

# Multi-Location On-Farm Evaluation of Cabbage (*Brassica oleracea* var. *Capitata*) Cultivar ‘Golden Acre’ for Yield and Profitability under Temperate Conditions

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## Abstract

Cabbage (*Brassica oleracea* var. *capitata*) is a major temperate vegetable crop cultivated extensively in Jammu AND Kashmir, valued for its rich nutritional profile, shorter maturity period, and high consumer demand. Despite its significance, productivity in farmers’ fields across Pulwama district remains sub-optimal due to the dominance of low-yielding local cultivars and traditional cultivation practices. The present study evaluated the performance and farmer-level acceptability of the improved cabbage cultivar Golden Acre through multi-location on-farm demonstrations conducted across five community sites of District Pulwama during 2018-2019 and 2019-2020. Two treatments were compared: T<sub>0</sub> (local check) and T<sub>1</sub> (Golden Acre). Golden Acre exhibited marked improvement in morphological and yield-attributing traits. It recorded higher plant height, greater number of wrapper leaves, superior head diameter, enhanced head compactness, and significantly higher marketable head weight relative to the local cultivar. Golden Acre achieved a mean yield of 245 q/ha, representing a 30.31% increase over the local variety (196.8 q/ha). Economic analysis revealed a benefit–cost ratio of 1:4 for Golden Acre as against 1:3.57 for the local check. The cultivar performed consistently across all five locations during both years, highlighting its adaptability to the temperate agro-climatic conditions of Pulwama. The findings demonstrate that Golden Acre is a high-yielding, early-maturing, and economically viable cabbage cultivar suited for wider dissemination in the district. Its superior morphological characteristics, yield advantage, and higher profitability make it a promising intervention to enhance cabbage productivity and farmer income under temperate conditions.

**Key words:** Cabbage, Golden Acre, On-farm demonstration, Yield performance, Profitability

Cabbage (*Brassica oleracea* var. *capitata*) is one of the most widely cultivated cool-season vegetables globally, valued for its high nutritional content, including vitamins C and K, antioxidants, glucosinolates, and dietary fibre [1]. In India, cabbage occupies a prominent place among cole crops, contributing significantly to vegetable production systems owing to its short duration, high market demand, and suitability for both kitchen gardens and commercial fields [2]. The temperate regions of Jammu and Kashmir, particularly District Pulwama, offer favourable conditions for cabbage cultivation due to cool temperatures, adequate moisture, and fertile soils. The productivity of cabbage is largely determined by its morphological and physiological traits, including plant height, wrapper leaf spread, head initiation behaviour, head diameter, compactness, and head weight [3]. Studies indicate that improved varieties with greater leaf area, better assimilate partitioning, and compact head formation often exhibit superior yield performance under temperate conditions [4]. Golden Acre, an early-maturing cabbage cultivar, is recognized for its medium-sized compact heads, attractive colour, shorter crop

duration, and high market acceptability. It has been successfully grown in several temperate vegetable-producing regions, where it has shown superiority in head compactness and uniformity over traditional cultivars [5].

Despite favourable agro-climatic conditions, cabbage productivity in Pulwama remains below potential, largely due to continued reliance on local, low-yielding varieties and limited adoption of improved cultivars. Yield gaps often arise from the use of inferior seed materials, inadequate crop management, and limited awareness of promising cultivars like Golden Acre. As noted by Bukhari *et al.* [6], adoption of improved cabbage varieties with enhanced morphological traits can substantially increase marketable yield and profitability among temperate growers. Multi-location on-farm demonstrations provide a reliable platform to assess the adaptability, stability, and farmer acceptability of improved cultivars under real-world production conditions. Demonstration-based approaches play a critical role in enhancing farmer confidence and accelerating the spread of improved technologies [7]. In cabbage, on-farm validation

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helps to determine cultivar performance in terms of head formation, yield uniformity, disease tolerance, and economic return under diverse micro-environments [8]. Given the productivity limitations associated with traditional cabbage cultivars in Pulwama, there is a need to systematically evaluate improved cultivars such as Golden Acre. The present study was undertaken during the 2019 and 2020 cropping seasons to assess the performance, yield advantage, profitability, and potential for farmer-level popularization of Golden Acre across five locations in District Pulwama under participatory on-farm demonstration settings.

## MATERIALS AND METHODS

The present investigation was conducted during two consecutive rabi cropping seasons of 2018–2019 and 2019–2020 across five community-managed farmer fields in District Pulwama, Jammu and Kashmir. The study area falls under the temperate agro-climatic zone and is characterized by cool summers, cold winters, and fertile clay-loam soils, which are well suited for the cultivation of cole crops, particularly cabbage. The selected locations represented typical farmer-managed field conditions of the district, ensuring realistic assessment of varietal performance under actual production environments.



Fig 1 Geographical distribution of on-field demonstration trial sites in Pulwama district, Jammu & Kashmir

Two cabbage treatments were evaluated during the study, comprising T<sub>0</sub>, the local cabbage cultivar commonly grown by farmers and used as the control, and T<sub>1</sub>, the improved cabbage cultivar Golden Acre. Certified seeds of the improved cultivar Golden Acre were supplied through the implementing department, whereas farmer-saved seeds were used for the local check, reflecting the prevailing farmer practice in the region.

The on-farm demonstrations were laid out following a Randomized Block Design (RBD) with two treatments and five replications, corresponding to the five selected locations. Uniform plot size, plant spacing of 45 × 45 cm, and plant population were maintained across all demonstration sites to minimize variability and ensure comparability of results. Seedlings were raised in nurseries using standard recommended practices and transplanted into the main field at the appropriate growth stage.

All agronomic practices were applied uniformly across treatments and locations in accordance with local package of practices for cabbage cultivation. Well-decomposed farmyard manure was incorporated into the soil prior to transplanting, and the recommended dose of fertilizers (NPK) was applied uniformly to all plots. Irrigation was provided as per crop requirement, while intercultural operations such as weeding and

earthing-up were carried out at appropriate stages. Plant protection measures were undertaken uniformly across treatments to manage pests and diseases, following local extension recommendations. Harvesting was carried out at marketable maturity, based on head compactness and size suitable for market acceptance.

Meteorological data pertaining to temperature, relative humidity, and rainfall during the cropping seasons were obtained from the nearest agro-meteorological station. The crop experienced typical temperate climatic conditions conducive to cabbage growth and head formation, with mean temperatures of 12.3 °C and 12.1 °C, relative humidity of 68% and 71%, and annual rainfall of 1313 mm and 982.2 mm during the 2018–2019 and 2019–2020 seasons, respectively.

Year	Temperature °C	Humidity (%)	Rainfall (mm)
2018	12.3	68	1313
2019	12.1	71	982.2

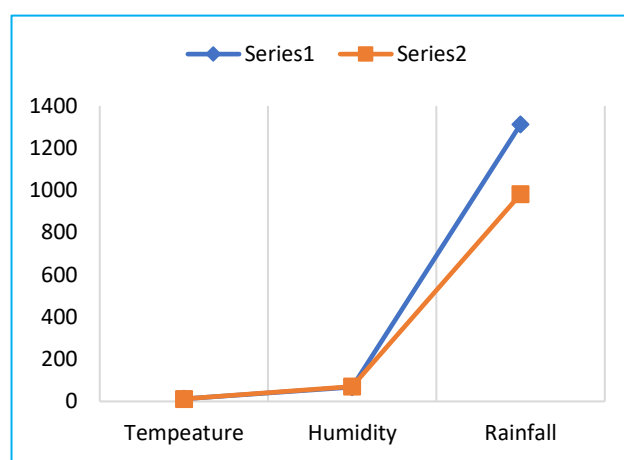


Fig 2 Meteorological data on temperature, relative humidity, and rainfall recorded during the cropping seasons

For recording observations, ten plants were randomly selected from each plot at each location. Data were collected on key morphological, phenological, and yield-related parameters, including plant height (cm), number of wrapper leaves per plant, leaf length and width (cm), days to head initiation, days to head maturity, head diameter (cm), head compactness index, marketable head weight (kg), and total marketable yield expressed in quintals per hectare (q ha<sup>-1</sup>). The recorded data were averaged across locations and seasons to assess the comparative performance of the improved cultivar Golden Acre against the local cabbage cultivar under temperate field conditions.

## RESULTS AND DISCUSSION

### Morphological performance

Golden Acre demonstrated superior morphological traits compared to the local cabbage cultivar. Averages across five locations are summarised as follows:

The improved cabbage cultivar Golden Acre exhibited marked superiority over the local cabbage cultivar with respect to all major morphological and phenological traits recorded across the five on-farm demonstration locations. The consistent enhancement in vegetative growth, head development, and maturity parameters clearly indicates the better genetic potential and adaptability of Golden Acre under the temperate agro-climatic conditions of Pulwama district. Golden Acre

recorded significantly greater plant height, attaining a mean height of 43.8 cm compared to 36.5 cm in the local cultivar. Increased plant height reflects enhanced vegetative vigour and better assimilatory capacity, which is essential for supporting head formation in cabbage. The number of wrapper leaves per

plant was also considerably higher in Golden Acre (22 leaves) than in the local variety (17 leaves). A higher number of wrapper leaves contributes to improved photosynthetic area, protection of the developing head, and ultimately better head size and quality [9].

Table 1 Morphological and yield-attributing traits of cabbage cultivars under on-farm demonstrations in Pulwama district

Trait	Local	Golden Acre
Plant height (cm)	36.5	43.8
Wrapper leaves (no.)	17	22
Leaf length (cm)	27.4	32.6
Leaf width (cm)	21.2	26.3
Days to head initiation	62	53
Days to maturity	105	92
Head diameter (cm)	11.8	15.6
Head compactness index	0.68	0.86
Marketable head weight (kg)	0.92	1.28

Leaf size parameters further highlighted the morphological advantage of Golden Acre. The cultivar produced longer and broader leaves, with an average leaf length of 32.6 cm and leaf width of 26.3 cm, as against 27.4 cm and 21.2 cm, respectively, in the local cultivar. Larger leaf area enhances light interception and photosynthetic efficiency, leading to greater biomass accumulation and efficient translocation of assimilates to the developing head [10]. In terms of phenological behaviour, Golden Acre showed early head initiation and maturity. The cultivar-initiated head formation at 53 days after transplanting, which was 9 days earlier than the local cultivar (62 days). Similarly, Golden Acre reached marketable maturity in 92 days, whereas the local cultivar required 105 days. Early head initiation and maturity are advantageous under temperate conditions, as they allow the crop to escape late-season stress, reduce exposure to pests and diseases, and enable farmers to access markets earlier for better price realization [11].

Head development traits clearly demonstrated the superiority of Golden Acre. The cultivar recorded a

significantly larger head diameter of 15.6 cm compared to 11.8 cm in the local cultivar. Moreover, Golden Acre exhibited a higher head compactness index (0.86) than the local variety (0.68), indicating the formation of denser and more compact heads. Head compactness is a critical quality attribute in cabbage, directly influencing market acceptability, shelf life, and transportability.

The cumulative effect of improved vegetative growth, early maturity, and superior head traits was reflected in higher marketable head weight. Golden Acre produced an average head weight of 1.28 kg, substantially exceeding the 0.92 kg recorded in the local cultivar. The increase in head weight is a direct outcome of enhanced leaf area, better assimilate partitioning, and compact head formation [12]. Overall, the superior morphological performance of Golden Acre across all evaluated traits and locations underscores its strong genetic potential and suitability for cultivation under temperate conditions. These morphological advantages formed the foundation for its higher yield and economic performance observed in the study.

Table 2 Yield performance of cabbage cultivars under on-farm demonstrations in Pulwama district (pooled over 2018–2020)

Parameter	Local cultivar	Golden Acre	Yield advantage of Golden Acre
Mean marketable yield (q ha <sup>-1</sup> )	196.8	245.0	+48.2 q ha <sup>-1</sup>
Yield increase (%)	-	-	30.31
Yield consistency across locations	Variable	Stable	High
Adaptability to field conditions	Moderate	High	Superior
Yield stability over years	Moderate	High	Consistent

### Yield performance

The improved cabbage cultivar Golden Acre recorded significantly higher marketable yields than the local farmer-grown cultivar across all five demonstration locations during both years of evaluation, clearly demonstrating its superior yield potential under the temperate agro-climatic conditions of Pulwama district. Pooled analysis of data revealed that Golden Acre achieved a mean marketable yield of 245 q ha<sup>-1</sup>, whereas the local cultivar recorded a comparatively lower yield of 196.8 q ha<sup>-1</sup>. This represented a substantial yield advantage of 30.31 percent over the local check, indicating the strong productivity gains achievable through the adoption of the improved cultivar [13]. The higher yield performance of Golden Acre can be directly attributed to its superior morphological and yield-attributing traits. The cultivar exhibited larger head diameter, greater head compactness, and higher marketable head weight, all of which play a crucial role in enhancing total yield per unit area. Improved vegetative vigour and a larger photosynthetic

surface area facilitated better biomass accumulation, while efficient assimilate translocation towards head development resulted in heavier and more uniform cabbage heads. These traits collectively contributed to increased marketable yield and reduced proportion of unmarketable produce [14].

Golden Acre maintained its yield superiority consistently across all five locations, despite minor variations in soil characteristics and micro-climatic conditions. Such consistency over diverse farmer-managed environments and over two consecutive cropping seasons reflects the cultivar's high adaptability and yield stability. Stability in performance is a critical attribute for farmer acceptance, as it minimizes production risk and ensures predictable returns under varying field conditions. The pronounced yield difference between Golden Acre and the local cultivar also highlights the inherent limitations of traditional cabbage varieties commonly cultivated in the district. The lower yield of the local cultivar can be attributed to smaller head size, reduced compactness,

delayed maturity, and lower head weight, which collectively restrict its productivity potential. The observed yield gap underscores the importance of varietal replacement as a key intervention for enhancing cabbage productivity in temperate regions [15-16]. Overall, the significant yield advantage, coupled with consistent performance across locations and

seasons, establishes Golden Acre as a high-yielding and reliable cabbage cultivar for the temperate conditions of Pulwama district. Adoption of this improved cultivar has strong potential to enhance cabbage production, improve resource-use efficiency, and increase farm-level profitability, thereby contributing to sustainable vegetable production systems.

Table 3 Economic analysis of cabbage cultivars under on-farm demonstrations in Pulwama district (pooled over 2018–2020)

Economic parameter	Local cultivar	Golden Acre	Economic advantage of Golden Acre
Cost of cultivation	Similar	Similar	–
Mean marketable yield	Lower	Higher	Increased gross returns
Marketable head quality	Moderate	Superior	Higher price realization
Gross returns	Lower	Higher	Improved income
Benefit cost (B:C) ratio	1:3.57	1:4.00	Higher profitability
Return per rupee invested	₹3.57	₹ 4.00	+ ₹ 0.43

#### Economic analysis

The superior yield performance and enhanced marketable head quality of the improved cabbage cultivar Golden Acre resulted in significantly higher economic returns compared to the local farmer-grown cultivar across all demonstration locations. Benefit cost (B:C) analysis clearly demonstrated the economic advantage of adopting Golden Acre under temperate conditions of Pulwama district. Golden Acre recorded a B:C ratio of 1:4, indicating that for every rupee invested in its cultivation, farmers realized a return of four rupees. In contrast, the local cabbage cultivar achieved a comparatively lower B:C ratio of 1:3.57, reflecting reduced profitability. Although the cost of cultivation for both treatments remained largely similar due to uniform agronomic practices, the improved cultivar generated substantially higher gross returns owing to its superior yield and better-quality produce [17].

The economic superiority of Golden Acre can be primarily attributed to its higher marketable head weight, greater head compactness, and uniform head size, all of which enhance consumer preference and market acceptability. Compact and well-formed heads fetch better prices in local markets and reduce post-harvest losses during handling and transportation. The increased yield per unit area further amplified total revenue, resulting in a more favorable cost return relationship. An additional economic advantage of Golden Acre was its early maturity compared to the local cultivar. Early harvesting enabled farmers to enter the market ahead of the peak supply period, thereby taking advantage of better price realization. Early maturity also reduced the duration of field occupancy, allowing timely preparation of land for subsequent crops and improving overall cropping system efficiency [18].

The consistent improvement in profitability observed across all five demonstration locations highlights the reliability and economic stability of Golden Acre under farmer-managed conditions. Even under varying micro-climatic and soil environments, the improved cultivar maintained a clear economic edge over the local variety. This consistency reduces production risk for farmers and strengthens confidence in the adoption of the improved technology [19]. Overall, the higher benefit–cost ratio, combined with superior yield and marketable quality, establishes Golden Acre as an economically viable and farmer-friendly cabbage cultivar for temperate regions. Replacing traditional local cabbage cultivars with Golden Acre can substantially enhance farm income, improve resource-use efficiency, and contribute to sustainable vegetable production in Pulwama district.

Table 4 Location-wise and seasonal yield stability of Golden Acre (qualitative assessment)

Criterion	Observation
Performance across locations	Superior at all five sites
Effect of soil variability	Minor influence
Effect of micro-climatic variation	Limited
Year-to-year yield variation	Low
Genotype × environment interaction	Favourable
Suitability for farmer adoption	High

#### Location-wise performance

The location-wise analysis of yield and growth performance revealed that the improved cabbage cultivar Golden Acre consistently outperformed the local farmer-grown variety across all five demonstration sites in District Pulwama during both years of study. Despite variations in field conditions, Golden Acre maintained its superiority in terms of morphological traits, head development, and marketable yield at every location, demonstrating its wide adaptability under temperate conditions. Minor variations in performance were observed among locations, which can be attributed to differences in micro-climatic factors such as temperature fluctuations, relative humidity, and rainfall distribution, as well as inherent variability in soil fertility, texture, and moisture-holding capacity [20]. Differences in farmer management skills and irrigation scheduling may have also contributed marginally to location-specific yield variations. However, these factors affected both treatments similarly and did not alter the relative ranking of the cultivars. Across all sites, Golden Acre consistently recorded higher head diameter, greater head compactness, and increased marketable head weight compared to the local cultivar. These stable yield-attributing traits enabled Golden Acre to achieve higher productivity irrespective of location-specific constraints. The ability of the cultivar to perform well under diverse farmer-managed environments highlights its physiological resilience and efficient utilization of available resources. The uniform superiority of Golden Acre across locations and seasons indicates strong genotype × environment compatibility, a critical attribute for varietal recommendation in temperate vegetable production systems [21]. Stability in performance reduces production risk for farmers and ensures dependable returns even under variable field conditions. Overall, the location-wise performance clearly establishes Golden Acre as a robust, adaptable, and high-performing cabbage cultivar suitable for cultivation across the diverse micro-environments of Pulwama district. Its consistent advantage over the local cultivar reinforces the potential for district-wide dissemination and adoption as a viable strategy to

enhance cabbage productivity and farmer income under temperate agro-climatic conditions.

The findings of the present study clearly demonstrate the superiority of the improved cabbage cultivar Golden Acre over the local farmer-grown cultivar with respect to all key morphological, phenological, and yield-attributing traits under the temperate agro-climatic conditions of Pulwama district [22]. Enhanced vegetative growth, expressed through greater plant height and increased leaf area, provided a strong physiological foundation for improved head development. These traits are crucial in cabbage, as larger and healthier foliage enhances photosynthetic efficiency, leading to greater biomass production and effective assimilate supply to the developing head. Golden Acre exhibited earlier head initiation and earlier maturity compared to the local cultivar, which is a highly desirable characteristic under temperate conditions. Early head initiation shortens the vegetative phase and promotes timely head formation, while early maturity allows the crop to escape late-season environmental stresses such as low temperatures, frost, or disease pressure. Early harvesting also enables farmers to access markets sooner, which often results in better price realization and reduced production risk. Similar advantages of early-maturing cabbage cultivars have been reported in other temperate regions, where early head formation and maturity contribute significantly to yield stability and economic gains [23].

The significantly larger head diameter and higher head compactness index observed in Golden Acre are particularly important from both yield and marketability perspectives. Compact and well-formed heads not only contribute to higher individual head weight but also enhance consumer preference, shelf life, and ease of transport [24]. The higher head compactness index in Golden Acre indicates efficient assimilate partitioning toward the economic sink, i.e., the cabbage head. This efficient partitioning reflects superior genetic potential and improved physiological efficiency, resulting in heavier and more uniform heads. Comparable improvements in head size, compactness, and marketable yield in improved cabbage cultivars have also been documented by Bukhari *et al.* [6]. The cumulative effect of superior vegetative growth, early phenological development, and improved head characteristics resulted in a substantial yield advantage of Golden Acre over

the local cultivar. The consistent yield superiority recorded across all five locations and over two consecutive years highlights the cultivar's adaptability and performance stability under diverse farmer-managed conditions [25]. Such stability is a critical criterion for varietal recommendation, as it ensures reliable performance across varying soil types, micro-climatic conditions, and management practices [26].

Economic analysis further strengthens the case for the adoption of Golden Acre, as the improved cultivar recorded a higher benefit–cost ratio than the local variety. The higher profitability is primarily driven by increased marketable yield, better head quality, and early maturity, which collectively enhance gross returns without significantly increasing production costs [27]. These results are in close agreement with earlier studies reporting that improved cabbage cultivars offer higher economic returns and improved livelihood opportunities for farmers when evaluated under on-farm conditions [28]. Overall, the discussion underscores that the superior morphological traits, yield performance, adaptability, and economic viability of Golden Acre make it a promising cabbage cultivar for temperate regions. The results strongly support the replacement of traditional low-yielding local cultivars with improved varieties like Golden Acre as an effective strategy to enhance cabbage productivity, profitability, and sustainability in temperate vegetable production systems.

## CONCLUSION

On-farm demonstrations conducted across five locations in Pulwama district during 2018-2019 and 2019-2020 revealed the superior performance of the cabbage cultivar Golden Acre over the local variety. Golden Acre exhibited improved morphological traits, larger and more compact heads, early maturity, and significantly higher yield, registering a 30.31 percent yield increase over the local cultivar. Economic analysis indicated a higher benefit–cost ratio (1:4), highlighting its profitability. Consistent performance across locations and years demonstrates its adaptability to temperate agro-climatic conditions. Golden Acre is therefore recommended for wider dissemination to enhance cabbage productivity and farmer income in Pulwama district.

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