and evolving global market dynamics.

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