**Estimation of inter relationship among the important heritable yield attributing traits and identification of promising genotypes of teasle gourd *(Momordica subangulata* Blume subsp. *renigera*) under Terai zone of West Bengal.**

**Abstract**

The experiment was conducted during summer seasons at instructional field, Department of Vegetable and Spice Crops, F/Hort., UBKV, Pundibari, CoochBehar. Twenty-five genotypes of teasle gourd *(Momordica subangulata* Blume subsp. *renigera*) were grown in randomized block design with three replications to estimate character association among important heritable traits for establishing the basis of selection and to ascertain promising line for the further crop improvement. Character association and path analysis exhibited that fruits per plant, fruit diameter, fruit length and primary branch could be selection criteria for isolation of germplasm for enhancement of yield. Residual effect estimated in this experiment calculated 0.18 implied contribution of the traits under study was approximately 78% that strongly justified incorporation of traits under study. The Principal Component Analysis minimized the dimension of larger dataset into four components cumulatively contributed 75.15% of the variation towards total variation with 29.84% in PC1 through size of internode, flower and fruit, 23.46% in PC2 through Quantity, yield and early flowering, 12% in PC3 through plant pigments and 9.84% in PC4 through growth and delayed harvesting. It was evident for existing of high degree of diversity among the germplasm available in East India. Among the selected genotypes viz., Nimbong Local 2, Pemling local 1, Malli Dara Local 1, Pedong Local 1, Allipurduar Local 1, Banshihari Local 1 which were attributed for early flowering, fruit size and yield, Pemling local 1considered most promising genotype.

**Keywords: Teasel gourd, Germplasm, Phenotypic Correlation, Genotypic Correlation, Path coefficient, Principle Component Analysis, Yield.**

**1. INTRODUCTION:**

The teasle gourd (*Momordica subangulata* Blume *subsp. renigera*), an allopolyploid belonging to the *Cucurbitaceae* family, developed as a result of hybridization between *M. dioica* (2n = 28) and *M. cochinchinensis* (2n = 28) followed by spontaneous chromosomal doubling (Mondal *et al.,* 2006). Teasle gourd is believed to be originated from India, perennial climber with tuberous roots that is dioecious in nature. Almost all vegetarian and non-vegetarian communities use its good flavour, aroma, and essential oil (Bhuiya et al., 1977). Teasle gourd is propagation through tuber or root propagated and primarily grown in Assam, West Bengal, Bihar, Orissa, North-eastern States, Maharashtra, Gujarat and Andaman Islands (Naik et al., 2014). It is popularly known as Bhat Karela in Assam and kakrol in West Bengal, is a highly valued and commercially significant vegetable crops that is grown for its fruits, which is used as vegetable purposed. In addition to having 84.1% moisture, 33 mg Ca, 42 mg P, 4.6 mg Fe, 1620 μg carotene, a high level of ascorbic acid, 3.1 g protein, 3.1 g fat, 3.0 g fiber, and 1.1 g minerals per 100 g of edible fruit, it also shows good nutritional value (Bhuiya *et al.,* 1977). Although the teasle gourd is a highly nutritious vegetable crop (Ram *et al.,* 2001; Singh *et al.,* 2009), but in India it is still considered as minor or underutilized crops.

While organizing hybridization programs and evaluating individual plants in segregating populations, breeders are interested and many chances for crop improvement through efficient selection of desired features due to in correlation and path coefficient studies between yield and other parameters (Ram *et al.,* 2004). Principal component analysis is a significant genetic diversity assessment technique used for showing the relative genetic variations in the genotype collections of different crop species. On the other hand, multivariate analysis in Indian *Momordica spp*. genotypes is not often reported, despite the potential medicinal and economic values (Dey *et al.* 2007, Shankar *et al.* 2009 and Singh *et al.* 2014). In this view of many advantages, current study was carried out to utilize multivariate analysis to classify a collection of teasle gourd genotypes and there was no research thrust made on teasle gourd improvement along with determination of character association and its utilization in breeding programme in North Bengal. Therefore, present experiment was laid out to estimate character association among important heritable traits for establishing the basis of selection and to ascertain promising line for the further crop improvement.

**2. MATERIALS AND METHODS**

In the present experiment there were twenty five highly diversified germplasm of teasle gourd (*Momordica subangulata* Blume subsp. *renigera*) collected from different parts of West Bengal and Sikkim Himalayan region, were evaluated to estimate character association among important heritable traits and to ascertain promising line for the further crop improvement during (March-July) of 2021 and 2022 at instructional field, Department of Vegetable and Spice Crops, Faculty of Horticulture, U.B.K.V., Pundibari, CoochBehar, West Bengal located at 26 º 40’ N latitude and 89 º 38' E longitudes at 43 m above mean sea level.The soil of the experimental site was sandy clay in texture having neutral pH and there were no significant differences in weather in both the experimental seasons but there was a more rainfall during the second year of experiment. During the experiment the maximum temperature was 34˚C and minimum temperature 19˚C with mean relative humidity of around 70-90%.The experiment was laid out in randomized complete block design with three replications for each treatment maintaining the spacing of 2 meters row to row and 1 meter plant to plant consisting of total 20 plants per treatment. To ensure normal fruit setting, planting materials (tuber) were planted in field at ratio of 10:1 (female: male). The genotypes were raised over trellises, made up of bamboos and nylon strings. All the recommended agronomic package (FYM @ 20t/ha, NPK @ 80: 60: 60 kg/ha) was applied at soil. The N, P and K supplied in the form of urea, single super phosphate and muriate of potash. The irrigation was done just after planting and following with fifteen days interval. Pre-planting weeding was done using herbicide, then done manually 25-30 days after planting and there after surround the crop root zone as per the requirement. Around the root zone at 60 cm radius area soil was raised and mulched; in between two rows irrigation channel of 50 cm was prepared. Used of insecticides and fungicides to protect the crop from pest and diseases attack and protective measures were followed to raise a healthy crop (Bhagat *et al.,* 2017). The data on 10 quantitative parameters, namely vine length (cm), primary branch, internode length (cm), node at first female flower, first harvest, ovary length (cm), fruit length (cm), fruit diameter (cm), number of fruit per plant and yield per plant (kg) were recorded during flower appearance and final harvesting of fruit from five healthy random female plants per treatments. Whereas total chlorophyll contain of leaf (mg/100g) and total chlorophyll contain of fruits (mg/100g) were estimated from the highly homogenized sample prepared from 3rd leaf and fruits from second harvested collected from 10 randomly selected healthy plants through Spectro-photometer. Thereby, recorded data of two consecutive years were pooled and subjected to statistical analysis. Genotypic and phenotypic correlation coefficient and path coefficient for different character combination was performed as per the Aljibour *et al.,* 1958 and Johnson *et al.,* 1955. Principal component analysis of 25 teasle gourd genotypes was performed based on twelve yield and its attributing traits to assess the magnitude of genetic variation.

**3. RESULT AND DISCUSSION:**

In this experiment twelve characters from twenty-five diversified genotypes of teasle gourd (*Momordica subangulata* Blume subsp. *renigera*) were statistically evaluated to understand the inter-relationship among them along with the yield for establishing the basis of crop breeding and isolation of superior genotypes consisted of desirable yield contributing traits. As the basis of selection, character association estimation at the genotypic and phenotypic levels was carried out to understand the interrelationships among the qualities that contribute to growth and yield (Kushwah and Bandhyopadhya, 2005).

Correlation related to present findings was presented (Figure 1). Yield per plant was significantly and positively correlated in both genotypic and phenotypic level with traits like number of fruits per plant (rg=0.63 and rp=0.62), fruit length (rg=0.48 and rp=0.52) and ovary length (rg=0.33 and rp=0.41), while negatively correlated with node at first female flower (rg=-0.44 and rp=-0.52). Similar findings were reported by Bharathi *et al.,* (2005) and Singh *et al.,* (2016). However, positive significant correlation only at genotypic level was also exhibited by vine length (0.37), primary branch (0.28), inter nodal length (0.35) and fruit diameter (0.63); suggested significant effect of these parameters on yield at genotypic level. Vine length was significantly and positively correlated with ovary length (rg=0.29 and rp=-0.42), inter nodal length (rg=0.29) and yield (rg=-0.37). Primary branch was significantly and negatively correlated with node at first female flower (rg=-0.38 and rp=-0.53), first harvest (rg=-0.34 and rp=-0.42), inter nodal length (rp= -0.49) and fruit diameter (rp=-0.46); whereas was significantly and positively correlated at genotypic and phenotypic level with number of fruits per plant (rg=0.47 and rp=0.47). Similarly finding were observed by Bharathi *et al.,* (2005). Internode length was positively and significantly associated with fruit length (rg=0.51 and rp=0.69), ovary length (rg=0.44 and rp=0.66), fruit diameter (rg=0.49 and rp=0.61) and total chlorophyll contain of leaf (rg=0.38 and rp=0.51). At both genotypic and phenotypic level significant and positive association of node first female flower appeared was obtained with first harvest (rg=0.30 and rp=0.44) but was negatively associated with numbers of fruit per plant (rg=-0.67 and rp=-0.75) and yield per plant (rg=-0.44 and rp=-0.52). Ovary length exhibited significant positive correlation at both genotypic and phenotypic for total leaf chlorophyll content (rg=0.41 and rp=0.47) and yield (rg=0.33 and rp=0.41). At both genotypic and phenotypic level significant and positive association of fruit length was observed with fruit diameter (rg=0.50 and rp=0.47), total leaf chlorophyll content (rg=0.49 and rp=0.59), inter nodal length (rg=0.51 and rp=0.69) and yield per plant (rg=0.48 and rp=0.52). Similarly, findings were reported by Rahman *et al.,* (2011), Sinha *et al.,* (2024) and Khan *et al.,* (2009). However, Number of fruits per plant was significantly and negatively in both genotypic and phenotypic correlation with node at first female flower (rg=-0.67 and rp=-0.75) and fruit diameter (rg=-0.33 and rp=-0.57) which were in accordance with the earlier observations reported by Rahman *et al.,* (2011) and Sinha *et al.,* (2024). Among the biochemical traits total chlorophyll contain of leaf in both genotypic and phenotypic level was significantly and positively associated with total chlorophyll contain of fruit (rg=0.63 and rp=0.64), fruit length (rg=0.49 and rp=0.59), inter nodal length (rg=0.38 and rp=0.51) and ovary length (rg=0.41 and rp=0.47). The present findings are supported by the research findings of Khan *et al.,* (2009), Sharma (2015), and Singh *et al.,* (2007).

Path analysis is one of the tools that further divide the correlation coefficient with yield into direct and indirect components in order to better understand the significance of the effect coefficient (Devi *et al.,* 2020). Path coefficient analysis is a multiple regression-based statistical method used to investigate the causal relationship between two or more independent variables and a dependent variable (Sinha *et al.,* 2024). The magnitude of path matrix (Table 1) from the current experiments exhibited the highest positive direct impact on yield per plant through the number of fruits per plant (1.466) followed by fruit diameter (0.794), fruit length (0.554) and primary branch (0.287). Hence, these traits could be considered selection basis for the enhancement of yield. Although, there significant negative indirect effect of fruit size was observed through fruit quantity on yield and *vice versa*, suggested existence of strong contrasting attribute. Although, node at which first female flower appeared exhibited high positive direct effect on yield (0.492) had significant and negative genotypic (-0.44) and phenotypic (-0.52) correlation clearly due to association with high negative indirect effect through number of fruits (-1.101) and primary branch (-0.152). Residual effect estimated in this experiment calculated 0.18 implied contribution of the traits under study was approximately 78% that strongly justified incorporation of traits under study. The reported results are probably the consequence of multiple genes influencing these traits working together. Our findings could be related to those of Sinha *et al.,* (2024), Rahman *et al.,* (2011), khan *et al.,* (2009), Dey *et al.,* (2007), Bhave*et al.,* (2003) and Sharma and Bhutani (2001).

The Principal Component Analysis was performed using 12 traits to obtain reduced numbers of factors accounts maximum variability out of total variability by minimizing the dimension of larger dataset with minimum loss of information. In present experiment total 12 Principal Components were computed in the analysis out of which four had eigen values greater than unity as proposed by Kaiser (1960), those cumulatively explained 75.15% of the variations, suggesting first four principal axes were adequate to explain the maximum variation in reduced dimension (Table 2 and Figure 2). The highest variation was explained by PC1 (29.84%) with an eigen value of 3.58. The principal components PC2, PC3 and PC4 explained variation of 23.46%, 12.00% and 9.84% respectively (Table 2).

The principal component PC1 had maximum loading through size of internode, flower and fruit (Table 2, Figure 4) *viz*., internode length (0.449) followed by fruit length (0.386), fruit diameter (0.362) and ovary length (0.322). The principal component PC2 exhibited maximum loading through Quantity, yield and early flowering *viz*., yield per plant (0.521), number of fruits per plant (0.416) and node at first female flower (-0.416). The principal component PC3 had maximum loading through plant pigments *viz*., total chlorophyll content of mature fruit (0.652) and leaf (0.428).The principal component PC4 had maximum loading through growth and delayed harvesting *viz*., first harvest (0.631) and vine length (0.354). The outcomes presented here are consistent with the findings of Sanwal *et al.* (2008), Singh *et al.* (2008), Singhal *et al.* (2010), Choudhary *et al*. (2011), Rabbani *et al.* (2012), Singh *et al.* (2014), and Jatav *et al.* (2019). Biplot for the twelve important traits of twenty-five germplasm of principle component analysis (Figure 3) exhibited that genotypes collected from a similar location had magnitude of variation almost towards in similar direction excepting the germplasm collected from Coochbehar which were more diversified. Although the genus Momordica from Southeast Asia was reviewed taxonomically (Bharathi *et al.,* 2013; De Wilde and Duyfjes, 2002), but current study revealed existence of distinct quantitative and high morphological divergence between the teasle gourd accessions available in East India, which had not been done in any quantitative studies previously. However, based on the maximum positive magnitude of the loading for different components germplasm Pundibari Local 1, Dinhatta Local 1, Ghoksadanga local 1 were considered suitable for node, flower and fruit size; Nimbong Local 2, Pemling local 1, Malli Dara Local 1, Pedong Local 1, Allipurduar Local 1, Banshihari Local 1 were considered suitable for quantity, yield and early flowering; Balarampur local 1, Ghoksadanga local 2, Kalchini Local 2 were considered suitable for plant pigment and Paiyong Local 1, Bagracoat local 1 were considered suitable for plant growth and delayed harvesting. Although, among all these genotypes Pemling local 1 was found most suitable variety with bigger fruit size and remarkable yield.

**Figure 1:** Genotypic coefficient of correlation (above diagonal) and phenotypic coefficient of correlation (below diagonal) for different traits.



\*Concentration of colour is indication for level of significance at 5%

rg= Genotypic correlation coefficient

rp= Phenotypic correlation coefficient

VL-vine length, PB-primary branch, INL-internode length, NFF-node at first female flower, FH-first harvest, OL-ovary length, FL-fruit length, FD-fruit diameter, NF-number of fruits per plant, TCL-total chlorophyll contains of leaf, TCF-total chlorophyll contains of fruit and YPP-yield per plant.

**Figure 2:** Percentage of variability explained by main principal components



**Figure 3:** Biplot for the 12 quantitative traits with 25 teasle gourd genotypes



**Table 1.** Genotypic Path coefficient of important traits on yield of teasle gourd.

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Charecters | VL | PB | IDL | NFF | FH | OL | FL | FD | NF | TCL | TCF | GenCor(RYPP) |
| VL | **-0.044** | 0.057 | 0.018 | -0.061 | 0.017 | -0.088 | 0.036 | 0.108 | 0.295 | 0.000 | 0.018 | 0.36 |
| PB | -0.009 | **0.287** | -0.038 | -0.260 | 0.094 | -0.002 | -0.169 | -0.363 | 0.692 | -0.001 | 0.006 | 0.24 |
| IDL | -0.010 | -0.140 | **0.077** | 0.150 | -0.085 | -0.138 | 0.381 | 0.485 | -0.483 | 0.013 | 0.023 | 0.27 |
| NFF | 0.005 | -0.152 | 0.024 | **0.492** | -0.099 | -0.008 | 0.066 | 0.261 | -1.101 | 0.002 | -0.010 | -0.52 |
| FH | 0.003 | -0.120 | 0.029 | 0.218 | **-0.225** | -0.059 | -0.043 | 0.077 | -0.163 | 0.003 | 0.024 | -0.26 |
| OL | -0.019 | 0.002 | 0.051 | 0.018 | -0.063 | **-0.208** | 0.315 | 0.251 | 0.024 | 0.012 | 0.025 | 0.41 |
| FL | -0.003 | -0.088 | 0.053 | 0.059 | 0.017 | -0.119 | **0.554** | 0.375 | -0.348 | 0.015 | 0.009 | 0.52 |
| FD | -0.006 | -0.131 | 0.047 | 0.162 | -0.022 | -0.066 | 0.262 | **0.794** | -0.830 | 0.006 | 0.010 | 0.23 |
| NF | -0.009 | 0.136 | -0.026 | -0.370 | 0.025 | -0.003 | -0.132 | -0.449 | **1.466** | -0.008 | -0.007 | 0.62 |
| TCL | -0.001 | -0.017 | 0.039 | 0.042 | -0.026 | -0.097 | 0.324 | 0.194 | -0.449 | **0.025** | 0.067 | 0.10 |
| TCF | -0.008 | 0.015 | 0.017 | -0.047 | -0.051 | -0.049 | 0.049 | 0.077 | -0.094 | 0.016 | **0.105** | 0.03 |

**\*Residual effect: 0.18.**

VL-vine length, PB-primary branch, INL-internode length, NFF-node at first female flower, FH-first harvest, OL-ovary length, FL-fruit length, FD-fruit diameter, NF-number of fruits per plant, TCL-total chlorophyll contains of leaf, TCF-total chlorophyll contains of fruit and YPP-yield per plant.

**Table 2:** Eigen values, percentage of variance and cumulative variance of first four principal components of Teasel gourd

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Eigen components** | **PC1** | **PC2** | **PC3** | **PC4** |
| Eigenvalue | 3.58 | 2.82 | 1.44 | 1.18 |
| Variance (%) | 29.84 | 23.46 | 12.00 | 9.84 |
| Cumulative (%) | 29.84 | 53.30 | 65.30 | 75.15 |
| **Principle components variable** | **PC1** | **PC2** | **PC3** | **PC4** |
| VL | 0.098 | 0.308 | -0.031 | 0.354 |
| PB | -0.255 | 0.321 | 0.181 | -0.148 |
| IDL | 0.449 | 0.100 | -0.101 | 0.173 |
| NFF | 0.252 | -0.416 | -0.084 | 0.130 |
| FH | 0.180 | -0.197 | 0.302 | 0.631 |
| OL | 0.322 | 0.267 | 0.102 | 0.265 |
| FL | 0.386 | 0.192 | -0.241 | -0.283 |
| FD | 0.362 | 0.001 | -0.337 | -0.099 |
| NF | -0.283 | 0.416 | 0.027 | 0.296 |
| TCL | 0.349 | 0.113 | 0.428 | -0.372 |
| TCF | 0.187 | 0.123 | 0.652 | -0.140 |
| YPP | 0.081 | 0.521 | -0.259 | 0.037 |

**Table 3:** First four principal components towards variation with 12 different characters

|  |  |  |  |
| --- | --- | --- | --- |
| Components | Characters | Category | Maximum contribution |
| PC1 | Internode length, ovary length, fruit length and fruit diameter. | Node, flower and fruit size | Pundibari Local 1, Dinhatta Local 1, Ghoksadanga local 1 |
| PC2 | number of fruits per plant, yield per plant and (-) node at first female flower. | Quantity, yield and early flowering | Nimbong Local 2, Pemling local 1, Malli Dara Local 1, Pedong Local 1, Allipurduar Local 1, Banshihari Local 1, |
| PC3 | Primary branch, Total chlorophyll contains of leaf and total chlorophyll contain of fruit | Plant pigment | Balarampur local 1, Ghoksadanga local 2, Kalchini Local 2 |
| PC4 | Vine length and first harvest | Growth and delayed harvesting | Paiyong Local 1, Bagracoat local 1 |

**4. CONCLUSION:**

Present experiment was clearly evident for existence of high degree of diversity among the genotypes of Teasel gourd collected from eastern India and characters *viz*., fruits per plant, fruit diameter, fruit length and primary branch could be most effective in isolation of germplasm with higher yield. Among the twenty-five genotypes, total six genotypes *viz*., Nimbong Local 2, Pemling local 1, Malli Dara Local 1, Pedong Local 1, Allipurduar Local 1, Banshihari Local, Pemling local 1 considered as most promising germplasm with respect to early flowering, fruit size and yield.

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