Factors Influencing Decreased Wheat Crop Yield in 2021-22

Shamsur Rehman[1*], Zaryab Shah[2], Maleeha Mehboob[3], Raja Zohaib Muqarrab[4], Sami Ullah kakar[5]
The university of Agriculture Peshawar
Corresponding Author: Shamsur Rehman Shams@aup.edu.pk

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ABSTRACT

Wheat is one of the most important sources of cereal grain which fulfills the food needs of around 40% of the world population. Numerous factors are responsible for the low yield of wheat like abiotic factors and low yielding varieties, improper inputs such as irrigation and fertilizers, sowing time, weeds, insect pests, post-harvest loses, temperature and moisture. A vast survey was conducted at University of Agriculture Peshawar Khyber Pakhtunkhwa to know about the grain yield losses of wheat from 2021 to 2022 This survey is based on grain yield losses of wheat by various factors. According to survey the highest spike m-2 losses (314) was occurred in 2020 followed by 2022, the highest grains spike-1 losses (16) and lighter thousand grain weight (41.21 g) was recorded in 2022 year while total grain yield the more grain yield losses was occured in 2021.Wheat cultivation decreased to 8,976 thousand hectares (2.1 %) against last years of 9,168 thousand hectares. The production of wheat declined to (3.9 %) compared to last year. In wheat the highest yield losses was occurred at tiller loss 39.8% by underground pest followed by lodging at reproductive stage 38% while lowest yield loss was recorded at grain spike-1 at field by birds eating which is 15.1%. The average loss of yield occured in wheat is 24.1%. It is concluded that various factors, including abiotic influences, improper inputs, pests, and post-harvest issues, contribute to wheat yield losses, highlighting the need for targeted interventions to enhance wheat production and mitigate these losses

INTRODUCTION

Wheat, scientifically known as Triticum aestivum L., is an annual plant that follows a determinate growth pattern and requires long daylight hours to thrive. It covers a significant portion of the Earth's surface, surpassing the cultivation of any other food crop. In terms of global cereal production, wheat holds the third position, trailing only behind maize and rice (FAO, 2014). As a staple in dietary consumption, wheat ranks second to rice. Approximately 65 percent of the wheat harvest is allocated for food purposes. Recognized as the most crucial cereal crop, wheat plays an integral role in addressing food security (Hussain et al., 2010). This importance is particularly evident in Pakistan, where it serves as a major staple food, contributing substantially to the nation's GDP (Aslam et al., 2014; Malik, 2006).

Wheat stands as a vital source of cereal grains, catering to the nutritional needs of nearly 40% of the global population (Giraldo et al., 2019). Given the projected increase in food demand, which is anticipated to rise between 50% and 100% by 2050, farmers worldwide face the imperative of enhancing agricultural productivity (Elferink and Schierhom, 2016). Achieving optimal cultivation productivity hinges on factors such as appropriate fertilization, accurate seed distribution, and timely execution of harvest activities (Cui et al., 2018). However, many farmers, especially in developing nations, rely predominantly on limited knowledge and past experiences, leaving them ill-equipped to compete in the international marketplace and fulfill the escalating needs of the modern world (Sinwar et al., 2020).

In Pakistan, agriculture constitutes a significant backbone of economic growth, contributing approximately 24% of the nation's GDP and employing nearly half of the workforce (Pakistan Bureau of Statistics, 2021-22). This sector holds substantial significance, not only for domestic employment but also as a crucial source of foreign exchange. Notably, the northern regions play a pivotal role in the sustainable agricultural expansion and overall development of the country (Menhas et al., 2019).

Agriculture forms a reliable income source for 70% of Pakistan's population and engages 44% of the workforce. Wheat, being a dependable food source, is cultivated extensively across various regions of the country to meet the increasing demands driven by population growth (Ejaz et al., 2020).

Addressing the necessity of meeting the food requirements for over 35% of the world's population, wheat contains unique proteins known as gluten within its seeds (Kausar and Shahbaz, 2013). However, several factors contribute to reduced wheat yields, including abiotic stressors, suboptimal crop varieties, inadequate irrigation and fertilization practices, unfavorable sowing times, weed infestations, and insect pests (Khan et al., 2012; Kibe et al., 2006; Aheer et al., 1993; Memon et al., 2013; Khattak et al., 2007).

The ongoing impacts of climate change have led to an escalation in the frequency, intensity, and duration of extreme cold events, thereby influencing the growth and development of wheat (Augspurger, 2013). Global warming has further hastened the growth cycle of wheat, causing a significant advancement in its temperature-sensitive phases and increasing the vulnerability of cold-related damage (Gu et al., 2008). This phenomenon has substantial implications for crop productivity.

Anticipated global warming and subsequent drought intensification are poised to negatively impact overall food production. Predicted temperature increases ranging from 1.5 to 5.8°C by 2100 pose formidable challenges for agricultural output (Ansari et al., 2014). Simultaneously, the world's increasing population, expected to reach nine billion by 2050, necessitates substantial growth in food supplies. The persistent threat of desertification due to continuous degradation of arable land compounds these challenges, further underscoring the importance of sustainable agricultural practices (Solomon, 2007).

Postharvest losses in wheat encompass both quantitative and qualitative dimensions. Quantitative losses manifest through reductions in grain weight or volume, while qualitative losses include diminished nutritional and processing quality, leading to economic repercussions such as reduced market value or access (Delgado et al., 2020).

The consequences of climate change are vividly illustrated by the continuous rise in extreme low-temperature events, influencing wheat growth dynamics and exacerbating cold-related damage (Asgspurger, 2013). These shifts, coupled with global warming, have notably altered the sensitive stages of wheat development, increasing the susceptibility of frost-related injury (Zheng et al., 2015).

Low temperatures significantly impact wheat production, causing reductions in photosynthetic rates, leaf area, dry matter accumulation, grain numbers, and grain filling rates, ultimately leading to yield losses (Valluru et al., 2012). Investigations into the effects of cold stress on wheat yield reveal substantial reductions in grain numbers per spike under cold stress conditions, resulting in notable declines in overall grain yield (Thakur et al., 2010).

Wheat crops exhibit delayed maturation due to prolonged cold periods during early growth stages, necessitating increased water inputs. Consequently, loss of grain production during dry seasons is interconnected with water scarcity for irrigation (Pandit et al., 2017). The extent of yield loss varies between 30% and 90% depending on crop stage and the severity and duration of water deficit stress (Pandit et al., 2018).

Both natural and artificially-induced lodging contribute to yield losses in wheat, with reported losses ranging from 0% to 80%. The variability in yield loss stems from factors such as the developmental stage at which lodging occurs, the degree of shoot displacement, whether lodging is natural or induced, and the genetic characteristics of the crop (Acreche and Slafer, 2011). Artificial lodging during stages such as ear emergence, milk, soft dough, and hard dough stages leads to respective yield reductions of 31%, 25%, 20%, and 12% (Weibel and Pendleton, 2005; Fischer and Stapper, 2007). Notably, the extent of yield loss correlates with the duration of lodging during the grain filling phase, with stems lodged at 45° resulting in lower yield losses compared to stems lodged at 80° (Fischer and Stapper, 2007).

LITERATURE REVIEW

Laghar et al. (2021) conducted an experiment about the losses occur during threshing. They observed that harvest losses (10-30%) in wheat represent one of the major factors affecting grain yield. these losses may be during harvesting and/or threshing operations. Although combined harvester is gaining popularity, however, in most parts of Pakistan, the wheat crop is still manually harvested and then mechanically threshed. Threshing losses were estimated by calculating the proportions of broken, unbroken grains and unthreshed ear heads.

Djanaguiraman et al. (2020) conducted an experiment about the effects of HT (high temperature) and Stress during anthesis stage. The Short episodes of high temperature (HT) stress during reproductive stages of development cause significant yield losses in wheat (Triticum aestivum L.). HT stress during anthesis stage decreased photosynthetic rate (17 and 25%, respectively) and grain yield plant− 1 (29 and 44%, respectively), and increased thylakoid membrane damage (61 and 68%, respectively).

Shah et al. (2020) conducted an experiment they observed that water deficit stress during pre-flowering and grain filling stages massively affects the plant performance due to imprecise traits function. Thus, the effect of water deficit stress on non-drought tolerant and drought tolerant maize lines were investigated. water deficit stress increased the flowering days, days to maturity, anthesis silk interval, decreased the leaf number, abnormal expression of secondary stress responsive traits, loss of normal root architecture which overall lead to a reduction in GY/ha. Water deficit stress at flowering and grain filling stage leads to significant yield penalty especially in non-drought tolerant lines than drought tolerant lines.

FAO (2014) conducted a survey about field emergence losses. Variety choice, sowing time, stored moisture and growing season rainfall are factors which influence the yield potential of a wheat crop. Early sowing with an optimal variety can lengthen the growing season and deliver increased yields. Delayed seeding or emergence–delayed sowing will shorten the growing season, reducing yield potentials.

Hongting et al. (2017¬) carried out a field experiment about the climate change has brought more low temperature events and posed an increasing risk to the global wheat production. In order to evaluate the effects of low temperature at booting stages on wheat grain yield and its components. Wheat yield was more sensitive to low temperature at booting stage. The spike number per plant (SNPP) and grain number per spike (GNPS) were more sensitive to low temperature at booting stages than 1000-grain weight (TGW).

Nagpal and kumar (2012) both observed that natural contamination of food grains is greatly influenced by environmental factors such as type of storage structure, temperature, moisture, etc. During storage, quantitative as well as qualitative losses occur due to insects, rodents, and micro-organisms. A large number of insect pests have been reported to be associated with stored grains. At any given time 60–70% of grains is stored on the farm in traditional structures like Kanaja, Kothi, Sanduka, earthen pots, Gummi and Kacheri. The storage losses at different stages have added up to about 36 per cent of the total post-harvest losses about 33.5 percent in wheat.

Pandey et al (2008) conducted an experiment they observed that limited water availability often results in deficit irrigation when deficit irrigation occurred during the vegetative stage and early reproductive stage, significant yield reductions of 22.6 and 26.4% were found for the respective seasons. Imposition of six or eight deficit irrigations during vegetative and reproductive phases reduced grain yield by up to 52% over all N levels. Yield reductions were associated with reduction in kernel numbers and to a lesser extent, kernel weight. Thus, grain yield reduction was nearly proportional to duration of deficit irrigation imposed during the season. Conversely, yield reduction to water shortage was much more severe at high N rates.

METHODOLOGY

A vast survey was conducted at University of Agriculture Peshawar. It was based on grain yield losses data of wheat from 2021 to 2022 on wheat crop. The parameters used during this survey were wheat parameters (number of spikes m-2, number of grain spike-1 and thousand grain weight and total grain yield). To collect the data about these parameters I visited different websites and different research papers and meets with supporting staff. The data were written in office file about the above mentioned parameters.

Different yield factors were included to estimate grain losses at various stages of crop:

1. Losses of grain seed sometimes demands reproductive units. Investigation of factor of inputs were survey for yield losses.
2. At reproductive stage, both flowering pollination, grain filling, number of grains were estimated
3. At harvesting yield components i.e spikes head, grains spike-1, 1000 grain weight were assessed.
4. At post harvesting losses in field, threshing and storing were assessed. Where temperature , moisture content of seeds, storage conditions affected by grain store pests were evaluated.

RESULT

Information regarding grain yield losses in Pakistan of wheat crop is given in table1. Information was collected on grain yield losses at different years from 2020 to 2022 of wheat crop. The maximum number of spike m-2 losses (314) were occurred in 2020 followed by 2022 and less losses number of spike m-2 (512) were recorded in 2021. In case of grain spike-1, the highest number of grain spike-1 losses (36) was recorded in 2021 year followed by 2022 while less number of grain spike- losses (40) was recorded in 2020 year. However heavier thousand grain weight (49.97 g) was recorded in 2020 followed by 2021 while lighter thousand grain weight (41.21 g) was recorded in 2022 year. In case of total grain yield the more grain yield losses (2257 kg ha-1) was obtained in 2021 followed by 2022 while less grain yield losses (3985 kg ha-1) was noted in 2020 year. Our results are in line with Armin and Asghripour (2011) who reported that increase in wild oat density resulted in the reduction of wheat yield through decrease in fertile tiller per plant and spike m-2. Thus it seems that presence of A. fatua in wheat even at low density can deprive millions of people of their food and animals of their feed.

Table 1. Grain Yield Approximate Losses at Various Stages in Wheat

Year	Spikes m^{-2}	Grains $spike^{-1}$	1000 grain weight (g)	Grain yield (kg ha^{-1})
2020	314	40	49.97	3985
2021	512	36	46.54	2257
2022	351	42	41.21	3818

Source: Pakistan Economic Survey 2021-2022

Information regarding grain yield losses in Pakistan of wheat crop is given in table 2. Information was collected on grain yield losses at different years from 2019 to 2022 of wheat crop. During 2021-22, area sown decreased to 8,976 thousand hectares (2.1 %) against last years of 9,168 thousand hectares. The production of wheat declined to 26.394 million tonnes (3.9 %) compared to 27.464 million tonnes production of last year. Wheat production declined due to decline in area sown, shortfall in irrigation water and drought conditions at sowing and less fertilizer off take. The yield of wheat declined to 26.394 kg ha-1 (1.9 %) compared to 2996 kg ha-1 yield of last year. Our results are documented by Kim et al. (2002) who investigated that herbicide dose for crop-weed competition and it was reported that dose of herbicide can be changed for weeds and herbicides used. Thus it seems that using higher seed rate of wheat suppresses the weeds and thus less dose of herbicide could be used. In light of the present studies, it is suggested that weeds should be managed before attaining vegetative growth to avoid grain yield loss in wheat

Table 2. Grain yield approximate losses of wheat in Pakistan at various years

	Area		Production		Yield	
Year	Hectares	% change	Tonnes	% Change	(kg ha^{-1})	% Change
2019-20	8805	-	25,248	-	2,868	-
2020-21	9168	4.1	27,464	8.8	2,996	4.5
2021-22	8976	- 2.1	26,394	-3.9	2,940	-1.9

Source: Pakistan Bureau of Statistics

Information regarding yield losses in wheat was given in table. 3. Information was collected at different stages of wheat. The highest yield losses was recorded at tiller loss 39.8% by underground pest followed by lodging at reproductive stage 38% while the yield losses due to weeds at all stages of competition, lighter seed, spikes m-2 at harvest , rainfall at flowering stage, grain yield losses and field harvest losses was recorded 33.2%, 27.5%, 23.4%, 20%., 17.3% and 16 %. The seed loss at sowing time by birds was recorded 16%. The lowest yield loss was recorded at grain spike-1 at field by birds eating which is 15.1%. The average loss of yield occured in wheat is 24.1% followed by table.

Table 3. Yield Approximate Losses at Various Stages in Wheat

Wheat Stages	Plant losses
Seed loss at sowing by birds/insects	16%
Tiller loss by underground pests	39.8%
Weeds loss at all stages competition	33.2%
Rainfall at flowering stage	20%
Lodging at reproduction stage	38%
Field harvest losses	16%
Threshing Loss (in straw)	10-13%
Spikes m^{-2} at harvest	23.4%
Grain $Spike^{-1}$ at field (by birds eating)	15.1%
Thousand grains weight (lighter seed)	27.5%
Grain yield losses	17.3%
Average loss (overall yield loss)	24.1%

CONCLUSION AND RECOMMENDATION

The conclusion drawn from this comprehensive analysis highlights the intricate nature of these challenges, encompassing abiotic factors, inadequate inputs, pest infestations, and post-harvest inefficiencies. To address these issues and improve wheat production, tailored interventions are imperative. Implementing strategies like precision agriculture for optimized input application, developing resilient wheat varieties, integrated pest management, and improving post-harvest handling techniques can effectively mitigate yield losses. Furthermore, enhancing awareness among farmers regarding optimal sowing practices, irrigation management, and pest control measures will be crucial in bolstering wheat yields and ensuring food security for a significant portion of the global population that relies on this essential cereal grain.

FURTHER STUDY

Advanced research in addressing wheat yield losses involves genetic modification for resilient varieties and precision agriculture using technology like drones, focusing on eco-friendly pest management and climate-resilient practices to optimize yields sustainably.

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