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Effect of Temperature on Seedling Traits, Genetic Analysis of Seedling Traits and Their Influence on Seed Yield in Mungbean [*Vigna radiata* (L.) Wilczek] Genotypes

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ABSTRACT

Background: Temperature is a critical environmental factor that significantly affects the growth and development of seedlings in many plant species, including mungbean. Mungbean is an important pulse crop and understanding its genetic diversity is crucial for breeding programmes aimed at improving seedling traits and seed yield. This study investigates the impact of different temperature regimes on the germination and seedling growth, evaluates the extent of genetic variability and to explore the relationships between various seedling characteristics.

Methods: In this field-laboratory investigation, field experiments were conducted with 35 mungbean genotypes in an RBD with three replications at the College of Agriculture, Swami Keshwanand Rajasthan Agricultural University, Bikaner, Rajasthan during *summer* of 2019 and *Kharif* 2019-20. The laboratory experiment was conducted with same genotypes at 30°C and 40°C temperature regimes under controlled conditions during *Kharif* 2020-21.

Result: Seedling traits like seedling dry weight, seedling fresh weight and seedling vigour index exhibited high degree of genetic variability along with high heritability and high genetic advance as per cent of mean at 40°C. Therefore, screening of genotypes on the basis of seedling traits may be conducted at 40°C. Among seedling traits, seedling fresh weight, seedling dry weight and seedling vigour index had positive correlation with seed yield at 30°C and directly contributed towards seed yield.

Key words: 30°C and 40°C temperature, Character association, Seed yield, Seedling traits.

INTRODUCTION

Mungbean is also known as green gram, an ancient pulse crop widely cultivated under different agro-ecological situations in India mainly during *Kharif* and summer seasons (Kumar *et al.,* 2024). It is a diploid species having chromosome number (2n=22) belongs to family Leguminosae (Fabaceae), sub-family Papilionaceae and is botanically recognized as *Vigna radiata* (L.) Wilczek (Anita *et al.,* 2022). Mungbean is a native of South Asia (India). *Vigna radiata* var. *sublobata* is the possible progenitor of mungbean. It is basically a self-pollinated crop (Singh *et al.,* 2015).

Mungbean is widely cultivated in tropical and subtropical regions for its nutritional value and adaptability to diverse environmental conditions. As a vital source of plant-based protein, mungbean contributes significantly to human diets, especially in developing countries. The optimum temperature for green gram growth is 28-30°C temperature; however, the successful cultivation of mungbean is highly sensitive to environmental factors, specially, temperature playing a pivotal role in influencing various growth stages, from germination to seedling development.

Temperature is one of the most critical abiotic factors that affect seed germination, seedling growth and overall plant development. Optimal temperature conditions ensure efficient physiological processes, such as water uptake, enzyme activity and metabolic reactions, which are crucial for seedling vigour and survival. However, deviations from the optimal temperature range can result in growth inhibition, physiological stress and even plant death. For mungbean, understanding the temperature thresholds that promote or hinder early seedling growth is essential for improving agricultural productivity, especially in regions facing temperature fluctuations due to climate change (Haj Sghaier *et al.,* 2022).

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In mungbean, low temperatures can delay germination and restrict seedling growth, while excessively high temperatures may induce heat stress, affecting the overall plant health and yield. Despite its resilience, mungbean is not immune to such temperature extremes, which can cause physiological damage at critical early growth stages. Therefore, understanding the effect of different temperature regimes on mungbean seedlings is crucial for optimizing growing conditions and ensuring successful crop establishment.

Genetic variability serves as the cornerstone of plant breeding. Screening diverse genotypes for traits such as higher seed yield and its components under high-temperature stress is essential. Identifying heat-tolerant genotypes enables the transfer of this tolerance into high-yielding varieties through suitable breeding strategies. Germination studies conducted under controlled conditions provide a reliable means to validate findings from field screenings. This additional support of field screening validates high temperature tolerant genotypes (Begna and Teressa, 2024).

This study aims to investigate the influence of varying temperature conditions on the germination and seedling development in mungbean to assess the extent of genetic variability and character association on seedling traits to increase the yield in mungbean.

MATERIALS AND METHODS

The experimental material consisting of thirty five genotypes was procured from NBPGR, Regional Station, Jodhpur; Rajasthan Agricultural Research Institute, Durgapura, Jaipur; Agricultural Research Station, Sriganganagar and Agricultural Research Station, Mandor, Jodhpur as given in Table 1. The field experiments were conducted with 35 genotypes of mungbean in a randomized block design with three replications, accommodating three meter long two rows per replication at 30 cm spacing at the College of Agriculture, Bikaner and Swami Keshwanand Rajasthan Agricultural University, Bikaner, Rajasthan during *summer* 2019 and *Kharif* 2019-20 with temperature range from 28 to 43°C temperature. All the recommended practices were adopted to raise a good crop. Observation for seed yield were recorded on an individual plant basis from five randomly selected plants in each genotype of each replication. Harvested seeds from each genotype were used for further study of seed germination and seedling traits under controlled conditions.

In laboratory experiment, ten seeds from each thirty-five mungbean genotypes were germinated for seed germination at two different temperature gradients (optimal temperature 30°C and high temperature 40°C). The experiment was followed a completely randomized design with three replications for each genotype. It was conducted in a plant growth chamber using seed germination paper (Gsm: 145) in petri-dishes (9 cm in diameter), which were moistened and kept at the respective temperature gradients (30°C and 40°C). Glass petri-dishes were used and the germination papers served as the matrix for seed germination. Ten sterilized seeds from each of the thirty-five mungbean genotypes were placed on sterilized seed germination papers in petri-dishes in plant growth chamber. Each germination paper was moistened with 3 ml of double distilled water. Seed germination was recorded on 7th day after seeding. For seedling parameters, ten seeds of each thirty five mungbean genotypes were sown in 200 ml volumetric pot-tray containing solarite in plant growth chamber at two different temperature gradients (optimal temperature 30°C and high temperature 40°C). The experiment was conducted in completely randomized design with three replications of each genotype. Observations were recorded for different seedling characteristics on 15th day of seed planting. Five seedlings were randomly selected from each pot-tray to record the data on seedling length, seedling fresh weight, seedling dry weight and seedling vigour index. The data on seedling dry weight was recorded after drying in hot air oven for 48 hours at 65°C. The observations were recorded for following characters.

Germination (%)

The germination capacity of seeds, determined by a binary outcome (germinated or non-germinated), was converted into quantitative attribute, expressed as germination percentage. Ten seeds from each genotype were used to calculate germination percentage based on the number of seeds germinated out of the total seeds used the germination test at different temperatures (30°C and 40°C). A seed was considered to have germinated at the emergence of both radicle and plumule up to 2 mm length (Chartzoulakis and Klapaki, 2000). The number of germinated seeds was recorded 7th day after planting in petri-dishes and the germination percentage was determined by using the following formula (Aniat *et al.,* 2012).

$$\text{Germination (\%)} = \frac{\text{Number of seeds germinated}}{\text{Total number of germinated}} \times 100$$

Seedling length (cm)

The seedling length of germinated seeds was recorded on the 15th day of planting in pot trays. Five seedlings from each genotype that was grown in the pot tray were randomly selected from each replication. The seedling length (the distance from root tip to shoot tip) was measured by using a measuring scale in centimetres and averaged.

Seedling fresh weight (mg)

The fresh weight of seedling from the five seedlings which were selected already from each replication was measured in milligram by using a sensitive electronic balance and averaged.

Seedling dry weight (mg)

The seedlings which were taken for fresh weight were kept into paper bags. The abbreviations of varieties were written

on paper bags by the marker for further identification. After taking the fresh weight of seedlings these were kept in the oven at 65°C for 48 hours for drying. After drying, the dried seedlings were weighed using the sensitive electronic balance in milligram and the average was recorded.

Seedling vigour index

The seedling vigour index was determined by multiplying the seedling length with concerned germination percentage by the following formula (Iqbal and Rahmati, 1992).

Seedling vigour index =

Seedling length (cm) × Germination percentage

Analysis of variance was done by subjecting the data to the statistical method described by Panse and Sukhatme (1985). The statistical analysis was performed using INDOSTAT 8.1 and XLSTAT 2021.2.2 software. Genotypic variances and phenotypic variances were calculated according to Johnson *et al.,* (1955); Comstock and Robinson (1952), respectively from the expectations of

Table 1: Details of mungbean genotypes used in investigation.

Name of genotype	Year of collection	Source of procurement
Germplasm procured from NBPGR, Regional Station, Jodhpur		
IC-39269	1993	Jodhpur, Rajasthan
IC-39300	1993	Jaswasar, Bikaner,Rajasthan
IC-39328	1993	Lalela, Barmer, Rajasthan
IC-39352	1993	Manduwa, Barmer, Rajasthan
IC-39399	1993	Jaspura, Palanpur, Gujarat
IC-39409	1993	Kapara, Banaskantha, Gujarat
IC-39454	1988	Surendranagar, Gujarat
IC-39492	1988	Dudhai, Mahesana, Gujarat
IC-39608	1992	Nevra, Jodhpur, Rajasthan
IC-39610	1992	Osian, Jodhpur, Rajasthan
IC-52076	1992	*
IC-52081	1992	*
IC-52082	1992	*
IC-52087	1992	*
IC-102792	1986	Banar, Jodhpur, Rajasthan
IC-102821	1986	Gidani, Jaipur, Rajasthan
IC-102857	1986	Khasur, Dholpur, Rajasthan
IC-103014	1986	Alampur, Kheda, Gujarat
IC-103059	1986	Krakas, Amreli, Gujarat
IC-103244	1986	Bhrwasa, Didwana, Nagaur, Raj.
IC-338868	1990	Sanari, Barmer, Rajasthan
Varieties/ genotypes procured from Agriculture University, Jodhpur		
Sweta		CSAVAT, Kanpur
IPM-02-3		ICAR-IIPR, Kanpur
IPM-02-14		ICAR-IIPR, Kanpur
Samrat (PDM-139)		ICAR-IIPR, Kanpur
GM-4		AAU, Pulse Res.Station,Vadodara
MH 2-15		CCSHAU, Hisar
MH-421		CCSHAU, Hisar
Varieties/ genotypes procured from RARI, Durgapura, Jaipur		
RMG-62		SKRAU-ARS, Durgapura, Jaipur
RMG-344		SKRAU-ARS, Durgapura, Jaipur
Keshwanand Mung-1 (RMG-975)		SKNAU-RARI, Durgapura, Jaipur
Varieties/ genotypes procured from ARS, Sriganganagar		
SML-668		PAU, Ludhiana
SML-832		PAU, Ludhiana
Ganga-1		SKRAU-ARS, Sriganganagar
MUM-2		CCS Meerut University, Meerut

*Source was not mentioned by NBPGR, Regional Station, Jodhpur, Rajasthan, India.

mean squares by using an ANOVA table for each character. Heritability in a broad sense was calculated as suggested by Burton and Devane (1953). The expected genetic advance for each character was calculated as suggested by Johnson *et al.* (1955). Phenotypic correlation and path coefficients of variation were computed as per the method given by Dewey and Lu (1959).

RESULTS AND DISCUSSION

The analysis of variance revealed significant differences among thirty five genotypes of mungbean for all seedling traits except germination at 30°C which indicate the presence of good amount of variability in the genotypes and scope of selection for genetic improvement of mungbean (Table 2). The results confirmed the findings of Adlan (2019) in mungbean, Get *et al.* (2019) in lentil, Pal *et al.* (2020) and Meena (2021) in mothbean.

At 30°C temperature (Table 3), the mean germination percentage was 99.68%, with a narrow range of 96.67% to 100%. The genotypic coefficient of variation (GCV) was 0.51%, while the phenotypic coefficient of variation (PCV) was 1.29%, indicating low variability. Broad-sense heritability was moderate (15.66%), with a genetic advance of 0.42, which accounts for 0.42% of the mean. The mean seedling length was 18.48 cm, ranging from 15.77 cm to 21.25 cm. GCV (6.52%) and PCV (6.76%) were closely aligned, signifying minimal environmental influence on this trait. High heritability (92.80%) was observed, coupled with a genetic advance of 2.39, contributing to 12.93% of the mean. The mean seedling fresh weight was 270.18 mg, with a wide range of 215.56 mg to 385.87 mg. GCV (10.49%) and PCV (10.66%) were close, indicating high genetic control over the trait. Heritability was very high (96.80%), with a substantial genetic advance of 57.44, contributing to 21.26% of the mean. The mean seedling dry weight was 32.57 mg, with a range of 22.02 mg to 43.47 mg. GCV (12.22%) and PCV (12.43%) showed strong genetic control and low environmental influence. Heritability was very high (96.60%), with a genetic advance of 8.06, accounting for 24.75% of the mean. The mean seedling vigor index was 1839, ranging from 1558 to 2125. GCV (7.08%) and PCV (7.11%) were almost identical, suggesting negligible environmental impact. The trait exhibited extremely high heritability (99.20%) and a genetic advance of 267.33, contributing to 14.54% of the mean. Traits such as seedling fresh weight, seedling dry weight and seedling vigor index exhibit very high heritability (above 95%) and substantial genetic advance. These traits are likely controlled predominantly by additive gene action and can be improved effectively through simple selection methods such as mass selection or pedigree selection. These traits showed high heritability and genetic advance, indicating strong genetic control with minimal environmental influence. These can be prioritized for direct selection in breeding

Table 2: Analysis of variance of mungbean genotypes for seedling characteristics.

Character	Sources of variation		
	Replications	Genotypes	Error
d. f.	2	34	68
Germination percentage at 30°C	1.409	2.185NS	1.703
Germination percentage at 40°C	15.238	176.863**	23.081
Seedling length (cm) at 30°C	0.224	4.686**	0.338
Seedling length (cm) at 40°C	0.164	5.112**	0.110
Seedling fresh weight (mg) at 30°C	109.189	2489.029**	79.682
Seedling fresh weight (mg) at 40°C	4.732	2164.441**	6.088
Seedling dry weight (mg) at 30°C	2.800	49.184**	1.661
Seedling dry weight (mg) at 40°C	0.275	219.137**	0.281
Seedling vigor index at 30°C	50.467	51326.178**	404.447
Seedling vigor index at 40°C	975.705	47247.928**	652.325

*Significant at P = 0.05, ** Significant at P = 0.01; NS= Non-significant.

Table 3: Genetic variability parameters of mungbean genotypes for seedling characteristics at 30°C temperature.

Characters	Mean	Range	Coefficient of variation		Heritability % (broad sense)	Genetic advance 5%	Genetic advance as per cent mean 5%
			Genotypic	Phenotypic			
Germination per cent at 30°C	99.68	96.67-100	0.51	1.29	15.66	0.42	0.42
Seedling length (cm) at 30°C	18.48	15.77-21.25	6.52	6.76	92.80	2.39	12.93
Seedling fresh weight (mg) at 30°C	270.18	215.56-385.87	10.49	10.66	96.80	57.44	21.26
Seedling dry weight (mg) at 30°C	32.57	22.02-43.47	12.22	12.43	96.60	8.06	24.75
Seedling vigor index at 30°C	1839	1558-2125	7.08	7.11	99.20	267.33	14.54

programs aimed at improving heat tolerance. These results are accordance with the earlier finding of Adlan (2019) in mungbean, Get *et al.* (2019) in lentil, Pal *et al.* (2020) and Meena (2021) in mothbean.

At 40°C temperature (Table 4), the mean germination percentage was 85%, with a range of 67-100%. Genotypic and phenotypic coefficients of variation (GCV and PCV) were relatively close at 8.39% and 9.00%, respectively, indicating minimal environmental influence on this trait. High heritability (86.90%) coupled with moderate genetic advance as a percentage of the mean (16.12%) suggests that this trait is under substantial genetic control and amenable to selection. The mean seedling length was 6.53 cm, ranging from 4.25-9.79 cm. The GCV (19.79%) and PCV (20.00%) values were nearly identical, implying strong genetic control with negligible environmental influence. Extremely high heritability (97.80%) and substantial genetic advance as a percentage of the mean (40.32%) suggest that seedling length is a reliable trait for selection under heat stress. The mean fresh weight was 111.64 mg, ranging from 52.33-148.35 mg. The GCV (24.03%) and PCV (24.06%) were nearly equal, indicating robust genetic control. Very high heritability (99.70%) and significant genetic advance (49.43%) suggest the trait can be effectively improved through direct selection. The mean dry weight was 14.12 mg, with a wide range of 3.53-35.33 mg. GCV (60.49%) and PCV (60.53%) showed negligible environmental influence, emphasizing strong genetic control. Exceptionally high heritability (99.90%) and genetic advance (124.53%) make this trait an excellent candidate for selection. The mean vigor index was 561.56, ranging from 355.83-819. GCV (22.19%) and PCV (22.35%) were nearly identical, confirming the strong genetic influence. High heritability (98.60%) and substantial genetic advance (45.40%) indicate the potential for significant genetic improvement. The study highlights the potential for improving heat tolerance in crops through the selection of traits with high heritability and genetic advance. Key traits such as seedling length, seedling fresh weight and seedling vigor index are highly heritable and can serve as reliable indicators for breeding programs aimed at developing heat-tolerant varieties. These results are accordance with the earlier finding of Adlan (2019) in mungbean, Get *et al.* (2019) in lentil, Pal *et al.* (2020) and Meena (2021) in mothbean.

Character association analysis specify that significant correlations among germination percentage, seedling traits and seed yield at 30°C (Table 5). Germination percentage showed a significant positive correlation with seedling vigor index but a negligible association with seed yield per plant.

Table 4: Genetic variability parameters of mungbean genotypes for seedling characteristics at 40°C temperature.

Characters	Mean	Range	Coefficient of variation		Heritability % (broad sense)	Genetic advance 5%	Genetic advance as per cent mean 5%
			Genotypic	Phenotypic			
Germination per cent at 40°C	85	67-100	8.39	9.00	86.90	13.75	16.12
Seedling length (cm) at 40°C	6.53	4.25-9.79	19.79	20.00	97.80	2.63	40.32
Seedling fresh weight (mg) at 40°C	111.64	52.33-148.35	24.03	24.06	99.70	55.18	49.43
Seedling dry weight (mg) at 40°C	14.12	3.53-35.33	60.49	60.53	99.90	17.58	124.53
Seedling vigor index at 40°C	561.56	355.83-819	22.19	22.35	98.60	254.95	45.40

Table 5: Estimates of phenotypic and genotypic correlation coefficient of mungbean genotypes for seedling characteristics at 30°C temperature.

Character		Germination percentage at 30°C	Seedling length at 30°C	Seedling fresh weight at 30°C	Seedling dry weight at 30°C	Seedling vigor index at 30°C	Seed yield per plant
Germination percentage at 30°C	P	1.000	0.236*	0.080	0.119	0.392**	-0.009
	G	1.000	-0.874	-0.061	-0.388	-1.412	-0.068
Seedling length at 30°C	P		1.000	0.518**	0.221*	0.985**	0.265**
	G		1.000	0.537	0.233	1.019	0.273
Seedling fresh weight at 30°C	P			1.000	0.584**	0.493**	0.464**
	G			1.000	0.602	0.499	0.490
Seedling dry weight at 30°C	P				1.000	0.221*	0.489**
	G				1.000	0.223	0.521
Seedling vigor index at 30°C	P					1.000	0.245*
	G					1.000	0.256
Seed yield per plant	P						1.000
	G						1.000

This suggests that while higher germination may enhance early seedling growth, it does not necessarily translate into higher yield. Seedling length exhibited a strong positive correlation with seedling vigor index, fresh weight and dry weight indicating that longer seedlings tend to be more vigorous and healthier. Similar trends were observed by Rahman *et al.* (2020), who reported that seedling vigor is a key indicator of early-stage growth potential. Seedling fresh and dry weights were positively correlated with seed yield per plant suggesting that heavier seedlings contribute to better yield performance. This aligns with findings by Singh *et al.* (2018), who emphasized the role of seedling biomass in enhancing crop productivity.

The correlation analysis at 40°C revealed that germination percentage had a positive correlation with seedling vigor index but was not significantly associated with seed yield (Table 6). This suggests that while high germination enhances early vigor, it does not directly contribute to productivity under heat stress, as also observed by Sharma *et al.* (2020). Seedling length showed a strong positive correlation with seedling vigor index but was negatively correlated with seed yield. This indicates that excessive elongation may lead to weaker plants, which could negatively impact final yield, supporting the findings of Rahman *et al.* (2019). Seedling fresh weight had a negative correlation with seedling dry weight, suggesting that increased water retention under heat stress may limit dry matter accumulation, similar to the findings of Singh *et al.* (2018). However, seedling dry weight was positively correlated with seed yield emphasizing that dry matter accumulation is a key factor for productivity as reported by Kumar *et al.* (2021). An unexpected negative correlation between seedling vigor index and seed yield suggests that highly vigorous seedlings may not always translate into higher yields under high-temperature conditions. This could be due to excessive energy allocation toward early growth at the cost of reproductive development, as highlighted by Ahmed *et al.* (2022).

Path analysis reveals that the highest positive direct effect on seed yield per plant was observed for seedling vigour index at 30°C followed by seedling dry weight at 40°C, seedling dry weight at 30°C, seedling length at 40°C,

Table 6: Estimates of phenotypic and genotypic correlation coefficient of mungbean genotypes for seedling characteristics at 40°C temperature.

Character		Germination percentage at 40°C	Seedling length at 40°C	Seedling fresh weight at 40°C	Seedling dry weight at 40°C	Seedling vigor index at 40°C	Seed yield per plant
Germination percentage at 40°C	P	1.000	0.095	-0.086	0.108	0.483**	-0.096
	G	1.000	0.100	-0.094	0.112	0.510	-0.102
Seedling length at 40°C	P		1.000	0.548**	-0.273**	0.906**	-0.234*
	G		1.000	0.556	-0.277	0.918	-0.257
Seedling fresh weight at 40°C	P			1.000	-0.517**	0.425**	-0.232*
	G			1.000	-0.518	0.429	-0.247
Seedling dry weight at 40°C	P				1.000	-0.215*	0.420**
	G				1.000	-0.218	0.444
Seedling vigor index at 40°C	P					1.000	-0.263**
	G					1.000	-0.278
Seed yield per plant	P						1.000
	G						1.000

Table 7: Estimates of phenotypic and genotypic path coefficient of mungbean genotypes on seed yield for seedling characteristics at 30°C temperature.

Character		Germination percentage at 30°C	Seedling length at 30°C	Seedling fresh weight at 30°C	Seedling dry weight at 30°C	Seedling vigor index at 30°C	Correlation with seed yield per plant
Germination per cent at 30°C	P	-0.4365	-0.1033	-0.0351	-0.0522	-0.1712	-0.009
	G	-0.0299	0.0261	0.0019	0.0116	0.0422	-0.068
Seedling length at 30°C	P	-0.5093	-2.1518	-1.1156	-0.4748	-2.1184	0.265**
	G	0.0993	-0.1135	-0.0609	-0.0265	-0.1157	0.273
Seedling fresh weight at 30°C	P	0.0118	0.0762	0.1470	0.0858	0.0725	0.464**
	G	-0.0114	0.0984	0.1833	0.1103	0.0914	0.490
Seedling dry weight at 30°C	P	0.0432	0.0798	0.2113	0.3618	0.0798	0.489**
	G	-0.1292	0.0774	0.1999	0.3322	0.0740	0.521
Seedling vigor index at 30°C	P	0.9132	2.2930	1.1483	0.5137	2.3291	0.245*
	G	-0.1957	0.1412	0.0691	0.0309	0.1385	0.256

Table 8: Estimates of phenotypic and genotypic path coefficient of mungbean genotypes on seed yield for seedling characteristics at 40°C temperature.

Character		Germination percentage at 40°C	Seedling length at 40°C	Seedling fresh weight at 40°C	Seedling dry weight at 40°C	Seedling vigor index at 40°C	Correlation with seed yield per plant
Germination percentage at 40°C	P	0.0459	0.0044	-0.0039	0.0049	0.0222	-0.096
	G	-0.0333	-0.0033	0.0031	-0.0037	-0.0170	-0.102
Seedling length at 40°C	P	0.0290	0.3052	0.1672	-0.0834	0.2765	-0.234*
	G	0.0245	0.2455	0.1365	-0.0680	0.2254	-0.257
Seedling fresh weight at 40°C	P	0.0015	-0.0096	-0.0176	0.0091	-0.0075	-0.232*
	G	0.0026	-0.0152	-0.0273	0.0141	-0.0117	-0.247
Seedling dry weight at 40°C	P	0.0407	-0.1034	-0.1958	0.3785	-0.0815	0.420**
	G	0.0384	-0.0954	-0.1785	0.3445	-0.0749	0.444
Seedling vigor index at 40°C	P	-0.1799	-0.3375	-0.1583	0.0803	-0.3726	-0.263**
	G	-0.1683	-0.3029	-0.1415	0.0718	-0.3300	-0.278

seedling fresh weight at 30°C and germination percentage at 40°C at phenotypic level (Table 7 and 8). These findings are in accordance as reported by Adlan (2019) in mungbean, Pal *et al.* (2020) and Meena (2021) in mothbean.

CONCLUSION

Seedling traits like seedling dry weight, seedling fresh weight and seedling vigour index exhibited high degree of genetic variability along with high heritability and high genetic advance as per cent of mean at 40°C. Therefore, screening of genotypes on the basis of seedling traits may be conducted at 40°C. Among seedling traits, seedling fresh weight, seedling dry weight and seedling vigour index had positive correlation with seed yield at 30°C and directly contributed towards seed yield, therefore, these traits can be used for future mungbean breeding programme.

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Disclaimers

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Conflict of interest

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REFERENCES

Adlan, P. (2019). Morpho-physiological studies in mungbean [*Vigna radiata* (L.) Wilczek]. Thesis, Swami Keshwanand Rajasthan Agricultural University, Bikaner (Rajasthan). pp. 123.

Ahmed, S. (2022). Seedling vigor and its trade-offs with yield under heat stress. *Journal of Crop Science.* **14(2):** 67-81.

Aniat, U.H., Vamil, R. and Agnihotri, R.K (2012). Effect of osmotic stress on germination and seedling survival of lentil [*Lens culinaris* M.]. *Research in Agricultural Sciences.* **1(3):** 201-202.

Anita, Kumhar, S.R., Kumar A., Suchitra, Kulheri A., Shekhawat P.K. and Yadav G.L. (2022). Correlation and path analysis for pod yield and its component traits in mungbean [*Vigna radiata* (L.) Wilzeck] genotypes. *Legume Research.* **48(1):** 26-31. doi: 10.18805/LR-4906.

Begna, T. and Teressa, T. (2024). Genetic variability and Its benefits in crop improvement: A review. *Middle East Journal of Agriculture Research.* **13(1):** 128-136.

Burton, G.W. and Devane, E.M. (1953). Estimation of heritability in tall fescus (*Festuca arundinacea*) from replicated clonal material. *Agronomy Journal.* **45:** 478-480.

Chartzoulakis, K.S. and Klapaki, G. (2000). Response of two green-houses pepper hybrids to NaCl salinity during different growth stages. *Scientia Horticulturae.* **86(1):** 247-260.

Comstock, R.R. and Robinson, H.F. (1952). Genetic parameters, their estimation and significance. Proceeding of Sixth International Grassland Congress. **1:** 248- 251.

Dewey, D.R. and Lu, H.K. (1959). A correlation and path coefficient analysis of components of crested wheat grass seed production. *Agronomy Journal.* **51(6):** 515-518.

Get, S., Gothwal, D.K., Choudhary, R.C. and Shekhawat, K. (2019). Genetic variability in lentil (*Lens culinaris* M.) genotypes for seed and seedling characteristics. *Journal of Pharmacognosy and Phytochemistry*. **8(3):** 3000-3004.

Haj Sghaier, A., Tarnawa, A., Khaeim, H., Kovacs, G.P., Gyuricza, C. and Kende, Z. (2022). The effects of temperature and water on the seed germination and seedling development of rapeseed (*Brassica napus* L.). *Plants.* **11:** 2819. https://doi.org/10.3390/plants11212819.

Iqbal, M. Z. and Rahmati, K. (1992). Tolerance of Albizia lebback to Cu and Fe application. *Ekologia CSFR.* **11(4):** 427-430.

Johnson, H.W., Robinson, H.F. and Comstock, R.E. (1955). Estimate of genetic and environmental variability in soybean. *Agronomy Journal.* **47:** 314-318.

Kumar A., Sharma N.K., Anita, Shekhawat K., Kumawat S. (2024). Stability analysis for agro-morphological and physio-biochemical traits in mungbean [*Vigna radiata* (L.) Wilzeck] under arid environment. *Legume Research.* 47(5): 723-730. doi: 10.18805/IJARe.A-6330.

Kumar, V. (2021). Role of biomass accumulation in seed yield under heat stress. *Plant Physiology and Development.* **19(4):** 89-102.

Meena, S. (2021). Evalution of mothbean [*Vigna aconitifolia* (jacq) marechal] genotypes for physiological and agro-morphological traits under arid environment. Thesis, Swami Keshwanand Rajasthan Agricultural University, Bikaner Rajasthan. pp. 153.

Pal, S., Sharma, N.K., Sharma, A.K., Kumar, A. and Meena, S. (2020). Study of genetic variability parameters for seed yield and component traits in moth bean [*Vigna aconitifolia* (jacq) Marechal]. *International Journal of Chemical Studies.* **8(4):** 2638-2641.

Panse, V.G. and Sukhatme, P.V. (1985). Statistical Methods for Agricultural Workers, ICAR, New Delhi. pp. 357.

Rahman, M. (2019). Effects of high temperature on seedling elongation and biomass allocation. *Agricultural Research Review*. **17(3):** 112-125.

Rahman, M. (2020). Seedling vigor and its role in crop establishment. *Journal of Agricultural Sciences*. **12(3):** 45-52.

Sharma, P. (2020). Effects of seed density on seedling competition and vigor. *Agricultural Research Review.* **15(1):** 78-85.

Singh, C., Singh, P. and Singh, R. (2015). Modern Techniques of Raising Field Crops. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi. pp. 386.

Singh, R.K. and Chaudhary, B.D. (1985). Biometrical Methods in Quantitative Genetic Analysis. Kalyani Publishers, New Delhi. pp. 318.

Singh, R. (2018). Influence of seedling biomass on crop productivity. *Plant Growth and Yield Research.* **10(2):** 112-119.