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Studies on Growth Performance and Evaluation of Cowpea (*Vigna unguiculata* (L.) Walp.) Genotypes for Seed Quality

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ABSTRACT: Cowpea is a nutrient-rich crop providing affordable protein, nitrogen fixation, drought resistance, and adaptability to challenging environments. The study characterized cowpea germplasm lines based on seed traits, including colour, shape, and eye colour, revealing significant variation. ANOVA of seed quality parameters showed significant differences among genotypes, except for moisture content and mean seedling length. Genotype EC 075180 exhibited the highest 100-seed weight (18.70 g), NBC 51 the lowest moisture content (7.54%), and V-578 the highest germination (96%). Other superior genotypes included SUPER 30 recorded root length (22.72 cm), IC 97767(10) noticed shoot length (18.00 cm), NBC 016 showed mean seedling length (33.07 cm) and vigour index-I (2983), and EC 390287 with vigour index-II (3844). DC 15 recorded the lowest electrical conductivity (2.67), EC 075180 the highest dehydrogenase activity (3.98), and EC 492292 the highest protein content (29.93%). Controlled deterioration reduced germination and seedling vigour, but NBC 14 maintained higher germination (75.00), indicating better vigour under stress. These genotypes are recommended for breeding programs to enhance yield and seed quality under prevailing conditions.

Keywords: cowpea, seed quality, controlled deterioration, germplasm, breeding program.

INTRODUCTION

Cowpea (*Vigna unguiculata* [L.] Walp.) is annual herbaceous plant, cultivated for its leaves, green pods, grains and adaptability to diverse agro-climatic conditions. Because of the high protein content and superior biological value on a dry weight basis of the green leaves, cowpeas are sometimes referred to as "vegetable meat" or "poor man's meat." They also supply fibre, vitamins, and minerals. Additionally, it is grown as a green manure, fodder, cover, or catch crop. Cowpea grains have higher percentage of vital minerals than meat, fish, or eggs, including calcium (826 mg/kg) and iron (53.2 mg/kg), both of which are excellent for lowering blood cholesterol (Rangel *et al.,* 2003; Achuba, 2006; Boukar *et al.*, 2019). In India, the mean grain yields of cowpea are between 249 to 980kg/ha which is far less than the potential yield 3t per hectare elsewhere (Molosiwa *et al.,* 2016). A major constraint to achieve this production of cowpea grains in the tropics and sub tropics is lack of high yielding cultivars and poor cultivation practices. Therefore, development of best performing, locally adaptable potential cultivars offer a simple and cost-effective method to produce higher yield. Seed quality traits are critical determinants of yield potential and crop performance, influencing germination, seedling vigour, and overall productivity. In cowpeas seed size is considered as an important trait as it directly influences productivity along with seed colours, which determine grain quality for marketing (Wirianto *et al.,* 2024). Characterizing germplasm based on seed morphological and physiological traits provides essential insights for breeding programs. Seed colour, shape, and eye colour are key morphological descriptors that vary significantly across genotypes, reflecting genetic diversity. Physiological traits, including seed germination, vigour indices, protein content, and dehydrogenase activity, further highlight genotype-specific performance under different conditions.

Although morphological and physiological traits are recognized as important, data on their variation across cowpea genotypes under stress conditions remains limited. This lack of information hinders the identification of genotypes with superior adaptive traits, which are crucial for improving crop performance. While previous studies have emphasized the importance of evaluating seed quality attributes, there is insufficient research on the response of cowpea genotypes to controlled deterioration—a key factor in simulating stress conditions (Sathya *et al.,* 2023). To address this gap, this study aims to characterize cowpea germplasm lines based on seed traits and quality parameters, identify superior genotypes, and evaluate their performance under controlled deterioration. The findings will offer valuable insights for breeding programs focused on enhancing seed quality and yield potential, particularly under stress conditions.

MATERIAL AND METHODS

Seed material. The experiment was conduct in the laboratory of the department of seed science and technology, G.K.V.K. at University of Agricultural Sciences Bangalore. 118 diverse germplasms along with two check varieties (C-152 and KBC-9) were evaluated for seed quality such as germination, seed moisture content, total dehydrogenase activity and protein content. Further, they were subjected to controlled deterioration test to study the effects of the ageing on the physiological statuses of seeds.

Seed morphological characterization. Seed traits of each genotype were observed at physiological maturity. Eye colour was recorded as tan brown, red, or black; seed colour as white, brown, red, or black; and seed shape as kidney, elliptical, or rhomboid.

Hundred seed weight. Cleaning was done to remove the cracked, broken and abnormal seeds, other seeds, foreign matters, etc. by hand picking. Hundred seeds were counted from the harvested plants of each plot and were weighed and expressed in grams.

Standard germination test. The germination test was conducted as per ISTA guidelines in the laboratory by using between paper method (Anon., 2021). One hundred seeds are randomly selected from each genotype in three replications and placed equidistantly on the paper towel, they are further rolled and kept in a germination chamber with a temperature of 25 ± 1°C and Relative humidity of 90 per cent. The first count and the final count of the germinated seedlings was taken on the 5th and 8th day respectively and the percentage of germination was expressed based on the number of normal seedlings present.

Seed germination = [No. of normal seedlings/No. of seed put for germination] × 100

Shoot length, root length and mean seedling length. From the standard germination test, shoot length (collar region to shoot tip), root length (collar region to primary root tip), and seedling length (primary root tip to apical shoot tip) were measured on ten randomly selected normal seedlings per genotype replication. Measurements were taken on the final count day and expressed as mean lengths in centimetres.

Seedling dry weight. Ten normal seedlings used for shoot and root length measurements were dried in a hot air oven at 80°C for 17 ± 1 hour, cooled in desiccators for 45 minutes, and weighed. The mean seedling dry weight was expressed in milligrams (mg).

Seedling vigour indices. Seedling vigour indices were calculated following (Abdul-Baki and Anderson 1973). Vigour index-I and Vigour index-II were computed as

Vigour index-I = Germination (%) × [Root + Shoot length (cm)]

Vigour index-II = Germination (%) × Mean seedling dry weight (mg)

Seed moisture content. Seed moisture content (%) was determined using the oven-dry method (Anon., 1985). Five grams of seeds were dried in aluminium cups at 103°C for 17 hours, and then cooled in desiccators for 30 minutes before weighing. The moisture content was calculated using the formula:

Seed moisture content (%) = $[M_2 - M_3] / [M_2 - M_1] \times 100$

Where, M_1 = The weight of the container with its lid; M_2 = The weight of the container with its lid and seeds before drying; M_3 = The weight of the container with lid and seeds after drying.

Electrical conductivity (µS/cm/gm). Twenty-five seeds from each genotype replication were soaked in 25 ml distilled water for 24 hours at 25 ± 1°C. The electrical conductivity (EC) of the seed leachate was measured using a digital conductivity meter (Model: Systronic 306), adjusted by subtracting the EC of distilled water, and expressed in µS/cm/gm (Anon., 2021).

Total Dehydrogenase (TDH) activity (A_{480}). The seed coats of 10 seeds of each genotype in three replications were removed, and the embryonic axes were soaked in 0.5% tetrazolium chloride solution, incubated at 25 ± 1°C in the dark for 4 hours. After thorough washing, the red formazan from stained embryos was eluted in 5 ml of 2-methoxy ethanol for 24 hours in an airtight container. The extract was decanted, and color intensity was measured at A480 using a spectrophotometer. Dehydrogenase activity was expressed as optical density at A_{480} (Perl *et al*., 1978).

Seed protein content. The total soluble protein content (%) was estimated as per the method prescribed by Lowry *et al*. (1951). Reagent solutions included sodium carbonate (Solution A), sodium potassium tartarate (1.35%), copper sulphate (5.5%), and Folin Ciocalteu reagent (FCR, 1:1 dilution). Solution C (A + B) was prepared fresh, and BSA served as the standard. 100 mg of dried sample was extracted with 0.1M sodium phosphate buffer (pH 7.0), centrifuged, and the supernatant was reacted with reagents, incubated, and absorbance was recorded at 660 nm. Protein content was calculated using a BSA standard curve and expressed as a percentage.

Adjustment of Seed Moisture Content for CD. After determining the initial seed moisture content (SMC). The moisture content of the seeds was adjusted to the desired value based on the ISTA (Anon., 2017 by using the formula.

$W_2 = [100 – A] \times [W_1/100 – B]$

Where, A = initial seed moisture content (%), B = desired seed moisture content (%), W_1 = initial weight of the seeds (g), W_2 = final weight of the seeds with desired moisture content (g)

Seeds of each replication imbibed on a moist germination /filter paper, placed in a suitable container.

Controlled Deterioration test. Once seeds have reached the required weight, each replication was placed in sealed aluminium foil packed and equilibrated at 4°C overnight to ensure an even distribution of moisture. Seeds package was then placed in a plastic envelope, allowing no ingression of water, and kept in a water bath at ±40°C for up to 24hr ± 15min. After which routine germination test is followed, only number of normal seedlings were and expressed as the percentage of germination.

Statistical Analysis. The statistical analysis and interpretation of the experimental data for controlled deterioration test was done by using Fisher's method of Analysis of Variance technique as outlined by Gomez and Gomez (1984). The level of significance used in 'F' and 't' tests was at five per cent. Critical difference values were calculated wherever F test was significant.

RESULT AND DISCUSSION

Seed morphological characterization. Cowpea germplasm lines were characterized based on seed colour, shape, and eye colour. Variations included 19 lines with white seeds, 24 with red, 4 with black, and 73 with brown (Fig. 1). Tan brown seed eye colour was observed in 92 lines, red in 15, and black in 13. Seed shapes were elliptical (48 lines), rhomboid (41), and kidney-shaped (31) (Table 2). Kabas *et al.* (2007) reported diverse seed coat colours, including white, cream, green, buff, red, brown, and black in cowpea. Henshaw (2008) noted various seed coat textures and shapes like kidney, rhomboid, ovoid, globose, and crowder.

Hundred seed weight. Cowpea genotypes and checks showed significant differences in 100-seed weight. Genotype EC-075180 recorded the highest weight (18.70 g), while among checks, KBC 9 had a higher seed index (10.67 g) (Table 3). This variation is attributed to genetic variability, efficient photosynthesis, and nutrient distribution during seed filling. Similar findings were reported by Peksen *et al.* (2004).

Seed germination. The primary objective of seed production is to achieve high germination rates. According to minimum seed certification standards, cowpea seeds should have at least 75 per cent germination. In this study, all cowpea genotypes exceeded this threshold. Seed germination varied significantly among different genotypes and checks. Genotype V- 578 recorded the highest seed germination (96.00 %) (Table 3). The high germination percentages may be attributed to genetic traits, water use efficiency, and nutrient uptake, which contribute to increased storage of food reserves that are utilized during germination and plant growth (Ranjitha *et al*., 2016). A similar effect of variety on seed germination and its components was observed by Olasoji *et al.* (2013).

Seed moisture content. Seed moisture content of different genotypes and checks resulted in non-significant difference for seed moisture content. Minimum moisture content was recorded in genotype NBC 51 (7.54 %), while maximum moisture content was recorded in genotype GW HOPE (11.29 %). Whereas, among checks C 152 recorded minimum moisture content (8.41 %) (Table 3). Similar results were reported by Ranasingh *et al.* (2021).

Shoot length, root length and mean seedling length. The shoot length varied significantly, with IC 97767(10) recording the highest (18.00 cm), followed by NBC 24 (15.50 cm), and IC 45061 with the lowest (6.34 cm). Root length also varied significantly, with SUPER 30 having the longest (22.72 cm), followed by C 33 (22.34 cm), and PMCP1131 the shortest (6.82 cm). Mean seedling length showed no significant variation; however, NBC 016 had the highest (33.07 cm), Overall, IC 97767(10) excelled in shoot length, SUPER 30 in root length, and NBC 016 in total seedling length, indicating its potential for breeding programs due to its balanced growth.

Seedling dry weight. Significant variation was observed, with EC 390287 recording the highest (43.27 mg), followed by CP 98 (41.97 mg), and GW HOPE the lowest (26.52 mg). Among checks, KBC 9 had the highest mean dry weight (36.20 mg).

Seedling vigour indices. Seedling vigour index-I showed no significant differences, with NBC 016 recording the highest value (2983), driven by high germination percentage and mean seedling length. Seedling vigour index-II varied significantly, with EC 390287 achieving the highest value (3844), followed by CP-98 (3747), and GW HOPE the lowest (2364). KBC 9 also excelled among checks (3222), attributed to high germination percentage and mean seedling dry weight (Table 3).

Electrical conductivity (µS/cm/gm). The electrical conductivity (µScm^{-1}g^{-1}) of cowpea genotypes, varied significantly. DC-15 recorded the lowest conductivity (2.67), followed by IC 402159 (3.34), while PCP 1124-1 had the highest (8.99). Among checks, C 152 exhibited the lowest value (4.13) (Table 3). Electrical conductivity, a sensitive indicator of seed quality, negatively correlates with other quality traits, as noted by Hibbard and Miller (1928); Natarajaratnam *et al.* (1987).

Total dehydrogenase activity (A480nm). Genotype EC- 075180 showed the highest TDH activity (3.98) whereas among the checks, KBC 9 exhibited the highest dehydrogenase activity (2.24) (Table 3). The increased total dehydrogenase activity could be attributed to the high vigour of seeds, which contain more active, living cells, supporting better germination and growth. Similar results were reported by Basu and Parida (2023).

Protein content (%). The significant variation in total seed protein content among genotypes and checks can be attributed to genetic differences, environmental factors, and the interaction between them. Genotype EC- 492292 exhibited the highest protein concentration of 29.93 per cent, indicating it possess genetic traits that enhance protein synthesis and accumulation during seed development (Table 3). Variations in physiological processes, such as nitrogen metabolism and storage protein synthesis, may also contribute to these differences across genotypes and checks. Similar findings were reported by Guo *et al.* (2022).

Controlled Deterioration (CD) Test. Under controlled deterioration, the percentage of normal seedlings and germination rate significantly declined at the (5%)

level, decreasing from 90.88 per cent in NBC 14 to 75.00 per cent after 24 hours, (48%) after 48 hours, and (24%) after 72 hours. Similarly, NBC 12 showed an initial germination rate of (91.83%), dropping to (60%) in 24 hours, 41 per cent in 48 hours, and 25 per cent in 72 hours (Table 4) (Fig. 2). As the ageing conditions intensified, with seed moisture content increasing to (20%) and the ageing period extending from 0 to 3 days, the decline in the percentage of normal seedlings followed a corresponding pattern. The decline was also prominent in all other 15 cowpea genotypes, though their magnitude were overall less in NBC 14 this can be due to higher 100 seed weight (13.64 gm), high germination (90.88%) and genetic factor. Similar findings were reported by Khan *et al.* (2015).

Table 1: Analysis of variance (ANOVA) for seed quality parameters in cowpea (*Vigna unguiculata* (L.) Walp) genotypes.

Sr. No.	Character	Mean sum of square	
		Genotype	Error
1.	Hundred seed weight	5.42*	2.34
2.	Moisture content	0.99^{ns}	0.82
3.	Germination percentage	110.23*	31.99
4.	Shoot length	7.16*	5.58
5.	Root length	17.27*	2.97
6.	Mean seedling length	10.60^{ns}	8.75
7.	Mean seedling dry weight	43.30*	8.52
8.	Vigour index I	117488.60*	35043.50
9.	Vigour index II	351996.90*	8699.45
10.	Electrical conductivity ($dScm^{-1}$ g^{-1})	1.51*	0.31
11.	Total dehydrogenase activity (A480nm)	0.71*	0.32
12.	Protein content (%)	15.21*	2.43
13.	Controlled deterioration	4070.09*	62.31

^{ns} P > 0.05; * P <= 0.05

Fig. 1. Variation in seed colour of distint cowpe genotypes.

Table 2: Characterization of cowpea germplasm for seed quality traits.

Sr. No.	No. of genotype	Character	Germplasm
1.		**Seed colour**	
	19	White	NBC 12, EC 170584, EC 458490, EC 458489, IC 402162, PCP1124-1, PMCP1131, IC 4506, NBC 38, NBC 8, PCP030601, V 604-7-3, EC 458430, VCP 17091, IC 402184, NBC 15, IC 58905, IC 603187, IT 9715497-38
	24	Red	V 578, TOME 774, NBC 27, GP 154, 27749(20), 97767(10), C 33, C 720, CB 10, CP 98, EC 472257, EC 472267, EC 492292, GC 1602, NBC 19, NBC 23, NBC 24, IC 402106, IC 402114, EC 458411, EC 458430, IC 402172, IC 402180, IC 402135
	73	Brown	C 152, KBC 9, 198355(45), 201095(32), 202329-89, 202521(93), 202804(83), 202854(97), 2574422(7), CPD 15, CPD 340, DC 15, EC 075180, EC 170584, EC 271040, EC 390287, EC 394779, EC 458438, EC 458440, KBC 2, KM 5, NBC 016, NBC 12, NBC 14, NBC 15, NBC 18, EC 458442, EC 458473, EC 458483, EC 458489, EC 458490, EC 458805, EC 472250, GC 1801, GC 1805, SUPER 30, NBC 68, NBC 8, NBC 98, TPTC-29, GC 3 (R), GC 810, GP 154, GW HOPE, IC 1070, IC 1071, IC 198326, IC 202290, IC 202325, IC 202711(58), IC 202777, IC 202781, IC 202792(72), IC 20287(99), IC 206240, IC 219489, IC 249588, IC 402125, IC 249593, IC 253251, IC 259105, IC 458470, IC 458485, IC 330996, IC 394708, IC 402048, IC 402098, IC 402101, IC 402104, IC 402159, IC 402162, IC 402164, IC 402166,
	4	Black	G 36, NBC 25, NBC 40, IC 402090
		Eye colour	
			C 152, KBC 9, 202329-89, 202521(93), 202804(83), C 720, CB 10, CP 98, CPD 15, CPD 340, IT 9715497-38, KBC 2, KM 5, NBC 016, NBC 12, DC 15, EC 075180, EC 170584, EC 271040, EC 390287, EC 394779, EC 458411, EC 458430, EC 458438, EC 458440, EC 458442, EC 458473, EC 458483, EC 458489, NBC 27, NBC 32, NBC 33, NBC 36,

2.	**92**	Tan Brown	NBC 38, PCP 0306 01, PCP 1124-1, PMCP 1131, SUPER 30, TOME 774, TPTC-29, V 240, V 578, V 585, V 604-7-3, VCP 17091, IC 402184, EC 458490, EC 458805, EC 472250, EC 472257, EC 472267, EC 492292, IC 202711(58), IC 202777, IC 202781, IC 202792(72), IC 20287(99), IC 206240, IC 219489, IC 249588, IC 249593, IC 253251, IC 259105, IC 330996, IC 394708, IC 402048, IC 402090, IC 402098, IC 402101, IC 402135, IC 402159, IC 402162, IC 402164, IC 402166, IC 402172, IC 402180, IC 4506, IC 45061, IC 458470, IC 458485, IC 58905
	15	Red	GP 154, NBC 27, NBC 15, IC 4506, 202854(97), 2574422(7), 27749(20), 97767(10), IC 603187, IC 402104, IC 402106, IC 402114, IC 402125, NBC 14, NBC 23
	13	Black	G 36, GC 1602, C 457, NBC 25, NBC 40, C33, NBC 8, NBC 98, 198355(45), 201095(32), IC 198326, IC 202290, IC 202325
		Seed shape	
3.	**31**	Kidney	C 152, 202854(97), 2574422(7), 27749(20), 97767(10), C 33, C 720, CB 10, CP 98, CPD 15, CPD 340, EC 458490, EC 458805, EC 472250, EC 472257, EC 472267, EC 492292, G 36, GC 1602, GC 1801, GC 1805, IC 402090, IC 402098, IC 402101, IC 402104, IC 402106, IC 402114, IC 402125, IC 402135, IC 402159, IC 402162
	48	Elliptical	KBC 9, 198355(45), 201095(32), 202329-89, 202521(93), 202804(83), DC 15, EC 075180, GC 3 (R), GC 810, GP 154, GW HOPE, IC 1070, IC 1071, IC 198326, IC 202290, IC 202325, IC 202711(58), IC 202777, IC 202781, IC 202792(72), IC 20287(99), IC 206240, IC 458470, IC 458485, IC 58905, IC 603187, IT 9715497-38, KBC 2, KM 5, NBC 016, NBC 12, NBC 14, NBC 15, NBC 18, NBC 19, NBC 23, NBC 24, NBC 98, PCP 0306 01, PCP 1124-1, PMCP 1131, SUPER 30, TOME 774, TPTC-29, V 240, V 578, V 585
	41	Rhomboid	EC 170584, EC 271040, EC 390287, EC 394779, EC 458411, EC 458430, EC 458438, EC 458440, EC 458442, EC 458473, EC 458483, EC 458489, IC 219489, IC 249588, IC 249593, IC 253251, IC 259105, IC 330996, IC 394708, IC 402048, IC 402164, IC 402166, IC 402172, IC 402180, IC 4506, IC 45061, NBC 25, NBC 27, NBC 32, NBC 33, NBC 36, NBC 38, NBC 40, NBC 4716, NBC 51, NBC 6, NBC 68, NBC 8, V 604-7-3, VCP 17091, IC 402184

Table 3: Hundred seed weight, moisture content, seed germination, seedling vigour index (I&II), electrical conductivity, total dehydrogenase activity and protein content of cowpea germplasms.

Genotype No.	Genotype	Hundred seed weight (g)	Moisture content (%)	Seed germination (%)	Seedling vigour index-I	Seedling vigour index-II	Electrical conductivity ($dScm^{-1} g^{-1}$)	Total dehydrogenase activity (A_{480})	Protein content (%)
G_1	C 152 (check 1)	10.35	8.41	90.03	2604	3068	4.13	1.95	22.04
G_2	KBC 9 (check 2)	10.69	9.13	89.76	2614	3222	4.16	2.24	22.66
G_3	IC 198355(45)	9.87	9.20	89.09	2615	3033	3.64	2.09	21.79
G_4	IC 201095(32)	10.12	8.95	89.98	2621	3137	3.80	2.05	22.18
G5	IC 202329-89	11.12	8.51	88.90	2726	3043	4.34	1.76	21.79
G6	IC 202521(93)	11.13	8.77	88.46	2823	3108	3.73	2.09	22.03
G7	IC 202804(83)	11.58	9.21	89.79	2618	2907	4.27	2.65	22.74
G8	IC 202854(97)	11.94	8.62	88.41	2485	2804	3.90	2.40	22.61
G9	IC 2574422(7)	11.38	8.48	88.41	2639	3079	4.79	2.16	21.87
G10	IC 27749(20)	10.90	9.00	88.94	2712	3227	3.54	1.54	21.30
G11	IC 97767(10)	13.39	9.11	90.00	2713	3246	3.77	1.74	22.95
G12	C 33	11.58	8.97	89.09	2354	3472	4.23	2.25	21.67
G13	C 720	11.39	7.98	90.71	2650	3707	4.58	1.77	22.47
G14	CB 10	11.67	9.20	89.90	2750	3348	4.00	2.11	21.96
G15	CP 98	11.84	9.42	89.94	2754	3747	4.25	1.65	21.76
G16	CPD 15	9.64	8.63	88.69	2583	3458	4.31	2.04	22.66
G17	CPD 340	9.79	9.59	88.98	2698	3482	4.17	1.80	21.61
G18	DC 15	10.61	9.23	89.29	2629	3338	2.67	2.02	21.10
G19	EC 075180	18.70	9.01	89.92	2585	3625	3.98	3.80	22.60
G20	EC 170584	10.56	8.98	88.68	2190	3613	4.60	2.39	21.25
G21	EC 271040	11.69	9.45	89.89	2651	3256	3.68	1.72	21.73
G22	EC 390287	11.78	8.06	89.49	2630	3844	4.55	2.14	22.56
G23	EC 394779	12.17	8.92	89.33	2633	3420	4.25	1.81	21.98
G24	EC 458411	10.27	8.42	89.83	2663	2970	3.97	2.30	22.98
G25	EC 458430	11.66	8.58	89.55	2714	3205	4.25	2.05	24.73
G26	EC 458438	11.86	8.69	89.20	2640	2913	3.75	2.15	24.09
G27	EC 458440	11.37	9.05	88.67	2604	3067	4.09	1.63	23.52
G28	EC 458442	11.81	8.73	88.34	2582	3012	4.35	2.18	23.36
G29	EC 458473	8.01	8.29	88.32	2653	2745	4.14	1.62	24.92

G30	EC 458483	10.02	8.38	89.93	2621	2817	4.02	2.05	23.93
G31	EC 458489	10.13	9.06	88.52	2567	3058	3.96	1.97	24.90
G32	EC 458490	10.37	8.65	88.57	2448	2870	4.43	2.05	25.32
G33	EC 458805	10.97	8.97	90.00	2702	2826	3.66	2.46	25.15
G34	EC 472250	10.34	8.18	89.34	2693	3042	4.25	1.55	25.02
G35	EC 472257	9.82	8.81	88.36	2687	3101	3.57	1.95	24.64
G36	EC 472267	11.12	8.45	89.52	2694	2984	4.09	2.10	24.76
G37	EC 492292	11.48	10.13	89.65	2307	2966	4.45	2.02	29.93
G38	G 36	11.92	8.86	87.94	2723	2915	3.64	2.04	24.4
G39	GC 1602	10.45	9.02	89.23	2577	2975	3.98	2.34	23.33
G40	GC 1801	10.10	8.97	88.54	2483	2867	3.83	2.05	23.46
G41	GC 1805	9.92	8.97	89.66	2592	2921	3.57	1.60	25.09
G42	GC 3 (R)	10.74	9.42	88.27	2328	3055	4.01	1.73	24.15
G43	GC 810	10.63	8.70	88.37	2488	2933	4.16	2.06	23.85
G44	GP 154	10.31	9.49	87.75	2335	3043	3.83	1.87	24.76
G45	GW HOPE	10.79	11.29	90.17	2547	2364	3.76	2.04	23.46
G46	IC 1070	10.27	8.09	89.83	2637	2428	3.73	2.55	25.53
G47	IC 1071	10.12	8.47	89.09	2563	2439	3.84	1.69	24.65
G48	IC 198326	11.14	9.25	89.82	2522	2484	4.35	1.35	24.64
G49	IC 202290	10.30	8.64	89.31	2610	2448	4.23	1.81	24.86
G50	IC 202325	11.21	8.51	88.59	2669	2547	4.04	1.73	25.52
G51	IC 202711(58)	10.55	8.02	88.98	2645	2480	3.91	2.19	24.02
G52	IC 202777	10.28	8.97	89.83	2611	2490	4.60	1.84	24.72
G53	IC 202781	10.64	8.99	89.50	2570	2407	6.35	2.01	24.81
G54	IC 202792(72)	9.75	8.82	88.64	2761	2467	4.37	2.10	24.00
G55	IC 20287(99)	10.65	8.77	89.82	2487	2484	4.09	2.24	23.52
G56	IC 206240	10.97	8.99	90.2	2814	2376	3.97	1.88	24.24
G57	IC 219489	10.46	8.23	89.94	2608	2404	4.08	2.04	24.09
G58	IC 249588	10.98	9.49	90.33	2569	3132	3.77	2.17	23.91
G59	IC 249593	10.49	8.10	90.20	2730	3175	3.43	1.84	20.05
G60	IC 253251	10.53	8.83	89.17	2775	3001	4.15	2.40	22.37
G61	IC 259105	8.72	9.02	89.43	2599	3098	4.39	2.06	20.67
G62	IC 330996	9.96	8.52	88.32	2530	2960	3.96	1.92	19.76
G63	IC 394708	11.45	9.04	89.66	2470	3270	4.60	2.39	19.92
G64	IC 402048	10.67	10.38	89.25	2572	3145	4.46	1.97	21.27
G65	IC 402090	11.27	8.83	92.51	2737	3176	4.44	2.15	22.46
G66	IC 402098	11.12	8.94	91.61	2636	3272	4.31	2.13	23.01
G67	IC 402101	11.27	8.72	92.54	2561	3191	3.87	1.72	21.1
G68	IC 402104	10.39	8.12	93.34	2933	3304	4.36	1.93	21.63
G69	IC 402106	10.38	8.27	92.45	2954	3153	4.11	1.74	20.43
G70	IC 402114	10.19	8.89	91.68	2634	3100	3.60	1.55	20.63
G71	IC 402125	11.17	8.35	92.4	2737	3085	4.07	1.87	19.71
G72	IC 402135	9.93	8.50	91.83	2660	3405	4.00	2.32	19.96
G73	IC 402159	10.50	9.29	93.52	2749	3361	3.34	2.46	19.98
G74	IC 402162	8.13	8.19	92.99	2706	3242	4.46	2.06	20.00
G75	IC 402164	10.78	8.94	93.07	2548	3239	3.85	1.75	20.79
G76	IC 402166	10.57	8.99	92.13	2899	3430	4.18	1.75	20.77
G77	IC 402172	10.70	9.62	92.06	2775	2978	4.11	2.21	20.82
G78	IC 402180	10.04	8.63	92.70	2788	3073	3.95	1.98	21.84
G79	IC 4506	9.22	8.43	93.09	2866	3013	3.67	2.30	20.43
G80	IC 45061	10.15	9.94	92.36	2675	3201	3.61	2.32	19.89
G81	IC 458470	11.39	9.77	91.28	2663	3199	3.98	2.16	21.52
G82	IC 458485	10.78	9.27	93.50	2935	2985	4.13	1.46	21.22
G83	IC 58905	11.86	9.51	91.71	2624	2982	4.05	2.34	13.34
G84	IC 603187	10.52	9.07	92.59	2687	3182	4.26	2.01	21.07
G85	IT 9715497-38	10.60	8.67	92.42	2798	3068	4.07	2.32	21.30
G86	KBC 2	12.60	8.01	92.52	2581	3164	3.77	2.08	21.34
G87	KM 5	10.39	8.79	92.32	2864	3296	4.21	2.01	19.40
G88	NBC 016	9.75	8.78	92.50	2983	3286	3.90	1.54	21.13
G89	NBC 12	13.42	7.97	91.83	2959	3144	3.84	1.67	21.73
G90	NBC 14	13.65	8.26	90.88	2905	2995	3.86	1.87	21.72
G91	NBC 15	11.30	8.20	92.57	2782	3228	3.74	2.06	22.16
G92	NBC 18	10.73	8.85	92.01	2838	3099	4.00	2.06	20.29
G93	NBC 19	12.23	8.45	91.68	2651	3131	4.15	1.63	20.61
G94	NBC 23	11.85	9.26	92.02	2606	3110	3.96	1.83	21.26
G95	NBC 24	11.94	9.33	91.82	2613	3210	4.04	2.13	21.99
G96	NBC 25	10.80	9.25	93.24	2701	3025	4.19	1.42	20.44
G97	NBC 27	11.01	9.22	92.88	2746	3036	4.66	1.90	20.70
G98	NBC 32	10.21	9.16	93.27	2665	3344	4.43	1.75	22.05
G99	NBC 33	11.34	7.88	92.21	2834	3435	3.81	2.42	20.23

G100	NBC 36	11.29	8.69	92.75	2852	3180	3.69	1.81	20.58
G101	NBC 38	11.29	9.65	94.38	2724	3231	3.93	1.99	22.50
G102	NBC 40	11.77	9.27	91.73	2859	3254	3.44	2.71	20.92
G103	NBC 4716	11.32	8.85	92.46	2648	3351	4.16	2.04	21.29
G104	NBC 51	11.66	7.54	92.71	2752	3212	4.33	2.23	20.19
G105	NBC 6	11.90	9.71	92.10	2655	2955	4.00	2.66	21.96
G106	NBC 68	11.55	10.47	93.59	2982	3408	4.50	1.96	22.51
G107	NBC 8	12.04	8.37	92.89	2569	3191	3.71	1.53	19.99
G108	NBC 98	11.89	8.62	92.52	2492	3360	4.27	1.83	21.66
G109	PCP 0306 01	10.62	7.67	94.89	2728	3291	3.82	1.76	21.39
G110	PCP 1124-1	10.94	9.16	94.16	2740	3204	8.99	2.01	19.16
G111	PMCP 1131	10.94	9.18	94.75	2689	3293	3.99	2.45	20.18
G112	SUPER 30	11.46	8.87	95.37	2831	3416	4.18	1.99	21.13
G113	TOME 774	10.14	9.11	94.82	2660	3226	4.11	2.31	20.40
G114	TPTC-29	9.96	9.50	94.34	2793	3090	3.99	2.04	21.53
G115	V 240	9.32	8.67	92.63	2578	3107	3.45	2.44	20.70
G116	V 578	17.12	8.49	96.00	2888	3387	4.40	2.07	21.52
G117	V 585	10.95	8.56	93.97	2823	3124	4.54	1.92	20.25
G118	V 604-7-3	11.13	9.06	95.31	2860	3366	4.17	2.00	21.85
G119	VCP 17091	10.92	9.32	95.00	1598	3209	4.01	1.68	21.80
G120	IC 402184	10.84	8.17	93.94	2687	3315	3.70	2.19	20.45
Mean		10.93	8.88	90.98	2661	3094	4.10	2.03	22.15
SEm±		0.73	0.46	0.73	93.60	46.64	0.28	0.29	0.78
CD (p=0.05)		2.04	1.27	2.04	260.32	129.70	0.77	0.79	2.17
CV (%)		1.62	3.26	4.62	4.03	3.01	3.59	3.13	4.05

Table 4: Seed germination of better performing cowpea (*Vgina unguiculata* (L.) Walp) genotype after controlled deterioration test.

Genotype No.	Genotype	Seed germination (%)			
		Initial	After 24 hr	After 48 hr	After 72 hr
G90	NBC 14	90.88	75	48	24
G89	NBC 12	91.83	60	41	25
G93	NBC 19	91.68	63	38	23
G88	NBC 016	92.50	56	49	19
G69	IC 402106	92.45	67	37	28
G38	G 36	87.96	64	44	24
G2	KBC 9	89.76	60	43	28
G19	EC 075180	89.92	56	48	21
G119	VCP 17091	95.00	53	35	29
G118	V 604-7-3	95.31	65	32	21
G116	V 578	96.00	57	42	26
G112	SUPER 30	95.37	60	46	20
G11	97767(10)	90.00	63	36	29
G105	NBC 6	92.10	54	31	18
G1	C 152	90.03	65	48	16
Mean			**61.2**	**41.2**	**23.4**
SEm±			**2.04**		
CD (p=0.05)			**2.82**		
CV (%)			**4.87**		

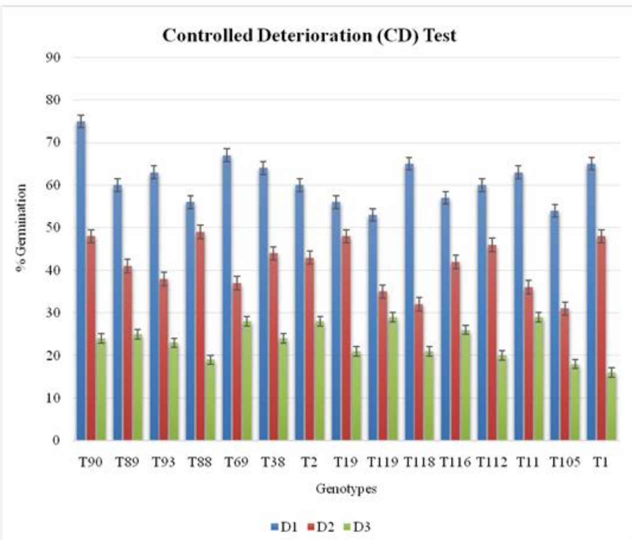

Fig. 2. Germination percentage of better performing cowpea genotypes after controlled deterioration test.

CONCLUSIONS

Key findings included superior performance by genotypes EC 075180, NBC 51, and V 578 for quality traits such as hundred-seed weight, moisture content, and germination rate, respectively. Genotypes like SUPER 30, IC 97767(10), NBC 016, and EC 390287 excelled in parameters like root length, shoot length, seedling vigour indices, and seedling dry weight.

Under controlled deterioration, NBC 14 demonstrated higher germination after stress conditions, showcasing its potential for stress tolerance and suitability for breeding programs aimed at improving seed vigour under challenging environments.

In conclusion, these genotypes exhibit significant potential for maximizing yields and producing superior-quality seeds. They can serve as valuable parental lines for breeding programs targeting enhanced productivity and adaptability to varied growing conditions.

FUTURE SCOPE

The results give scope for improvement of cowpea breeding and seed quality. The morphological diversity, high germination with V-578, highest seed weight with EC- 075180 and maximum protein content with EC-492292, present the prospects for breeding for high yielding, nutrient rich verities. Genotype superior in seedling vigour with (IC-97767(10), SUPER 30) can impart better early growth. Indicators of seed quality such as electrical conductivity and dehydrogenase activity support efficient screening, but controlled deterioration tests provide information toward the development of genotypes with better storage potential. Genetic and physiological studies coupled with advanced tools like marker-assisted selection and genomic studies can accelerate the development of robust, high-quality varieties of cowpea specifically tailored to diverse agro-climatic conditions towards sustainable agriculture and food security.

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Conflict of Interest. None.

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