regulatory networks has also provided important molecular foundations for understanding the mechanisms underlying high-yield formation in cucumber (Dey et al., 2023).

Table 1 Coefficient of variation, heritability and genetic advance of yield and quality traits (Adopted from Lnu et al., 2025)

Trait	Mean	CV (%)	GCV (%)	PCV (%)	H2 (b.s.) (%)	G.A (%)	G.A (as % mean)
G.	16.08	5.75	13.58	14.77	84.66	4.14	25.76
Fruit diameter	3.57	6.04	15.99	17.1	87.53	1.1	30.84
Fruit weight	157.67	9.88	27.45	29.13	88.81	84.03	53.29
Pistil length	3.74	4.38	11.79	12.58	87.8	0.85	22.76
Internodal length	10.19	3.07	20.86	21.09	97.84	4.33	42.5
Vine length	328.52	4.13	25.65	25.98	97.45	171.33	52.15
Number of female flowers per node	1.21	7.24	26.44	27.43	92.89	0.63	52.49
Number of fruits set per node	0.15	14.95	34.36	37.41	84.38	0.09	65
Number of fruits per plant	14.81	4.98	35.43	35.77	98.12	10.71	72.29
Fruit setting percentage	13.34	19.28	2.36	39.83	0.35	0.04	0.29
Fruit yield per plant	2.14	14.62	24.61	27.64	79.35	0.97	45.18
TSS	2.66	9.3	12.76	15.82	65.06	0.56	21.21
Flesh to seed cavity ratio	1.94	14.94	12.47	19.56	40.67	0.32	16.38
Water content	97.51	0.78	0.17	0.79	4.68	0.08	0.08
Vitamin C	3.08	9.24	16.85	19.19	77	0.94	30.45

2.3 Population structure and stress-resistance-related traits

Population structure is an important factor affecting light energy utilization efficiency and yield per unit area in cucumber populations, mainly involving plant architecture, planting density, spatial leaf distribution, and canopy ventilation and light transmission capacity. A reasonable population structure can improve the uniformity of light interception within the canopy and enhance photosynthetic efficiency, thereby promoting dry matter accumulation and fruit formation. In contrast, excessively high planting density or overly luxuriant plant architecture can intensify competition among plants, leading to canopy closure, premature senescence of lower leaves, and increased disease incidence. Under protected cultivation and high-density planting conditions, optimizing population structure, improving the field microclimate, and enhancing the canopy light environment are important agronomic measures for increasing continuous fruiting ability and yield per unit area in cucumber.

Different cucumber germplasm resources exhibit significant differences in vegetative growth vigor, fruit characteristics, environmental adaptability, and yield potential, and they often form distinct groups in cluster analyses (Serhiienko et al., 2025). In evaluations of landraces and breeding materials, researchers have identified several groups showing superior performance in fruit number, fruit size, and overall yield. These materials can serve as important resources for selecting high-yield parental lines, genetic mapping, and heterosis utilization. Such rich genetic diversity is not only beneficial for the improvement of high-yield traits but also provides important material foundations for studying the genetic mechanisms underlying complex quantitative traits in cucumber (Kaur et al., 2024).

Stress-resistance-related traits are important guarantees for achieving high and stable cucumber yield. Cucumber is sensitive to low temperature, high temperature, drought, and salt stress, and adverse environmental conditions can lead to reduced photosynthesis, abnormal floral organ development, and decreased fruit-setting rate, thereby significantly affecting yield and fruit quality. In recent years, traits such as drought tolerance, salt tolerance, and resistance to viral diseases have gradually been incorporated into evaluation systems for high-yield cucumber breeding. Quantitative genetic studies have shown that some stress-related traits and disease indices possess certain levels of heritability and may be genetically associated with flowering habits and fruit development traits, indicating the potential for the synergistic improvement of stress resistance and high yield. With the development of marker-assisted selection, genomic selection, and gene-editing technologies, important genes and QTLs related to low-temperature tolerance, salt tolerance, disease resistance, and fruit development have gradually been