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Character Association Between Yield and Its Attributes among African Marigold Cultivars under Rayalaseema Conditions

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ABSTRACT

The experiment "Evaluation of African marigold (*Tagetes erecta* L.) cultivars under Rayalaseema region of Andhra Pradesh" assessed eleven marigold varieties in the local agro-climatic conditions using a Randomized Block Design with three replications per cultivar. The marigold cultivars exhibited significant variations in vegetative growth, flowering, yield, and carotenoid content. Tennis Ball Plus had the tallest plants (104.34 cm) and widest spread (56.17 cm) at 90 days after transplanting (DAT), whereas Dimpal (65.40 cm and 34.57 cm) had the lowest measurements. Orange Glory showed the highest count of primary branches (19.03) and stem girth (6.60 cm) at 90 DAT, with Dimpal (8.90 and 3.56 cm) having the lowest values. Mydukur Local (31.93 and 45.00 days) had the quickest flower bud initiation and opening, while Pusa Basanti Gainda (43.47 and 54.93 days) took the longest. Mydukur Local (50.33 days) had the shortest time to 50% flowering, while Pooja (63.33 days) took the longest. Orange Glory had the longest flowering duration (76.93 days), most flowers per plant (83.20) and the highest flower yield per plot (9.43 kg) while Dimpal (36.07 days, 29.39 and 4.04 kg) had the lowest counts. Siri had the highest fresh weight (13.26 g), in contrast to Dimpal (5.50 g) with the lowest. Among the varieties, Ashtagandha Plus had the longest shelf life (6.67 days), while Chitvel Local had the shortest (2.87 days). Siri contained the highest carotenoid levels (84.82 mg), while Bidhan marigold-2 had the lowest content (24.77 mg). Correlation studies revealed significant and positive associations between yield and various traits such as number of flowers per plant, number of primary branches, plant height (cm), flowering duration, flower diameter (cm), plant girth (cm), plant spread, flower weight, and shelf life.

Key words: *Tagetes erecta, Vegetative characters, Flowering characters, Carotenoid content, Correlation studies.*

Introduction

African marigolds play a crucial role in enhancing agricultural yield through their role as companion plants. By strategically planting marigolds alongside other crops, farmers can significantly reduce the reliance on chemical pesticides, leading to healthier plant growth and ultimately increased yield. Furthermore, marigolds have a unique ability to purify

soil by absorbing and eliminating specific pollutants. Including marigolds in crop rotation plans disrupts the life cycles of pests and pathogens, thereby curbing their proliferation in the soil and fostering the growth of healthier subsequent crops.

Beyond their agrarian benefits, African marigolds hold a prominent place in the floral and landscaping industries due to their vibrant colors and captivating blooms. Their utilization in floral arrangements, decorative elements, and landscape design greatly bolsters the floral and ornamental sectors. While initially cultivated for ornamental purposes, these marigolds possess untapped potential for industrial applications, particularly in producing medicinal extracts. Notably, their anti-inflammatory and antiseptic properties offer promising avenues for creating natural skincare and wellness products. Moreover, the pigments present in African marigold flowers hold promise for natural dye production. These eco-friendly dyes are finding increased applications in the textile and fashion industries, catering to the growing demand for sustainable and environmentally conscious products. Beyond their applications in various industries, African marigolds hold scientific significance as well. They can serve as valuable model organisms for diverse biological studies, encompassing areas such as plant physiology, genetics, and biochemistry.

Crop yield results from the complex interplay of various interconnected traits. Gaining a comprehensive grasp of how these traits interact with each other is immensely valuable in the realm of plant breeding. The effectiveness of selecting for yield hinges largely on understanding both the direction and strength of relationships between yield, its component traits, and the traits themselves. Assessing character associations furnishes insights into the nature and scope of connections between pairs of traits, facilitating informed choices in crop enhancement efforts. Correlation studies primarily serve to gauge the potential of various traits for indirect selection, as emphasizing one trait could inadvertently impact other related traits. Simple correlation coefficients provide a means to establish these relationships, shedding light on which traits should be considered when aiming to enhance economic attributes. A strong positive correlation between traits implies that improving one trait would correspondingly better other linked traits. For the purpose of discerning the relationships among yield and its component traits, correlation coefficients are statistically calculated across fourteen traits. This analysis aims to uncover both the directions and the degrees of associations within this network of traits.

Materials and Methods

The study was conducted during the kharif season at Dr. YSRHU - College of Horticulture, Anantharajupeta, Annamayya district, Andhra Pradesh in 2022-23. The research encompassed the assessment of 11 distinct cultivarsof African marigold.

These cultivars were Pusa Basanti Gainda, Pusa Narangi Gainda, Bidhan Marigold-2, Orange Glory, Siri, Ashtagandha Plus, Tennis Ball Plus, Pooja, Dimpal, Mydukur Local and Chitvel Local. The experimental layout adhered to a Randomized Block Design, with each cultivar being replicated three times.

Observations were made on various attributes, including plant height, plant spread, number of primary branches per plant, stem girth, days to first flower bud appearance, days to first flower opening, days to 50% flowering, flowering duration, fresh weight of flower, shelf life, diameter of flower, carotenoid content, number of flowers per plant and yield per plot. To facilitate this, five plants were randomly chosen from each replication for data collection.

Correlations were worked out by using the formula suggested by Karl Pearson (1948).

$$\text{Coefficient of correlation } r\,(x_i . x_j) = \frac{\text{COV}\,(x_i . x_j)}{\sqrt{\text{V}\,(x_i)\,.\,\text{V}\,(x_j)}}$$

Were, r (x_i. x_j) = Correlation between i^{th} and j^{th} character, COV (x_i. x_j)) = Covariance between i^{th} and j^{th} character, V (x_i) = Variance of i^{th} character, V (x_j) = Variance of j^{th} character.

Significance of correlation coefficients was tested by comparing correlation coefficients with the table values (Fisher and Yates, 1963) at n - 2 degrees of freedom at 5% and 1% levels where 'n' denotes the total number of pairs of observations used in the calculation. The formula is as below

$$t = \frac{|r|}{\sqrt{1-r^2}}\sqrt{n-2}$$

Results and Discussion

Among the cultivars, Tennis Ball Plus recorded the

highest plant height (104.34 cm) followed by Orange Glory (93.03 cm). Conversely, the lowest plant heightwas noted in the Dimpal variety (65.40 cm) at 90 days after transplanting (DAT) (Table 1). At 90 DAT, maximum plant spread was observed in Tennis Ball Plus (56.17 cm) on par with Bidhan Marigold-2 (54.40 cm), Orange Glory (52.30 cm) and Pusa Basanti Gainda (48.54 cm) while Dimpal recorded the lowest plant spread (34.57 cm)(Table 1). Regarding primary branches plant^{-1} at 90 DAT, Orange Glory exhibited the highest number (19.03) which was on par with Tennis Ball Plus (17.70) whereas the lowest was observed in Dimpal (8.90) (Table 1). Maximum stem girth was observed in Orange Glory (6.60 cm) at 90 DAT on par with Tennis Ball Plus (6.16 cm), Astagandha Plus (6.18 cm), Pusa Narangi Gainda (6.10 cm), Pusa Basanti Gainda (5.69 cm) and Bidhan Marigold – 2 (5.66 cm) while the lowest stem girth was recorded in Dimpal (3.56 cm) (Table 1).

The observed variations in plant height, spread, primary branches, and stem girth among different marigold cultivars at 90 days after transplanting (DAT) are likely attributed to specific genomic sequences, suggesting a genetic basis for these traits (Kaur, 2023). Environmental conditions favouring dominant gene expression may contribute to disparities among cultivars (Manik and Sharma, 2016). Unique genetic compositions and their interactions with the environment contribute to fluctuations in plant characteristics (Suvija *et al.,* 2019).

Mydukur Local (31.93 days, 45.00 days and 50.33 days) cultivar recorded minimum number of days taken for the first flower bud appearance, first flower opening and 50% flowering which was on par with Chitvel Local (32.47 days, 47.06 days and 50.67 days respectively) while the maximum days taken for the first flower bud appearance and first flower opening were observed in Pusa Basanti Gainda (43.47 days and 54.93 days) whereas maximum days for 50% flowering was observed in Pooja (63.33 days) (Table 1). The variety Orange Glory displayed the longest flowering duration (76.93 days) followed by the Tennis Ball Plus (68.67 days) and the shortest flowering duration was seen in Dimpal (36.07 days) (Figure 1).

The timing of flowering events, such as first bud appearance, opening, and 50% flowering, is linked to the plant's food supply, influenced by the growth rate, carbohydrate accumulation, nutrient uptake, and climatic factors (Singh *et al.,* 2017 and Bhusaraddi *et al.* 2022). Genetic control and environmental factors likely cause variations in flowering duration (Choudhary *et al.,* 2014).

Total number of flowers per plant (83.20) and maximum flower yield per plot(18.53 kg) were noticed in the Orange Glory cultivar followed by Tennis Ball Plus (73.25 and 16.77 kg respectively). Whereas the lowest was recorded in Dimpal variety (29.39 and 4.04 kg) (Figure 1).

The number of flowers per plant is influenced by plant vigor, primary and secondary branches, with

Table 1. Vegetative and Flowering characters of African marigold cultivars

Cultivars	Plant Height (cm)	Plant Spread (cm)	1^0 branches	Stem Girth (cm)	Days taken for first bud appearance	Days taken for first flower appearance	50% flowering
T_1 - Pusa Basanti Gainda	84.00^{cd}	48.54^{ab}	11.96^{cd}	5.69^{abc}	43.47^{a}	54.93^{b}	61.00^{a}
T_2 - Pusa Narangi Gainda	80.42^{cd}	47.99^{b}	12.87^{c}	6.10^{ab}	41.73^{ab}	51.40^{a}	63.00^{a}
T_3 - Bidhan Marigold - 2	78.24^{d}	54.40^{ab}	16.60^{b}	5.66^{abc}	41.80^{ab}	49.80^{bcd}	57.33^{b}
T_4 - Orange Glory	93.03^{b}	52.30^{ab}	19.03^{a}	6.60^{a}	36.07^{d}	47.40^{ef}	53.00^{cd}
T_5 – Siri	87.61^{bc}	47.33^{b}	16.47^{b}	5.10^{bcd}	37.93^{cd}	50.73^{bc}	54.33^{bc}
T_6 - Tennis Ball Plus	104.34^{a}	56.17^{a}	17.70^{ab}	6.16^{a}	39.07^{bcd}	49.86^{bcd}	55.33^{bc}
T_7 - Astagandha Plus	87.69^{bc}	47.01^{b}	16.73^{b}	6.18^{a}	39.07^{bcd}	49.00^{cde}	56.00^{bc}
T_8 – Pooja	75.95^{de}	42.97^{b}	10.50^{de}	4.49^{def}	37.73^{cd}	48.66^{def}	63.33^{a}
T_9 – Dimpal	65.40^{f}	34.57^{c}	8.90^{e}	3.56^{f}	39.80^{bc}	49.26^{cd}	56.66^{b}
T_{10} - Mydukur Local	68.86^{ef}	37.26^{c}	9.70^{e}	3.91^{ef}	31.93^{e}	45.00^{g}	50.33^{d}
T_{11} - Chitvel Local	76.86^{de}	43.50^{b}	10.93^{cde}	4.72^{cde}	32.47^{e}	47.06^{f}	50.67^{d}
Mean	82.04	46.54	13.76	5.29	38.28	49.38	56.45
S. Em±	2.99	2.61	0.73	0.35	1.05	0.59	1.08
CD at 5%	8.83	7.71	2.17	1.03	3.10	1.74	3.17

genotypes having more primary branches producing a higher flower count (Lohar *et al.* 2018 and Srinivas and Rajasekharam 2020). Cultivars excelling in various traits, including flower quantity, tend to have higher flower yields (Bharathi and Jawaharlal, 2014; Bhusaraddi *et al.*, 2022 and Bhusal *et al.*, 2023).

Siri had the highest fresh weight (13.26 g) and flower diameter (7.89 cm), Astagandha Plus recorded the second highest fresh weight (10.05 g) and a similar flower diameter (7.76 cm). Whereas, Dimpal had the lowest fresh weight (5.50 g) and the smallest flower diameter (3.43 cm)(Figure 1). Astagandha Plus and Tennis Ball Plus had the longest shelf life (6.67 days and 6.27 days, respectively) and Siri had the highest carotenoid content (84.82 mg 100 g^{-1}), followed by Pusa Basanti Gainda (64.50 mg 100 g^{-1}), with Bidhan Marigold - 2 having the lowest carotenoid content (24.77 mg 100 g^{-1}) among the cultivars studied (Figure 1).

Floral weight variations are linked to genetic makeup, flower size, and petal count, with water and carbohydrate content influencing dry matter accumulation and flower size (Gulia *et al.*, 2017). Longer shelf life in marigold flowers may be due to increased water retention, reduced desiccation, and genetic variations among cultivars. Carotenoid content variations are associated with flower color and genetic differences among cultivars (Bhattwal *et al.* 2019, Lydia 2019 and Shilpa *et al.*, 2022).

Correlation studies

The results on the analysis of correlation coefficients between yield and its attributing characters are presented here under

Plant height (cm) was found to exhibit highly significant positive correlation with yield per plot (0.87), flower diameter (0.78), number of flowers per plant (0.78), number of primary branches (0.74), flowering duration (0.73), plant girth (0.72) and shelf life (0.69). The correlation of this trait with plant spread (0.41), days taken for first bud appearance (0.36) and days taken for first flower opening (0.30) was found significant at 5% (Table 2).

Plant spread (cm) showed highly significant and positive association with traits *viz.*, flowering duration (0.75), number of primary branches (0.71), flower diameter (cm) (0.71), plant girth (cm) (0.70), number of flowers per plant (0.65) and yield per plot (0.61), shelf life (0.53), days taken for first bud appearance (0.46), fresh weight (g) (0.45). Positive and significant association of this character was worked out with plant height (cm) (0.41) and days taken for first flower opening (0.38) (Table 2).

The correlation between the number of primary branches and the followingvariables like yield per plot (0.89), flowering duration (0.86), number of flowers per plant(0.80), flower diameter (cm) (0.78), plant height (cm) (0.74), plant girth (cm) (0.73), plant spread (cm) (0.71), shelf life (0.68) and fresh weight (g) (0.52) shows highly positive and significant correlation.

Plant girth (cm)was found to exhibit highly positive and significant association with flower diameter (cm) (0.77), number of primary branches (0.73), plant height (cm) (0.72), yield per plot (0.72), flowering duration (0.71), plant spread (cm) (0.70), shelf life (0.68), number of flowers per plant (0.68), days taken for first bud appearance (0.59) and days taken for first flower opening (0.44). The correlation of this

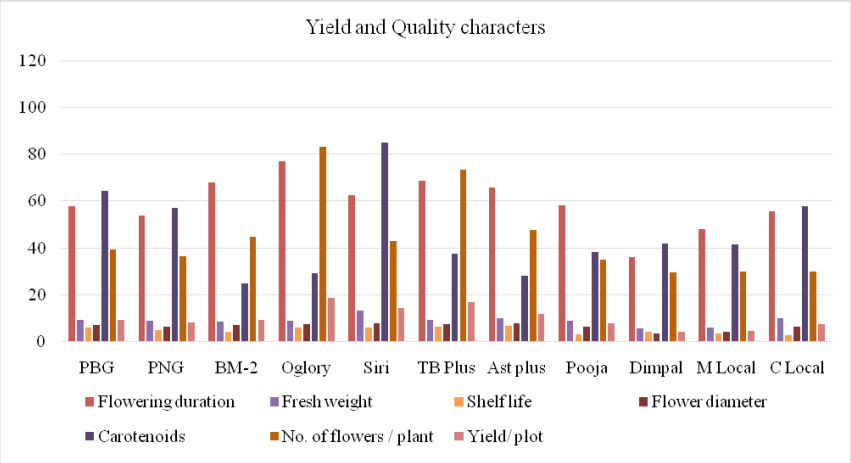

Fig. 1. Yield and Quality characters of African marigold cultivars

trait with fresh weight (g) (0.40) was found significant at 5% (Table 2).

Taller plants exhibit increased lateral branching and stem girth, supporting healthier growth and larger flowers. Height facilitates greater sunlight absorption, enhancing photosynthesis and flower production (Naik *et al.,* 2004; Singh and Saha, 2009 and Bharathi *et al*., 2014 in African marigold). Larger stem girth indicates robust plants, contributing to more primary branches and flowers, leading to extended shelf life (Vishnupriya *et al.,* 2015; Negi *et al.,* 1983 and Mukesh *et al.* 2012).

The character days taken for first bud appearance exhibited highly positive and significant correlation with days taken for first flower opening (0.76), 50% flowering (0.64), flower diameter (cm) (0.61), plant girth (cm) (0.59), plant spread (cm) (0.46) and shelf life (0.44). Positive and significant association of this character was worked out with flowering duration (0.42), fresh weight (g) (0.42) and plant height (cm) (0.36)(Table 2).

Days taken for first flower opening showed a highly positive and significant correlation with days taken for first bud appearance (0.76), 50% flowering (0.70), fresh weight (g) (0.47), flower diameter (cm) (0.47) and plant girth (cm) (0.44). The correlation of this trait was found positive and significant at 5% with plant spread (cm) (0.38), shelf life (0.35) and carotenoids (mg 100 g^{-1}) (0.35) (Table 2).

Days taken for 50% flowering exhibited highly positive and significant correlation with days taken for first flower opening (0.70) and days taken for first bud appearance (0.64)(Table 2).

A positive correlation is observed between days for first bud appearance, first flower opening, and 50% flowering. Longer bud development may lead to delayed flower maturation. A positive correlation is also noted between flower opening time and diameter (Kumar et al. 2014in African marigold).

Number of primary branches (0.86), yield per plot (0.86), flower diameter (cm) (0.85), number of flowers per plant (0.78), plant spread (cm) (0.75), Plant height (cm) (0.73), plant girth (cm) (0.71), shelf life (0.60) and fresh weight (g) (0.52) recorded highly positive and significant correlation with flowering duration (Table 2).

Fresh weight of a flower (g) was found highly positive and significant correlation with flower diameter (cm) (0.77), shelf life (0.58), yield per plot (0.55), number of primary branches (0.52), flowering duration (0.52), plant height (cm) (0.48), days taken

Table 2. Correlation coefficients between yield and its attributes in African marigold cultivars

Variables	Plant height (cm)	Plant spread (cm)	Number of primary branches	Plant girth (cm)	Days taken for first bud appearance	Days taken for first flower opening	50% flowering	Flowering duration	Fresh weight (g)	Shelf life	Flower diameter (cm)	Carotenoids (mg 100 g^{-1})	Number of flowers $plant^{-1}$	Yield/ plot
Plant height (cm)	1													
Plant spread (cm)	0.41*	1												
Number of primary branches	0.74**	0.71**	1											
Plant girth (cm)	0.72**	0.70**	0.73**	1										
Days taken for first bud appearance	0.36*	0.46**	0.28	0.59**	1									
Days taken for first flower opening	0.30	0.38*	0.22	0.44**	0.76**	1								
50% flowering	-0.04	0.16	-0.15	0.15	0.64**	0.70**	1							
Flowering duration	0.73**	0.75**	0.86**	0.71**	0.42*	0.23	0.04	1						
Fresh weight	0.48**	0.45**	0.52**	0.39*	0.42*	0.47**	0.22	0.52**	1					
Shelf life	0.69**	0.53**	0.68**	0.68**	0.44**	0.35*	0.002	0.60**	0.58**	1				
Flower diameter (cm)	0.78**	0.71**	0.78**	0.77**	0.61**	0.47**	0.24	0.85**	0.77**	0.72**	1			
Carotenoids (mg 100 g^{-1})	0.28	0.21	0.24	0.21	0.02	0.35*	0.11	0.31	0.36*	0.14	0.22	1		
Number of flowers $plant^{-1}$	0.78**	0.65**	0.80**	0.68**	0.06	-0.04	-0.31	0.78**	0.18	0.53**	0.56**	0.35*	1	
Yield/plot	0.87**	0.61**	0.89**	0.72**	0.21	0.15	-0.20	0.86**	0.55**	0.70**	0.79**	0.32*	0.91**	1

* Significant at 5% level of significance; ** significant at 1% level of significant

for first flower opening (0.47) and plant spread (cm) (0.45). This character was found significant at 5% with days taken for first bud appearance (0.42), plant girth (cm) (0.39) and carotenoids (mg 100 g^{-1}) (0.36) (Table 2).

Shelf life of a flower exhibited highly positive and significant correlation with flower diameter (cm) (0.72), yield per plot (0.70), plant height (cm) (0.69), number of primary branches (0.68), plant girth (cm) (0.68), flowering duration (0.60), fresh weight (g) (0.58), plant spread (cm) (0.53), number of flowers per plant (0.53) and days taken for first bud appearance (0.44)(Table 2).

Diameter of a flower (g)was found highly positive and significant association with flowering duration (0.85), yield per plot (0.79), plant height (cm) (0.78), number of primary branches (0.78), fresh weight (g) (0.77), plant girth (cm) (0.77), shelf life (0.72), plant spread (cm) (0.71), days taken for first bud appearance (0.61), number of flowers per plant (0.56) and days taken for first flower opening (0.47) (Table 2).

Carotenoid content (mg 100 g^{-1}) showed a positive and significant correlation with fresh weight (g) (0.36), number of flowers per plant (0.35), days taken for first flower opening (0.35) and yield per plot (0.32) (Table 2).

Number of flowers per plant showed highly positive and significant correlation with yield per plot (0.91), number of primary branches (0.80), flowering duration (0.78), plant height (cm) (0.78), plant girth (cm) (0.68), plant spread (cm) (0.65), flower diameter (cm) (0.56) and shelf life (0.53). Positive and significant association of this character was worked out with carotenoids (mg 100 g^{-1}) (0.35)(Table 2).

Flower yield per plot showed highly positive and significant correlation with number of flowers per plant (0.91), number of primary branches (0.89), plant height (cm) (0.87), flowering duration (0.86), flower diameter (cm) (0.79), plant girth (cm) (0.72), shelf life (0.70), plant spread (cm) (0.61) and fresh weight (g) (0.55) (Table 2).

Extended flowering duration correlates with increased flowers per plant and higher yield, suggesting longer duration contributes to higher productivity (Singh and Saha, 2009 and Kumar *et al.,* 2014). Physiologically superior cultivars with higher fresh weight and flower yield may exhibit enhanced carotenoid content due to better pigment biosynthesis (Swathi and Naik, 2017 in African marigold and Nazir *et al.* 2023 in Gladiolus).

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Conflict of Interest

None

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