



## Revolutionizing harvesting in hilly regions: An agro-morphological study of HD-3180 wheat and Kent Oats

Sheikh Aadil Mushtaq<sup>1</sup>, Sanjay Khar<sup>1</sup>, Obaid Zaffar<sup>1</sup>, Sherab Dolma<sup>1</sup>, Zubair Khan<sup>2</sup>

<sup>1</sup> Division of Farm Machinery and Power Engineering, Faculty of Agricultural Engineering, Sher-e Kashmir University of Agricultural Sciences and Technology, Jammu, Jammu and Kashmir, India

<sup>2</sup> Sher-e-Kashmir University of Agricultural Sciences & Technology of Kashmir, Jammu and Kashmir, India

### Abstract

Agricultural mechanization plays a pivotal role in enhancing productivity and reducing labour intensity. The design of harvesting equipment requires an in-depth understanding of crop-specific agro-morphological parameters to ensure efficiency and suitability. This study focused on analysing the agro-morphological characteristics of HD-3180 wheat and Kent oats varieties, providing essential insights for designing various harvester components. The parameters such as row spacing, crop-to-crop spacing, plant height, stem diameter, tiller count, and grain yield were measured and analysed. The wheat variety exhibited a mean plant height of 95 cm, stem diameter of 3.5 mm, and grain yield ranging from 18 to 30 g per plant, indicating the need for precise cutting mechanisms to handle moderate biomass efficiently. In contrast, the oats variety showed taller plants with a mean height of 105 cm, thicker stems averaging 4.2 mm, and higher grain yields of 30–50 g per plant, necessitating a more robust cutter bar and higher capacity feeding systems. The findings underscore the critical role these parameters play in optimizing cutter bar dimensions, effective field capacity, and the overall performance of harvesters. This study is vital for designing and developing harvesters suited to the specific agro-morphological traits of cereal crops, improving cutting efficiency, reducing grain loss, and promoting effective mechanization to enhance harvesting practices in hilly regions.

**Keywords:** Mechanisation, Smart Agriculture, Hill Agriculture, Small Farms

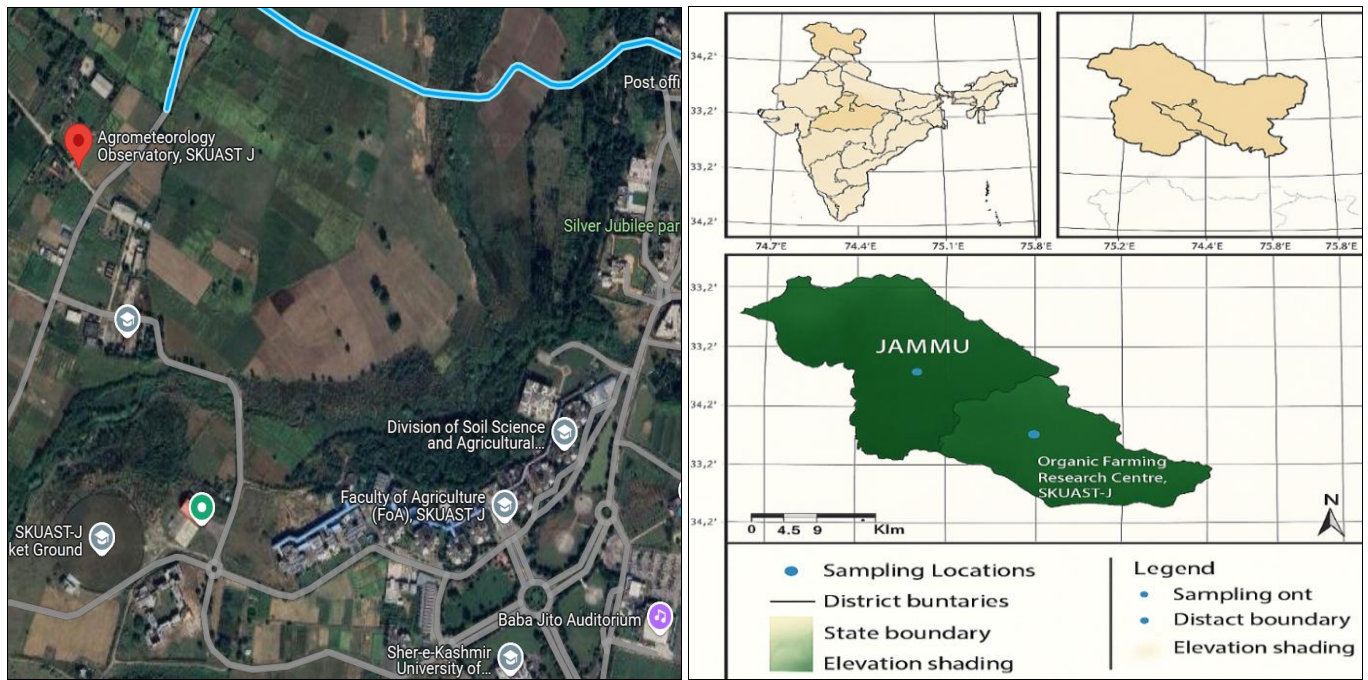
### Introduction

India ranks among the top global producers of wheat and oats, yet its harvesting operations largely rely on labour-intensive practices. While mechanization has made strides, the design of harvesters for specific crops remains a challenge due to the diverse agro-morphological features of crop varieties. Understanding these parameters is essential to ensure compatibility and efficiency. This research identified and evaluated the morphological characteristics of HD-3180 wheat and Kent oats, focusing on their application in harvester design. In the Jammu Division, the cultivation of wheat and oats is an essential part of the region's agricultural landscape. The HD-3180 wheat variety and Kent oats are two of the most prominent crops grown, offering significant economic benefits to the farmers. The HD-3180 wheat variety, recognized for its high yield potential and resistance to common wheat diseases, is one of the most widely cultivated varieties in the Jammu Division. As per the Directorate of Economics and Statistics (DES), wheat production in Jammu and Kashmir for the year 2022-23 was approximately 3.12 million metric tonnes, with a per hectare yield averaging 2.5 tonnes (DES, 2022) <sup>[2]</sup>. The variety's adaptability to both irrigated and rainfed conditions has made it a reliable choice for farmers in the region. The optimal growing conditions for HD-3180 wheat include moderate temperatures and adequate moisture during the growing season, both of which are prevalent in Jammu's plains. Kent oats, a high-quality forage crop, is also extensively cultivated in the Jammu Division. According to recent agricultural surveys, oats production in Jammu accounts for approximately 0.25 million hectares, with an

average yield of 2.2 tonnes per hectare (Agricultural Census, 2021) <sup>[1]</sup>. Kent oats are favoured for their nutritional value as animal feed and their role in soil fertility through crop rotation. The cool winter climate of Jammu, particularly in the hilly areas, supports the optimal growth of oats, making it an important crop for farmers in both food and livestock production. As these crops are integral to the farming economy of Jammu Division, optimizing the harvesting process through mechanization becomes crucial. While manual harvesting methods have been traditionally employed, they are increasingly becoming unsustainable due to labour shortages and high labour costs (Mushtaq *et al.*, 2024 and Dolma *et al.*, 2024) <sup>[4]</sup>. As noted by Khatri *et al.*, 2022 <sup>[3]</sup>, mechanized harvesting can lead to a 30-40% reduction in labour costs and an increase in harvesting efficiency.

Therefore, designing and developing a harvester prototype capable of effectively handling both HD-3180 wheat and Kent oats varieties is crucial for improving post-harvest management and meeting the growing demands of the agricultural sector in Jammu Division. This research focused on the parameters that are important for the development of a multi-crop harvester that can accommodate the unique characteristics of both wheat and oats, considering factors such as crop height, stem thickness, and field conditions. The findings of this study are expected to provide valuable insights for the design of harvesters that can enhance productivity, reduce losses, and ultimately contribute to the sustainability of agricultural practices in the region.

## Materials and Methods



**Fig 1:** Geographical location and sampling sites of the study area

### 1. Study Area and Experimental Design

The present investigation, titled “Revolutionizing Harvesting in Hilly Regions: An Agro-morphological Study of HD-3180 Wheat and Kent Oats,” was carried out at the Organic Farming Research Centre (OFRC), under the aegis of Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu (SKUAST-J). The research site is located at the Main Campus, Chatha, geographically positioned at 32°40' North latitude and 74°58' East longitude, with an elevation of 332 meters above mean sea level as shown in Fig. 1. The area lies in the Shiwalik foothills of the North-Western Himalayas, which is characterized by a subtropical climate, undulating terrain, and diverse agro-ecological conditions. These features make the region ideal for evaluating the adaptability and performance of cereal crops under hilly topographies. The soil at the experimental site is generally sandy loam in texture, with moderate fertility, well-drained properties, and a slightly alkaline pH, which collectively offer suitable conditions for the cultivation of rabi season cereals like wheat and oats. A Randomized Complete Block Design (RCBD) was adopted for the study to ensure experimental reliability and minimize the effects of environmental variability. The experiment consisted of three replications, with each replication containing all treatments in a randomized layout. This statistical design was chosen to facilitate accurate assessment of agro-morphological traits and to enhance the precision of the data collected. The primary focus was to evaluate and compare the agro-morphological performance of two cereal varieties — HD-3180 (wheat) and Kent (oats) — under field conditions, with emphasis on traits that influence harvest efficiency, biomass yield, and suitability for mechanized operations in

undulating and sloped agricultural landscapes. The location of the study area is visually represented in Figure 1, which contextualizes the sampling region within the larger framework of districts of Jammu & Kashmir.

### 2. Agro-morphological Parameters Assessed

The agro-morphological properties of both HD-3180 wheat and Kent oats relevant to harvester design were assessed. The Row spacing and crop-to-crop spacing were measured using a measuring tape along predetermined rows, ensuring consistency across the field. For plant height, a measuring tape was used to record the height of plants from the base to the tip of the tallest tiller at the time of sampling as shown in Fig 2. The plant population was calculated by counting the number of plants in a 1m<sup>2</sup> area, performed at multiple locations within the field to ensure representative sampling. The days to 50% flowering and days to maturity were recorded by observing the plants regularly and noting the stage when 50% of the plants had flowered and when they reached full maturity, respectively. The total tillers and effective tillers per plant were counted by selecting a random sample of plants and recording the number of tillers, distinguishing between total and effective tillers. The stem diameter was measured using a Vernier calliper at the base of the stem, ensuring accurate diameter readings at the point of maximum thickness. For 1000 grain weight, grains from multiple plants were harvested, dried, and weighed to calculate the average mass of 1000 grains. Finally, grain yield per plant was determined by harvesting a random sample of plants, threshing, and weighing the grains. All measurements were performed at multiple locations across the field to account for spatial variability and ensure representative data for both crops.



**Fig 2:** Study Area and Assessed Agro-morphological Traits of HD-3180 Wheat and Kent Oats

## Results and Discussion

### 1. Agro-Morphological Properties of HD-3180 Wheat and Kent Oats variety

The agro-morphological evaluation of HD-3180 wheat and Kent oats reveals distinct variations that play a crucial role in the design and optimization of harvesters, particularly for challenging hilly terrains as presented in the Table 3.1 and 3.2. The HD-3180 wheat variety exhibited a mean row spacing of 20 cm and a crop-to-crop spacing of 10 cm, reflecting a moderately dense planting pattern, which directly impacts cutter bar width and the adjustment of cutting mechanisms for efficient harvesting as also highlighted by Mushtaq *et al.*, 2024 [4]. The average plant height of 95 cm with a standard deviation of 4.2 cm indicates a relatively uniform crop stand, which facilitates consistent cutting height settings and reduces the risk of lodging losses during harvest operations. The observed mean stem diameter of 3.5 mm indicates the necessity for a moderately robust cutting mechanism that can effectively manage medium-thickness stems without compromising cutting precision, a requirement also emphasized by Kumar and Yadav (2020) [8] in their analysis of crop stem characteristics and cutting tool design. The plant population density, averaging 30 plants/m<sup>2</sup> with a coefficient of variation (CV) of 8.33%, reflects moderate variability in crop growth patterns. This necessitates a harvester design capable of accommodating such variations to prevent clogging and ensure smooth material flow through the cutter bar, as also highlighted by Verma *et al.* (2021) in their study on harvesting dynamics under variable crop stands. The observed yield-related parameters, specifically the 1000-grain weight averaging 40 g and a grain yield per plant ranging between 18 to 30 g with a coefficient of variation (CV) of 16%, indicate a moderate level of biological variability within the crop stand. This variability places a significant emphasis on the need for precision-engineered threshing and grain collection systems in mechanized harvesters. Efficient handling of grain output is essential not only to maintain the integrity of the grains but also to minimize post-harvest losses—an issue of critical concern in smallholder farming systems where even marginal losses can impact economic viability.

Designing threshing mechanisms that accommodate grain size and weight variability helps reduce mechanical damage and grain shattering during processing. Moreover, recovery efficiency in such contexts must be optimized to ensure maximum grain retention. Similar recommendations were made by FAO (2018) [6], that reported grain recovery efficiency is highly sensitive to the uniformity of grain size and feeding rates. Hence, adopting designs that are

responsive to yield parameter variability can bolster overall harvesting performance and contribute to sustainable agricultural practices, especially in resource-constrained environments

In contrast, the Kent oats variety demonstrated larger morphological traits, with a mean row spacing of 22 cm and a crop-to-crop spacing of 10 cm, suggesting a slightly sparser plant distribution that requires broader cutter bar settings for optimal performance (Patel *et al.*, 2022) [9]. The mean plant height of 105 cm and a thicker stem diameter of 4.2 mm necessitate a more powerful cutting mechanism to handle increased stem resistance and prevent mechanical failures during harvesting operations. The plant population density was notably higher (45 plants/m<sup>2</sup>), with a low CV (3.21%), indicating uniform crop distribution that can increase biomass load, requiring a feeding system capable of managing higher throughput without causing blockages as supported by the findings of Sharma & Singh, 2021 [11]. Furthermore, the effective tiller count of 6 per plant and grain yield ranging from 30 to 50 g (CV: 12.5%) highlight the need for an adaptive feeding and threshing mechanism to handle larger grain volumes efficiently, ensuring high output while minimizing grain damage as aligned with Gupta *et al.*, 2020 [7]. The observed variations in tiller number and plant height also suggest the necessity for adjustable cutting height mechanisms to accommodate irregular crop growth, which is common in hilly regions due to uneven terrain and microclimatic variations (Rana *et al.*, 2019) [10].

These findings emphasize the critical need for designing harvesters that can adapt to the specific agro-morphological characteristics of cereal crops grown in hilly regions. The significant differences between HD-3180 wheat and Kent oats—in plant height, stem diameter, population density, and yield—highlight the importance of flexible harvester components such as adjustable cutter bars, reinforced cutting blades, and efficient feeding systems. Such tailored designs can bolster cutting efficiency, minimize grain loss, and enhance the overall mechanization process, especially for small and marginal farmers operating in difficult terrains (ICAR, 2021). This research underscores the broader need for region-specific mechanization strategies that consider crop morphology, thereby ensuring more effective and sustainable harvesting practices in diverse agricultural landscapes.

### 2. Statistical Analysis and Graphical Representation

A t-test was performed to compare wheat and oat parameters, confirming statistically significant differences ( $p < 0.05$ ) in stem diameter, plant height, and grain yield.

The graphs showing comparative morphology (e.g., bar plots of key traits) were prepared to visually aid harvester

design engineers in understanding critical differences as shown in Fig 3.

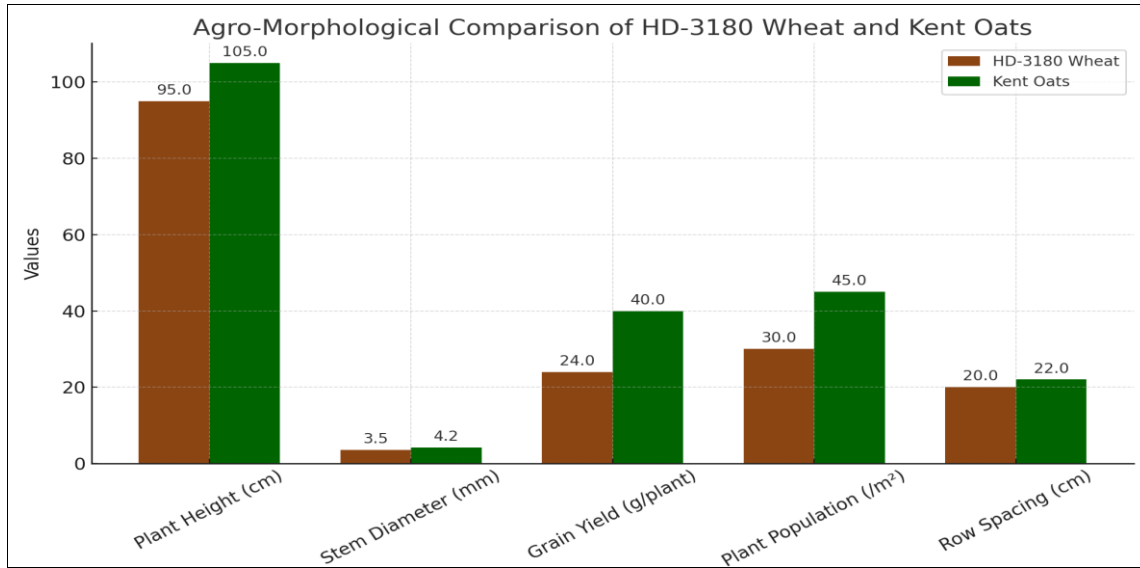


Fig 3: Comparison of key agro-morphological parameters between HD-3180 wheat and Kent oats.

### 3. Engineering Implications for Harvester Design

The morphological traits of the crop, particularly stem diameter and plant height, are critical determinants in the structural and functional design of harvesting mechanisms. A larger stem diameter necessitates a more robust cutting blade to ensure clean severance without shattering, while plant height influences the optimal cutting height settings to minimize stubble loss and enhance harvest efficiency. Row spacing and inter-row crop spacing directly affect the selection of cutter bar width; improper matching can lead to ineffective crop engagement or unharvested strips, thereby increasing field losses.

Plant population density and the average number of tillers per plant play a decisive role in shaping the feeding mechanism and the capacity of the conveyor system. Denser

crop stands with higher tiller counts demand a stronger, more consistent material handling setup to prevent clogging and ensure continuous flow through the cutting and feeding units. This aligns with the findings of Mushtaq *et al.* (2024) [4] and Sharma & Singh (2021) [11], who emphasized the need for adaptable feeding systems under varying crop densities. Moreover, grain yield is a pivotal factor in sizing the threshing and separation units. Higher yields necessitate increased threshing capacity and a larger grain collection bin to avoid frequent unloading cycles, which can otherwise reduce operational efficiency. Consequently, an integrated understanding of these crop parameters is essential to guide the engineering design of a harvester tailored to specific agro-morphological conditions.

Table 1: Relevant Agro-morphological properties of the HD-3180 wheat crop variety pertinent to the harvester design

Parameters	Minimum	Maximum	Mean	Standard deviation	Coefficient of variation (%)
Row spacing (cm)	18	22	20	1.1	5.5
Crop-to-crop spacing (cm)	8	12	10	0.8	8
Plant height (cm)	90	100	95	4.2	4.42
Plant population (per m <sup>2</sup> )	25	35	30	2.5	8.33
Days to 50% flowering	80	90	85	3.5	4.12
Days to maturity	120	130	125	2.8	2.24
Total tillers (per plant)	5	7	6	0.6	10
Effective tillers (per plant)	3	5	4	0.5	12.5
Stem diameter (mm)	3.2	3.8	3.5	0.3	8.57
1000 grain weight (g)	35	45	40	2.5	6.25
Grain yield per plant (g)	18	30	25	4	16

Table 2: Relevant Agro-morphological properties of the Kent oats crop variety pertinent to the harvester design

Parameter	Minimum	Maximum	Mean	Standard deviation	Coefficient of variation (%)
Row spacing (cm)	20	24	22	1.2	5.45
Crop-to-crop spacing (cm)	8	12	10	0.9	9
Plant height (cm)	98	110	105	5.1	4.86
Plant population (per m <sup>2</sup> )	43	48	45	1.44	3.21
Days to 50% flowering	85	95	90	4	4.44
Days to maturity	130	140	135	3.5	2.59
Total tillers (per plant)	6	10	8	1	12.5
Effective tillers (per plant)	4	8	6	0.8	13.33
Stem diameter (mm)	3.7	4.7	4.2	0.4	9.52

1000 grain weight (g)	30	40	35	2.2	6.29
Grain yield per plant (g)	30	50	40	5	12.5

### Conclusion and Future Scope

The agro-morphological characteristics of HD-3180 wheat and Kent oats significantly influence the engineering design requirements for efficient and crop-specific harvesting. The findings of this study underscore that a standardized, one-size-fits-all harvesting solution is inadequate, particularly in regions with diverse crop profiles and challenging topographies. Instead, adaptive design features such as adjustable cutter bar heights, resilient and flexible cutting blades, and modular feeding systems are essential to ensure optimal performance across varying crop conditions. Future research should focus on field validation of the proposed design parameters through prototype development and testing under real-world conditions, especially in undulating terrains typical of hill farming zones. Additionally, incorporating IoT-enabled systems for real-time adjustment of machine parameters could further enhance operational efficiency and crop-specific adaptability. Scaling up these solutions for commercial deployment would be instrumental in promoting inclusive mechanization and sustainable agricultural practices, particularly in the hilly and resource-constrained regions of India.

### References

1. Agricultural Census. Agricultural statistics at a glance. Government of India, 2021.
2. DES. Directorate of Economics Statistics, Ministry of Agriculture Farmers Welfare, Government of India, 2022. Retrieved from <http://www.des.gov.in>
3. Khatri S, Shrestha S. Mechanization in fruit cultivation. present status, issues, constraints future aspects of nepal. *Acta Mechanica Malaysia*,2022;5(2):35-43.
4. Mushtaq SA, Khar S, Sharma S, Singh JP. Study of morphological characteristics of basmati-370 paddy variety pertinent to paddy harvester design, 2024.
5. Dolma S, Singh JP, Sharma S, Khar S, Ud MM, Mushtaq SA. *et al.* Study on physical mechanical characteristics of Kufri Badshah potato tuber for planter design optimization.
6. FAO. The State of Food, Agriculture 2018. Migration, Agriculture Rural Development. Food Agriculture Organization of the United Nations, 2018.
7. Gupta R, Singh J, Verma P. Influence of plant morphological traits on harvester efficiency in cereal crops. *Journal of Agricultural Engineering*,2020;57(2):134-142. ICAR. 2021. Mechanization of Hill Agriculture. A Way Forward. Indian Council of Agricultural Research.
8. Kumar V, Yadav S. Design considerations for cutting mechanisms in small-scale harvesters. *International Journal of Agricultural Science Technology*,2020;8(3):210-217.
9. Patel A, Sharma R, Mehta K. The impact of crop spacing on mechanization efficiency in oats. *Agricultural Mechanization in Asia, Africa, Latin America*,2022;53(1):22-29.
10. Rana N, Verma S, Kumar R. Harvesting challenges in hilly regions. A review. *Indian Journal of Hill Farming*,2019;32(1):45-53.
11. Sharma P, Singh R. Effect of plant density stem strength on harvester performance in cereal crops. *Journal of Crop Improvement*,2021;35(4):375-389.
12. Singh A, Yadav R, Kumar S. Design development of mechanized harvesters for small-scale farmers. *International Journal of Agricultural Engineering*,2019:56(1):67-75.