Assessment of different elite mango varieties suitable for North western plain zones of Uttar Pradesh

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ARTICLE INFO	ABSTRACT
	The evaluation of different mango varieties was conducted during 2019-20 and 2020-21. The experiment was laid out in a randomized block design (RBD) with four varieties, namely, Ambika, Pusa Arunima, Kesar, and Dashehari-51, each replicated three times. The plants were spaced at 4x4 m intervals. The results obtained demonstrated significant variations in various parameters, ranging from minimum to maximum values. The canopy spread ranged from 1.77 to 7.49 m, stem girth from 16.67 to 40 cm, number of fruits per plant from 21 to 118, fruit length from 92.04 to 123.28 mm, fruit width from 56.02 to 77.41 mm, and fruit weight from 202 to 591 g. However, the number of primary branches (2-3) and plant height (1.54-4.35 m) were found to be nonsignificant. Based on the morpho-economic traits, Pusa Arunima appeared to be a superior variety in terms of tree morpho-economic traits, while others were considered moderate. Considering the average number of fruits per plant and fruit weight (g) over a two-year period, Pusa Arunima clearly outperformed the other three varieties in terms of yield. Furthermore, Pusa Arunima, Kesar, and Ambika exhibited more marketable fruit traits. These findings emphasize the significant diversity among the examined mango cultivars. Therefore, it is crucial to protect and preserve these valuable genetic resources for future breeding programs aimed at developing novel and commercially viable cultivars.

Introduction

Mango (*Mangifera indica* L.), renowned and cherished worldwide, stands as one of the most favored fruit crops. Its cultivation thrives in tropical and subtropical regions, as documented by Joshi *et al.* (2013). Belonging to the Anacardiaceae family, this dicotyledonous fruit traces its origin back to the Indo-Burmese region, as observed by Subramanyam *et al.* (1975) and Tjiptono *et al.* (1984). Commercially grown mango varieties owe their existence to meticulous selection processes, encompassing crucial factors such as fruit size, color, shape, flavor, aroma, and taste. Additionally, attributes such as juice content, TSS/acid balance, and maturity time play a significant role in the selection, as stated in various studies. Notably, India's commercial mango varieties have largely emerged as natural chance choices that have evolved over time, according to the research by

Dey and Singh (2004). India is home to the largest mango germplasm collection in the world, comprising an impressive array of approximately 1500 diverse mango varieties and landraces spread across different regions. Bhalekar *et al.* (2016) highlight mango as the most significant fruit cultivated for export in India, underscoring its economic importance.

Mango production extends beyond India, with several nations standing out as major contributors. Adikshita *et al.* (2018) note that India, China, Thailand, Indonesia, the Philippines, Pakistan, Brazil, Bangladesh, the USA, various African nations, and Mexico rank among the top mango-producing countries globally. Within India, the states of Uttar Pradesh, Andhra Pradesh, Karnataka, Maharashtra, Bihar, Gujarat, Tamil Nadu, Odisha, West Bengal, and Jharkhand take the lead in mango production. With an impressive output of 20.52 million tonnes per year from an area spanning 2.30 million hectares, India solidifies its position as the world's foremost mango-producing nation, as reported by Anon. (2020). The production of mangoes predominantly takes place in developing countries situated within tropical regions. This agricultural pursuit holds immense significance due to the popularity and demand for mangoes worldwide. The cultivation of mangoes in the North Western Plain Zones of Uttar Pradesh faces several challenges and difficulties. The region experiences specific agro-climatic conditions, including variations in temperature, rainfall patterns, and soil characteristics, which can significantly impact mango cultivation. Additionally, the changing climatic conditions due to global warming and the associated risks of extreme weather events further exacerbate the challenges faced by mango growers in this region.

To overcome these difficulties and ensure sustainable mango production, it is crucial to assess and identify elite mango varieties that are well-suited for the specific agro-climatic conditions of the North Western Plain Zones of Uttar Pradesh. These elite varieties should possess desirable traits such as high yield potential, resistance to pests and diseases, tolerance to abiotic stresses, superior fruit quality, and adaptability to local growing conditions. This study aims to evaluate different elite mango varieties and their performance in the North Western Plain Zones of Uttar Pradesh. Through meticulous field trials and rigorous data collection, we will assess various morpho-economic traits of these mango varieties, including canopy spread, stem girth, number of fruits per plant, fruit length, fruit width, and fruit weight. Additionally, we will examine the flowering and fruiting patterns of each variety to determine their suitability for the local climatic conditions.

The performance of mango varieties is greatly influenced by factors such as morpho-economic characteristics. Mango flowering, which is a crucial component of mango productivity and largely a varietal trait influenced by weather, is a complex phenomenon. Because of their propensity to change in reaction to environmental changes, the conclusions drawn from the morphological assessment can be misleading (Sankar *et al.*, 2011). Mango cultivars have been shown to exhibit different flowering patterns in subtropical and tropical environments (Davenport 2003). Shoot initiation is the first step in the mango flowering process, which is followed by floral differentiation and panicle emergence (Murti and Upreti 2000). The majority of mango cultivars go through all of these growth stages between October and December in both tropical and subtropical environments. Environmental factors now in effect as well as the age of terminal resting shoots are related to the induction of floral bud production (Davenport 1997). One of the requirements for effective mango production is the evaluation of mango cultivars for a certain set of ecosystems (Singh and Singh 1996). The weather and the genotypes of the different varieties have a large impact on mango flowering, which is one of the most crucial qualities because it directly influences production. Mangoes only have a brief blossoming cycle that lasts two to three weeks. The mango plant bears both staminate and perfect blooms on the same panicle because it is andromonoecious (Singh *el. al.*,2015). The flowering season in western Uttar Pradesh lasts from February to March. The mango production situation in northwest Uttar Pradesh is significantly impacted by a study analyzing many elite mango varieties suitable for the zone of the northwestern plain. The findings of this study will not only provide valuable insights into the performance and adaptability of

different mango varieties but also contribute to the development of sustainable mango cultivation practices in the North Western Plain Zones of Uttar Pradesh. By identifying elite varieties that are well adapted to the region, mango growers can enhance their productivity, improve fruit quality, and mitigate the risks associated with climate change. This study will serve as a significant step toward ensuring the long-term viability and profitability of mango cultivation in the North Western Plain Zones of Uttar Pradesh. By addressing the major difficulties and challenges faced by mango growers in this region, we aim to provide practical solutions and contribute to the sustainable development of the mango industry.

Material and Methods

Geographically, the experimental field is located at 29°04' north latitude, 77°42' east longitude, and an altitude of 237.75 meters above the mean sea level (coordinates based on Google Earth imagery). The observations focused on various morphoeconomic characteristics during the specified observation period, including date to first flowering, date to full bloom, number of primary branches, canopy spread (m), stem girth (cm), plant height (m), number of fruits per plant, fruit length (mm), fruit width (mm), and fruit weight (g).

To ensure a scientifically sound experimental design, the study employed a randomized block design (RBD). The experiment consisted of four different mango varieties, each replicated thrice, resulting in a total of 12 experimental units. Morphological characterization was carried out following the standard mango descriptors developed by the International Plant Genetic Resources Institute (IPGRI) in 2006 (IPGRI, 2006). The observation of flowering-related events involved recording daily observations from February to March. The emergence of the date to first flowering and the date to full bloom was determined by closely monitoring the anthesis of the first flower until the last one. The duration of these events was calculated by counting the number of days required for the plant to complete its flowering process.

The number of primary branches per plant was manually counted throughout the trial period. To obtain the average value, the total number of primary branches was divided by the number of plants within each replication of the mango varieties. The canopy spread was measured as the mean diameter in two directions, namely, north–south and east–west. A measuring tape or other appropriate measuring tool was used to determine the distance in metermetres (m). For the mature tree's trunk girth measurement, a measuring tape was wrapped around the trunk at a height of 50 centimeters above the ground, and the circumference was recorded in centimeters (cm).

To measure plant height, a long, straight, premeasured, and marked stick was used. The stick was placed vertically from the base of the tree to the tip of the highest shoot, and the height was recorded in metermetres (m).

The number of fruits per plant was determined by counting the total number of fruits produced by each replication of the mango genotype. For the assessment of morphological fruit characteristics such as fruit length, fruit width (mm), and fruit weight (g), five fruits were randomly collected from each cultivar within each replication. The average length of the five fruits was measured using Vernier calipers, measuring from the fruit's base to its tip. The average width of the five fruits was measured at their widest point using Vernier calipers. Fruit weight was determined by averaging the weights of five randomly selected fruits within each replication. The total fruit weight was divided by the total fruit number to obtain the average fruit weight.

To analyze the acquired observations, the statistical approach recommended by Gomez and Gomez (1984) was employed. This approach is a standard method widely used for statistical analysis in agricultural research.

Results and Discussion

The mango data presented in Table 1 and Figure 1 reveal interesting findings regarding the four studied cultivars. Among them, cv. Dashehari-51 displayed the earliest flower initiation on 28th February, while the latest flower initiation in the same cultivar was observed on 3rd March during the 2019-20 season (Table 1). In the subsequent 2020-21 season, cv. Dashehari-51 once again exhibited the earliest flower initiation on 1st March, followed by Kesar on 6th March and Ambika on 12th March. On the other hand, cv. Pusa Arunima had the latest flower initiation on 14th March. The

Table 1: Flower initiation and full blossom dates for 2019-20 and 2020-21

Cultivars	Date to first flowering						Date to full bloom					
Replication	R1		R2		R3		R1		R2		R3	
Year	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
Ambika	2 Mar	15 Mar	2 Mar	12 Mar	2 Mar	15 Mar	19 Mar	28 Mar	19 Mar	25 Mar	19 Mar	28 Mar
Pusa Arunima	2 Mar	16 Mar	2 Mar	18 Mar	2 Mar	14 Mar	16 Mar	25 Mar	16 Mar	24 Mar	16 Mar	16 Mar
Kesar	1 Mar	9 Mar	1 Mar	8 Mar	1 Mar	6 Mar	18 Mar	19 Mar	18 Mar	15 Mar	18 Mar	20 Mar
Dashehari-51	3 Mar	1 Mar	28 Feb	2 Mar	28 Feb	2 Mar	15 Mar	12 Mar	15 Mar	10 Mar	15 Mar	16 Mar

data further indicate that cv. Dashehari-51 had the earliest full blossom, occurring on 15th March, while cv. Ambika had the latest full blossom on 19th March in the 2019-20 season (Table 1). Similarly, in the 2020-21 season, cv. Dashehari-51 had the earliest full blossom on 10th March, while cv. Ambika once again displayed the latest full blossom on 28th March. These results align closely with the findings of Azam *et al.* (2018), who reported that mango flowering typically begins in the last week of January and continues until the second week of March. It is worth noting that mango flowers are highly influenced by temperature, particularly chilling temperatures, and higher temperatures during flower induction can have a negative impact. Studies by Dambreville *et al.* (2013) and Sukhvibul *et al.* (1999) have demonstrated that elevated temperatures affect flower initiation, full blossom, inflorescence size, and flower quantity per inflorescence in mango. Considering that mango flowering is a critical stage susceptible to climatic variations, unfavorable environmental factors such as rain, humidity, temperature, light, wind, drought, and waterlogging can significantly impact flowering in a negative manner.The key morpho-economic characteristics of the plant samples are summarized in Table 2 and Figure 2. The number of primary branches per plant did not show any significant variation. However, in both 2019-20 and 2020-21, the number of primary branches per plant remained consistent. The highest number of primary branches was observed in cv. Pusa Arunima (3), Kesar (3), and Dashehari-51 (3), while cv. Ambika had the lowest number of primary branches (2). Canopy spread exhibited significant differences between the two years, 2019-20 and 2020-21. In 2019-20, cv. Pusa Arunima had the widest canopy spread (7.08 m), followed by cv. Ambika (6.33 m), Dashehari-51

(5.52 m), and Kesar (1.77 m). Similarly, in 2020-21, cv. Pusa Arunima again showed the maximum canopy spread (8.20 m), followed by cv. Ambika (7.49 m), Dashehari-51 (6.56 m), and Kesar (2.53 m). Stem girth displayed significant variation, with cv. Pusa Arunima exhibiting the maximum stem girth (35 cm) among all four cultivars in 2019-20. It was followed by cv. Ambika (32.33 cm), Dashehari-51 (31.33 cm), and Kesar (16.67 cm). A similar pattern was observed in 2020-21, with cv. Pusa Arunima (40 cm) having the maximum stem girth, followed by cv. Ambika (36 cm), Dashehari-51 (34 cm), and Kesar (19.67 cm). In terms of plant height, cv. Pusa Arunima had the tallest plants (3.03 m) in 2019-20, while cv. Kesar had the shortest plant height (1.54 m) during the same period. Cultivars Ambika and Dashehari-51 had plant heights of 2.48 m and 2.25 m, respectively, in 2019-20. In 2020-21, cv. Pusa Arunima again had the tallest plants (4.35 m), followed by cv. Dashehari-51 (3.06 m), Ambika (3.04 m), and Kesar (2.16 m). However, the observed data for plant height were not found to be significant.

In 2019-20, cv. Dashehari-51 yielded the highest number of fruits per plant (62), followed by cv. Kesar (28), Pusa Arunima (22), and Ambika (21). However, in 2020-21, cv. Pusa Arunima outperformed the other cultivars, producing the maximum number of fruits per plant (118), followed by Dashehari-51 (109), Ambika (84), and Kesar (35). The obtained data were found to be significant.According to Westwood and Blaney (1963), fruit size plays a crucial role in breeding programs for selecting superior genotypes. In terms of fruit length, cv. Pusa Arunima displayed the longest fruits (115.85 mm) in 2019-20. In the same year, Kesar, Ambika, and Dashehari-51 had fruit lengths of 109.58 mm, 104.39 mm, and 92.04 mm, respectively. In 2020-21, cv. Pusa Arunima again

Table 2: Morpho-economic trait values for four mango varieties in 2019-20 and 2020-21

Characters	Ambika		Pusa Arunima		Kesar		Dashehari-51		CD		CV	
Year	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
Number of primary branches	2	2	3	3	3	3	3	3	N.S.	N.S.	26.32	21.65
Canopy spread (m)	6.33	7.49	7.08	8.20	1.77	2.53	5.52	6.56	1.06	1.38	10.31	11.14
Stem girth (cm)	32.33	36.00	35.00	40.00	16.67	19.67	31.33	34.00	10.30	12.68	17.90	19.57
Plant height (m)	2.48	3.04	3.03	4.35	1.54	2.16	2.25	3.06	N.S.	N.S.	21.88	46.03
Number of fruits per plant	21	84	22	118	28	35	62	109	30.40	38.05	45.30	22.02
Fruit length (mm)	104.39	109.44	115.85	123.28	109.58	100.01	92.04	102.65	5.44	8.36	11.45	3.84
Fruit width (mm)	66.47	64.91	76.80	77.41	68.14	62.37	56.02	65.82	6.63	8.29	4.96	6.13
Fruit weight (g)	261.00	403.33	591.67	390.00	316.00	251.67	202.33	208.33	15.23	72.59	2.23	11.60

exhibited the longest fruit length (123.28 mm), followed by Ambika (109.44 mm), Dashehari-51 (102.65 mm), and Kesar (100.01 mm). The data were found to be significant. Regarding fruit width, cv. Pusa Arunima had the widest fruits (76.80 mm) in 2019-20, followed by Kesar (68.14 mm), Ambika (66.47 mm), and Dashehari-51 (56.02 mm). In 2020-21, cv. Pusa Arunima maintained its lead, with fruits having the highest width (77.41 mm), followed by Dashehari-51 (65.82 mm), Ambika (64.91 mm), and Kesar (62.37 mm). The differences observed among the four varieties were significant. Based on the mean value of the number of fruits per plant and fruit weight (g) over the two-year period (2019-20, 2020-21), cv. Pusa Arunima emerged as the highest yielding variety, followed by Ambika, Dashehari-51, and Kesar. The data obtained from this experiment were found to be significant. According to Harada *et al.* (2005), fruit size and weight can be influenced by genetic variables associated with phylogenetic behavior.

Analyzing fruit weight per fruit, cv. Pusa Arunima produced the heaviest fruits (591.67 g) in 2019-20, followed by Kesar (316 g), Ambika (261 g), and Dashehari-51 (202.33 g). In 2020-21, cv. Ambika recorded the heaviest fruits among the four cultivars (403.33 g), followed by Pusa Arunima (390 g), Kesar (251.67 g), and Dashehari-51 (208.33 g). The differences observed were significant. Stanley *et al.* (2000) noted that fruit

weight is influenced by genetic, environmental, and cultural factors, all of which interact to determine the final outcome. Genotypes with a higher innate ability to efficiently utilize resources are capable of producing larger fruits. The impact of climate change on agriculture necessitates consideration of the rising levels of atmospheric CO_2, which is a primary driver of climate change. CO_2 plays a crucial role in essential plant processes such as photosynthesis. The fluctuating pattern of cool evenings and relatively warm winters has had a detrimental effect on mango flowering. Additionally, the increasing average temperatures are already affecting mango production. Therefore, rapid climate change should be of paramount concern for mango growers, scientists, and consumers alike.

Mangoes possess a diverse range of genetic resources, providing an advantage for breeding and selection programs aimed at adapting to climate change. Higher temperatures could potentially benefit mango fruit development. However, elevated temperatures also lead to physiological changes in mango fruit. Excessive light, by enhancing photosynthesis, may contribute to larger fruit size (Urban *et al.*, 2003) in mangoes. Furthermore, increased concentrations of CO_2 can improve fruit quality by enhancing fruit dry mass through enhanced photosynthesis. In nonirrigated orchards, it is widely recognized that drought can have both positive and negative effects on fruit quality. While drought decreases fruit size (Spreer

et al., 2009), it can improve fruit quality (Léchaudel *et al.*, 2005) in mangoes by increasing the dry matter content and sugar concentration.

Conclusion

All four varieties of mango tested in the experiment were found to be promising for cultivation under the North Western Plain Zones of Uttar Pradesh and can further be recommended for research trials, mass multiplication programmes and ultimately adoption by farmers and orchardists. On the basis of morpho-economic traits, Pusa Arunima appeared to be a more promising and superior variety in terms of tree morphology, and others were found to be moderate. Furthermore, it can be concluded that the fruits of Pusa Arunima, Kesar and Ambika had more marketable fruit traits. Among the four varieties, the highest-yielding variety was recorded in Pusa Arunima, followed by Ambika and

Dashehari-51, based on the mean value of the number of fruits per plant and fruit weight (g) over two years. The present study also confirms that there is much diversity in mango cultivars studied in this experiment, and hence, it becomes necessary to preserve and conserve these unique genetic resources for future breeding programs for the development of innovative, market-driven cultivars.

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Conflict of interest

The authors declare that they have no conflict of interest.

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