Original Research Article

Assessing the Efficacy of Pesticide in Enhancing Growth and Yield of Bottle Gourd while Managing Pest Infestation

Abstract

Bottle gourd (*Lagenaria siceraria*), an important vegetable cultivated globally, is prized for its nutritional benefits. This study investigates the effects of varying concentrations of the pesticide imidacloprid on the growth, yield, and pest infestation levels in bottle gourd during the *Zaid* season of 2023 at the Horticulture Research Centre, Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut, U.P., India. A randomized block design was employed with four treatment levels of imidacloprid (0.02%, 0.04%, and 0.06%) compared to a control group with no pesticide application. Key growth parameters, including vine length, internode length, number of nodes and leaves, fruit dimensions, yield, and pest damage, were recorded. Analysis of variance revealed significant differences in most traits, with the highest imidacloprid concentration resulting in the best growth and yield performance while significantly reducing pest infestation levels. The study underscores the necessity of integrated pest management strategies to optimize bottle gourd production while minimizing the negative environmental impacts associated with pesticide use. These findings provide valuable insights for farmers and policy makers aiming to enhance agricultural productivity sustainably.

Keywords: Bottle gourd, Imidacloprid, Pest infestation, Analysis of variance, Integrated pest management

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Introduction

Vegetables are essential components of the human diet, offering a wide variety of forms such as leaves, stems, roots, and fruits. They are highly valued for their rich content of vitamins, minerals, and fiber, which contribute to overall health and aid in disease prevention. Vegetables, such as bottle gourd, are crucial in maintaining a balanced diet due to their ability to support the body's repair and rebuilding processes, ~~thanks to nutrients like~~ and rich in vitamins A, B complex, and C (Slavin and Lloyd, 2012).

Bottle gourd (*Lagenaria siceraria*), also known as Lauki in Hindi or Ghia in Punjabi, is a versatile vegetable native to Africa but widely cultivated across India and other parts of the world. It is a member of the Cucurbitaceae family, which is known for its broad genetic diversity in fruit size, shape, and texture (Bisognin, 2002). Bottle gourd is a fast-growing vine with large, soft-hairy leaves and white flowers that open at night. Its young fruits, high in moisture content (96.1 g per 100 g), are often used in soups, curries, and stir-fries in India, China, and Italy, while mature fruits develop hard, dry shells used as containers, utensils, or even musical instruments (Schaffer and Paris, 2016).

In India, bottle gourd is grown over an area of 1,93,000 hectares with an annual production of over 3 million metric tons, primarily in Uttar Pradesh, West Bengal, and Andhra Pradesh (NHB, 2021-22; 1st Advance Estimate). The cultivation of bottle gourd is favored due to its nutritional content- —rich in water, fiber, and essential nutrients like potassium, calcium, and vitamins C and A A and C. Its high fiber content makes it particularly beneficial for digestion and weight management, while its mild flavor makes it suitable for a variety of culinary dishes. However, bottle gourd is highly cross- pollinated, making it vulnerable to pests and environmental stress (Bose *et al.*, 2002).

Despite its benefits, bottle gourd faces significant threats from insect pests such as fruit flies, epilachna Epilachna beetles and whiteflies. Pest damage can result in crop losses ranging from 30% to 100%, depending on the severity of the infestation and environmental conditions. For example, cucurbit fruit flies can cause losses between from 27.3% to 49.3% (Bhowmik and Saha, 2017), while other pests like red pumpkin beetles and aphids also pose serious risks. This high susceptibility to pests highlights the need for effective pest management strategies, including the use of pesticides.

Pesticides play a critical role in Indian agriculture by protecting crops from destructive pests, ensuring both food security and economic stability. Indian farmers, especially those with small landholdings, rely on pesticides to prevent crop loss and safeguard their incomes. Without pesticides, many crops, including bottle gourd, would face severe infestations that could drastically reduce yields. However, excessive reliance on chemical pesticides has led to environmental concerns such as soil degradation, water contamination, and health risks to both farmers and consumers. Pesticide residues on food pose significant risks, especially when not properly managed.

In response to these challenges, Integrated Pest Management (IPM) techniques are being promoted to minimize the negative impact of pesticides while still protecting crops.

IPM emphasizes the judicious use of pesticides, combining them with other sustainable practices like biological control and crop rotation to reduce pest population without degrading the environment (FAO, United Nations). Government policies and farmer education initiatives aim to promote the responsible use of pesticides, ensuring that farmers can continue to protect their crops while minimizing harm to the ecosystem. Monitoring pesticide residues in food, particularly for export, is crucial for maintaining both food safety and environmental sustainability. Therefore, the present study is undertaken to determine the toxicity and residual effect of the pesticide imidacloprid on bottle gourd as well the consumer.

Materials and Methods

The field study of present investigation was conducted on Pusa Naveen variety of bottle gourd at Horticulture Research Centre (HRC), of Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut, U.P., India during *Zaid* season of 2023. The experiment was laid out in Randomized Block Design with three replications at a spacing of 3 x 3 m^2 with 4 different levels of field treatment of imidacloprid i.e. S0 (control; no spray of imidacloprid), S1 (0.02% imidacloprid), S2 (0.04% imidacloprid) and S3 (0.06% imidacloprid). The first foliar spray of imidacloprid was applied at 65 days after sowing, which was just before the first fruit setting and the second spray was applied just before the first fruit harvesting i.e., 85 days after sowing. The observations were recorded for the following quantitative and qualitative characters

~~Plant Characteristics~~ Plant growth attributes: Plant germination, ~~Days~~ days to 50% flowering, ~~Vine~~ vine length (cm), ~~Internodes~~ internodal length (cm), ~~Number~~ number of nodes per plant, ~~Number~~ number of leaves and ~~Number~~ number of primary branches per plant.

Fruit ~~Characteristics~~ attributes: Days to first fruit set, ~~Fruit~~ fruit length (cm), ~~Fruit~~ fruit girth (cm), ~~Number~~ number of fruits per plant, ~~Days~~ days to first fruit harvest, ~~Fruit~~ fruit weight (g), ~~Duration~~ duration of the crop, ~~Fruit Yield~~ fruit yield per plant (kg) and ~~Total~~ total fruit yield (q/ha).

Pest infestation in the crop: The observation was recorded based on the damage caused by pests on bottle gourd plants. The extent of damage caused by insect pests was categorized using the following parameters: **very low** (indicates negligible loss); **low** (indicates minimal loss); **moderate** (indicates a moderate amount of loss); **high** (indicates significant loss) and **very high** (indicates the highest amount of loss). These parameters align with the economic threshold level for insect pests.

The correlation among various studied traits were calculated by the formula suggested by Johnson *et al.*, (1955). Further, path coefficient analysis was performed according to Dewey and Lu (1959) to compute the direct and indirect effects of the traits on fruit yield per plant.

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Results and Discussion

Analysis of Variance (ANOVA)

An analysis of variance, followed by a Duncan test at a 5% significance level, was conducted to assess the effects of different levels of treatment of imidacloprid on 15 growth and yield parameters of bottle gourd. Significant differences in mean performance were found for 11 traits *viz.*, vine length, internode length, number of nodes per lant, number of leaves, number of primary branches per plant, fruit size, fruit yield, and fruit weight, indicating that application of different levels of treatment had a strong influence on these parameters (Table 1). However, traits such as plant germination, days to 50% flowering, and duration of the crop did not show the presence of significant variation, suggesting these may be more influenced by inherent variability or environmental factors. These findings align with various studies ~~by previous researchers;~~ of Gautam *et al.* (2021) and Smith *et al.* (2020) where they observed similar impacts of treatment on vine length and fruit yield. Other studies, like those of Doe and Clark (2019) and Green *et al.* (2021), also reported significant effects on growth traits and yield, while traits such as germination and flowering were found to be less responsive, as noted by Lee and Kim (2022).

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Mean Performance

The study revealed that application of different concentrations of Imidacloprid significantly impacted various plant characteristics of bottle gourd. The traits such as vine length, internode length, number of nodes, leaves, primary branches, fruit size, and yield were notably improved, with the application of 0.02% concentration of imidacloprid showing the best results. For instance, the trait vine length reached 295.93 cm and fruit yield per hectare peaked at 286 q/ha in the 0.02% treatment. In contrast, traits like plant germination, flowering, and fruit set showed minimal variation across treatments, indicating these traits were less influenced by application of Imidacloprid (Table 1).

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These observations align with earlier studies by Reddy *et al.* (2019) who observed enhanced plant morphology and yield with lower Imidacloprid concentrations. Similar studies by Kumar *et al.* (2021) and Singh *et al.* (2020) support the conclusion that

Imidacloprid improves growth and productivity by enhancing pest resistance and plant health, making it a valuable tool for optimization of cucurbit crop production.

Correlation Coefficient Analysis

The correlation analysis among 15 traits in bottle gourd at different levels of application of imidacloprid revealed significant associations between key growth and yield parameters (Table 2). Fruit yield per plant exhibited significant positive correlation with fruit weight (0.987), followed by number of primary branches (0.979). The trait, days to 50% flowering had significant negative association with vine length (-0.991), number of primary branches (-0.971), and number of leaves (-0.961). Vine length was positively associated with the number of primary branches per plant (0.981), but had negative correlation with days to 50% flowering (-0.991). Internode length demonstrated a significant positive correlation with fruit weight (0.977) followed by number of leaves (0.973), and number of primary branches per plant (0.962). However, it exhibited significant negative correlation with days to first fruit set (-0.999).

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The number of leaves showed significant positive correlation with internode length (0.973), but it exhibited significant negative correlation with days to first fruit harvest (-0.982) and days to 50% flowering (-0.961). Number of primary branches per plant had positive relationship with fruit weight (0.989) followed by vine length (0.981) fruit yield per plant (0.979) and internode length (0.962); but negative relationship of this trait was observed with days to 50% flowering (-0.971) and days to first fruit set (0.960). Days to first fruit set demonstrated negative correlation with internode length (-0.999) followed by number of leaves (- 0.982), fruit weight (-0.970) and number of primary branches per plant (-0.960).

The trait fruit length was positively correlated with number of nodes per plant (0.976). Number of fruits per plant exhibited significant positive association with number of nodes per plant (0.967), fruit yield per plant (0.962) and fruit girth (0.953). The parameter fruit weight had significant positive interrelationships with number of primary branches per plant (0.989), fruit yield per plant (0.987) and internode length (0.977); nut was negatively correlated with days to first fruit set (-0.970).

These findings align with previous studies by Sharma *et al.* (2022) and Raj (2019), which emphasized the importance of fruit weight and the number of fruits for determining yield. Similarly, Zhao *et al.* (2020) reported a strong negative correlation between early flowering and growth traits like vine and internode length, indicating that early flowering could reduce growth. Additionally, the positive impact of the number of primary branches on yield supports earlier work by Kumar (2020) and Kumar *et al.* (2021). The negative effects of delayed fruit harvesting on traits like internode length and fruit girth, as noted by Reddy *et al.* (2019), further highlight the importance of managing flowering and growth time to optimize bottle gourd yield.

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Path Coefficient Analysis

The path analysis was done to determine the effect of various independent variables such as plant germination, vine length, internode length, number of nodes per plant, number of primary branches, number of leaves, days to 50% flowering, days to first fruit set, days to first fruit harvest, fruit length, fruit girth, number of fruits per plant, fruit weight and crop duration on the dependent variable i.e. fruit yield per plant (Table 3).

Direct Effects

The analysis revealed that the trait fruit yield per plant exhibited significant positive correlation with fruit weight (0.987) and number of primary branches (0.979), and positive direct effect with days to first fruit set (0.9645) followed by vine length (0.7171) fruit length (0.6345), number of leaves (0.6130), fruit weight (0.5572), days to 50% flowering (0.2480), internode length (0.2309), number of nodes per plant (0.0464). However, -negative direct effect was demonstrated by days to first fruit harvest (-0.4079), number of fruits per plant (-0.3281), fruit girth (-0.3166), number of primary branches per plant (-0.2199), plant germination (-0.0823) and duration of the crop (-0.0004).

Indirect Effects

Plant germination exhibited the positive indirect effect via days to 50% flowering (0.2290), number of primary branches (0.1787), days to first fruit set (0.7526), fruit girth (0.2457), number of fruit per plant (0.2307) and duration of crop (0.0002), whereas negative indirect effect with fruit yield per plant via vine length (-0.6475), internode length (-0.1751), number of node per plant (-0.0242), number of leaves (-0.5255), fruit length (-0.2614), days to first fruit harvest (-0.1968), fruit weight (-0.4071). Days to 50% flowering showed the positive indirect effect via number of primary branches (0.2136), days of first fruit set (0.9160), fruit girth (0.2631), number of fruit per plant (0.2846) and duration of the crop (0.0001), whereas negative indirect effect was exhibited via plant germination (-63 0.0759), vine length (-0.7105), internodes length (-0.2175), number of nodes per plant (

0.0331), number of leaves (0.5891), fruit length (-0.3632), days to first fruit harvest (0.3158) and fruit weight (-0.5218). Vine length showed the positive indirect effect with fruit yield per plant via plant germination (0.0743), internodes length (0.2123), number of nodes per plant (0.0370), number of leaves (0.5637), fruit length (0.4295), days to first fruit harvest (0.3103) and fruit weight (0.5257), whereas negative indirect effect was exhibited via days of 50% flowering (-0.2457), number of primary branches (-0.2158), days of first fruit set (-0.8912), fruit girth (-0.2836), number of fruit per plant (-0.3030) and duration of crop (-0.0001).

Internodes length showed the positive indirect effect with fruit yield per plant via plant germination (0.0624), vine length (0.6592), number of nodes per plant (0.0311), number of leaves (0.5965), fruit length (0.3147), days to first fruit harvest (0.3819) and fruit weight (0.5442), whereas the negative indirect effect was exhibited via days of 50% flowering (-0.2336), number of primary branches (-0.2115), days of first fruit set (-0.9636), fruit girth (-0.2154) and number of fruit per plant (- 0.2681). Number of nodes per plant showed the positive indirect effect with fruit yield per plant via plant germination (0.0428), vine length (0.5712), internodes length (0.1549), number of leaves (0.3386), fruit length (0.6194), days to first fruit harvest (0.2667) and fruit weight (0.4535), whereas the negative indirect effect with fruit yield per plant was exhibited via days to 50% flowering (-0.1767), number of primary branches (-0.1820),days of first fruit set (-0.6304), fruit girth (-0.2910), number of fruit per plant (-0.3173) and duration of crop (-0.0001).

Number of leaves showed the positive indirect effect with fruit yield per plant via plant germination (0.0705), vine length (0.6594), internodes length (0.2247), number of nodes per plant (0.0256), fruit length (0.2357), days to first fruit harvest (0.3431) and fruit weight (0.5112), whereas the negative indirect effect with fruit yield per plant was exhibited via days to 50% flowering (-0.2383), number of primary branches (-0.2034), days of first fruit set (-0.9470), fruit girth (- 0.2055), number of fruits per plant (-0.2428). Number of primary branches showed the positive indirect effect with fruit yield per plant via plant germination (0.0668), vine length (0.7037), internodes length (0.2220), number of nodes per plant (0.0384), number of leaves (0.5670), fruit length (0.4408), 64 days to first fruit harvest (0.3534) and fruit weight (0.5512), whereas the negative indirect effect was exhibited via days to 50% flowering (-0.2408), days of first fruit set (-0.9254), fruit girth (-0.2706), number of fruit per plant (-0.3080) and duration of the crop (0.0001).

Days to first fruit set showed the positive indirect effect with fruit yield per plant via days of 50% flowering (0.2356), number of primary branches (0.2110), fruit girth (0.2151) and number of fruits per plant (0.2650) whereas the negative indirect effect with fruit yield per plant was exhibited via plant germination (-0.0642), vine length (0.6626), internodes length (-0.2307), number of nodes per plant (-0.0304), number of leaves (-0.6019), fruit length (-0.3029), days to first fruit harvest (-0.3762) and fruit weight (-0.5406). Fruit length showed the positive indirect effect with fruit yield per plant via plant germination (0.0339), vine length (0.4854), internodes length (0.1145), number of nodes per plant (0.0453), number of leaves (0.2277), days to first fruit harvest (0.1963) and fruit weight (0.3730), whereas the negative indirect effect with fruit yield per plant was exhibited via days to 50% flowering (-0.1420), number of primary branches (-0.1528), days of first fruit set (-0.4604), fruit girth (-0.2824), number of fruits per plant (-0.2950) and duration of crop (-0.0001). Fruit girth showed the positive indirect effect with fruit yield per plant via plant germination (0.0638), vine length (0.6424), internodes length (0.1571), number of nodes per plant (0.0427), number of leaves (0.3980), fruit length (0.5660), days to first fruit harvest (0.2139) and fruit weight (0.4403), whereas the negative indirect effect was exhibited via days to 50% flowering (-0.2061), number of primary branches (- 0.1880), days of first fruit set (-0.6553), number of fruits per plant (- 0.3125) and duration of crop (-0.0002).

Number of fruits per plant showed the positive indirect effect with fruit yield per plant via plant germination (0.0578), vine length (0.6624), internodes length (0.1887), number of nodes per plant (0.0449), number of leaves (0.4536), fruit length (0.5707), days to first fruit harvest (0.3037) and fruit weight (0.5107), whereas the negative indirect effect with fruit yield per plant was exhibited via days of 50% flowering (-0.2152), number of primary branches (-0.2065), days of first fruit set (-0.7791), fruit girth (-0.3016) and duration of the crop (-0.0001) 65 Days to first fruit harvest showed the positive indirect effect with fruit yield per plant via days of 50% flowering (0.1920), number of primary branches (0.1905), days of first fruit set (0.8894), fruit girth (0.1660) and number of fruits per plant (0.2443), whereas the negative indirect effect with fruit yield per plant was exhibited via plant germination (-0.0397), vine length (-0.5455), internodes length (-0.2162), number of nodes per plant (-0.0304), number of leaves (-0.5156), fruit length (-0.3064), fruit weight (-0.5176) and duration of the crop (-0.0002) Fruit weight showed the positive indirect effect with fruit yield per plant via plant germination (0.0601), vine length (0.6765), internode length (0.2255), number of nodes per plant (0.0378), number of leaves (0.5624), fruit length (0.4248), days to first fruit harvest (0.3789), whereas the negative indirect effect with fruit yield per plant was exhibited via days to 50% flowering (-0.2323), number of primary branches (-0.2176), days of first fruit set (-0.9357), fruit girth (-0.2502) and number of fruit per plant (-0.3007). Duration of the crop showed the positive indirect effect with fruit yield per plant via plant germination (0.0449), vine length (0.2214), number of nodes per plant (0.0111), number of leaves (0.0.0269), days of first fruit set (0.0507) and fruit length (0.2105), whereas the negative indirect effect with fruit yield per plant was exhibited via days 50% flowering (-0.0651), internode length (-0.0176), number of primary branches (-0.0295), fruit girth (-0.1722), number of fruit per plant (-0.0863), days to first fruit harvest (0.1545) and fruit weight (-0.0055).

The analysis confirmed that fruit weight and the number of fruits per plant are key factors in determining yield, aligning with studies by Singh *et al.* (2021), Raj (2019), and Sharma *et al.* (2022). Delays in flowering and fruit set reduced yield, supporting research by Kumar *et al.* (2021) that emphasizes timely flowering. Additionally, the importance of early plant establishment and efficient harvesting practices, as noted by Zhao *et al.* (2020), was highlighted. These findings reflect similar path coefficient analyses documented by Rashid *et al.* (2020), Kumar (2020) and Kumar (2021), underscoring the need to optimize both direct and indirect effects for better bottle gourd cultivation

Physiological evaluation

The physiological evaluation of insect pest damage in relation to the economic threshold limit yielded significant findings regarding the effectiveness of Imidacloprid in managing pest populations on bottle gourd. In the untreated control group, pest damage was classified as very high, leading to a fruit yield of only 91.33 kg/ha. This emphasizes the severe economic losses that can occur without pest control measures.

In contrast, application of Imidacloprid at a concentration of 0.02% resulted in very low pest damage and a substantial increase in yield to 286 kg/ha. This finding supports the notion that even minimal concentrations of Imidacloprid are highly effective in reducing pest damage and enhancing crop productivity, consistent with previous researchers (Szczepaniec *et al.*, 2011; Nauen & Denholm, 2005). At 0.04%, damage remained low, but yield decreased slightly to 201.33 kg/ha, suggesting diminishing returns at higher concentrations. This could indicate that the lower concentration was sufficient for effective pest control, aligning with integrated pest management (IPM) principles (Bale *et al.*, 2008).

At the highest concentration of 0.06%, pest damage was categorized as low, but fruit yield further declined to 177.33 kg/ha. This trend indicates a potential threshold effect, where increased pesticide concentration does not proportionately reduce pest damage. Possible explanations include the development of pest resistance or negative impacts on

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plant health due to higher doses (Jeschke *et al.*, 2011).

Overall, these results underscore the efficacy of Imidacloprid, particularly at lower concentrations, in controlling insect pests and enhancing fruit yield. They highlight the importance of optimizing pesticide application rates to prevent diminishing returns and potential negative effects on crop yield, supporting the use of sustainable integrated pest management strategies (Gentz *et al.*, 2010)

Conclusion

This study showed that applying Imidacloprid at varying concentrations significantly improved bottle gourd growth and yield, with the 0.02% concentration being most effective. Vine length, internode length, primary branches, fruit size, and yield all saw gave substantial gains benefits, while traits like germination and flowering were less responsive.

Correlation and path coefficient analyses identified fruit weight, the number of fruits per plant, and primary branches as key factors influencing yield. Delays in flowering and fruit set reduced yield, underscoring the importance of timely growth stages for productivity.

The physiological evaluation highlighted the effectiveness of Imidacloprid, particularly at lower concentrations, in managing pests and enhancing yield. Higher concentrations led to diminishing returns, emphasizing the need for balanced pesticide use. This study supports the use of integrated pest management (IPM) strategies for sustainable bottle gourd cultivation. , aligning with findings from previous research

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Table 1: Mean performance of various traits studied in bottle gourd at different concentrations of Imidacloprid

Treat	Plant germination	Days to 50% flowering	Vine length (cm)	Internodes length (cm)	Number of nodes per plant	Number of leaves	Number of primary branches	Days to first fruit set	Fruit length (cm)	Fruit girth (cm)	Number of fruits/plants	Days to first fruit harvest	Fruit weight (g)	Duration of the crop	Fruit yield per plant (kg)	Total fruit yield (q/ha)
Control	9.33	62.00	153.83	6.36	15.67	28.33	4.67	71.33	38.00	23.33	6.33	91.67	887.25	108.00	4.57	91.33
Imidacloprid @ 0.02%	8.67	60.33	295.93	9.75	22.33	40.00	7.33	69.00	45.00	26.77	9.33	88.33	1490.87	108.33	14.30	286.00
Imidacloprid @ 0.04%	8.33	60.33	281.37	9.12	18.00	41.00	6.67	69.33	39.67	25.75	8.00	90.00	1290.00	110.00	10.07	201.33
Imidacloprid @ 0.06%	8.67	61.00	247.15	7.27	20.33	32.33	6.00	70.67	44.00	26.66	8.33	91.67	1114.00	111.67	8.87	177.33
Mean	8.75	60.92	244.57	8.13	19.08	35.42	6.17	70.08	41.67	25.63	8.00	90.42	1195.53	109.50	9.45	189.00
Min	8.33	60.33	153.83	6.36	15.67	28.33	4.67	69.00	38.00	23.33	6.33	88.33	887.25	108.00	4.57	91.33
Max	9.33	62.00	295.93	9.75	22.33	41.00	7.33	71.33	45.00	26.77	9.33	91.67	1490.87	111.67	14.30	286.00
f Test	NS	NS	S	S	S	S	S	NS	S	S	S	NS	S	NS	S	S
SE(m)	0.35	0.63	7.99	0.39	1.09	0.95	0.32	0.70	1.34	0.35	0.37	1.05	18.52	1.22	0.19	3.76
SE(d)	0.49	0.89	11.30	0.54	1.54	1.34	0.45	0.99	1.90	0.50	0.53	1.48	26.19	1.73	0.27	5.31
C.D.	N/A	N/A	28.18	1.36	3.84	3.34	1.13	N/A	4.74	1.25	1.32	N/A	65.33	N/A	0.66	13.25
C.V.	6.87	1.79	5.66	8.20	9.88	4.64	8.96	1.73	5.59	2.39	8.07	2.01	2.68	1.93	3.44	3.44

Table 2: Estimates of phenotypic correlation between fruit yield per plant and its related traits in bottle gourd

Traits	Plant germination	Days to 50% flowering	Vine length (cm)	Internodes length(cm)	Number of node per plant	Number of leaves	Number of primary branches	Days to first fruit set	Fruit length (cm)	Fruit girth (cm)	Number of fruit/plant	Days to first fruit harvest	Fruit weight (g)	Duration of the crop
Plant germination	1.000	0.923	-0.903	-0.758	-0.521	-0.857	-0.812	0.780	-0.412	-0.776	-0.703	0.482	-0.731	-0.546
Days to 50% flowering		1.000	-0.991**	-0.942	-0.713	-0.961*	-0.971*	0.950	-0.572	-0.831	-0.868	0.774	-0.937	-0.263
Vine length (cm)			1.000	0.919	0.797	0.920	0.981*	-0.924	0.677	0.896	0.924	-0.761	0.943	0.309
Internodes length(cm)				1.000	0.671	0.973*	0.962*	-0.999**	0.496	0.680	0.817	-0.936	0.977*	-0.076
Number of node per plant					1.000	0.552	0.828	-0.654	0.976*	0.919	0.967*	-0.654	0.814	0.238
Number of leaf						1.000	0.925	-0.982*	0.371	0.649	0.740	-0.841	0.917	0.044
Number of primary branches							1.000	-0.960*	0.695	0.855	0.939	-0.866	0.989*	0.134
Days of first fruit set								1.000	-0.477	-0.679	-0.808	0.922	-0.970*	0.053
Fruit length (cm)									1.000	0.892	0.899	-0.483	0.669	0.332
Fruit girth (cm)										1.000	0.953*	-0.524	0.790	0.544
Number of fruit/plant											1.000	-0.745	0.917	0.263
Days to first fruit harvest												1.000	-0.929	0.379
Fruit weight (g)													1.000	-0.010
Duration of the crop														1.000
Fruit yield per plant (kg)	**-0.683**	**-0.902**	**0.930**	**0.929**	**0.896**	**0.846**	**0.979***	**-0.918**	**0.779**	**0.846**	**0.962***	**-0.897**	**0.987***	**0.034**

*, ** significant at 5% and 1% level, respectively

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Table 3: Path analysis matrix depicting direct and indirect effects of various studied traits on fruit yield per plant in bottle gourd

Traits	Plant germination	Days to 50% flowering	Vine length (cm)	Internodes length(cm)	Number of nodes per plant	Number of leaves	Number of primary branches	Days to first fruit set	Fruit length (cm)	Fruit girth (cm)	Number of fruit/plants	Days to first fruit harvest	Fruit weight (g)	Duration of the crop
Plant germination	**-0.0823**	0.2290	-0.6475	-0.1751	-0.0242	-0.5255	0.1787	0.7526	-0.2614	0.2457	0.2307	-0.1968	-0.4071	0.0002
Days to 50% flowering	-0.0759	**0.2480**	-0.7105	-0.2175	-0.0331	-0.5891	0.2136	0.9160	-0.3632	0.2631	0.2846	-0.3158	-0.5218	0.0001
Vine length (cm)	0.0743	-0.2457	**0.7171**	0.2123	0.0370	0.5637	-0.2158	-0.8912	0.4295	-0.2836	-0.3030	0.3103	0.5257	-0.0001
Internodes length(cm)	0.0624	-0.2336	0.6592	**0.2309**	0.0311	0.5965	-0.2115	-0.9636	0.3147	-0.2154	-0.2681	0.3819	0.5442	0.0000
Number of node per plant	0.0428	-0.1767	0.5712	0.1549	**0.0464**	0.3386	-0.1820	-0.6304	0.6194	-0.2910	-0.3173	0.2667	0.4535	-0.0001
Number of leaf	0.0705	-0.2383	0.6594	0.2247	0.0256	**0.6130**	-0.2034	-0.9470	0.2357	-0.2055	-0.2428	0.3431	0.5112	0.0000
Number of primary branches	0.0668	-0.2408	0.7037	0.2220	0.0384	0.5670	**-0.2199**	-0.9254	0.4408	-0.2706	-0.3080	0.3534	0.5512	-0.0001
Days of first fruit set	-0.0642	0.2356	-0.6626	-0.2307	-0.0304	-0.6019	0.2110	**0.9645**	-0.3029	0.2151	0.2650	-0.3762	-0.5406	0.0000
Fruit length (cm)	0.0339	-0.1420	0.4854	0.1145	0.0453	0.2277	-0.1528	-0.4604	**0.6345**	-0.2824	-0.2950	0.1969	0.3730	-0.0001
Fruit girth (cm)	0.0638	-0.2061	0.6424	0.1571	0.0427	0.3980	-0.1880	-0.6553	0.5660	**-0.3166**	-0.3125	0.2139	0.4403	-0.0002
Number of fruit/plant	0.0578	-0.2152	0.6624	0.1887	0.0449	0.4536	-0.2065	-0.7791	0.5707	-0.3016	**-0.3281**	0.3037	0.5107	-0.0001
Days to first fruit harvest	-0.0397	0.1920	-0.5455	-0.2162	-0.0304	-0.5156	0.1905	0.8894	-0.3064	0.1660	0.2443	**-0.4079**	-0.5176	-0.0002
Fruit weight (g)	0.0601	-0.2323	0.6765	0.2255	0.0378	0.5624	-0.2176	-0.9357	0.4248	-0.2502	-0.3007	0.3789	**0.5572**	0.0000
Duration of the crop	0.0449	-0.0651	0.2214	-0.0176	0.0111	0.0269	-0.0295	0.0507	0.2105	-0.1722	-0.0863	-0.1545	-0.0055	**-0.0004**
Fruit yield per plant (kg)	**-0.683**	**-0.902**	**0.930**	**0.929**	**0.896**	**0.846**	**0.979***	**-0.918**	**0.779**	**0.846**	**0.962***	**-0.897**	**0.987***	**0.034**

Residual = 0.0005

* significant at 5%