PERFORMANCE OF DIFFERENT OATS (*Avena sativa* L) VARITIES UNDER AGRO CLIMATIC CONDITIONS OF DISTRICTS KASUR AND OKARA PUNJAB, PAKISTAN.

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ABSTRACT: *A field study was undertaken to assess the comparative performance of ten oats (Avena sativa L.) varieties CK-1, Ravi, AVON, F-411, S-2000, Super Green, S-2011, S-2002, Ever Green, and Barkat at two locations: the Buffalo Research Institute (BRI), Pattoki, District Kasur and the Livestock Production Research Institute (LPRI), Bahadurnagar, Okara. The experiment at both sites was established using a Randomized Complete Block Design (RCBD) with three replications. All varieties received a uniform fertilizer application of 125 kg N ha⁻¹ and 125 kg P_2O_5 ha⁻¹ to ensure consistent nutrient availability across treatments. Crop was harvested at milking stage of growth for its Physical yield contributing parameters i.e. green fodder yield (t/ha), plant height (Cm), No. of leaves per tiller & No. of tillers per plant. Maximum green fodder yield was harvested from Ever Green i.e. 30 t/ha compared to Ravi, F-411, AVON, CK-1, S-2000, S-2002, Super green, S-2011 & Barkat i.e.11,12,13.15, 18,23, 27, 27 & 27 t/ha respectively. Maximum plant height i.e. 255 (cm), Number of tillers per plant (22), Number of leaves per tiller (9) and dry matter 32.85 % were achieved in oats variety ever green compared to other varieties. Plant samples were collected and analyzed for quality parameters. It was found that Ever-green variety of oats yield Crude Protein 9.5%, Total minerals (Ash) 10.84%, dry matter 32.85%, NDF 65% & ADF,35% which was more than other varieties. Ever green yield less ether extract i.e. 1.25 % than other varieties.*

Key Words: *Avena sativa; comparative, Oat varieties, Climatic conditions, Pakistan.*

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INTRODUCTION

Oat (*Avena sativa* L.) is a principal winter-season forage crop of considerable importance in mixed crop–livestock production systems in Punjab. It is cultivated under both irrigated and rainfed conditions and has been the focus of targeted varietal development and release programs within the state, reflecting its agronomic and economic significance (Shakil *et al*., 2023.; Kapoor & Hilli, 2022). The crop is widely recognized as a dual-purpose winter forage adapted to regional production environments (Shakil *et al*., 2023.). Although published reports emphasize its suitability for winter cultivation, they do not provide a unified specification combining approximately 400 mm seasonal precipitation, a temperature range of 16–32°C, and a four-month growth duration. Instead, agronomic descriptions typically refer to timely sowing, irrigation responsiveness, and winter cropping windows as determinants of optimal performance (Ayub *et al*., 2013; Shakil *et al*., 2023.).

Among winter fodder crops, oat is distinguished by its high green biomass productivity. Field evaluations in Punjab and adjoining regions have documented green fodder yields ranging from approximately 63.7 to 80.0 t ha⁻¹ under improved agronomic management (Kaur & Goyal, 2017). Certain recently released cultivars have demonstrated maximum yields exceeding 80 t ha⁻¹ under optimized spacing and management practices (Kapoor & Hilli, 2022). Multi-year varietal trials further indicate statistically superior green forage and dry matter yields of improved cultivars compared with standard checks (Shakil *et al*., 2023; Kapoor & Hilli, 2022). Oat is also well suited to multicut systems; comparative studies of single- and double-cut regimes report higher cumulative green and dry fodder yields under successive harvest management, supporting its utility in sustained forage

production systems (Wadhwa *et al*., 2010; Kaur & Goyal, 2017).

Breeding programs in Punjab and associated research centers have prioritized the development of cultivars with improved maturity windows, enhanced forage yield, superior nutritive value, and greater resilience to biotic and abiotic stresses. Newly released varieties exhibit favorable flowering and maturity durations aligned with regional production cycles and demonstrate substantial yield advantages over existing checks (Shakil *et al*., 2023; Kapoor & Hilli, 2022). Nutritional evaluations also report improved forage quality attributes and high palatability in animal feeding assessments (Wadhwa *et al*., 2010; Kaur & Goyal, 2017). Furthermore, the incorporation of stress tolerance and climate resilience into breeding objectives reflects ongoing efforts to enhance adaptation under variable winter environments (Shakil *et al*., 2023; Kapoor & Hilli, 2022). Collectively, these findings underscore the strategic importance of oat as a high-yielding, quality winter forage crop for Punjab's livestock production systems.

Despite these agronomic advantages, varietal performance in oat (*Avena sativa* L.) is strongly influenced by genotype × environment (G×E) interactions (Kebede *et al*., 2023a; Ahmad *et al*., 2014). Environmental determinants, including soil properties, rainfall patterns, temperature variability, and associated climatic factors, significantly affect yield expression and stability (Desheva & Valchinova, 2024; Kebede *et al*., 2023b). As commercial production environments offer limited scope for modification, genetic improvement represents the principal strategy for enhancing performance stability and productivity (Holland *et al*., 2002). Through hybridization and modern breeding approaches, efforts are directed toward developing genotypes capable of maintaining consistent performance across heterogeneous environments (Lorencetti *et al*., 2002; Carvalho *et al*., 2023). Because crop yield reflects the combined influence of genetic constitution and environmental conditions, no single cultivar is expected to perform uniformly across all agro-climatic regions (Kebede *et al*., 2023a). Ideally, improved cultivars should integrate high yield potential with broad adaptability (Holland *et al*., 2002; Lorencetti *et al*., 2002).

Although oat (*Avena sativa* L.) is widely cultivated, systematic evaluations of its forage performance under specific local conditions in Pakistan remain relatively limited. Recent studies have demonstrated positive associations between biomass yield and key morphological traits such as plant height, leaf area, and tiller density, indicating their utility as selection criteria for enhanced forage production (Gandahi *et al*., 2021; Ayub *et al*., 2011; Niazi *et al*., 2020). Comparative assessments of cultivars under different agro-ecological conditions have revealed substantial variation in green fodder and dry matter yields, with certain advanced lines and locally adapted genotypes consistently outperforming standard checks (Ayub *et al*., 2013; (Bhatti *et al*., 1992; Khan *et al*., 2022; Niazi *et al*., 2020). Additional multi-location and environment-specific investigations have further confirmed the adaptability and suitability of oat as a forage crop across diverse agro-climatic zones of Pakistan (Gandahi *et al*., 2021; Khan *et al*., 2022; Ayub *et al*., 2011).

In light of the increasing demand for high-quality forage in dairy-based production systems, region-specific evaluation of superior oat genotypes is essential. Accordingly, the present study was undertaken to assess the performance of oat as a green fodder crop under the agro-ecological conditions of Okara District, with the objective of enhancing forage availability and improving livestock productivity.

MATERIALS AND METHODS

The study was carried out during the Rabi season 2024–2025 at Livestock Production Research Institute, Bahadurnagar (Okara) & Buffalo Research Institute Pattoki (Kasur) located at 30.808500° N latitude and 73.459396° E longitude. The area exhibits a semi-arid climate, with winter temperatures reaching as low as 3°C and summer temperatures rising to 45°C. The region receives about 509 mm of annual rainfall. BRI, Pattoki District Kasur is at roughly 31.017° N latitude, 73.850° E longitude, with low elevation variations (around 632 ft average), dominated by cropland, and lies about 73 km from Lahore on the N-5 Highway, near the Changa Manga forest. (Google Geographical Data, 2024).

Prior to sowing, surface soil samples (0–30 cm) were collected systematically from each plot. Each composite sample comprised five randomly extracted core samples that were thoroughly mixed to obtain a representative sample. These samples were analyzed for major physico-chemical attributes, including soil texture, organic matter percentage, available phosphorus (ppm), available potassium (ppm), calcium carbonate ($CaCO_3$, %), electrical conductivity (EC dS m^{-1}), and soil pH. Soil analyses were performed according to the standardized procedures described in the USDA Salinity Laboratory Handbook (U.S. Salinity Laboratory Staff, 1954). The resulting soil characteristics are summarized Table.1.

A field trial was conducted during the Rabi season of 2024–25 to evaluate the performance of ten oat varieties under irrigated conditions at two locations: the Livestock Production Research Institute (LPRI), Bahadurnagar, Okara, and the Buffalo Research Institute (BRI), Pattoki (Kasur). At BRI Pattoki, the tested varieties comprised S-2000, S-2002, S-2011, Ever Green, Super Green, and Barkat, whereas CK-1, F-411, Ravi, and AVON were evaluated at LPRI Bahadurnagar.

Table:-1 Physio-Chemical properties of soils.

Property	Buffalo Research Institute, Pattoki (Kasur)	Livestock Production Research Institute, Bahadurnagar Okara
	Soil sampling Depth 0-30 cm	
EC (d S m^{-1})	2.03	1.80
Soil pH	7.97	8.2
Calcium Carbonate ($CaCO_3$, %)	5.4	4.5
Organic Matter (%)	0.42	0.85
Available Phosphorus (ppm)	7.1	7.5
Available Potassium (ppm)	64	200
Saturation percentage	41	35
Textural Class	Loam	Loam

The experiment at both sites was established using a Randomized Complete Block Design (RCBD) with four replications. Each experimental unit measured 6 × 3 m². Nitrogen fertilizer was applied at a total rate of 125 kg N ha^{-1} in two equal splits: the first application at the time of initial irrigation and the second at the booting stage.

For yield assessment, a net plot area of 1 m² was harvested from each experimental unit at the panicle initiation stage to determine green fodder yield. Additionally, a one-kilogram composite plant sample from each plot was collected for laboratory analysis of forage quality parameters, including dry matter percentage, crude protein, ether extract, ash content, acid detergent fiber (ADF), and neutral detergent fiber (NDF). At the milking stage, ten plants were randomly selected from each plot to record morphological traits, specifically plant height (cm) and number of tillers per plant. All other cultural and agronomic practices were maintained uniformly across treatments throughout the experimental period.

RESULT AND DISCUSSION

Physical data analysis of different oat varieties

Green fodder yield (t ha^{-1}): The results summarized in Table 2 and Figure 1 indicate pronounced differences among oat varieties with respect to green fodder yield. The variety *Ever Green* recorded the highest yield (30 t ha^{-1}), outperforming all other tested genotypes. These yield variations are largely attributable to inherent genetic differences, particularly morphological traits such as plant stature and tiller production, which substantially influence total biomass accumulation.

Comparable trends were reported by Gebremedhn *et al*. (2015), who observed significant variability in green fodder yield and associated growth attributes among oat genotypes. In their investigation, Lampton emerged as the highest-yielding variety (67.2 t ha^{-1}), a performance linked to its superior morphological features, including greater plant height (178 cm), a higher number of tillers per plant (14.2), increased tiller density per square meter (256), and more leaves per tiller (6.89). In contrast, the lowest yield (44.5 t ha^{-1}) was recorded for the Jasari variety. Overall, Lampton demonstrated clear superiority over other evaluated lines, including 8235-CI, 80-SA-95, 8251-CI, 8237-CI, 80-SA-130, and Jasari, underscoring the critical role of genotype-specific traits in determining forage productivity.

Plant height (cm): The results summarized in Table 2 and Figure 1 for plant height (cm) indicate clear varietal differences. Ever Green produced the greatest plant height (255 cm), exceeding all other tested varieties, including S-2000, S-2002, S-2011, Super Green, Barkat, CK-1, F-411, Ravi, and AVON. Generally, Oat varieties have a significant and varying effect on plant height due to their different genetic makeups. This variation means some varieties grow much taller than others, a trait that also correlates with green fodder yield. Such differences are expected because plant height is strongly genotype-dependent in oat; consequently, varieties with contrasting genetic backgrounds often express markedly different stature under the same growing conditions. This trait is also agronomically relevant because taller growth is frequently associated with increased green fodder production.

Tillering capacity per plant: The observations presented in Table 2 and Figure 1 highlight significant variation among oat varieties in terms of tiller production per plant. Ever *Green* exhibited the highest tillering capacity, producing an average of 22 tillers per plant, thereby surpassing all other evaluated varieties. Differences in tiller number among varieties are primarily governed by genetic constitution and their interaction with prevailing environmental conditions. Enhanced tillering is agronomically advantageous, as it contributes directly to increased vegetative biomass and, consequently, higher fodder and grain yields.

These findings are consistent with the results reported by Guanlu Zhang *et al*. (2025), who

demonstrated that increased tiller number per plant was strongly associated with superior hay yield. In their study, the variety Ever-leaf 126 achieved the highest hay production (11,819.33 kg ha^{-1}) compared with nine other oat varieties, underscoring the pivotal role of tillering ability in determining forage productivity.

Number of leaves per tiller: The results for the number of leaves per tiller are presented in Table 2 and Figure 1. Leaf production per tiller is a key morphological trait influencing vegetative growth and overall biomass accumulation in fodder crops. Variations in leaf number directly affect photosynthetic capacity and, consequently, green fodder yield. Statistical analysis indicated a significant varietal effect on this parameter, with leaf number per tiller ranging from 6 to 9 among the tested genotypes.

The variety *Ever Green* recorded the highest leaf count per tiller (9), followed by S-2002 and S-2011, each producing an average of 8 leaves per tiller. In contrast, S-2000, Ravi, and AVON exhibited the lowest values, averaging 6 leaves per tiller. These findings are consistent with earlier reports by Hussain *et al*. (2005), Naeem *et al*. (2005), and Bhatti *et al*. (1992), who also observed significant genotypic differences in leaf production among oat varieties.

Leaf length (cm): The measurements of leaf length (cm) are summarized in Table 2 and illustrated in Figure 1, which showed the oats variety ever green give maximum leaf length i.e. 65 cm as compared to other varieties. In general oat varieties showed a significant difference in leaf length, with specific varieties consistently exhibiting longer or shorter leaves across different studies and environmental conditions. This variation is primarily due to the genetic makeup of each variety and is a key factor in overall plant size and green fodder yield.

The present findings are consistent with the observations of Nilamani *et al*. (2025), who observed substantial variability among evaluated traits. In their investigation, seed yield per square meter exhibited the greatest coefficient of variation (27.77%). This was succeeded by variation in leaf length (20.30%), total grains per panicle (19.72%), dry matter yield (19.82%), and number of tillers per plant (16.04%), collectively reflecting substantial phenotypic variability among the assessed traits.

Forage quality characteristics of Oat varieties: The results summarized in Table 3 and Figure 2 present the comparative nutritional composition of the evaluated oat varieties. Forage quality is a critical determinant of livestock performance, as it directly influences animal growth, health status, and the productivity and composition of milk and meat. The provision of nutritionally balanced fodder is therefore essential for optimizing both the quantity and quality of livestock-derived products.

Among the tested genotypes, the variety *Ever Green* demonstrated superior performance for several nutritional parameters. It recorded the highest dry matter content (32.85%), crude protein (9.5%), ash (10.48%), acid detergent fiber (NDF; 65%), and neutral detergent fiber (ADF; 35%) compared with the other varieties. However, its ether extract (fat) content was relatively lower (1.25%) than that observed in the remaining genotypes. These findings indicate substantial varietal differences in chemical composition, reflecting underlying genetic variability.

Table: -2 Comparative study of oats varieties for physical yield contributing characters

Variety	Green fodder yield (T/ha)	Plant height (cm)	Number of tillers per plant	Number of leave per tiller	Leaf length (cm)
S-2002	23	220	18	8	54
S-2000	18	225	19	6	45
Super green	27	216	11	7	57
S-2011	27	235	11	8	60
Ever green	30	255	22	9	65
Barkat	27	250	19	7	50
CK-1	15	187	12	7	64
F-411	12	156	11	7	52
Ravi	11	149	10	6	47
AVON	13	176	11	6	54

In general, oat varieties exhibit significant diversity in nutritional attributes, with some genotypes characterized by higher protein concentrations, others by elevated fiber fractions, and some by greater mineral or lipid content. Similar trends were reported by Guanlu *et al*. (2025), who observed variation in crude protein and crude fat contents among oat varieties, noting that protein levels increased in most genotypes, whereas fat content either declined or increased depending on the variety. Their study further demonstrated marked differences in fiber fractions: the variety Kona recorded the highest neutral detergent fiber (55.03%) and acid detergent fiber

(42.95%) values, while Qinghai 444 exhibited the greatest neutral detergent fiber concentration. Conversely, Ever leaf 126 showed the lowest neutral detergent fiber content among the evaluated varieties. Comparable patterns of varietal variability in forage quality traits were also documented by Nilamani *et al.* (2025), reinforcing the importance of genotype selection in improving fodder nutritional value.

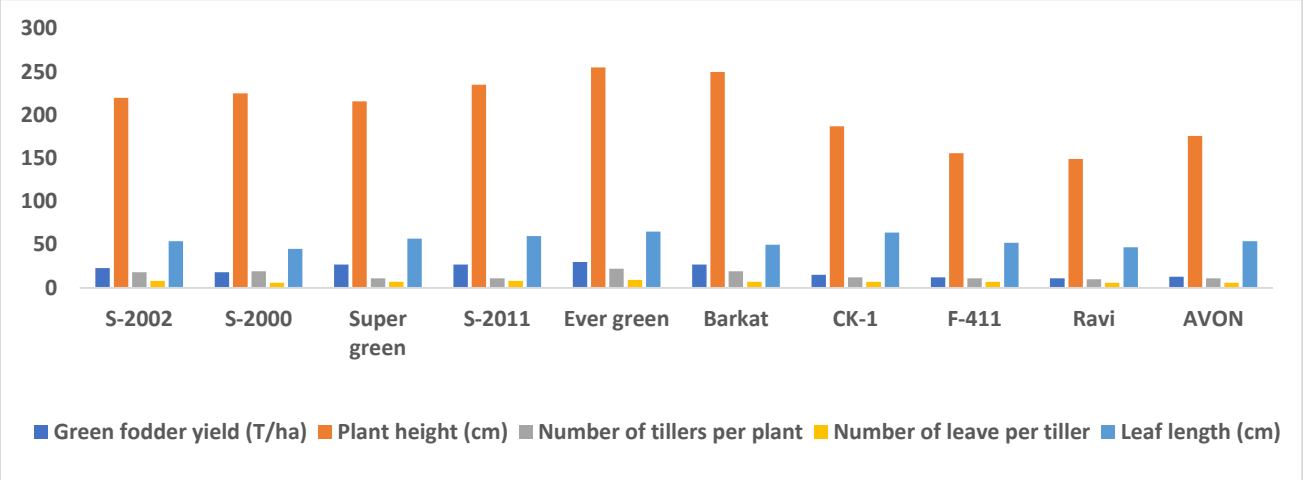

Figure:-1. Comparative study of oats varieties for physical yield contributing characters

Table :-3 Comparative study of oats varieties for nutritional composition parameters.

Variety	Dry matter (D.M.)	C.P	Total minerals (Ash) (%)	Ether Extract	NDF	ADF
S-2002	26.92	7.85	9.56	1.30	62	38
S-2000	27.80	6.69	10.00	1.35	55	45
Super green	29.30	7.92	8.56	1.45	60	40
S-2011	30.00	8.22	10.23	1.35	55	45
Ever green	32.85	9.50	10.48	1.25	65	35
Barkat	30.25	8.45	9.85	1.45	58	42
CK-1	27.85	7.92	10.04	1.33	56	44
F-411	24.92	7.79	9.55	1.43	60	40
Ravi	24.01	7.50	9.08	1.52	55	45
AVON	27.14	7.84	10.33	1.41	62	38

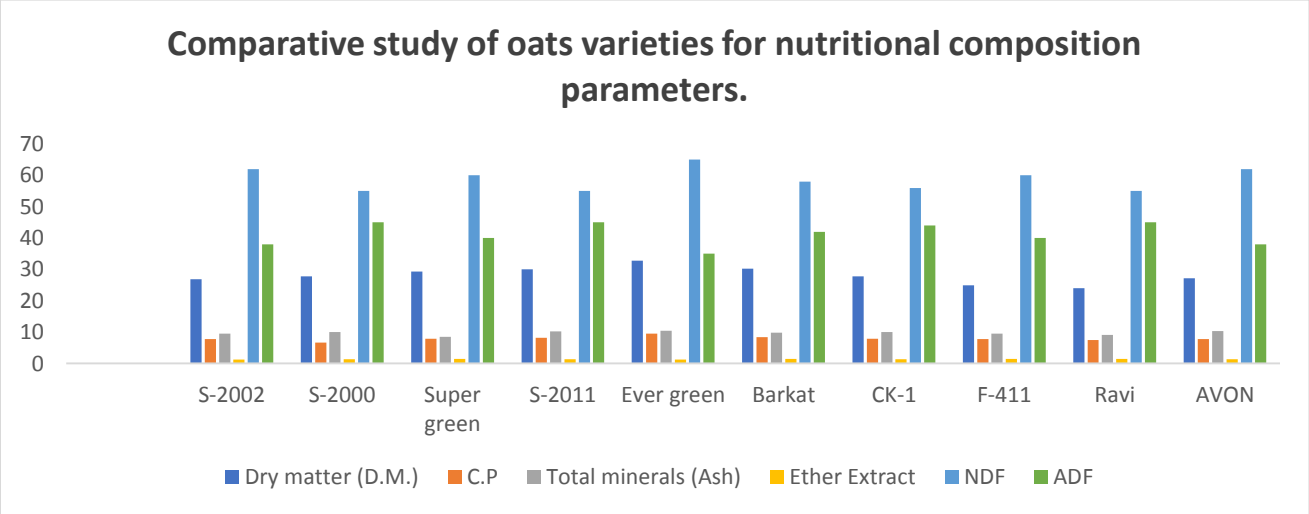

Figure:-2 Comparative study of oats varieties for Nutritional quality parameters

Conclusions: Considerable variability was evident among the evaluated oat genotypes with respect to both morphological attributes and nutritional quality parameters, indicating substantial genetic diversity for these traits. On the basis of overall performance, the variety *Ever Green* emerged as the most promising genotype, combining superior green fodder yield with comparatively higher crude protein content.

In view of its favorable agronomic and nutritional characteristics, *Ever Green* may be considered a suitable candidate for large-scale cultivation in Punjab to enhance the availability of high-quality, nutrient-rich fodder for livestock production systems.

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