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Assessment of Genetic Variability, Character Association and Path Coefficient Analysis in Gomphrena (*Gomphrena globosa* L.) Genotypes for Productivity and Quality Traits

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ABSTRACT

An experiment was conducted during November 2021–March, 2022 at the experimental block of Floriculture and Landscape Architecture, College of Horticulture, Bagalkot, Karnataka, India using thirteen different Gomphrena (*Gomphrena globosa* L.) genotypes under randomized block design to determine the extent of genetic variability. The phenotypic coefficient of variation (PCV) was higher than genotypic coefficient coefficient of variation (GCV) for all growth, flowering, yield and quality traits under study. Higher GCV and PCV was observed for number of leaves plant^{-1}, moderate for plant height, number of secondary branches, stem girth, days to bud initiation, inflorescence length, individual flower weight, number of flowers plant^{-1}, yield plant^{-1} and shelf life. High heritability combined with high genetic advance over mean was recorded for plant height, secondary branches, number of leaves, stem girth, days to bud initiation, inflorescence length, individual flower weight, number of flowers and yield plant^{-1}. The flower yield plant^{-1} had significantly positive association with plant height, plant spread in N-S and E-W direction, number of primary and secondary branches, number of leaves, stem girth, duration of flowering, stalk length, inflorescence length, flower diameter, number of flowers plant^{-1} and individual flower weight. The character association studies revealed that, flower yield plant^{-1} had direct and positive association with plant spread, stem girth, number of secondary branches, individual flower weight, diameter of flower, inflorescence length, stalk length, days to flowering, bud initiation, number of leaves and plant height.

KEYWORDS: Gomphrena, character association, genetic variability

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1. INTRODUCTION

Bachelor's button is an everlasting flower crop commercially cultivated in India and is used as loose flower both as fresh flower and as dry flower. It signifies special importance due to its bright inflorescence, hardiness and ease in cultivation, salability, short duration and easy transportation (Kumar et al., 2023). The Globe Amaranth (*Gomphrena globosa* L.) is native to North America, South America, Myanmar and India (Jiang et al., 2011). Commonly known as 'Globe Amaranth', 'makhmali' (Nepali), Rakta mallika (Sanskrit), Adike huvvu/rudrakshi huvvu (Kannada) and 'Gul-e-makhmal (Hindi), Gundi (Kashmiri). The genus belongs to the family Amaranthaceae with chromosome number 2n=38 consists of about 100 species of half-hardy annual, biennial and herbaceous perennial plants, but only one species *Gomphrena globosa* with its cultivars is in general cultivation. About 18 generas and over 50 species have been reported from India. It symbolizes immortality and endless love. The flower has amazing ability to last for years when dried (Kumar et al., 2024). It is one of the hardiest garden annual bedding plant which blooms continuously throughout summer and early fall, known for its colorful inflorescence. It grows up to 30–120 cm in height, stems are branched, erect and has bushy appearance. The leaves are opposite, oblong, 4–6 cm in long, and woolly-white when young, becomes sparsely white-hairy as they are aged. The round-shaped or clover like or button like flower inflorescences are visually dominant feature and cultivars exhibit shades of magenta, purple, red, orange, white, pink and lilac but the most common color is magenta. Within the flower heads, the true flowers are insignificant, tiny, white to yellow trumpets that are only visible close up and inconspicuous. It occupies seventh position in the world dry flower market (Kumar et al., 2023). In India, it is majorly grown in Karnataka, Tamil Nadu, Kerala and in Andhra Pradesh. In Karnataka, it is commercially grown in Dharwad, Belagavi, Raichur and Bellary Districts. Gomphrena is commercially grown for loose flowers and as well as cut flowers for making garlands, pomanders, bouquets, flower balls, wreath, greeting cards, potpourris, flower arrangements, stage decorations during marriages, indoor decoration and widely used during Onam, the famous Kerala festival to decorate Pookolam and Bathukamma festival in Telangana (Yaseen et al., 2021).

Crop improvement to a large extent is greatly depends on existing genetic variability. Selection of superior variety depends upon the variation that exists in a particular crop (Poulose et al., 2020). Variability in a population w.t.r phenotypic expression of a character is mainly governed by the genetic make-up of the plant, the environment in which it is grown (Sharma et al., 2025) and the interaction between the genotype and environment (Allard and Bradshaw, 1964; Bhargav et al., 2019). For any effective selection programme, the information on nature and the magnitude of variability present in genetic stocks, characters, heritability and genetic advance are important (Khangjarakpam et al., 2014). As Gomphrena shows wide range of variability with respect to flower colour, size and vegetative characters, there is a need to screen genotypes for the identification of superior genotypes for improved quality and high yield (Jinks and Pooni, 1982). The yield is largely depends on genetic variability, correlation and association between quantitative and qualitative characters (Rai et al., 2017; Tanya and Kaur, 2023). As Gomphrena is gaining importance now-a-days and the crop improvement is mainly depends on exploring existing genetic diversity of genotypes for crop improvement in this context paper deals on 'Assessment of genetic variability and character association for growth, flowering, yield and quality traits in Gomphrena genotypes'. Thus, the experiment was conducted on thirteen Gomphrena (*Gomphrena globosa* L.) genotypes under randomized block design to determine the extent of genetic variability.

2. MATERIALS AND METHODS

The experiment was conducted during November, 2021-March, 2022 at the experimental block of Floriculture and Landscape Architecture, College of Horticulture, Bagalkot using thirteen different Gomphrena genotypes in a randomized block design with 3 replications. The genotypes belonged to four colours, AGS-1, AGS-5, AGS-9, AGS-17-purple colour; AGS-2, AGS-4, AGS-6, AGS-8-pink colour; AGS-3, AGS-7, AGS-10, AGS-16-white colour and AGS-14–red colour (Plate 1). The spacing followed was 30×30 cm^2. In each treatment 5 randomly selected plants were choosen to record observations on 19 yield and yield attributing traits viz., plant height (cm), plant spread in N-S and E-W direction (cm), number of primary and secondary branches $plant^{-1}$, number of leaves, stem girth (mm), days to first flower bud initiation, days taken for bud to flower opening, days to 50% flowering, duration of flowering, stalk length, inflorescence length (cm), flower

Plate 1: Individual flower of different Gomphrena genotypes

diameter (cm), individual flower weight (g), number of flowers plant^{-1} and yield plant^{-1} (g). The mean values were taken for analysis of variance (ANOVA) given by Panse and Sukhatme (1978). The genetic variability estimates, character association and correlation of traits were done by using Indostat software, windows 11.

3. RESULTS AND DISCUSSION

The analysis of variance showed there exist highly significant (p<0.05) differences among the genotypes for growth, flowering, yield and quality traits (Table 1) which helps for further breeding programme to develop superior varieties. Among all the traits under study, the value of GCV ranges between 3.17 to 21.55%, PCV of 3.46 to 21.55%, heritability of 49.72 to 99.99% and genetic advance over mean of 5.98 to 44.38% (Table 1). The trait number of leaves plant^{-1} had showed highest genotypic and phenotypic coefficient of variation, heritability and GAM (21.55%, 21.55%, 99.99% and 44.38%) among all the growth, flowering, yield and quality traits.

Least range of GCV, PCV and GAM (3.17%, 3.46% and 5.98%) was observed in duration of flowering, least heritability (49.72%) in days from bud to full flower opening. In flowering traits highest GCV, PCV and GAM (13.02%, 16.29% and 21.42%) was observed in days to bud initiation, highest heritability in days to 50% flowering (86.17%). Among the yield traits maximum variability per centage (19.35%, 19.35%, 99.99% and 39.19%) was observed in yield plant^{-1}. In flower quality traits, highest GCV and PCV (17.25% and 18.91%) was reported in inflorescence length, heritability and genetic advance as per cent of mean (91.27% and 19.24%) on display life of flower, similarly least variation (6.99%, 8.07% and 12.48%) of GCV, PCV and GAM in stalk length and least heritability of 49.76% was reported in shelf life of Gomphrena flower. The magnitude of phenotypic coefficients of variation (PCV) were higher than genotypic coefficients of variation (GCV), though difference was very less, showing that the traits were less influenced by environmental factors for the expression of traits. Similar findings were reported by Kumar et al. (2024) in Gomphrena, gerbera and balsam by Ghimiray et al. (2015), Khangjarakpam et al. (2014), Bhargav et al. (2019) in China aster and Pal et al. (2018) in Balsam and Sharma et al. (2025) in Marigold.

Correlation between different genotypes regarding several traits provided information about nature and extent of association between the traits, which would help in upgradation of characters by selection. As yield was an

Table 1: Genetic variability estimates for growth, flowering, yield and quality parameters in Gomphrena genotypes

Sl. No.	Characters	Mean	Range		GCV (%)	PCV (%)	h^2 (%)	GAM (%)
			Min	Max				
1.	Plant height (cm)	57.06	23.73	65.80	18.37	18.44	99.25	37.71
2.	Plant spread [N-S] (cm)	49.03	42.27	56.13	8.91	9.15	94.95	17.89
3.	Plant spread [E-W] (cm)	44.93	37	53.53	8.76	8.98	95.15	17.60
4.	Primary branches	8.19	6.6	9.27	9.33	11.61	64.64	15.46
5.	Secondary branches	24.97	15.2	28.4	13.02	13.79	89.08	25.31
6.	Number of leaves	416.72	214.67	564.47	21.55	21.55	99.99	44.38
7.	Stem girth (mm)	8.78	4.52	11.31	16.76	17.7	89.68	32.69
8.	Days for bud initiation	10.49	9	15	13.02	16.29	63.84	21.42
9.	Days from bud to flower	9	8	10.33	6.79	9.64	49.72	9.87
10.	Days for 50% flowering	35.13	31.67	41	7.26	7.82	86.17	13.87
11.	Duration of flowering	64.14	61	67	3.17	3.46	83.87	5.98
12.	Stalk length (cm)	19.31	16.41	22.61	6.99	8.07	75.09	12.48
13.	Inflorescence length (cm)	3.53	2.53	4.74	17.25	18.91	83.15	32.40
14.	Flower diameter (mm)	1.86	1.45	2.16	8.9	9.82	83.43	16.88
15.	Individual flower weight (g)	2.64	1.79	3.19	16.51	17.41	89.88	32.23
16.	Number of flowers plant^{-1}	246.16	167	279.53	11.19	11.19	99.89	23.04
17.	Yield plant^{-1} (g)	585.14	357.7	763.57	19.35	19.35	99.99	39.19
18.	Display life (days)	32.28	27	37	9.77	10.23	91.27	19.24
19.	Shelf life (days)	5.88	5	7	11.29	16	49.76	16.4

dependent variable, which depended on association of independent variables along with environmental condition. This would reveal the nature and extent of association between growths, flower and yield traits. Number of flowers, individual flower weight and yield plant^{-1} were given prime importance as they contributed to economic value. From table 2 and 3, it was observed that at genotypic and phenotypic level of correlation, the yield plant^{-1} of Gomphrena had positive significant at 1% correlation with plant height (0.539/0.539), plant spread in N-S direction (0.513/0.500), number of secondary branches (0.541/0.511), stem girth (0.756/0.715), duration of flowering (0.660/0.602), stalk length (0.442/0.383), inflorescence length (0.527/0.482), individual flower (0.820/0.770) and number of flowers (0.603/0.602). Negatively correlated with days to bud initiation (-0.435/0.346), days for bud to flower opening

Table 2: Genotypic correlation of flower yield and its contributing traits in Gomphrena genotypes

@	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}
X_1	1	0.603**	0.333*	0.609**	0.896**	0.720**	0.927**	-0.898**	-0.529**	-0.493**
X_2		1	0.750**	0.2	0.429**	0.334*	0.682**	-0.278	-0.462**	-0.058
X_3			1	0.206	0.174	0.22	0.411**	0.046	-0.700**	0.244
X_4				1	0.810**	0.623**	0.517**	-0.657**	-0.957**	-0.701**
X_5					1	0.616**	0.831**	-0.933**	-0.595**	-0.731**
X_6						1	0.708**	-0.547**	-0.470**	-0.227
X_7							1	-0.727**	-0.457**	-0.392*
X_8								1	0.374*	0.861**
X_9									1	0.513**
X_{10}										1

@	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}	X_{16}	X_{17}
X_1	0.292	0.690**	0.729**	-0.013	0.138	0.937**	0.539**
X_2	0.730**	0.489**	0.525**	0.361*	0.302	0.680**	0.513**
X_3	0.702**	0.085	0.244	0.298	0.187	0.434**	0.343*
X_4	-0.068	0.009	0.421**	-0.649**	-0.078	0.416**	0.312*
X_5	-0.03	0.509**	0.570**	-0.205	0.197	0.802**	0.541**
X_6	0.227	0.268	0.259	0.081	-0.128	0.629**	0.355*
X_7	0.478**	0.744**	0.664**	0.242	0.376*	0.948**	0.756**
X_8	0.01	-0.645**	-0.635**	0.2	-0.045	-0.796**	-0.435**
X_9	-0.480**	0.04	-0.392*	0.316*	-0.174	-0.463**	-0.537**
X_{10}	0.089	-0.245	-0.463**	0.379*	-0.276	-0.386*	-0.477**
X_{11}	1	0.195	0.398**	0.533**	0.543**	0.419**	0.660**
X_{12}		1	0.502**	0.278	0.231	0.805**	0.442**
X_{13}			1	-0.293	0.345*	0.619**	0.527**
X_{14}				1	0.422**	0.239	0.373*
X_{15}					1	0.282	0.820**
X_{16}						1	0.603**
X_{17}							1

*Significant at p=0.05 level; **Significant at p=0.01 level; X_1: Plant height (cm); X_2: Plant spread in N-S direction (cm); X_3: E-W direction (cm); X_4: Number of primary branches plant^{-1}; X_5: Secondary branches; X_6: Number of leaves; X_7: Stem girth (mm); X_8: Day for bud initiation; X_9: Days for bud to flower; X_{10}: 50% flowering (days); X_{11}: Duration of flowering (days); X_{12}: Stalk length (cm); X_{13}: Inflorescence length (cm); X_{14}: Diameter of flower (cm); X_{15}: Individual flower weight (g); X_{16}: Number of flowers; X_{17}: Yield plant^{-1} (g)

Table 3: Phenotypic correlation of flower yield and its contributing traits in Gomphrena genotypes

@	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}
X_1	1	0.586**	0.329*	0.491**	0.842**	0.717**	0.883**	-0.725**	-0.370*	-0.449**
X_2		1	0.727**	0.111	0.407**	0.325*	0.630**	-0.232	-0.361*	-0.064
X_3			1	0.158	0.184	0.215	0.383*	0.027	-0.526**	0.247
X_4				1	0.595**	0.501**	0.400**	-0.342*	-0.461**	-0.489**
X_5					1	0.582**	0.730**	-0.675**	-0.364*	-0.613**
X_6						1	0.671**	-0.436**	-0.332*	-0.21
X_7							1	-0.556**	-0.335*	-0.332*
X_8								1	0.254	0.616**
X_9									1	0.309*
X_{10}										1

@	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}	X_{16}	X_{17}
X_1	0.264	0.589**	0.664**	-0.007	0.13	0.933**	0.537**
X_2	0.649**	0.433**	0.498**	0.306	0.294	0.665**	0.500**
X_3	0.648**	0.077	0.245	0.284	0.191	0.423**	0.335*
X_4	0.004	-0.051	0.218	-0.409**	-0.114	0.342*	0.251
X_5	0.013	0.492**	0.523**	-0.129	0.194	0.761**	0.511**
X_6	0.208	0.232	0.237	0.074	-0.121	0.628**	0.355*
X_7	0.428**	0.624**	0.570**	0.226	0.345*	0.899**	0.715**
X_8	0.056	-0.336*	-0.531**	0.154	-0.084	-0.633**	-0.346*
X_9	-0.338*	-0.025	-0.428**	0.271	-0.122	-0.329*	-0.381*
X_{10}	0.106	-0.223	-0.335*	0.380*	-0.236	-0.358*	-0.444**
X_{11}	1	0.209	0.342*	0.463**	0.433**	0.385*	0.602**
X_{12}		1	0.411**	0.223	0.146	0.700**	0.383*
X_{13}			1	-0.223	0.321*	0.564**	0.482**
X_{14}				1	0.406**	0.221	0.340*
X_{15}					1	0.268	0.777**
X_{16}						1	0.602**
X_{17}							1

*Significant at p=0.05 level; **Significant at p=0.01 level; X_1: Plant height (cm); X_2: Plant spread in N-S direction (cm); X_3: E-W direction (cm); X_4: Number of primary branches plant^{-1}; X_5: Secondary branches; X_6: Number of leaves; X_7: Stem girth (mm); X_8: Day for bud initiation; X_9: Days for bud to flower; X_{10}: 50% flowering (days); X_{11}: Duration of flowering (days); X_{12}: Stalk length (cm); X_{13}: Inflorescence length (cm); X_{14}: Diameter of flower (cm); X_{15}: Individual flower weight (g); X_{16}: Number of flowers; X_{17}: Yield plant^{-1} (g)

(0.537/0.381) and days to 50% flowering (-0.477/-0.444). At 5% level of significance, yield at genotypic and phenotypic level correlated with E-W direction (0.343/0.335), number of leaves (0.355/0.335) and diameter of flower (0.373/0.340). Positive and non-significant effect of number of primary branches plant^{-1} with yield at phenotypic level. From this it was confirmatory that, for increase of flower yield in Gomphrena selection might be based on plant height, plant spread in E-W and N-S direction, primary and secondary branches, number of leaves, stem girth, duration of flowering, stalk length, flower height, diameter, individual flower weight and number of flowers plant^{-1}. With increase in vegetative traits, yield was positively correlated with increase in photosynthetic efficiency and reproductive development of the crop. The results were confirmatory with Kumar et al. (2024) in Gomphrena, Tirakannanavar et al. (2015) in China aster and Choudhary et al. (2015) in marigold.

Selection of genotypes based on correlation might be misleading because it showed only association between the traits, while, path coefficient explained contribution of individual traits either direct or indirect on yield character (Table 4 and 5). From the genotypic path analysis, Flower yield plant^{-1} had direct positive impact on individual flower

Table 4: Genotypic path analysis of flower yield and its contributing traits in different Gomphrena genotypes

@	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9
X_1	0.7882	0.4752	0.2626	0.6647	0.7423	0.5674	0.731	-0.708	-0.4169
X_2	-0.1695	-0.2811	-0.2108	-0.1632	-0.1284	-0.0938	-0.1917	0.0781	0.1298
X_3	-0.005	-0.0112	-0.015	-0.0078	-0.0024	-0.0033	-0.0061	-0.0007	0.0105
X_4	0.2909	0.2002	0.1808	0.3449	0.2939	0.1783	0.2924	-0.2339	-0.2406
X_5	-0.1048	-0.0508	-0.0175	-0.0948	-0.1112	-0.0729	-0.0964	0.1086	0.0632
X_6	-0.132	-0.0612	-0.0403	-0.0948	-0.1202	-0.1834	-0.1299	0.1003	0.0863
X_7	0.9422	0.6927	0.4179	0.8613	0.8806	0.7195	1.0159	-0.7385	-0.4646
X_8	0.0785	0.0243	-0.004	0.0592	0.0853	0.0478	0.0635	-0.0874	-0.0327
X_9	0.0732	0.0639	0.0969	0.0966	0.0787	0.0651	0.0633	-0.0518	-0.1385
X_{10}	0.1422	0.0167	-0.0703	0.114	0.2109	0.0655	0.1128	-0.2482	-0.1478
X_{11}	0.208	0.5222	0.5006	0.1993	0.0569	0.1683	0.3406	0.0089	-0.3422
X_{12}	0.3717	0.263	0.0457	0.2453	0.315	0.1443	0.4005	-0.3473	0.0215
X_{13}	-0.4407	-0.317	-0.1473	-0.4518	-0.397	-0.1562	-0.4009	0.3834	0.2366
X_{14}	0.0002	-0.0059	-0.0049	0.0018	0.0025	-0.0013	-0.004	-0.0033	-0.0052
X_{15}	0.0506	0.1108	0.0685	0.129	0.0793	-0.0469	0.138	-0.0164	-0.0638
X_{16}	-1.5549	-1.1292	-0.7194	-1.2788	-1.4058	-1.0435	-1.5736	1.3215	0.7677

@	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}	X_{16}	pR^2
X_1	-0.3888	0.2302	0.5441	0.5749	-0.0104	0.1086	0.7386	0.4248
X_2	0.0163	-0.2061	-0.1373	-0.1475	-0.1015	-0.0848	-0.1913	-0.1441
X_3	-0.0036	-0.0105	-0.0013	-0.0036	-0.0044	-0.0028	-0.0065	-0.0051
X_4	-0.1364	0.0965	0.1571	0.258	-0.0378	0.1212	0.2658	0.2156
X_5	0.0814	-0.0089	-0.0651	-0.0731	0.0169	-0.024	-0.0942	-0.0645
X_6	0.0417	-0.0433	-0.0491	-0.0474	-0.0149	0.0234	-0.1153	-0.0651
X_7	-0.3977	0.4859	0.7555	0.6742	0.2461	0.3817	0.9634	0.7676
X_8	-0.0752	-0.0011	0.0563	0.0554	-0.0175	0.0039	0.0696	0.0380
X_9	-0.071	0.0665	-0.0055	0.0542	-0.0437	0.0241	0.0641	0.0743
X_{10}	-0.2882	-0.0255	0.0706	0.1334	-0.1093	0.0794	0.1113	0.1376
X_{11}	0.0631	0.7123	0.1348	0.2776	0.382	0.3808	0.2977	0.4677
X_{12}	-0.132	0.1019	0.5385	0.2702	0.1494	0.1241	0.4332	0.2375
X_{13}	0.2796	-0.2354	-0.3031	-0.6041	0.1771	-0.2082	-0.3737	-0.3183
X_{14}	-0.0062	-0.0088	-0.0046	0.0048	-0.0164	-0.0069	-0.0039	-0.0061
X_{15}	-0.1012	0.1964	0.0846	0.1266	0.1549	0.3673	0.1035	0.3011
X_{16}	0.6409	-0.6934	-1.3346	-1.0265	-0.3973	-0.4677	-1.6594	-1.0002

Residual effect: R Square=1.0606 Residual Effect=SQRT(1-1.0606); *Significant at p=0.05 level; **Significant at p=0.01 level; X_1: Plant height (cm); X_2: Plant spread in N-S direction (cm); X_3: E-W direction (cm); X_4: Number of primary branches plant^{-1}; X_5: Secondary branches; X_6: Number of leaves; X_7: Stem girth (mm); X_8: Day for bud initiation; X_9: Days for bud to flower; X_{10}: 50% flowering (days); X_{11}: Duration of flowering (days); X_{12}: Stalk length (cm); X_{13}: Inflorescence length (cm); X_{14}: Diameter of flower (cm); X_{15}: Individual flower weight (g); X_{16}: Number of flowers; X_{17}: Yield plant^{-1} (g)

Table 5: Phenotypic path analysis of flower yield and its contributing traits in different Gomphrena genotypes

@	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9
X_1	0.1716	0.1024	0.0569	0.1432	0.1604	0.1233	0.1564	-0.1418	-0.0782
X_2	-0.4836	-0.81	-0.6011	-0.4624	-0.3644	-0.268	-0.5375	0.2096	0.3353
X_3	0.5843	1.3075	1.762	0.9052	0.2785	0.384	0.7072	0.0676	-1.0904
X_4	-1.4724	-1.0067	-0.906	-1.7635	-1.4799	-0.9051	-1.454	1.0608	1.078
X_5	1.155	0.5558	0.1953	1.0367	1.2354	0.8053	1.0409	-1.095	-0.5887
X_6	0.2061	0.0949	0.0625	0.1472	0.1869	0.2867	0.1994	-0.1438	-0.1167
X_7	1.2592	0.9165	0.5543	1.1387	1.1637	0.9602	1.3811	-0.9066	-0.5534
X_8	-0.5262	-0.1647	0.0244	-0.3829	-0.5642	-0.3191	-0.4178	0.6365	0.2016
X_9	-0.0147	-0.0133	-0.0199	-0.0197	-0.0153	-0.0131	-0.0129	0.0102	0.0322
X_{10}	0.3296	0.0414	-0.169	0.2658	0.4842	0.1526	0.2554	-0.5248	-0.2902
X_{11}	-0.1896	-0.4735	-0.4593	-0.1746	-0.0557	-0.1542	-0.3085	-0.0189	0.281
X_{12}	0.2655	0.1903	0.0333	0.179	0.2295	0.1035	0.2843	-0.21	0.0045
X_{13}	0.7041	0.5138	0.2436	0.7173	0.6393	0.2502	0.6279	-0.5898	-0.4034
X_{14}	-0.0058	0.1816	0.1558	-0.0588	-0.0732	0.0418	0.1259	0.\0965	0.1565
X_{15}	0.0768	0.1699	0.1069	0.1931	0.1212	-0.0712	0.2073	-0.034	-0.0853
X_{16}	-1.5217	-1.0978	-0.6992	-1.2439	-1.3696	-1.0223	-1.5137	1.1854	0.6522

@	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}	X_{15}	X_{16}	pR^2
X_1	-0.0819	0.0484	0.1118	0.1211	-0.0019	0.0232	0.1606	0.0923
X_2	0.0485	-0.571	-0.3782	-0.4171	-0.2761	-0.2421	-0.5469	-0.4116
X_3	0.4315	1.2049	0.1438	0.4301	0.5152	0.3313	0.7576	0.5999
X_4	0.6791	-0.4583	-0.7747	-1.2678	0.1945	-0.599	-1.3491	-1.0942
X_5	-0.8667	0.1024	0.6958	0.7916	-0.1698	0.2634	1.0406	0.7126
X_6	-0.0634	0.0658	0.0729	0.0719	0.0225	-0.0359	0.1803	0.1018
X_7	-0.511	0.6343	0.9635	0.8692	0.3264	0.5038	1.2858	1.0239
X_8	0.4839	0.0179	-0.3279	-0.3762	0.1153	-0.0381	-0.4641	-0.2533
X_9	0.0135	-0.0135	0.0004	-0.013	0.0094	-0.0048	-0.0129	-0.0150
X_{10}	-0.6902	-0.0651	0.1632	0.2868	-0.262	0.1804	0.2596	0.3213
X_{11}	-0.0634	-0.6717	-0.1316	-0.2493	-0.3418	-0.3331	-0.2729	-0.4276
X_{12}	-0.0964	0.0798	0.4075	0.1902	0.1044	0.0807	0.3114	0.1706
X_{13}	-0.4146	0.3703	0.4656	0.9978	-0.2664	0.3353	0.5974	0.5093
X_{14}	0.2023	0.2712	0.1365	-0.1423	0.5328	0.2217	0.1239	0.1924
X_{15}	-0.1485	0.2818	0.1126	0.191	0.2365	0.5684	0.1574	0.4575
X_{16}	0.6116	-0.6607	-1.2425	-0.9734	-0.3781	-0.4502	-1.626	-0.9799

Residual effect: R Square=1.0000 Residual effect=SQRT(1-1.0000); pR^2: Partial regression; *Significant at p=0.05 level; **Significant at p=0.01 level; X_1: Plant height (cm); X_2: Plant spread in N-S direction (cm); X_3: E-W direction (cm); X_4: Number of primary branches plant^{-1}; X_5: Secondary branches; X_6: Number of leaves; X_7: Stem girth (mm); X_8: Day for bud initiation; X_9: Days for bud to flower; X_{10}: 50% flowering (days); X_{11}: Duration of flowering (days); X_{12}: Stalk length (cm); X_{13}: Inflorescence length (cm); X_{14}: Diameter of flower (cm); X_{15}: Individual flower weight (g); X_{16}: Number of flowers; X_{17}: Yield plant^{-1} (g) weight (0.3673), stalk length (0.5385), duration of flowering (0.7123), stem girth (1.0159), number of primary branches (0.3449) and plant height (0.7882).

Whereas, direct negative effect on plant spread in North-South and East-West direction (-0.2811 and -0.015), number of secondary branches (-0.1112), number of leaves (-0.1834), days to bud initiation (-0.0874), days from bud to flower opening (-0.1385), 50% flowering (-0.2882), inflorescence length (-0.6041), diameter of flower (-0.0164) and number of flowers per plant (-1.6594). From phenotypic path analysis, Dependent variable yield had shown significantly direct negative effect on number of flowers plant^{-1} (-1.626), positive indirect association with 50% flowering (0.6116), bud to flower (0.6522) and bud initiation (1.1854). Indirect and negatively associated with plant height (-1.5217), plant spread in N-S and E-W direction (-1.0978 and -0.6992), primary and secondary branches (-1.2439 and -1.3696), leaves count (-1.0223), stem girth (-1.5137), duration of flowering (-0.6607), stalk length of flower (-1.2425), inflorescence length (-0.9734), flower diameter (-0.3781) and individual flower weight (-0.4502). From the path analysis at both genotype and phenotypic level, it was reported that yield could be increased by direct selection of characters like individual flower weight, number of flowers, stalk length of flower, duration of flowering, stem girth, number of primary branches and plant height. Similar observations on effect of yield were found by Rai et al. (2017) in China aster, Kumar et al. (2024) in Gomphrena, Poulose et al. (2020), Tanya and Kaur (2023) in Marigold and Kumar et al. (2012) in Chrysanthemum.

4. CONCLUSION

High broad sense heritability coupled with high genetic advance as per cent of mean was observed for plant height, secondary branches, leaves, stem girth, days too bud initiation, flower length, individual flower weight, number of flowers and yield plant^{-1}. Parameters like plant spread, number of branches and leaves, flower diameter, inflorescence length, stalk length, duration of flowering and individual flower weight had significantly direct association and positively correlated with yield plant^{-1} of Gomphrena genotypes, thus selection of these characters accounted for improvement in total crop yield.

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