



AGRONOMY

A REVIEW ON AGRONOMIC ERRORS AND THEIR SOLUTIONS IN WHEAT, RICE, MAIZE AND BERSEEM

Ameer Hamza^{*1}, Hamza Khan² and Kamran Khan³

ABSTRACT

A review was conducted to study and synthesize major agronomic errors and their corrective strategies in four economically important crops: wheat (*Triticum aestivum* L.), rice (*Oryza sativa* L.), maize (*Zea mays* L.), and berseem (*Trifolium alexandrinum* L.). Agronomic errors in wheat are noticed in seeding rate, fertilizer use, irrigation, and weed management that result in 20–25% yield loss. Whereas in rice errors plant population, nutrient control, planting, and irrigation and account for 15–30% loss. Maize is also affected by improper planting depth, shortage of nutrients, improper pest guarding, and inadequate crop rotation and accounts for 15–25% loss in yield. Berseem yield is also affected by agronomic errors in date of sowing, irrigation, soil fertility management, and weed control and account for 10–20% loss. The findings highlight the importance of optimal sowing time, balanced fertilizer application, scheduling of irrigation, and integrated weed and pest management has in managing yield gaps as well as sustaining the system.

KEYWORDS: *Triticum aestivum*; *Trifolium alexandrinum*; *Oryza sativa*; agronomic management; yield losses; irrigation; scheduling; Pakistan

^{1,3}Student BSc (Hons) Agri.

Department of Soil and
Environmental Sciences,

²Student BSc (Hons) Department
of Agronomy, University of
Agriculture, Peshawar, Pakistan.

^{*}Corresponding author's email:
ameerhamzakha8@gmail.com

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INTRODUCTION

Wheat (*Triticum aestivum* L.) widely sown crop occupies the most fertile area internationally. In contemporary world, where the food consumption has risen with the rise in population, the human needs and dependence will tend the wheat yield to grow continuously (Gbegbelegbe *et al.*, 2017; Igrejas and Branlard, 2020). Whereas, in present era, climatic change has affected the wheat yield by drought and imbalance in seasonal precipitation. The climatic change is undeniable indicating factor affecting the wheat yield. Drought and seasonal precipitations become increasingly serious with the aggravation of climate change (Berg and Sheffield, 2018)

Rice (*Oryza sativa* L.) plays a major role in the country's agricultural economy. Pakistan is ranked 11th in the world for rice production and 4th in the world for rice export. Rice has influenced the culture, lifestyle, and economics of tens of millions of people around the world. Rice is life for more than half of humanity. The United Nations named the year 2004 as the "World Year of Rice" due to its significance. Rice produces about 13% of the country's annual foreign exchange (Junejo, 2014). About sixty percent of people around the world depend on rice as a staple food. Rice was consumed more than 430 million metric tonnes

worldwide in 2008. The list of byproducts of paddy/rice is very long e.g. flakes, saved in cans, fermentation products, rice straw animal feed, caps, boards, husk of rice is used in paper industry and different products are made in the poultry sector. It can be used to make biscuits and cattle feed because it is high in protein. Rice bran oil is commonly used in the soap industry. Refined oils such as cottonseed oil and corn oil can serve as cooling mediums. Additionally, industries use rice bran wax, a byproduct of rice bran oil (Esa *et al.*, 2013).

As per the report of Pakistan Bureau of Statistics, maize (*Zea mays* L.) crops are approximately grown on 1229,000 hectares fertile land of Pakistan with the annual production of 6100 metric tonnes in 2019. Adding 2.5% agricultural value as 0.5% to GDP, (GoP. 2019). Maize crop ranked third crops of Pakistan after wheat and rice (Khan *et al.* 2020). In Pakistan, the Khyber Pakhtunkhwa and Punjab provinces have been contributing about 90% of the total maize per annum yield in Pakistan (GoP. 2019). Maize crop, also known as corn, is included in the significant grain crops of the world (Shiferaw *et al.* 2011). The Maize crop is grown globally, with the United States that produce 384,781 metric tonnes maize yield in 2016 (GoP. 2017), the second producers are China, and Brazil (Ranum *et al.*

2014). Maize is a monocot, and diploid plant having 20 chromosomes. This plant being a C4 plant, that's why is water-efficient as compared to C3 plants i.e rice and wheat (Morneau 2016). Its adjustment varies to soil and various climatic conditions, this crop can easily be grown along the coast-line and also at higher altitudes, its temperature requirement ranges from 25-35°C for excellent growth (Jaidka *et al.* 2019).

Berseem (*Trifolium alexandrinum* L.) is a one of the most important winter season leguminous fodder crop in India known as king of the fodder crop. After Egypt and Pakistan, India is having the highest area under berseem cultivation (Muhammad *et al.*, 2014). In India, it is grown in approximately 2 million hectares area (Pandey and Roy, 2011). The crop cultivated under irrigated condition provides highly palatable, succulent and nutritious green fodder (800-850 q/ha) in 5-6 cuttings. Berseem fodder has 20% crude protein, 62% total digestible nutrients, and digestibility is 65%. The milk production in dairy animals is well known, and that feeding of green fodder enhances and stimulates.

REVIEW OF LITERATURE

Mousa *et al.* (2024) investigated that aerobic rice farming is an innovative method that uses less water and improves water efficiency compared to traditional methods. It's important to grow rice types that can handle dry conditions to ensure sustainable production despite climate changes. This study looked at how ten different rice types responded to varying irrigation levels during aerobic farming in a Mediterranean climate over two summers. They used different amounts of water: well-watered, mild drought, moderate drought, and severe drought. The results showed significant differences among the rice types in how they grew and the quality of their grains under different water conditions. Based on how they handled drought, the rice types were sorted into three groups ranging from tolerant to sensitive. The drought-tolerant types like Giza-179, Hybrid-1, Giza-178, and Line-9399 produced more yield and used water more efficiently compared to sensitive types. These drought-tolerant types are recommended for farming in areas with scarce water and could be useful in breeding programs to develop more drought-resistant rice for aerobic farming. The study also found that certain measures like relative water content, chlorophyll content, and enzymes like peroxidase and catalase were closely linked to how well the rice grew under drought conditions. These measures could be quick indicators for assessing drought tolerance in rice breeding programs in dry areas.

Chaudhary *et al.* (2023) studied that rice is a major food for over half the world's population, mostly grown using the labor-intensive puddled transplanted

rice (PTR) method. However, PTR is becoming less profitable due to water scarcity, high labor and energy requirements, soil health issues, and methane emissions. Direct-seeded rice (DSR) is gaining popularity as an alternative. It uses less water and labor, reduces methane emissions, and costs less while yielding comparably. Upgrading rice varieties and better farming practices support this shift. Challenges like increased weeds and environmental issues require improved weed, water, and nutrient management strategies. Biotechnological approaches and tailored farming techniques can make DSR sustainable and reduce its environmental impact, promoting eco-friendly and cost-effective rice production.

Simao *et al.* (2023) investigated the effect of the previous crop on winter wheat grain yield through the modulation of sowing date and its impact on plant available water at sowing, and temperatures during the critical period for yield determination. A no-tillage rainfed field experiment was established in 2019 at Ashland Bottoms, KS. Winter wheat was sown either after summer fallow, full-season soybean, double-cropped soybean, or corn—thus, resulting in a range in sowing dates of 270–326 days of the year (September 27 to November 22). The optimum sowing date for the site based on grain yield was estimated at day of year 296 ± 5 (October 18 to 28). Winter wheat after summer fallow and after a full-season soybean crop resulted in the greatest yields, whether sown at the optimum date or slightly later than optimum. Winter wheat yield was positively related to plant available water at sowing. Later sowing dates were most likely to reduce plant available water at sowing, and could delay wheat's development resulting in higher temperatures occurring during the critical period for yield determination (i.e., the days surrounding anthesis). Later sowing also shortened grain filling duration due to an overall later cycle and elevated temperatures. thus, adjusting winter wheat sowing dates is the first step that determines the crop's yield potential through improved plant available water at sowing, and reduced temperatures during the critical period for yield determination. When following a summer crop, winter wheat should be sown as soon as the previous crop is harvested to try to mitigate these negative effects of late sowing.

Zhou *et al.* (2023) investigated how nitrogen fertilization and planting density affect grain filling is vital for grain security. In double-cropping paddy field trials, three nitrogen levels (N1: conventional, N2: 10% reduction, N3: 20% reduction) and three planting densities (D1: conventional, D2: 20% increase, D3: 40% increase) were tested at two sowing dates (S1: conventional, S2: ten days later) in 2019–2020. Results showed S1 yields were 8.5–14% higher than S2. Reducing nitrogen (N2

to N3) decreased yields by 2.8–7.6%, but increasing densities (D1 to D3) improved yields by 6.2–19.4%. The highest yield was from N2D3, 8.7–23.8% higher than other treatments. Yield improvements were due to more panicles per m² and spikelets per panicle, driven by superior grain filling. Increased density enhanced grain filling, whereas reducing nitrogen lowered superior grain filling. Thus, N2D3 is the best strategy to boost yield and grain filling for double-cropping rice under varying sowing dates.

Jańczak-Pieniżek *et al.* (2022) studied that currently, due to climate change and for both environmental and economic reasons, it's recommended to consider alternative cropping systems alongside the traditional conventional system, especially for new wheat varieties. This study aimed to compare the effects of an integrated system (INTEG) and the conventional system (CONV) on the physiological aspects, yield, mineral content of grain, and protein quality of two winter wheat varieties, Hymalaya (hybrid) and Formacja (population), considering changing hydrothermal conditions during the study years. The field experiment took place from 2016 to 2019 in Przecław, Poland. The results showed that the CONV system generally had better physiological parameters and higher grain yields compared to the INTEG system. The Hymalaya variety in the CONV system had a more efficient photosynthesis process, leading to higher yields similar to Formacja in the INTEG system. Using the CONV system also improved grain quality traits and increased the total amount of certain gluten proteins. However, the INTEG system resulted in higher levels of certain minerals in Hymalaya grain and a more favorable composition of gluten proteins compared to Formacja. Overall, variations in weather conditions influenced the quality traits and protein content differently, with periods of low rainfall during wheat ripening favoring higher quality but lower yields.

Horvat *et al.* (2022) conducted a field experiments were conducted, aiming to evaluate whether the late-season foliar urea application (35 kg N ha⁻¹) is effective in improving grain yield and protein-related quality in ten common wheat cultivars during two consecutive growing seasons. On average, late urea application significantly ($p < 0.05$) increased grain yields, thousand kernel, and hectoliter weight. The total grain protein significantly ($p < 0.05$) increased by 17.5% under urea application, while dough mixing behavior was improved by increasing flour water absorption and reducing the degree of softening. Considering dough elastic properties, the changes in dough energy and maximum resistance under urea application were strongly cultivar dependent and their values compared to control varying from -12.7%

to +42.4% and -25.1% to +7.7%, respectively. The distribution of grain storage proteins was significantly influenced by late urea application, but to a lesser extent than the total grain proteins. The proportion of total gliadins, α - and γ -gliadins increased by 5.3%, 5.8%, and 6.5%, respectively, while total glutenins and high-molecular weight glutenins decreased by 4.5% and 7.4%, respectively. In summary, the late-season application of urea has greatly improved the protein-related quality without considerable disruption of the storage proteins composition.

Afrida and Tampubolon (2022). Investigated that the deficiency of primary macronutrients can inhibit the vegetative growth of the plants. The study aimed to obtain the influence of nutrient omission techniques fertilization (NOTF) on the agronomic characteristics, nutrient uptake and to determine the growth limiting factors for maize. This research was located on the farmer field in Padang Bulan, Medan Baru, North Sumatra, Indonesia, from December 2020 to March 2021. This research was applied the Randomized Block Design within the single factor through NOTF that has been converted (urea: superphosphate: KCl = 0.15: 0.10: 0.025 g kg⁻¹). The treatment are as unsing F_0 = control; F_1 = N + P + K; F_2 = P + K; F_3 = N + K; F_4 = N + P All the treatments were three replications. The parameters were processed using ANOVA and continued by a Duncan Multiple Range Test (DMRT) at $P < 0.05$. The F_1 - F_4 treatments significantly increased plant height, number of leaves, leaf area, fresh weight of root and shoot, and dry weight of root and shoot for maize. It was found in the highest plant height, the number of leaves, and the dry weight of root at the N + P fertilization. However, the N + P + K fertilization increased leaf area, fresh weight, and dry weight of shoot. It showed the highest concentration and uptake nutrient of total-N, total-P, and total-K. The novelty of this study found the limiting factor that inhibited the maize growth was the non-fertilization of nitrogen.

Salama *et al.* (2020) studied that berseem clover is a popular crop in the Mediterranean, with many different varieties that vary in how well they grow and their quality. It's important to accurately understand these differences so we can choose the best ones for breeding and feeding purposes. In this study, we looked at five cuts from the top five Egyptian berseem clover varieties (Helaly, Serw, Giza6, Gemmeza1, and Sakha4). Giza6 stood out with higher yields and more dry matter on the third cut, plus it had good protein content and gas production on that cut, along with high fiber degradation and propionate concentrations on the second cut. It also had lower ammonia levels on the third and fifth cuts. Generally, the third cut gave the best yield, except for Sakha4. It also had a better leaf-

to-stem ratio compared to the fourth and fifth cuts. The first three cuts had more degraded fiber than the last two, and the first cut had lower propionate in Helaly and Gemmeza1 compared to other cuts. Overall, we recommend focusing on cultivating high-yielding, high-quality varieties like Giza6 and harvesting three cuts for breeding and feeding programs.

MATERIALS AND METHODS

A survey on title “Agronomic errors and its solution in wheat, rice, maize and berseem” was conducted at University of Agriculture Peshawar. A comprehensive literature search was conducted using online academic databases. Together the required information, data were compiled from relevant published research papers, official agricultural reports, and credible online scientific sources. The collected information was organized in an office file for the parameters listed above. Wheat agronomic errors are incorrect seeding rate, inadequate fertilizer application, improper irrigation and poor weed management. Rice agronomic errors are suboptimal transplanting density, imbalanced nutrient management, delayed planting and poor water management. Maize agronomic errors are incorrect planting depth, nutrient deficiency, inadequate pest control and poor crop rotation practices. Berseem agronomic errors are improper sowing time, inadequate irrigation, poor soil fertility management and weed infestation.

RESULTS AND DISCUSSION

Wheat: Wheat yield losses are primarily attributed to imbalanced fertilizer use (20–25%), poor weed management (15–20%), incorrect seed rate (15–20%), and improper irrigation scheduling (10–15%). Inadequate nutrient application limits tillering and canopy development, while weed competition reduces nutrient and moisture availability. Studies show nutrient mismanagement can reduce wheat yields by 20–50%, supporting the 20–25%

figure (Alemayehu *et al.*, 2025). Weed interference commonly causes 15–25% losses in wheat (Oerke, 2006). Improper irrigation scheduling often reduces yields by 10–15%, especially in arid and semi-arid zones. To solve these problem to minimize the losses it is recommended to use the recommended fertilizer rate and at right time. Manual weeding and timely herbicide application is important, adjust seeding rate according to soil type and condition to minimize the losses due to poor weeding management and improper seeding rate respectively, moreover scheduling irrigation based on the crop stages and soil moisture condition is the best way to minimize the losses due to improper irrigation.

Rice: Data regarding losses in rice yield due to different agronomic errors and their solution are given in table 2. Data shows that losses in rice yield was the highest (1000 kg/ha) due to suboptimal transplanting density which accounted for about 20–30% to the total yield followed by imbalance nutrient management (800 kg/ha) accounted for about 15–25% of the yield. The lowest losses in rice yield were recorded for delayed planting (500 kg/ha) which is about 10–15% of the yield Field spacing trials report 20–30% losses under suboptimal transplanting configurations (Chuhan *et al.*, 2019). Nutrient imbalance studies show 15–25% losses in productivity (Sharma *et al.*, 2019). Delayed sowing or transplanting reduces yield by 10–15% (Fang *et al.*, 2023). The possible solutions to these problems are optimizing plant density to minimize the competition, integrated nutrient management efficient water management practices and to adhere to optimal plant window in order to minimize the losses in yield due to suboptimal transplanting density, imbalance nutrient management, poor water management and delayed planting respectively.

Maize: The data (Table 3) show that the highest losses in maize yield was due to incorrect planting depth (1200 kg/ha) which is 20–25% of the total yield, followed by nutrient deficiency (1000 kg/ha) which accounts for

Table 1: Wheat yield losses due to agronomic different errors and their solutions

Agronomic error	Solution	Loss of crop yield	Percentage yield loss
Incorrect seeding rate	Adjust seeding rate based on soil type and conditions	500 kg/ha	15–20%
Inadequate fertilizer application	Balanced fertilizer application based on soil tests	700 kg/ha	20–25%
Improper irrigation	Scheduled irrigation based on crop stage and soil moisture	400 kg/ha	10–15%
Poor weed management	Timely herbicide application and manual weeding	600 kg/ha	15–20%

about 18-22% of the yield maize. The lowest losses in yield were recorded for poor crop rotation (800 kg/ha) and it is about 15-20% of the total yield. In order to minimize these losses the possible solutions are given in the same table. They are adjust planting depth to 4-5 cm, use soil test to guide proper fertilization, integrated pest management and implement proper crop rotation to minimize the losses due to Incorrect planting depth, Nutrient deficiency, Inadequate pest control and Poor crop rotation practices respectively. Research shows incorrect planting depth affects emergence and reduces yield by 20–25% (Nemergut *et al.*, 2024). Nutrient omission trials report 15–30% losses depending on severity (Széles *et al.*, 2023). Table 3 Maize yield losses due to different Agronomic errors and their solutions.

Berseem: Yield losses due to different agronomic error in berseem crop and also providing the possible solution to the errors. The data (Table 4) shows that highest losses in the berseem crop was due to inadequate irrigation (700 kg/ha) which is equal to 15-20% of the total yield followed by improper sowing time (600 kg/ha) and poor irrigation (500 kg/ha) respectively where both losses is equal to about 10-15% individually. The lowest losses in berseem yield was recorded for weed infestation (400 kg/ha), equals to about 8-12% of the total yield losses. The possible solutions in order to minimize the losses and get higher yields are regular irrigation at 7-10 days interval, sowing at recommended time (oct-nov), regular soil testing and balanced fertilization and early weeding and herbicide use for inadequate irrigation, improper

Table 2: Rice yield losses due to different agronomic errors and their solutions

Agronomic error	Solution	Loss of crop yield	Percentage yield loss
Suboptimal transplanting density	Optimize planting density and spacing	1000 kg/ha	20-30%
Imbalanced nutrient management	Integrated nutrient management (INM)	800 kg/ha	15-25%
Delayed planting	Adhere to optimal planting window	500 kg/ha	10-15%
Poor water management	Efficient water management practices	700 kg/ha	15-20%

Table 3: Maize yield losses due to different agronomic errors and their solutions

Agronomic error	Solution	Loss of crop yield	Percentage yield loss
Incorrect planting depth	Adjust planting depth to 4-5 cm	1200 kg/ha	20-25%
Nutrient deficiency	Use soil tests to guide fertilization	1000 kg/ha	18-22%
Inadequate pest control	Integrated pest management (IPM)	900 kg/ha	15-20%
Poor crop rotation practices	Implement proper crop rotation	800 kg/ha	15-20%

Table 4: Berseem yield losses due to different agronomic errors and their solutions

Agronomic error	Solution	Loss of crop yield	Percentage yield loss
Improper sowing time	Sow at recommended time (October-November)	600 kg/ha	10-15%
Inadequate irrigation	Regular irrigation at 7-10 days interval	700 kg/ha	15-20%
Poor soil fertility management	Regular soil testing and balanced fertilization	500 kg/ha	10-15%
Weed infestation	Early weeding and herbicide use	400 kg/ha	8-12%

sowing time, poor soil fertility management and weed infestation respectively. Berseem is highly responsive to water availability; irrigation frequency significantly affects biomass production (Din *et al.*, 2014). Delayed sowing reduces yield by 10–15% (Kaur *et al.*, 2019). Weed interference commonly reduces fodder yield by 8–12%.

The highest losses in wheat yield are due to inadequate fertilizer applications while the agronomic error that accounts with the lowest losses in the yield of wheat is improper irrigation. Besides this poor weed management and incorrect seeding rate also contributes the losses in wheat yield higher than improper irrigation and lower than inadequate fertilizer application. A recommended fertilizer rate at right time, manual weeding and timely herbicide application, adjust seeding rate and proper irrigation scheduling can minimize these losses. These findings are at par with Bashir *et al.* (2006) who also reported that inadequate fertilizer application, poor weed management, incorrect seeding rate and improper irrigation are the main agronomic errors that can cause yield losses in wheat crop.

Among different agronomic errors that can cause a significant loss in rice yield, suboptimal transplanting density causes the highest yield losses while yield losses among all the errors are caused by delayed planting. Moreover imbalance nutrients management also causes a significant yield loss. To minimize these losses optimizing plant density, integrated nutrient management, efficient water management practices and to adhere to optimal plant window are the possible solutions. These discussions are in line with Qiu *et al.* (2022) also state that proper nutrient management and irrigation can increase the yield in rice field. While improper methods can lead to significant losses in yield of rice.

The highest losses in maize yield occurs due to incorrect planting depth while the lowest losses in yield of maize crop occurs due to poor crop rotations. Besides these two agronomic errors nutrient deficiency and inadequate pest control. These are agronomic errors and can be corrected if the management is done properly like adjust planting depth, do soil test to guide proper fertilizations, integrated pest management and implement proper crop rotation according to soil and region. This discussion aligns with the findings of Doren *et al.* (1976), who reported that improper tillage and crop rotation significantly affect maize yield. There are different agronomic errors due to which the reduction in yield occurs in berseem. Among these agronomic errors, the highest losses occur due to inadequate irrigation, improper sowing time, poor irrigation and weed infestations respectively. These losses can minimize by regular irrigation at 7-10

days interval, sowing at recommended time, regular soil testing, balanced fertilization and early weeding and herbicide use. This discussion is at par with Din *et al.* (2014) who also reported Berseem sown on 15 November and treated with 10 irrigations produced the highest raceme weight, number of seeds per head, 1000-seed weight, seed yield, and biological yield, all of which were significantly higher.

CONCLUSION

Agronomic errors substantially reduce the yield and profitability of major crops such as wheat, rice, maize, and berseem in Pakistan and similar agro-ecological zones. The findings of this study demonstrate that inadequate fertilizer application in wheat, suboptimal transplanting density in rice, incorrect planting depth in maize, and inadequate irrigation in berseem are the leading factors responsible for significant yield losses. These errors, however, can be mitigated through the adoption of best agronomic practices such as site-specific nutrient management, proper irrigation scheduling, recommended seed rates, and integrated pest and weed management. Furthermore, farmers' education and extension services should emphasize the importance of timely field operations, balanced fertilization, and sustainable water use to enhance crop productivity. Future research should focus on precision agriculture technologies and adaptive management practices under changing climatic conditions to minimize agronomic inefficiencies and maximize yield potential.

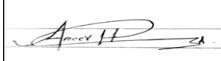
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CONTRIBUTION OF AUTHORS

Sr. No.	Authors' name	Contribution	Signature
1.	Ameer Hamza	Conceptualized the literature, collected the data and wrote-up the manuscript.	
2.	Hamza Khan	Reviewed and proof read the manuscript.	
3.	Kamran Khan	Collected the data and assisted in research work.	