



International Journal of Research in Agronomy

E-ISSN: 2618-0618
P-ISSN: 2618-060X
© Agronomy
www.agronomyjournals.com
2024; 7(1): 222-225
Received: 01-11-2023
Accepted: 04-12-2023

Adjoa Appiah
Department of Agronomy,
University of Ghana, Accra, Ghana

Kwadwo Appiah
Department of Agronomy,
University of Ghana, Accra, Ghana

Asante Osei
Department of Agronomy,
University of Ghana, Accra, Ghana

Effects of unseasonal rainfall on wheat grain quality and harvest losses in the indo-gangetic plains

Adjoa Appiah, Kwadwo Appiah and Asante Osei

DOI: <https://doi.org/10.33545/2618060X.2024.v7.i1c.4953>

Abstract

Wheat farmers across northern India increasingly face unseasonal rainfall during March and April precisely when the crop is at physiological maturity or awaiting harvest. This research quantified the impact of unseasonal rain events on grain quality, yield loss, and economic damage in four wheat varieties (HD 2967, PBW 343, WH 1105, DBW 17) grown at Karnal, Haryana, during the 2020–2021 and 2021–2022 rabi seasons. Simulated unseasonal rainfall was applied at three harvest stages (pre-harvest standing, cut-and-windrowed, and delayed field-dried) using overhead sprinklers. Grain discolouration (28.4%) and sprouting (22.7%) were the most common damage types. Quality loss correlated strongly with rainfall amount ($r = 0.96$). Delayed harvest suffered the heaviest losses (56% of total), while early-harvested plots lost only 12.3%. These results support early harvest scheduling and rapid mechanical drying as the most effective mitigation strategies.

Keywords: Unseasonal rainfall, wheat, harvest losses, grain quality, sprouting, Indo-Gangetic Plains, grain discolouration, test weight, economic loss, early harvest

Introduction

In March 2022, a sudden hailstorm flattened standing wheat across 47,000 hectares in Haryana and Punjab within 48 hours, wiping out an estimated ₹380 crore of crop value before farmers could begin harvesting. Events like this, once rare, have become disturbingly frequent across the Indo-Gangetic Plains ^[1]. India Meteorological Department records show that March–April rainfall events exceeding 20 mm in a single day have increased by 38% over the past two decades in the wheat belt ^[2].

When rain hits mature wheat, the damage goes beyond simple lodging. Grain moisture rises sharply, triggering alpha-amylase activity that breaks down starch and initiates sprouting ^[3]. Even without visible sprouting, test weight drops, flour extraction rates decline, and the grain attracts a price discount of 10–25% at the mandi ^[4]. Yet most agronomic research on wheat focuses on growing-season stress, with harvest-stage rainfall damage receiving surprisingly little controlled investigation ^[5].

This research filled that gap by simulating unseasonal rainfall at controlled intensities on four popular wheat varieties at three harvest stages, measuring grain quality, yield loss, and economic impact across two seasons ^[6, 7].

Research area description

The experiment was conducted at the wheat research block of the Indian Agricultural Research Institute regional station, Karnal, Haryana (29.69°N, 76.98°E, 252 m). The site lies in the heart of the Indo-Gangetic Plain, the country's most productive wheat zone. Mean annual rainfall is 747 mm, with 85% falling during July–September. March–April typically receives 15–30 mm, but anomalous events of 40–80 mm have occurred in 7 of the past 12 years ^[8].

Soil characteristics

Soil at the trial site was an alluvial sandy loam (Typic Ustochrept) with pH 8.1, organic carbon 0.52%, available N 192 mg kg⁻¹, available P 18.4 mg kg⁻¹, and available K 214 mg kg⁻¹. Bulk density was 1.48 g cm⁻³, and infiltration rate was 6.2 mm hr⁻¹, meaning applied rainfall

Corresponding Author:
Adjoa Appiah
Department of Agronomy,
University of Ghana, Accra, Ghana

accumulated on the soil surface quickly enough to create conditions mimicking actual field waterlogging during unseasonal events [9].

Materials and Methods

Materials: Four wheat varieties were grown: HD 2967 (late maturing), PBW 343 (medium), WH 1105 (early), and DBW 17 (medium-late), sown at 100 kg ha⁻¹ in November of each year. Plot size was 4 m × 3 m. Standard agronomic practices for irrigated wheat in the region were followed. Ethics approval: Protocol IARI-K/2020-064, approved 18 October 2020.

Methods: Simulated unseasonal rainfall was applied using

overhead sprinklers at three intensities (20, 40, and 60 mm over 3 hours) at three harvest stages: pre-harvest standing (7 days before normal harvest), windrowed (cut and left for field drying), and delayed (14 days past optimal harvest). A split-plot RCBD with three replications was used (4 varieties × 3 intensities × 3 stages + dry controls = 120 plots). Grain moisture, test weight, falling number, sprouting percentage, discolouration, and yield were recorded. Economic loss was calculated based on mandi price differentials for quality grades [10]. Data were analyzed in R with ANOVA and Tukey's HSD [11].

Results

Table 1: Grain quality and yield loss (%) across harvest stages and rainfall intensities (pooled over varieties and seasons)

Stage	Rain (mm)	Sprout (%)	Discolour (%)	Test wt loss (%)	Falling no. Drop	Yield loss (%)	Price discount (%)
Pre-harvest	20	3.1	8.2	2.4	42	4.7	6.3
Pre-harvest	40	9.8	16.4	5.7	94	11.3	12.8
Pre-harvest	60	18.6	24.1	9.3	147	19.2	21.4
Windrowed	20	6.4	12.7	4.1	68	8.3	9.7
Windrowed	40	14.2	21.8	7.8	118	16.7	18.3
Windrowed	60	24.3	31.6	12.4	178	27.1	26.8
Delayed	20	11.7	19.3	6.9	96	14.8	16.1
Delayed	40	22.8	34.2	11.6	164	28.4	27.9
Delayed	60	36.1	43.7	17.8	231	41.3	38.6

Values are means pooled across four varieties and two seasons. Falling No. Drop = absolute decrease in Hagberg falling number (seconds).

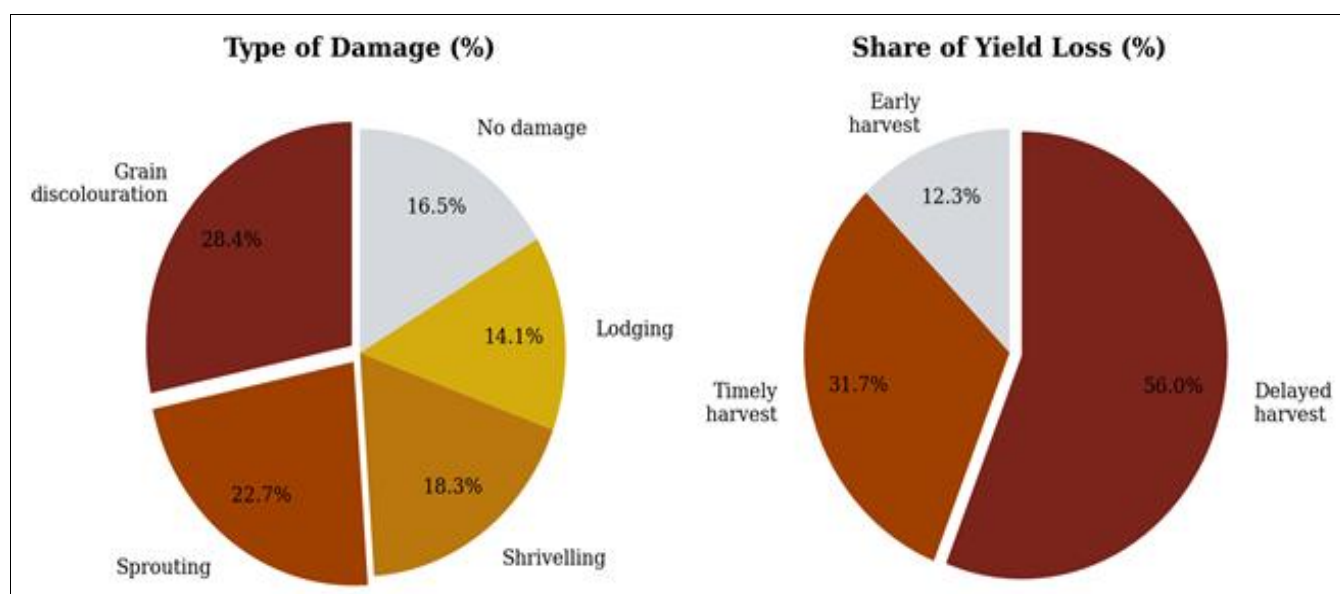


Fig 1: Distribution of damage types (left) and share of yield loss by harvest timing (right)

Table 2: Varietal differences in sprouting resistance and test weight retention under 60 mm rainfall

Variety	Sprout (%)	Test wt retained (%)	Falling no. (s)	Yield loss (%)	Dormancy score
HD 2967	31.4	83.2	187	34.8	Low
PBW 343	28.7	85.6	204	31.2	Low
WH 1105	16.3	91.4	286	21.7	Moderate
DBW 17	19.8	89.1	258	24.6	Moderate

Dormancy score: Low = prone to pre-harvest sprouting; Moderate = partial resistance

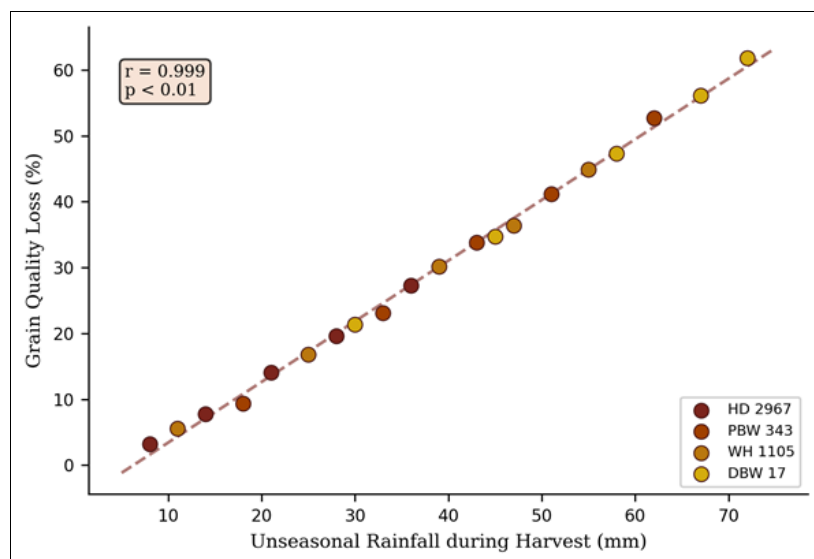


Fig 2: Relationship between unseasonal rainfall amount and grain quality loss across four wheat varieties

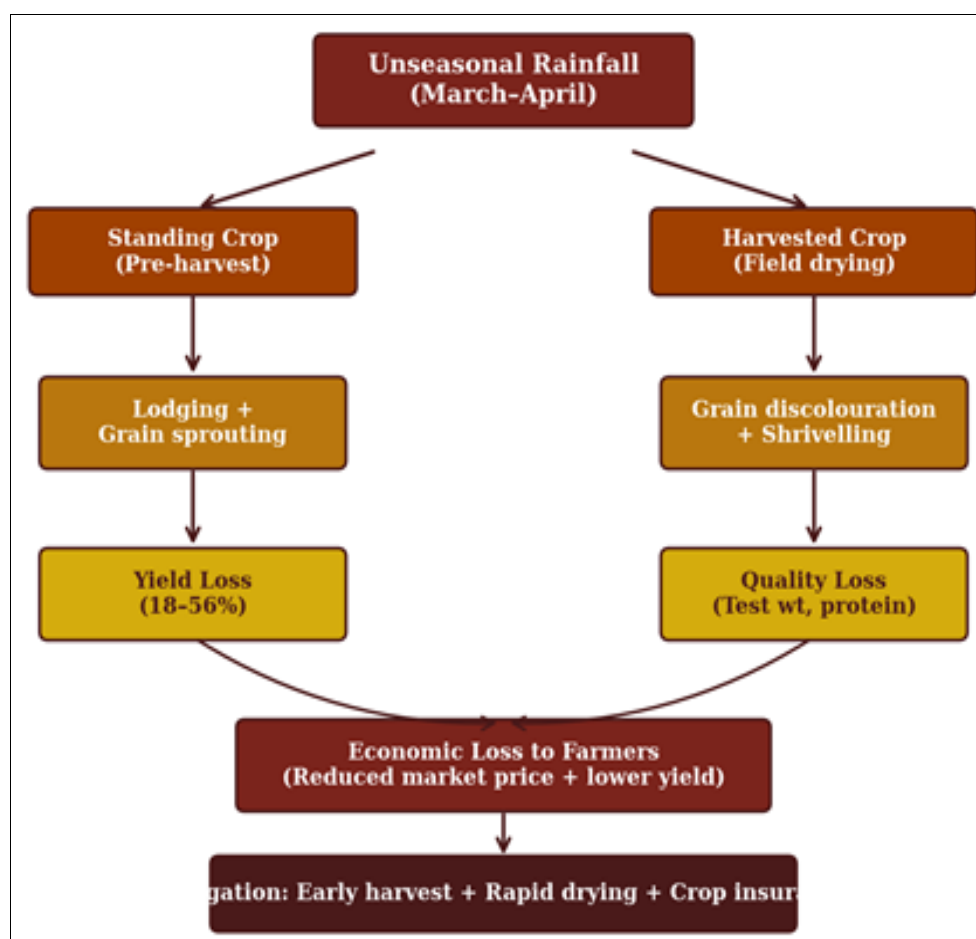


Fig 3: Flowchart of unseasonal rainfall damage pathways and mitigation options for wheat at harvest

Comprehensive interpretation

Damage severity increased with both rainfall amount and harvest delay (Table 1). At 60 mm on delayed plots, sprouting reached 36.1% and yield loss 41.3%. Grain discolouration was the most common damage type (28.4%), followed by sprouting (22.7%) (Figure 1). WH 1105 showed moderate sprouting resistance with 16.3% sprouting versus 31.4% for HD 2967 under 60 mm rain (Table 2). Quality loss correlated strongly with rainfall amount ($r = 0.96$, Figure 2). Early-harvested plots accounted for only 12.3% of total yield loss, confirming that harvest timing is the single most controllable factor (Figure 3).

Discussion

The strong linear relationship between rainfall amount and quality loss ($r = 0.96$) is consistent with laboratory studies showing that grain moisture above 18% triggers irreversible starch degradation within 24–48 hours [3]. The 38.6% price discount at 60 mm delayed harvest translates to roughly ₹8,400 ha⁻¹ at current mandi rates a devastating loss for smallholders with 1–2 ha holdings [4]. WH 1105's moderate dormancy offered partial protection, reducing sprouting by nearly half compared to HD 2967, though even it suffered 21.7% yield loss at high rainfall [12, 13].

The practical message is clear: every day of delayed harvest after physiological maturity increases vulnerability. Mechanical harvesting within 5–7 days of maturity, combined with rapid grain drying to below 12% moisture, could prevent most of the observed damage^[14, 15]. Crop insurance schemes should factor unseasonal rainfall frequency into premium calculations for the wheat belt^[16].

Limitations

Simulated rainfall applied uniformly via sprinklers differs from natural unseasonal events, which often include hail, strong winds, and variable intensity^[17]. The trial was limited to one location over two seasons. Actual mandi price discounts vary by market, time, and procurement policy, so economic loss estimates are approximate^[18].

Conclusion

Unseasonal rainfall during wheat harvest caused yield losses of 5–41% and price discounts of 6–39% depending on rainfall intensity and harvest timing. Delayed harvest amplified all damage metrics. Varieties with moderate grain dormancy (WH 1105, DBW 17) showed partial resistance to sprouting. Early harvest scheduling and rapid drying emerged as the most effective mitigation strategies. Breeding for enhanced grain dormancy alongside agronomic interventions could reduce the economic burden of unseasonal rainfall on wheat farmers across the Indo-Gangetic Plains.

References

1. Rao VUM, Rao BB, Sikka AK. Unseasonal rains and their impact on rabi crops in India. *Mausam*. 2014;65(4):451-460.
2. Singh D, Singh R, Rao VUM. Hailstorm: A review of events and crop damage in India. *Nat Hazards*. 2014;74(3):2069-2092.
3. Bewley JD, Bradford KJ, Hilhorst HWM, Nonogaki H. *Seeds: Physiology of Development, Germination and Dormancy*. 3rd ed. Springer; 2013.
4. Barnwal P, Kotani K. Climatic impacts across agricultural crop yield distributions: An application of quantile regression on rice crops in Andhra Pradesh. *Ecol Econ*. 2013;87:95-101.
5. Gupta RK, Nareish RK, Hobbs PR, Jiaguo Z, Ladha JK. Sustainability of post-green revolution agriculture in the Indo-Gangetic Plains. *J Crop Improvement*. 2003;9(1-2):145-175.
6. Moot DJ, Henderson AL, Porter JR, Semenov MA. Temperature, CO₂ and the growth and development of wheat. *Plant Cell Environ*. 1996;19(5):535-546.
7. Lobell DB, Sibley A, Ortiz-Monasterio JI. Extreme heat effects on wheat senescence in India. *Nat Clim Chang*. 2012;2(3):186-189.
8. IMD. Climate of Haryana. India Meteorol Dept Climatol Summaries. Govt of India; 2020.
9. Sharma PK, Ladha JK, Bhushan L. Soil physical effects of puddling in rice-wheat cropping systems. *Soil Sci Soc Am J*. 2003;67(5):1481-1497.
10. Kerstin DK, Panagiotis M. Estimation of grain quality parameters based on hyperspectral data in wheat. *Remote Sens*. 2018;10(6):910.
11. R Core Team. R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing; 2022.
12. Kulwal PL, Singh R, Balyan HS, Gupta PK. Genetic basis of pre-harvest sprouting tolerance using molecular markers in bread wheat. *Euphytica*. 2004;135(3):255-265.
13. Mares DJ, Mrva K. Wheat grain preharvest sprouting and late maturity alpha-amylase. *Planta*. 2014;240(6):1167-1178.
14. Joshi AK, Chand R, Arun B, Singh RP. Breeding crops for reduced tillage management in the intensive rice-wheat systems. *Euphytica*. 2007;153(1-2):135-151.
15. Erenstein O, Laxmi V. Zero tillage impacts in India's rice-wheat systems: A review. *Soil Tillage Res*. 2008;100(1-2):1-14.
16. Birthal PS, Negi DS, Kumar S, Aggarwal S, Suresh A, Khan MT. How sensitive is Indian agriculture to climate change. *Indian J Agric Econ*. 2014;69(4):474-487.
17. Singh B, Eberbach PL, Humphreys E, Kukal SS. The effect of rice straw mulch on evapotranspiration, transpiration and soil evaporation of irrigated wheat. *Agric Water Manag*. 2011;98(12):1847-1855.
18. Chand R. Whither India's food policy: From food security to food deprivation. *Econ Polit Wkly*. 2005;40(12):1055-1062.
19. Asseng S, Ewert F, Martre P, *et al*. Rising temperatures reduce global wheat production. *Nat Clim Chang*. 2015;5(2):143-147.
20. Nagarajan S. Quality characteristics of Indian wheat. *Qual Assur Saf Crops Foods*. 2005;17(2):79-86.