**Analysis of Genetic Variability, Correlation and Path Coefficients for various agronomic and quality traits in Bottle Gourd [Lagenaria siceraria (Molina) Standl.] Genotypes**

**ABSTRACT**

The study was conducted during *Kharif* season of 2023 in the Experiment Field of Urban Technological Park Habbak, Srinagar, Jammu & Kashmir. The experiment was conducted based on Randomized Complete Block Design (RCBD) with three replications and a plant spacing of 2 × 1 m. A total of 41 bottle gourd genotypes, 2 of which were checks – Pusa Naveen and Pusa Santushti, were studied. Observations were taken on growth, yield attributes, seed traits and quality parameters. Analysis of variance showed considerable differences exist among the genotypes for all the traits. The phenotypic coefficient of variation (PCV) was found marginally greater than the genotypic coefficient of variation (GCV) for all the traits, which indicates insignificant environmental influence. For the seed cavity width the highest PCV and GCV values were recorded 56.43 and 56.33 respectively.  The high estimates of heritability along with high genetic gain were observed in fruit diameter (0.990 and 79.83) which suggests that selection would be effective due to the predominance of additive genetic effects. Broad-sense heritability estimates across all the traits appeared high ranging from 77% to 99%. Correlation analysis revealed strong positive relationship between fruit yield per hectare and fruit yield per plant, average fruit weight, vine length, number of primary branches, and number of fruits per plant. The assessment by the path coefficient analysis results showed that the strongest direct effects were: average fruit weight, number of primary branches, number of fruits per plant, and vine length on the yield per hectare.

***Keywords****:* ***Bottle gourd; correlation; genetic advance; genetic variability; heritability; path analysis.***

1. **INTRODUCTION**

The bottle gourd [*Lagenaria siceraria* (Molina)Standl.], which belongs to the family of Cucurbitaceae, is one of the most important gourds in tropical and subtropical agriculture. This is because it has been grown for many centuries and has been cultivated for various reasons including dietary, cultural, medicinal and practical (Brdar-Jokanović *et al.,*2024) . In India Bihar, Uttar Pradesh, and Madhya Pradesh have stand out as major producers which illustrates the adaptability of the crop to different soils, climates and other agricultural conditions. As reported by National Horticulture Board (NHB) India’s total output stands at 3444.54 thousand metric tonnes of which Bihar contributes 17.29%, Madhya Pradesh 14.71%, and Uttar Pradesh 14.47%. This implies the importance of the crop in the country’s production of vegetables and the economic welfare of the farmers and the rest of the people in the country (NHB, 2023-2024).

The genetics of bottle gourd is quite fascinating, because it shows great diversity in traits such as fruit yield, vine length, fruit weight, and others. This variability is caused mostly by its out crossing behavior which had been averaging between 60–80% in previous studies (Harika *et al.*,2012; Khansa *et al.,*2024). Such a high level of out crossing increases genetic diversity which allows for unprecedented opportunities for the breeders to evaluate and improve upon economically and agriculturally important traits (Islam *et al.,*2021). All of these factors also dictate how much the total yield is and where the crop can be grown and how well the crop will perform in terms of quality and resilience.

Yield, being a complex quantitative trait, is influenced by a plethora of genetics and environmental effects. Effective breeding programs require detailed knowledge about these effects, especially about associations between the yield and its determinants. Through analysis of these associations, breeders can set out selection priorities for the required targets and assist in the development of better genotypes. Correlation analysis is among the tools which are important in the understanding of the relationships among the traits. For example, if fruit weight, number of fruits per plant, and yield exhibit strong positive correlation, then the traits are important components in selection approaches. But correlation is also not enough in this regard, as it does not distinguish between the direct and indirect cause for the yield (Kumar *et al.*,2012).

The path coefficient analysis enhances correlation studies by decomposing relationships into direct and indirect effects, providing clearer insights into how particular attributes influence yield (Mashilo *et al.*,2016). This perspective also allows the selection of traits that are most likely to be critical to the overall success of the selection and therefore enhances efficiency of the selection process. For instance, even though traits such as fruit length or vine length are likely to be more related in the harvest, their effect on the yield may be overshadowed by the number of fruits per plant. By considering only those traits that have the highest direct effect, breeders are enabled to make logical decisions and standards thus saving on resources and breeding efforts.

The variability and environmental sensitivity inherent in bottle gourd further necessitate precise genetic investigations. Distinguishing between traits that are heritable and those that are largely environmentally determined is important for success of breeding programs. The quantitative analyses of genotypic and phenotypic coefficients of variation are informative regarding the amount of variability existing for the trait. With heritability and genetic advance estimates, such analyses allow breeders to assess which traits are likely to respond positively to selection (Dubey *et al.*,2022). Such a trait measured with high heritability and significant genetic advance is likely to be ideal for improvement having strong genetic base.

Like many other polygenic crops, the bottle gourd has a rather intricate genetic mechanism which adds to the complexity of its breeding. Such traits as yield and fruit quality, being polygenic, require a more in depth examination of the genotype of the crop. This requires screening large numbers of genotypes over a number of different environments for the best ones. The identification and utilization of such genotypes becomes very crucial to the increase in yield potential in a given agro-climatic zone.

The present study is aimed at evaluating genetic diversity, correlation, and path coefficient among bottle gourd genotypes with respect to yield and its related components. The systematic study of relations among traits enhances the understanding of genetic systems that control the yield of the crop among the breeders. It is this understanding that forms the start point towards the breeding of superior genotypes adaptable to certain agro-climatic conditions thereby increasing the economic viability of bottle gourd farming.

**2. MATERIAL AND METHODS**

The study was conducted during the *Kharif* season of 2023 at the Urban Technological Park, Habbak, Srinagar, Jammu and Kashmir. The latitude and longitude of the site are 34.16° N and 74.83° E respectively, with an elevation of 1608 meters above mean sea level. This area has a temperate climate, with warm summers, a low of 5.26°C in October, and a high of 31.40°C in August. The area had the highest rainfall in the month of April. Yield and yield components evaluation was carried out on forty-one morphologically diverse bottle gourd genotypes comprising of two checks Pusa Naveen and Pusa Santushti. A randomized complete block design (RCBD) was employed for the single-factor experiment. Standard cultural practices, including appropriate manuring, irrigation, pest management, and weeding, were undertaken according to the recommended agronomic practices to ensure maximum growth of the crop.

Observations were recorded from five randomly selected plants per genotype per replication on various phenological, vegetative, and yield parameters. The evaluated traits included node number at which the Ist male flower appears, node number at which the Ist female flower appears, number of primary branches, days to the appearance of the Ist male flower, days to the appearance of the Ist female flower, days to anthesis of the Ist male flower, days to anthesis of the Ist female flower, sex ratio (male to female flowers), days to the Ist fruit harvest, days to the last fruit harvest, vine length (m), number of fruits per plant, average fruit weight (kg), fruit length (cm), fruit diameter (cm), seed cavity width (cm), flesh thickness (cm), rind thickness (mm), seed cavity weight (g), flesh weight (g), fruit yield per plant (kg), fruit yield per hectare (q), number of seeds per fruit, 100 seed weight (g), total sugars (%), dry matter content (%), Vitamin C content (mg/100 g), total soluble solids (°Brix), chlorophyll content (mg/100 g), and crude fiber content (%).

The analysis of variance (ANOVA) was carried out following the guidelines set by Panse and Sukhatme (1957). The method suggested by Johnson et al. (1955) was used to calculate genotypic and phenotypic variance. The phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) in respect of each trait were computed according to Burton’s formula (Burton, 1952). These coefficients were categorized according to the classes established by Sivasubramanian and Menon (1973) into three levels low (0–10%), moderate (10–20%) and high (above 20%). Broad–sense heritability was evaluated using the method suggested by Burton and Devane (1953) and the heritability levels were classified as low (0–30%), moderate (30–60%) and high (above 60%), as recommended by Robinson et al. (1949). The genetic advance at 5% selection intensity was worked out according to the equations given by Lush (1949) and Johnson et al. (1955).In addition to that, the genetic advance as a percentage of the mean was classified as low (0–10%), moderate (10–20%) and high (above 20%) on the basis of the classification by Johnson et al.(1955)

Genotypic and phenotypic correlation coefficients were estimated using the method of Panse and Sukhatme (1957). For path coefficient analysis, the methodologies of Wright (1921) and Li (1956) were employed. All the statistical treatment and analysis were done with the help of R software at the Division of Agricultural Statistics, SKUAST-kashmir, Shalimar.

**3. RESULTS AND DISCUSSION**

Forty-one genotypes of bottle gourd in this study were examined to understand genetic variability, heritability, genetic advance (expressed as percentage of mean), correlation and path analysis. Results of the analysis of variance indicated significant differences in all thirty traits, suggesting that the germplasm under investigation possessed sufficient variability. [Table 1 (a, b)]. The observed range of values for various traits (Table 2) demonstrated ample genetic variability, a critical prerequisite for selection. These findings align with previous studies by Harika *et al.* (2012), Jain and Singh (2016), Jain *et al.*(2017), Rambabu *et al.* (2017), Kumar *et al.* (2018), Khan *et al.* (2020), Rashid *et al.* (2020a), Sohi et al. (2021), Dubey *et al.* (2022), Khansa *et al.* (2024), and Das *et al.* (2024).

The observed variability in phenotypes is a combination of genetic, environmental factors, and genotype x environment interactions, which necessitates the subdivision of the variability into phenotypic and genotypic coefficient of variation in order to gain insights into the heritable aspects. The estimates for these coefficients, provided in Table 2, indicated that phenotypic and genotypic coefficients of variation were indeed similar in their values, although the former was slightly greater, thus indicating the influence of the environment on expression of the trait. These findings are consistent with reports by Damor *et al.* (2016), Rambabu *et al.* (2017), Khan *et al.* (2020), Rashid *et al.* (2020a), Chandramouli *et al.* (2021), and Khansa *et al.* (2024).

Characters with moderate to high coefficients of variation have more potential for selection improvement. High phenotypic and genotypic coefficients of variation combined with a wide range of variability suggest a significant contribution of additive genetic variance, making the trait more heritable and responsive to selection. Although the phenotypic coefficients of variation were slightly higher than genotypic coefficients, the narrow difference suggests that most of the variation observed was genetic rather than environmental. Similar findings were reported by Deepthi *et al.* (2016), Damor *et al.* (2016), Rambabu *et al.* (2017), Ahmad *et al.* (2019), Rashid *et al.* (2020a), and Duhan *et al.* (2022).

Low values of phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) were noted for traits such as days to last fruit harvest (2.82, 2.81), days to anthesis of the Ist female flower (5.63, 5.55), days to Ist fruit harvest (5.75, 5.72), days to appearance of the Ist female flower (5.81, 5.71), days to anthesis of the Ist male flower (6.50, 6.43), days to appearance of the Ist male flower (6.59, 6.53) and flesh weight (9.81, 9.61). These findings align with those of Pandey *et al.* (2021) and Khansa *et al.* (2024).

Moderate values of PCV and GCV were observed for crude fiber content (11.158, 10.954), vine length (11.54, 10.24), node number at which the Ist female flower appears (13.48, 13.20), vitamin C content (13.511, 13.504), node number at which the Ist male flower appears (13.58, 13.12), sex ratio (15.14, 14.95), fruit yield per plant (17.85, 15.76), fruit yield per hectare (19.32, 16.95), total soluble solids (TSS) (19.455, 19.424), dry matter content (19.714, 19.710) and rind thickness (19.95, 19.04), indicating a moderate level of variability within the genetic material studied. Similar observations were reported by Chikkeri *et al.* (2018) and Dubey *et al.* (2022).

High values of PCV and GCV were recorded for traits such as seed cavity width (56.43, 56.33), fruit diameter (39.14, 38.95), number of seeds per fruit (35.25, 35.10), total sugars (29.887, 29.858), flesh thickness (28.90, 27.01), number of fruits per plant (24.90, 24.46), average fruit weight (24.36, 24.13), chlorophyll content (22.439, 22.402), fruit length (22.19, 22.13), seed cavity weight (22.19, 22.15), 100 seed weight (20.85, 20.71) and number of primary pranches (20.97, 20.95), indicating a broad genetic base for these traits. Similar results were observed by Deepthi *et al.* (2016) and Chandrashekhar *et al.* (2018).

Those with relatively high coefficients of variation might have a good possibility to be improved through selection. High variability and a substantial coefficient of variation, especially both phenotypic as well as genotypic, would suggest that the said characteristics are likely to be under selection. However, inheritability cannot be fully determined solely based on phenotypic and genotypic coefficients of variation. Therefore, heritability would be a better estimate for breeders because it splits the environmental effects from total variability, thus making it possible to determine more accurately the selection pressure. Together with genetic advance, as suggested in previous studies, selection becomes more effective in improving desirable traits.

Selection progress is very closely associated with genetic gain. High heritability along with high genetic advance as a percentage of the mean makes traits ideal for selection due to additive genetic effects. On the contrary, high heritability with low genetic advance reveals that there is a strong predominance of non-additive genetic action, where environmental factors are likely to be important and selection would be less effective. Similarly, low heritability with a high genetic advance indicates the masking of additive genetic effects due to environmental influences that, nonetheless, still provide grounds for selection. Still, traits with low heritability and low genetic advance are mainly controlled by the environment and, therefore, are ineffective for selection.

In this study, the values of broad-sense heritability were high for all traits, ranging from 77% to 99%, meaning that environmental influence was minimal and traits were effectively transmitted to the progeny. This demonstrates the importance of genetic factors in the expression of traits and their potential use in phenotypic selection.These findings are consistent with those of Emina et al. (2012), Sharma and Sengupta (2013), Singh *et al.* (2014), Sultana *et al.* (2018), Rashid *et al.* (2020a), Chikkeri *et al.* (2018), Varalakshmi *et al.* (2018), and Khansa *et al.* (2024).

Traits like the node number for the appearance of Ist male and female flowers, number of primary branches, sex ratio, number of fruits per plant, average fruit weight, fruit length, fruit diameter exhibited high heritability along with high genetic advance as percentage of mean (GAM). Similarly, seed cavity width, flesh thickness, rind thickness, seed cavity weight, fruit yield per plant, fruit yield per hectare, number of seeds per fruit, 100-seed weight, total sugars, dry matter content, vitamin C content, total soluble solids (TSS), chlorophyll content, and crude fiber content demonstrated these genetic parameters. These traits would therefore be largely under additive genetic influence and amenable to strong improvement through selection. These findings align with those of Rambabu *et al.* (2017), Chandrashekhar *et al.* (2018), Kumar *et al.* (2020), Rashid *et al.* (2020a), Singh *et al.* (2023) and Khansa *et al.* (2024).

Of these, fruit yield per hectare is particularly important in assessing the commercial potential of a variety or hybrid and is considered a key objective in breeding program. The combination of having high heritability with high GAM for this trait indicates that selection of high-yielding genotypes from the current germplasm collection may be a viable strategy. Similar observations have been reported by Singh *et al.* (2014), Damor *et al.* (2016), Rambabu *et al.* (2017), Varalakshmi *et al.* (2018), Ahmad *et al.* (2019), Singh *et al.* (2021), and Kumar *et al.* (2024).

Yield improvement remains the cornerstone of crop breeding, as it is a primary objective for any plant breeder. Yield, being a polygenic trait, is heavily influenced by environmental factors, necessitating a comprehensive understanding of its association with other quantitative traits. While variability studies highlight the potential for improvement in specific traits, they do not provide insights into the relationships between these traits and economically important characteristics such as yield. To make effective indirect selections for enhancing economic traits, it is vital to analyze the interrelationships between various attributes and yield-related factors.

The purpose of correlation studies is to understand the relationships between high heritability traits and economically important characteristics, throwing light on their contribution to the genetic framework of a crop. Phenotypic correlations refer to the degree of association between two traits, which involves both genetic and environmental factors that, at times, mask the underlying genetic relationship. Genotypic correlations analyze genetic associations between traits in the same way but yield more clear-cut insights of interaction between the genes controlling them. These are very crucial to determine an efficient selection approach. The relationships among traits with respect to their linkage with fruit yield per hectare at genotypic and phenotypic levels were estimated as correlation coefficients from variances and covariances. Table 3 provides the genotypic (rg) and phenotypic (rp) correlation coefficients for various traits.

Fruit yield per hectare, a major yield-related economic trait, had showed positive and significant correlations with multiple attributes, including the number of primary branches, days to last harvest, vine length, number of fruits per plant, average fruit weight, fruit length, fruit diameter, seed cavity weight, flesh weight, and also fruit yield per plant at both levels of genotypic as well as phenotypic. In addition, a high positive phenotypic correlation was observed between fruit yield per hectare and 100-seed weight. These results align with findings from previous studies conducted by Deepthi *et al.* (2012), Janaranjani and Kanthaswamy (2015), Thakur *et al.* (2017), Panigrahi *et al.* (2018), Sultana *et al.* (2018), Kunjam *et al.* (2019), Abhishek *et al.* (2020), Chouhan *et al.* (2020), Rashid *et al.* (2020b), Duhan *et al.* (2022), and Khansa *et al.* (2024).

The nature of the relationships between component traits and yield is illustrated in correlation analysis, which explains only general associations without causality. Path coefficient analysis, originated by Wright (1921) and developed further by Dewey and Lu (1959), breaks down correlation coefficients into direct and indirect effects of the traits to yield. This technique assesses the direct influence of one trait on another, providing breeders with clear understanding of key yield contributing traits to optimize the application of genetic resources for selective improvement.

When the correlation coefficient between a causal factor and its outcome is close to its direct effect, and both are statistically significant, this indicates a true relationship; hence, selection for that trait will be effective. If a positive correlation has arisen from a negative or negligible direct effect, indirect effects are implicated, and therefore, they need to be considered in the selection. In cases where there is a negative correlation but the direct effect is positive and significant, the restricted simultaneous selection method is suggested to reduce the adverse indirect impacts while leveraging the direct impact. In cases where both the correlation and direct effect are negative, selection based on the trait is not recommended.

The path analysis in this study identified average fruit weight (0.810) as having the most substantial direct positive effect on fruit yield per hectare, followed by the number of primary branches (0.808), number of fruits per plant (0.780), vine length (0.694), and flesh weight (0.553). Genotypic correlations for these traits with fruit yield per hectare were 0.848, 0.810, 0.799, 0.824, and 0.684, respectively, confirming that direct selection for these traits is likely to enhance yield in bottle gourd. Conversely, traits like days to appearance of the first male flower (-0.809), days to appearance of the first female flower (-0.775), and days to anthesis of the first male flower (-0.773) demonstrated negative direct effects, suggesting limited relevance in selection programs for bottle gourd improvement. The results, which break down the genotypic correlation coefficients into direct and indirect effects on yield, are presented in Table 4.

These findings are consistent with earlier studies conducted by Deepthi *et al.* (2012), Janaranjani and Kanthaswamy (2015), Muralidharan *et al.* (2017), Thakur *et al.* (2017), Sultana *et al.* (2018), Kunjam *et al.* (2019), Rashid *et al.* (2020b), Singh *et al.* (2020), and Khansa *et al.* (2024). The residual effect was calculated at 0.025, indicating that the selected traits significantly account for yield variability. Similar minimal residual effects were also observed in bottle gourd studies by Kunjam *et al.* (2019).

**4. CONCLUSION**

The analysis of variance showed highly significant differences for all traits studied. The phenotypic and genotypic coefficients of variation ranged between 2.82 and 56.43 and between 2.81 and 56.33, respectively, indicating minimal environmental influence on the traits' expression. High estimates of heritability (77–99%) across all the traits indicated significant genetic influence, though non-additive genetic effects may also contribute. Correlation analysis revealed significant positive associations (at 1% and 5% level of significance) between fruit yield per hectare and various traits including number of primary branches, vine length and average fruit weight, but negative correlations were observed with flower appearance and days to first fruit harvest. Path coefficient analysis revealed that the greatest direct effect on fruit yield was from average fruit weight. Since selection efficiency depends on both heritability and genetic gain, the efficiency of selection for average fruit weight, as well as for the number of fruits per plant and vine length, should be assessed based on their genetic parameters to make meaningful genetic improvement in bottle gourd varieties.

**Table 1(a): Analysis of variance for various agronomic and quality characters in bottle gourd [*Lagenaria siceraria* (Molina) Standl.]**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Mean sum of squares** | | | | | | | | | | | | | | | | | |
| **Source of Variation** | **d.f** | **Node no. at which 1st male flower appears** | **Node no. at which 1st female flower appears** | **No. of primary branches** | **Days to appearance of 1st male flower** | **Days to appearance of 1st female flower** | **Days to anthesis of 1st male flower** | **Days to anthesis of 1st female flower** | **Sex Ratio** | **Days to 1st Fruit Harvest** | **Days to Last Fruit Harvest** | **Vine Length (m)** | **No. ofFruits /Plant** | **Average Fruit Weight (kg)** | **Fruit Length (cm)** | **Fruit Diameter (cm)** |
| **Blocks** | 2 | 0.432 | 0.958 | 2.290 | 0.101 | 0.671 | 0.298 | 0.442 | 0.304 | 5.577 | 8.508 | 0.903 | 0.461 | 0.013 | 0.023 | 1.386 |
| **Treatments** | 40 | 2.806 \*\* | 4.852\*\* | 31.452\*\* | 29.223\*\* | 27.640\*\* | 33.326\*\* | 29.119\*\* | 5.111\*\* | 52.653 \*\* | 48.953\*\* | 1.345 \*\* | 8.333 \*\* | 0.397\*\* | 234.483 \*\* | 27.227\*\* |
| **Error** | 80 | 0.066 | 0.067 | 0.016 | 0.164 | 0.319 | 0.242 | 0.276 | 0.043 | 0.183 | 0.172 | 0.110 | 0.100 | 0.002 | 0.416 | 0.090 |

\*\*= Significant at 1%

**Table 1(b): Analysis of variance for various agronomic and quality characters in bottle gourd [*Lagenaria siceraria* (Molina) Standl.]**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Mean sum of squares** | | | | | | | | | | | | | | | | |
| **Source of Variation** | **d.f** | **Seed cavity length (cm)** | **Flesh Thickness (cm)** | **Rind Thickness (mm)** | **Seed Cavity Weight (g)** | **Flesh Weight (g)** | **Fruit Yield/ Plant (kg)** | **Fruit Yield/ Hectare (q)** | **No. of Seeds/ Fruit** | **100 Seed Weight (g)** | **Total Sugars (%)** | **Dry Matter content (%)** | **Vitamin C content (mg/100g)** | **TSS (0Brix)** | **Chlorophyll content (mg/100g)** | **Crude Fiber content (%)** |
| **Blocks** | **2** | 0.013 | 0.023 | 1.386 | 0.781 | 0.229 | 0.559 | 111.700 | 107.700 | 2.395 | 0.073 | 0.073 | 0.027 | 0.072 | 0.367 | 0.037 |
| **Treatments** | **40** | 0.397\*\* | 234.483 \*\* | 27.227\*\* | 20.616 \*\* | 0.769\*\* | 0.876\*\* | 16767.800 \*\* | 16405.100 \*\* | 7.495\*\* | 1.083 \*\* | 5.196 \*\* | 3.458 \*\* | 1.688 \*\* | 270.336\*\* | 0.089\*\* |
| **Error** | **80** | 0.002 | 0.416 | 0.090 | 0.023 | 0.035 | 0.028 | 1.200 | 1.700 | 0.418 | 0.001 | 0.001 | 0.001 | 0.002 | 0.296 | 0.001 |

\*\*= Significant at 1%

**Table 2: Estimates of mean, range, phenotypic variance, genotypic variance, phenotypic and genotypic coefficients of variation, heritability and genetic advance (as % of mean) for various characters in bottle gourd [*Lagenaria siceraria* (Molina) Standl.]**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **S.no** | **Parameter** | **Mean** | **Range** | **Phenotypic variance (σ2p)** | **Genotypic variance (σ2g)** | **Phenotypic coefficient of variation (PCV) (%)** | **Genotypic coefficient of variation (GCV) (%)** | **Heritability h2 (broad sense)** | **Genetic gain (Genetic advance as % of mean)** |
| **1.** | Node number at which 1st male flower appears | 7.26 | 5.40 - 8.60 | 0.980 | 0.913 | 13.58 | 13.12 | 0.932 | 26.09 |
| **2.** | Node number at which 1st female flower appears | 9.55 | 7.33 - 12.20 | 1.662 | 1.595 | 13.48 | 13.20 | 0.960 | 26.65 |
| **3.** | Number of primary branches | 15.44 | 10.40 - 21.27 | 10.495 | 10.479 | 20.97 | 20.95 | 0.999 | 43.13 |
| **4.** | Days to appearance of 1st male flower | 47.00 | 40.13 - 51.67 | 9.850 | 9.686 | 6.59 | 6.53 | 0.983 | 13.34 |
| **5.** | Days to appearance of 1st female flower | 51.82 | 44.80 - 56.53 | 9.426 | 9.107 | 5.81 | 5.71 | 0.966 | 11.57 |
| **6.** | Days to anthesis of 1st male flower | 51.08 | 44.53 - 55.47 | 11.270 | 11.028 | 6.50 | 6.43 | 0.979 | 13.10 |
| **7.** | Days to anthesis of 1st female flower | 55.17 | 48.60 - 59.73 | 9.891 | 9.615 | 5.63 | 5.55 | 0.972 | 11.28 |
| **8.** | Sex ratio | 8.69 | 6.55 - 10.63 | 1.732 | 1.690 | 15.14 | 14.95 | 0.976 | 30.42 |
| **9.** | Days to 1st fruit harvest | 73.20 | 63.20 - 78.73 | 17.673 | 17.490 | 5.75 | 5.72 | 0.990 | 11.72 |
| **10.** | Days to last fruit harvest | 143.74 | 134.53 - 149.80 | 16.432 | 16.261 | 2.82 | 2.81 | 0.990 | 5.75 |
| **11.** | Vine length (m) | 6.25 | 5.32 - 7.89 | 0.522 | 0.411 | 11.54 | 10.24 | 0.789 | 18.74 |
| **12.** | Number of fruits/ plant | 6.75 | 3.60 - 10.40 | 2.845 | 2.744 | 24.90 | 24.46 | 0.965 | 49.50 |
| **13.** | Average fruit weight (kg) | 1.50 | 0.90 - 2.25 | 0.134 | 0.132 | 24.36 | 24.13 | 0.981 | 49.25 |
| **14.** | Fruit length (cm) | 39.92 | 14.00 - 60.67 | 78.438 | 78.022 | 22.19 | 22.13 | 0.995 | 45.46 |
| **15.** | Fruit diameter (cm) | 7.72 | 4.65 - 16.03 | 9.136 | 9.046 | 39.14 | 38.95 | 0.990 | 79.83 |
| **16** | Seed cavity width (cm) | 4.66 | 2.22 - 12.75 | 6.887 | 6.865 | 56.43 | 56.33 | 0.997 | 22.85 |
| **17** | Flesh thickness (cm) | 1.83 | 1.23 - 2.65 | 0.280 | 0.244 | 28.90 | 27.01 | 0.873 | 51.99 |
| **18** | Rind thickness (mm) | 2.80 | 1.55 - 3.85 | 0.311 | 0.283 | 19.95 | 19.04 | 0.911 | 37.44 |
| **19** | Seed cavity weight (g) | 361.13 | 200.59 - 622.54 | 5590.056 | 5588.847 | 22.19 | 22.19 | 0.999 | 45.70 |
| **20** | Flesh weight (g) | 866.39 | 509.75 - 1301.55 | 5469.472 | 5467.815 | 9.81 | 9.81 | 0.999 | 20.21 |
| **21** | Fruit yield/ plant (kg) | 9.74 | 4.24 - 14.52 | 3.035 | 2.359 | 17.85 | 15.76 | 0.780 | 23.30 |
| **22** | Fruit yield/ ha (q) | 485.74 | 221.21 - 714.58 | 8814.264 | 6786.983 | 19.32 | 16.95 | 0.770 | 34.93 |
| **23** | No. of seeds/ fruit | 298.35 | 108.27 - 544.27 | 11192.424 | 11191.277 | 35.25 | 35.10 | 0.886 | 72.61 |
| **24** | 100 seed weight (g) | 20.46 | 11.87 - 26.66 | 18.139 | 17.907 | 20.85 | 20.71 | 0.992 | 42.39 |
| **25** | Total sugars (%) | 2.01 | 1.13 - 2.99 | 0.361 | 0.361 | 29.887 | 29.858 | 0.998 | 61.448 |
| **26** | Dry matter content (%) | 6.68 | 4.20 - 8.73 | 1.733 | 1.732 | 19.714 | 19.710 | 0.999 | 40.593 |
| **27** | Vitamin C content (mg/100g) | 7.95 | 6.20 - 10.10 | 1.154 | 1.152 | 13.511 | 13.504 | 0.997 | 27.804 |
| **28** | TSS (0Brix) | 3.86 | 2.24 - 4.93 | 0.564 | 0.562 | 19.455 | 19.424 | 0.999 | 39.948 |
| **29** | Chlorophyll content (mg/100g) | 42.35 | 25.37 - 64.21 | 90.309 | 90.013 | 22.439 | 22.402 | 0.996 | 46.072 |
| **30** | Crude fiber content (%) | 1.56 | 1.28 - 1.83 | 0.030 | 0.029 | 11.158 | 10.954 | 0.964 | 22.155 |

**Table 3: Estimates of genotypic correlation (Above diagonal) and phenotypic correlation (Below diagonal) coefficients among different characters in bottle gourd [*Lagenaria siceraria* (Molina) Standl.]**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **NMA** | **NFA** | **NOPB** | **DAPMF** | **DAPFF** | **DAMF** | **DAFF** | **SR** | **DFFH** | **DLFH** | **VL** | **NOFPP** | **AFW** | **FL** | **FD** | **SCWD** | **FT** | **RT** | **SCW** | **FLW** | **FYPP** | **NOSPF** | **100SW** | **FYPH** |
| **NMA** | **-** | **0.871\*\*** | **0.348 \*\*** | **0.181** | **-0.168** | **0.186** | **0.`179** | **-0.419 \*\*** | **0.159** | **0.145** | **0.874 \*\*** | **0.504 \*\*** | **0.02** | **-0.211** | **0.132** | **0.143** | **0.136** | **0.093** | **0.237** | **0.203** | **-0.680 \*\*** | **-0.158** | **-0.264\*\*** | **-0.760\*\*** |
| **NFA** | **0.821\*\*** | **-** | **0.170** | **0.173** | **0.173** | **0.178** | **0.181** | **0.325 \*** | **0.155** | **0.140** | **0.180** | **-0.375 \*** | **-0.093** | **-0.158** | **0.223** | **0.232** | **0.269** | **0.018** | **0.105** | **0.118** | **-0.648 \*\*** | **-0.167** | **-0.170** | **-0.686\*\*** |
| **NOPB** | **0.218 \*\*** | **0.169** | **-** | **-0.169** | **-0.186** | **-0.198** | **-0.186** | **0.359\*** | **0.199** | **-0.148** | **0.826\*\*** | **0.455 \*\*** | **0.712\*\*** | **0.118** | **0.260 \*\*** | **-0.258** | **-0.179** | **-0.055** | **0.134** | **-0.041** | **0.712 \*\*** | **0.795\*\*** | **0.206** | **0.810\*\*** |
| **DAPMF** | **0.177** | **0.168** | **-0.166** | **-** | **0.989\*\*** | **0.979\*\*** | **0.975\*\*** | **0.169** | **0.661\*\*** | **0.480\*\*** | **0.150** | **-0.165** | **-0.089** | **-0.226** | **0.208** | **0.189** | **0.302** | **0.008** | **0.136** | **0.188** | **-0.728\*\*** | **-0.144** | **-0.145** | **-0.809\*\*** |
| **DAPFF** | **-0.161** | **0.170** | **-0.179** | **0.964 \*\*** | **-** | **0.981\*\*** | **0.994 \*\*** | **0.138** | **0.653\*\*** | **0.487\*\*** | **0.146** | **-0.157** | **-0.040** | **-0.208** | **0.366\*** | **0.143** | **0.299** | **-0.013** | **0.098** | **0.227** | **-0.688 \*\*** | **-0.198** | **-0.198** | **-0.775\*\*** |
| **DAMF** | **0.17** | **0.176** | **-0.188** | **0.965\*\*** | **0.962\*\*** | **-** | **0.979 \*\*** | **0.143** | **0.622\*\*** | **0.502\*\*** | **-0.192** | **-0.149** | **-0.037** | **-0.148** | **0.402\*\*** | **0.147** | **0.132** | **0.010** | **0.080** | **0.175** | **-0.686\*\*** | **-0.179** | **-0.183** | **-0.773\*\*** |
| **DAFF** | **-0.172** | **0.179** | **-0.183** | **0.954\*\*** | **0.980\*\*** | **0.964\*\*** | **-** | **-0.146** | **0.666\*\*** | **0.499 \*\*** | **-0.193** | **-0.149** | **-0.012** | **-0.219** | **0.371\*** | **0.139** | **0.130** | **-0.033** | **0.125** | **0.215** | **-0.659\*\*** | **-0.181** | **-0.183** | **-0.747 \*\*** |
| **SR** | **-0.400 \*\*** | **0.314 \*\*** | **0.356 \*\*** | **0.152** | **0.137** | **0.132** | **-0.135** | **-** | **-0.184** | **-0.132** | **0.401\*\*** | **0.615\*\*** | **-0.153** | **-0.168** | **0.003** | **-0.059** | **0.044** | **-0.146** | **0.061** | **-0.192** | **-0.402\*\*** | **0.339\*** | **0.353\*** | **-0.407\*\*** |
| **DFFH** | **0.157** | **0.136** | **0.197\*** | **0.652\*\*** | **0.641\*\*** | **0.613\*\*** | **0.655\*\*** | **-0.181** | **-** | **0.479\*\*** | **-0.162** | **-0.284** | **-0.096** | **-0.134** | **0.197** | **0.143** | **0.123** | **-0.112** | **0.185** | **-0.041** | **-0.495\*\*** | **-0.160** | **-0.509 \*\*** | **-0.556 \*\*** |
| **DLFH** | **0.144** | **0.138** | **-0.138** | **0.474\*\*** | **0.479\*\*** | **0.494 \*\*** | **0.493\*\*** | **-0.126** | **0.478\*\*** | **-** | **-0.147** | **0.443\*\*** | **0.162** | **-0.206** | **0.154** | **0.164** | **0.130** | **0.108** | **0.091** | **0.240** | **0.467 \*\*** | **-0.148** | **0.439\*\*** | **0.542\*\*** |
| **VL** | **0.775\*\*** | **0.178** | **0.733\*\*** | **0.136** | **0.183** | **-0.181** | **-0.181** | **0.367 \*\*** | **-0.151** | **-0.141** | **-** | **0.524\*\*** | **0.331\*\*** | **0.145** | **0.133** | **-0.135** | **-0.162** | **-0.037** | **0.211\*\*** | **0.241\*\*** | **0.741 \*\*** | **0.190** | **0.197** | **0.824\*\*** |
| **NOFPP** | **0.478 \*\*** | **-0.364 \*\*** | **0.447 \*\*** | **-0.156** | **-0.146** | **-0.147** | **-0.148** | **0.601\*\*** | **-0.276\*\*** | **0.433\*\*** | **0.473\*\*** | **-** | **-0.658\*\*** | **0.084** | **-0.167** | **-0.204** | **-0.175** | **-0.061** | **-0.206** | **-0.285\*\*** | **0.628\*\*** | **0.156** | **0.168** | **0.799 \*\*** |
| **AFW** | **0.017** | **-0.088** | **0.704\*\*** | **-0.086** | **-0.039** | **-0.033** | **-0.009** | **-0.132** | **-0.095** | **0.159** | **0.294\*\*** | **-0.640\*\*** | **-** | **0.240\*** | **0.259\*** | **0.079** | **0.242\*** | **0.095** | **0.259\*** | **0.293\*\*** | **0.782\*\*** | **-0.096** | **0.267\*** | **0.848\*\*** |
| **FL** | **-0.201\*** | **-0.157** | **0.118** | **-0.223** | **-0.204 \*** | **-0.144** | **-0.121** | **-0.165** | **-0.134** | **-0.204 \*** | **0.125** | **0.081** | **0.238\*\*** | **-** | **-0.306\*\*** | **-0.208** | **-0.153** | **0.179** | **0.201** | **0.195** | **0.254\*** | **0.147** | **0.125** | **0.288\*** |
| **FD** | **0.118** | **0.219\*** | **0.258\*\*** | **0.204\*\*** | **0.359 \*\*** | **0.394 \*\*** | **0.363\*\*** | **0.003** | **0.196** | **0.146** | **0.129** | **-0.162** | **0.249\*\*** | **-0.303\*\*** | **-** | **0.951\*\*** | **0.732\*\*** | **0.204** | **0.192** | **0.209** | **0.281\*** | **0.198** | **-0.181** | **0.489\*\*** |
| **SCWD** | **0.125** | **0.226 \*** | **0.158** | **0.184** | **0.137** | **0.142** | **0.138** | **-0.058** | **0.132** | **0.149** | **-0.130** | **-0.201** | **0.078** | **-0.192\*** | **0.945\*\*** | **-** | **0.550 \*\*** | **0.135** | **0.081** | **0.043** | **-0.185** | **0.366 \*\*** | **-0.104** | **-0.157** |
| **FT** | **0.131** | **0.237\*\*** | **-0.160** | **0.277\*\*** | **0.270\*\*** | **0.129** | **0.127** | **0.043** | **0.113** | **0.128** | **-0.156** | **-0.174** | **0.236\*\*** | **-0.143** | **0.678\*\*** | **0.517\*\*** | **-** | **-0.201\*** | **0.112** | **0.269\*** | **0.206** | **-0.191** | **-0.134** | **0.210** |
| **RT** | **0.087** | **0.010** | **-0.052** | **0.010** | **-0.012** | **0.007** | **-0.033** | **-0.141** | **-0.110** | **0.102** | **-0.003** | **-0.066** | **0.093** | **0.172** | **0.193\*** | **0.132** | **-0.197\*** | **-** | **0.057** | **0.145** | **0.050** | **0.027** | **-0.067** | **0.116** |
| **SCW** | **0.228\*** | **0.101** | **0.134** | **0.134** | **0.096** | **0.079** | **0.123** | **0.061** | **0.184 \*** | **0.090** | **0.203\*\*** | **-0.203 \*** | **0.256\*\*** | **0.193\*** | **0.191\*** | **0.081** | **0.106** | **0.054** | **-** | **0.245\*** | **0.453\*\*** | **0.336\*** | **-0.012** | **0.554\*\*** |
| **FLW** | **0.195\*** | **0.113** | **0.041** | **0.187** | **0.223 \*** | **0.173** | **0.121** | **-0.189** | **-0.041** | **0.239\*\*** | **0.232\*\*** | **-0.280\*\*** | **0.290\*\*** | **0.194\*** | **0.198\*** | **0.043** | **0.265\*\*** | **0.139** | **0.212\*\*** | **-** | **0.553\*\*** | **-0.093** | **-0.127** | **0.684\*\*** |
| **FYPP** | **-0.620 \*\*** | **-0.602 \*\*** | **0.669\*\*** | **-0.683\*\*** | **-0.634 \*\*** | **-0.634\*\*** | **-0.614 \*\*** | **-0.380\*\*** | **-0.461\*\*** | **0.444 \*\*** | **0.655\*\*** | **0.625\*\*** | **0.777\*\*** | **0.243\*\*** | **0.376\*\*** | **-0.176** | **0.198\*** | **0.041** | **0.434\*\*** | **0.543\*\*** | **-** | **0.183** | **0.199** | **0.986 \*\*** |
| **NOSPF** | **-0.157** | **-0.158** | **0.794 \*\*** | **-0.137** | **-0.180** | **-0.178** | **-0.179** | **0.335\*\*** | **-0.159** | **-0.148** | **0.180** | **0.155** | **-0.095** | **0.146** | **0.197 \*** | **0.365 \*\*** | **-0.180** | **0.025** | **0.230 \*\*** | **-0.093** | **0.181** | **-** | **-0.147** | **0.128** |
| **100SW** | **-0.255\*\*** | **-0.168** | **0.196\*\*** | **-0.132** | **-0.182** | **-0.182** | **-0.181** | **0.348\*\*** | **-0.501\*\*** | **0.433\*\*** | **0.196 \*** | **0.163** | **0.258\*\*** | **0.124** | **-0.177** | **-0.101** | **-0.130** | **-0.064** | **-0.012** | **-0.125** | **0.195\*** | **-0.142** | **-** | **0.208** |
| **FYPH** | **-0.734\*\*** | **-0.673\*\*** | **0.793\*\*** | **-0.802\*\*** | **-0.757\*\*** | **-0.760\*\*** | **-0.731\*\*** | **-0.401\*\*** | **-0.551 \*\*** | **0.540\*\*** | **0.739\*\*** | **0.700\*\*** | **0.846 \*\*** | **0.282\*\*** | **0.484\*\*** | **-0.155** | **0.199\*** | **0.114** | **0.548\*\*** | **0.681\*\*** | **0.932\*\*** | **0.125** | **0.201\*\*** | **-** |

\*, \*\*= Significant at 5% and 1% respectively

NMA: Node number at which 1st male flower appears, NFA: Node number at which 1st female flower appears, NOPB: Number of primary branches, DAPMF: Days to appearance of 1st male flower, DAPFF: Days to appearance of 1st female flower, DAMF: Days to anthesis of 1st male flower, DAFF: Days to anthesis of 1st female flower, SR: Sex Ratio, DFFH: Days to 1st Fruit Harvest, DLFH: Days to Last Fruit Harvest, VL: Vine Length (m), NOFPP: Number of Fruits/Plant, AFW: Average Fruit Weight (kg), FL: Fruit Length (cm), FD: Fruit Diameter (cm), SCWD: Seed cavity width (cm), FT: Flesh Thickness (cm), RT: Rind Thickness (mm), SCW: Seed Cavity Weight (g), FLW: Flesh Weight (g), FYPP: Fruit Yield/Plant (kg), FYPH: Fruit Yield/Hectare (q), NOSPF: No. of Seeds/Fruit, 100SW: 100 Seed Weight (g), TS: Total Sugars (%), DM: Dry Matter content (%), VITC: Vitamin C content (mg/100g), TSS: Total Soluble Solids (°Brix), CC: Chlorophyll content (mg/100g), CFC: Crude Fiber content (%).

**Table 4: Path matrix showing direct (diagonal) and indirect (off diagonal) effects of different traits on fruit yield in bottle gourd [*Lagenaria siceraria* (Molina) Standl.]**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **NMA** | **NFA** | **NOPB** | **DAPMF** | **DAPFF** | **DAMF** | **DAFF** | **SR** | **DFFH** | **DLFH** | **VL** | **NOFPP** | **AFW** | **FL** | **FD** | **SCWD** | **FT** | **RT** | **SCW** | **FLW** | **NOSPF** | **100SW** | **Genotypic correlation with yield** |
| **NMA** | **-0.740** | 0.509 | 0.080 | -0.340 | -0.916 | 0.619 | 0.896 | 0.104 | -0.009 | -0.109 | -0.570 | -0.497 | 0.017 | -0.002 | 0.314 | -0.388 | -0.121 | 0.016 | -0.011 | 0.042 | 0.666 | -0.282 | **-0.760\*\*** |
| **NFA** | -0.252 | -**0.586** | 0.066 | -0.213 | -0.231 | 0.509 | -0.123 | 0.179 | -0.008 | -0.089 | -0.299 | -0.166 | -0.061 | -0.003 | 0.264 | -0.099 | -0.096 | 0.110 | -0.009 | 0.036 | 0.547 | -0.158 | **-0.686\*\*** |
| **NOPB** | 0.507 | -0.400 | **0.808** | 0.148 | 0.404 | -0.483 | -0.796 | -0.096 | 0.008 | 0.072 | 0.472 | 0.467 | 0.052 | 0.001 | -0.184 | 0.108 | 0.085 | -0.007 | 0.006 | -0.005 | -0.660 | 0.294 | **0.810\*\*** |
| **DAPMF** | -0.303 | 0.483 | 0.082 | **-0.763** | -0.382 | 0.354 | 0.500 | 0.085 | -0.010 | -0.121 | -0.398 | -0.465 | -0.057 | -0.002 | 0.269 | -0.164 | -0.114 | 0.005 | -0.008 | 0.042 | 0.477 | -0.310 | **-0.809\*\*** |
| **DAPFF** | -0.301 | 0.488 | 0.078 | -0.347 | **-0.745** | 0.656 | 0.001 | 0.088 | -0.010 | -0.126 | -0.482 | -0.348 | -0.022 | -0.008 | 0.264 | -0.167 | -0.116 | 0.002 | -0.011 | 0.050 | 0.644 | -0.332 | **-0.775\*\*** |
| **DAMF** | -0.383 | 0.459 | 0.080 | -0.335 | -0.474 | **-0.738** | 0.686 | 0.078 | -0.009 | -0.128 | -0.383 | -0.247 | -0.045 | -0.002 | 0.291 | -0.058 | -0.021 | 0.005 | -0.004 | 0.040 | 0.634 | -0.199 | **-0.773\*\*** |
| **DAFF** | -0.285 | 0.477 | 0.076 | -0.229 | -0.388 | 0.653 | **-0.739** | 0.084 | -0.010 | -0.128 | -0.354 | -0.218 | -0.003 | -0.002 | 0.268 | -0.165 | -0.110 | -0.018 | -0.006 | 0.048 | 0.643 | -0.314 | **-0.747 \*\*** |
| **SR** | 0.243 | -0.277 | -0.035 | 0.273 | 0.233 | -0.230 | -0.323 | **-0.370** | 0.002 | 0.042 | 0.290 | 0.128 | -0.212 | -0.002 | 0.007 | 0.023 | -0.016 | -0.010 | -0.003 | -0.010 | -0.284 | 0.131 | **-0.407\*\*** |
| **DFFH** | -0.291 | 0.327 | 0.052 | -0.290 | -0.268 | 0.146 | 0.488 | 0.039 | **-0.515** | -0.122 | -0.256 | -0.063 | -0.061 | -0.001 | 0.217 | -0.137 | -0.048 | -0.013 | -0.009 | -0.030 | 0.479 | -0.179 | **-0.556 \*\*** |
| **DLFH** | -0.249 | 0.243 | 0.029 | -0.348 | -0.430 | 0.358 | 0.344 | 0.047 | -0.008 | **0.478** | 0.116 | -0.367 | 0.104 | -0.002 | 0.316 | -0.196 | -0.108 | 0.023 | -0.005 | 0.056 | 0.342 | -0.204 | **0.542\*\*** |
| **VL** | 0.501 | -0.419 | -0.079 | 0.341 | 0.532 | -0.497 | -0.432 | -0.109 | 0.008 | 0.074 | **0.694** | 0.536 | 0.020 | 0.002 | -0.225 | 0.243 | 0.073 | -0.002 | 0.004 | -0.021 | -0.738 | 0.296 | **0.824\*\*** |
| **NOFPP** | 0.578 | -0.210 | -0.044 | 0.642 | 0.538 | -0.724 | -0.464 | -0.162 | 0.004 | 0.085 | 0.466 | **0.780** | -0.458 | 0.001 | -0.118 | 0.085 | 0.053 | -0.008 | 0.009 | -0.052 | -0.471 | 0.248 | **0.799 \*\*** |
| **AFW** | -0.024 | -0.051 | -0.007 | 0.119 | 0.331 | -0.054 | -0.005 | 0.083 | 0.001 | -0.038 | 0.020 | -0.663 | **0.810** | 0.006 | 0.078 | -0.034 | -0.062 | 0.015 | -0.011 | 0.057 | 0.179 | 0.112 | **0.848\*\*** |
| **FL** | 0.196 | -0.086 | -0.012 | 0.103 | 0.013 | -0.207 | -0.197 | 0.041 | 0.002 | 0.037 | 0.109 | 0.091 | 0.029 | **0.220** | -0.217 | 0.121 | 0.046 | 0.028 | 0.001 | 0.020 | -0.207 | 0.096 | **0.288\*** |
| **FD** | -0.325 | 0.133 | 0.024 | -0.342 | -0.364 | 0.721 | 0.430 | -0.002 | -0.004 | -0.105 | -0.217 | -0.166 | 0.382 | -0.005 | **0.421** | -0.333 | -0.267 | 0.102 | -0.043 | 0.009 | 0.409 | -0.004 | **0.489\*\*** |
| **SCWD** | -0.033 | 0.036 | 0.024 | -0.067 | -0.080 | 0.059 | 0.092 | 0.014 | -0.005 | -0.009 | -0.034 | -0.044 | 0.056 | -0.006 | 0.086 | **-0.123** | -0.078 | 0.022 | -0.009 | 0.010 | 0.108 | -0.164 | **-0.157** |
| **FT** | -0.066 | 0.064 | 0.025 | -0.070 | -0.018 | 0.020 | 0.025 | -0.016 | -0.002 | -0.079 | -0.057 | -0.065 | 0.148 | -0.001 | 0.148 | -0.033 | **0.194** | 0.013 | -0.015 | -0.018 | 0.051 | -0.045 | **0.210** |
| **RT** | -0.103 | 0.019 | 0.004 | -0.048 | -0.016 | 0.064 | -0.003 | 0.034 | 0.001 | -0.035 | -0.008 | -0.052 | 0.098 | 0.002 | 0.156 | -0.058 | -0.027 | **0.108** | -0.003 | 0.025 | -0.027 | -0.020 | **0.116** |
| **SCW** | -0.237 | 0.024 | 0.012 | -0.214 | -0.111 | 0.066 | 0.038 | -0.018 | -0.003 | -0.026 | -0.068 | -0.203 | 0.183 | 0.001 | 0.348 | -0.035 | -0.038 | 0.010 | **0.520** | -0.003 | 0.271 | -0.001 | **0.554\*\*** |
| **FLW** | -0.214 | 0.137 | 0.002 | -0.316 | -0.257 | 0.367 | 0.248 | 0.046 | 0.001 | -0.068 | -0.074 | -0.272 | 0.106 | 0.001 | 0.292 | -0.021 | 0.015 | 0.025 | 0.001 | **0.553** | 0.170 | -0.098 | **0.684\*\*** |
| **NOSPF** | 0.084 | -0.085 | -0.096 | 0.065 | 0.071 | -0.098 | -0.090 | -0.090 | 0.048 | 0.097 | 0.018 | 0.075 | -0.097 | 0.003 | -0.069 | 0.064 | 0.098 | 0.005 | 0.014 | -0.086 | **0.102** | 0.085 | **0.128** |
| **100SW** | 0.020 | -0.104 | -0.074 | 0.105 | 0.070 | -0.109 | -0.103 | -0.096 | 0.007 | 0.107 | 0.108 | 0.093 | 0.129 | 0.003 | -0.026 | 0.026 | 0.038 | -0.008 | 0.001 | -0.050 | -0.120 | **0.182** | **0.208** |

**RESIDUAL EFFECT= 0.025**

**Disclaimer (Artificial intelligence)**

Option 1:

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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