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RESEARCH ARTICLE

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Influence of Polymer Coated Bioagents on Seed Yield and Quality Attributes in Pigeonpea Genotypes

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ABSTRACT

Background: Pigeonpea [*Cajanus cajan* (L.) Millsp.] is a vital legume crop in the semiarid tropics of Asia, Eastern Africa and the Caribbean Islands. The availability of healthy, pathogen free seeds plays a pivotal role in achieving an optimal plant population and subsequently influencing yield parameters in pigeonpea.

Methods: The laboratory and field experiments were arranged using a completely randomized design and a randomized block design with a factorial concept, involving eight genotypes and three bioagents.

Result: Seed mycoflora was 8.2% higher with the standard blotter method (32.65%) than with the water agar method (30.17%). *Aspergillus niger* (9.77%) and *A. flavus* (9.97%) were the predominant seed mycoflora species identified across various pigeonpea genotypes. Among the pigeonpea genotypes, BSMR-736 showed the highest performance, with plant height (12.4%), number of primary branches (14.7%), secondary branches (21.6%), number of pods per plant (40.6%), seeds per pod (15.9%), seed yield per plant (22.7%) and seed yield per hectare (30.9%) compared to the mean of the tested genotypes. TS-3R took the minimum days to reach 50% flowering (99.70) and maturity (149.63). The combination of polymer @ 3 ml kg^{-1} + *Trichoderma harzianum* and *Pseudomonas fluorescens* each @ 5 g kg^{-1} demonstrated positive effects on various growth and yield traits, pods per plant (47.0%), seed yield per plant (14.3%) and seed yield per hectare (6.7%) over the treated mean. The application of bioagents, especially the combination of polymer with seed treatment using *T. harzianum* and *P. fluorescens*, exhibited the potential to enhance overall plant performance.

Key words: Bioagents, Genotypes, Pigeonpea, Plant growth, Seed mycoflora, Seed treatment, Yield.

INTRODUCTION

Pigeonpea [*Cajanus cajan* (L.) Mills.] is cultivated in tropical and subtropical regions worldwide, known for its impressive protein content of 21 per cent. It is one of the most important pulse crops cultivated globally in 6.99 mha with total production and productivity of 5.96 mt and 813 kg ha^{-1}, respectively. In India, it is grown in an area of 4.1 mha, producing nearly 3.41 mt with an average productivity of 827 kg ha^{-1} (Anonymous, 2025). It also fixes 120-170 kg ha^{-1} of atmospheric nitrogen throughout the cropping season (Adu-Gyamfi *et al*., 1997).

Diseases have been reported as a limiting factor to the production of pigeonpea worldwide. Over hundred pathogens have been identified as attackers of pigeonpea, including *Cercospora* leaf spot, *Alternaria* leaf spot, Phyllody, Sterility mosaic disease, *Fusarium* wilt and *Rhizoctonia* root rot. While only a few seed borne pathogens cause economic losses and also, they can lead to seed abortion, rot, necrosis, reduced germination capacity and seedling damage (Khanzada *et al*., 2002). It is worth noting that only a limited number of these pathogens, primarily *Fusarium udum* have been identified as seed borne, causing significant economic losses. Interestingly, the seed borne nature of other pathogens associated with pigeonpea genotypes remains unrecorded.

The effects of seed coating with different polymeric formulations in general, deteriorate at slower pace as manifest in high germination percentage (Kumar *et al*., 2007).

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Since the polymer film coat may act as a physical barrier, which has been reported to reduce the leaching of inhibitors from the seed coverings and may restrict oxygen diffusion to the embryo (Vanangamudi *et al*., 2003). The use of bioagents for seed treatment provides an economical and effective method to safeguard seeds and seedlings against early pathogen attacks to crop (Rajeswari and Kumari, 2009). Hence, potential bioagents *viz., Trichoderma viride*, *T. harzianum*, *Bacillus subtilis* and *Pseudomonas fluorescens* are useful for managing seedborne pathogens.

In view of above, this research aims to explore the potential of pigeonpea genotypes in combination of polymer coating with biological seed treatment techniques by addressing these critical aspects, contribute to the advancement of sustainable agriculture and support efforts towards achieving nutritional and food security through environmental sustainability.

MATERIALS AND METHODS

An experiment was conducted in *Kharif* season 2022 at Research Farm, Regional Agricultural Research Station, Vijayapur, under northern dry zone (Zone 3 and Region II) of Karnataka [situated at 160 49′ N latitude, 750 43′ E longitude and at an altitude of 593 m above mean sea level (MSL)]. Seed samples were assessed for the presence of seed borne fungi using the water agar and standard blotter methods, in accordance with the guidelines outlined in the Anonymous, (1996). In the field experiment, seeds were planted at a spacing of 90 x 30 cm on a 5 m row plot with factorial design and the factor-I consisted of eight genotypes *i.e.* V_1 : KRG-33, V_2 : TS-3R, V_3 : Asha, V_4 : BSMR-736, V_5 : Maruti, V_6 : GRG-152, V_7 : Gulyal Local and V_8 : GRG-811. The factor-II consisted of three bioagent treatments B_1 : Polymer @ 3 ml kg^{-1} + *Trichoderma harzianum* @ 10 g kg^{-1}, B2: Polymer @ 3 ml kg^{-1} + *Pseudomonas fluorescens* @ 10 g kg^{-1} and B_3 : Polymer @ 3 ml kg-1 + *Trichoderma harzianum* and *Pseudomonas fluorescens* each @ 5 g kg^{1} of seeds. From the five randomly selected plants from each plot, growth and yield parameters were recorded. The seed quality parameters like seed germination (%), shoot length (cm), root length (cm), seedling dry weight (g), seedling vigour index I and II and electrical conductivity were assessed. For per cent seed germination 100×4 seeds were tested between layers of paper towel substrata at 25 °C temperature by keeping in seed germinator as per ISTA (2025), shoot length and root length and seed dry weight was recorded, from which seedling vigour index I and II was calculated, respectively as suggested by Abdul Baki and Anderson (1973) using following formula:

Seedling vigour index I =

Germination (%) × [Shoot length (cm) + Root length (cm)]

Seedling vigour index II =

Germination (%) × Seedling dry weight (mg)

The electrical conductivity (µS cm^{-1} g^{-1}) was measured by following the standard procedure (Agrawal and Dadlani, 1987).

Statistical analysis

All the data analyzed statistically. The data collected from the experiment was subjected to the analysis of variance appropriate for a factorial randomized block design for field and completely randomized design for laboratory studies as outlined by Sundararaj *et al.* (1972) and critical differences

Table 1: Detection of seed mycoflora in pigeonpea genotypes by water agar method and standard blotter method.

Genotypes	Seed infection (%)											
	Aspergillusniger		*Aspergillusflavus*		*Rhizopus* sp.		*Penicillium* sp.		*Fusarium* sp.		Total mycoflora frequency (%)	
	WA	SB	WA	SB	WA	SB	WA	SB	WA	SB	WA	SB
KRG-33	7.60	6.30	7.30	9.30	3.30	3.60	2.20	5.00	1.30	2.30	21.70	26.50
TS-3R	10.32	10.06	9.90	8.83	2.90	6.60	4.20	4.63	-	2.26	27.32	32.40
Asha	12.00	15.60	12.90	14.80	6.60	7.40	6.20	4.30	1.90	2.90	39.60	45.00
BSMR-736	3.00	5.30	4.30	5.00	3.00	2.00	2.60	1.30	0.60	0.60	14.50	14.20
Maruti	5.60	5.30	6.20	5.30	4.20	6.60	2.00	3.90	0.90	2.30	18.90	23.40
GRG-152	8.60	10.30	12.60	11.30	4.65	4.60	1.20	7.50	1.20	3.00	28.25	36.70
Gulyal Local	24.40	12.30	14.59	15.60	12.16	10.60	13.70	8.60	4.10	3.60	68.9	50.70
GRG-811	6.60	8.90	7.00	9.60	4.60	7.20	3.30	4.00	0.66	2.60	22.16	32.30
Mean TFC	9.77	9.26	9.35	9.97	5.18	6.08	4.43	4.90	1.52	2.45	30.17	32.65

WA: water agar method SB: Standard blotter method.

were calculated at five per cent level for field experiment and one per cent level for laboratory experiment.

RESULTS AND DISCUSSION

The study investigated the presence and distribution of seed-borne mycoflora pathogens in various pigeonpea genotypes specifically *Fusarium* sp., *Aspergillus flavus*, *Aspergillus niger*, *Rhizopus* sp. and *Penicillium* sp., using both the water agar plate and standard blotter paper methods (Table 1). Seed infection was slightly higher under the standard blotter method (32.65%) compared to water agar (30.17%). *Aspergillus* spp. dominated in both methods, with *A. niger* (9.77%) and *A. flavus* (9.97%) as the most prevalent, while *Fusarium* showed the least incidence (<2.5%). Genotypic differences were pronounced: Gulyal Local recorded the maximum infection (68.9% in WA, 50.7% in SB), nearly fivefold higher than BSMR-736, which consistently showed the least infection (~14%). Thus, *Aspergillus* emerged as the major seed contaminant, while BSMR-736 demonstrate less susceptible (~52-57% lower infection than mean) across both methods. Significantly, the standard blotter method consistently yielded higher infection rate compared to the water agar method in most genotypes. This aligns with previous research by Charya and Reddy (1979) and Kumar *et al.* (2017), who identified several seed-borne fungi using agar plate and blotter methods in chickpea, pigeonpea, greengram and blackgram seeds. Similar findings were reported by Mali *et al.* (2008) for greengram and blackgram seeds, detecting various fungal species through agar plate.

Significant variations in seed quality attributes were observed among different pigeonpea genotypes (Table 2). Genotype KRG-33 was significantly superior germination (93.35%), followed by TS-3R (92.28%). Genotype TS-3R recorded the highest values for shoot length (9.45 cm), root length (13.54 cm), seedling dry weight (463.79 mg), SVI I and SVI II (2122 and 42796, respectively). Additionally, it exhibited lower electrical conductivity of seed leachates (26.18 µS cm^{-1} g^{-1}). Conversely, genotype Asha showed lower seed quality attributes, including germination (84.19%), shoot length (8.25 cm), root length (9.24 cm), seedling dry weight (305.08 mg), SVI I and SVI II (1473 and 25911, respectively). It also recorded a higher electrical conductivity of seed leachates (33.29 µS cm^{-1} g^{-1}). Electrical conductivity increases with the release of solutes from cells when membrane integrity is poor; such leakage also creates a favorable environment for fungal pathogens (Ermis, 2022).

The findings underscore the impact of pigeonpea genotypes on seed quality parameters, with observed variations attributed to genetic differences and environmental interactions (Sandhyakishore *et al.,* 2025). Contaminated seeds can lead to disease outbreaks and reduced agricultural productivity, making seed health tests crucial for achieving food security (Chaudhari *et al*., 2017).

Plant growth traits such as plant height, number of branches and phenology showed significant variation among pigeonpea genotypes and bioagent treatments (Table 3 and 4). BSMR-736 attained the maximum height (132.96 cm), followed by GRG-811 (124.48 cm), whereas Gulyal Local was the shortest (97.59 cm). Among treatments, the combination of polymer + *T. harzianum* + *P. fluorescens* (B3) was most effective (122.23 cm), compared to single inoculations (B1 and B2). BSMR-736 also produced the highest number of primary (16.79) and secondary branches (26.93), while Gulyal Local had the fewest (12.70 and 18.49). This indicates that genotype largely determined plant stature, though bioagent combinations enhanced vegetative growth.

The superiority of BSMR-736 may be due to its longer maturity duration, as late and medium maturing genotypes generally attain greater height than early types, consistent with Egbe (2012). The effectiveness of B3 over single treatments can be attributed to synergistic mechanisms, including antibiotic production, systemic resistance and secretion of growth-promoting compounds such as glucose oxidase. Sandheep *et al.* (2013) also demonstrated that mixtures of bacterial and fungal inoculants provided better protection and growth stimulation than single isolates. Bioagent combinations in the present study also increased

Table 2: Seed quality parameters of different pigeonpea genotypes.

Genotypes	Germination (%)	Shootlength (cm)	Rootlength (cm)	Seedling dry weight (mg/10 seedlings)	Seedling vigour index I	Seedling vigour index II	Electrical conductivity (µS cm^{-1} g^{-1} seed fresh weight)
KRG-33	93.35(75.08)*	9.119	11.59	353.73	1934	33028	25.78
TS-3R	92.28(73.90)	9.454	13.54	463.79	2122	42796	26.18
Asha	84.19(66.59)	8.253	9.24	307.90	1473	25911	33.29
BSMR-736	86.41(68.38)	9.030	10.79	352.71	1713	30487	32.27
Maruti	94.33(76.25)	8.173	7.77	305.08	1504	28782	22.63
GRG-152	87.85(69.62)	8.599	9.82	341.48	1619	29993	31.73
Gulyal local	90.90(72.46)	8.974	10.55	350.93	1775	31896	28.46
GRG-811	88.95(70.59)	8.952	10.11	345.91	1696	30770	29.18
Mean	89.78 (71.60)	8.82	10.43	352.69	1729	31708	25.78
S. Em ±	0.62	0.21	0.27	10.17	32.25	945.99	0.79
CD @ 1 %	1.86	0.61	0.82	30.49	96.69	2836.06	2.37

NOTE: NS- Non-significant*Figures in the parenthesis are arcsine transformed values.

Table 3: Effect of different bioagents and genotypes on field performance in pigeonpea.

Treatment	Plant height (cm)				Number of primary branches				Number of secondary branches			
	B_1	B_2	B_3	Mean	B_1	B_2	B_3	Mean	B_1	B_2	B_3	Mean
V_1	101.77	99.29	105.77	102.28	13.43	13.47	13.23	13.38	17.14	15.89	19.84	17.62
V_2	123.89	117.03	124.00	121.64	15.47	14.60	15.75	15.27	25.21	23.64	27.64	25.50
V_3	124.20	121.31	124.99	123.50	13.75	13.48	14.00	13.74	19.23	18.06	22.19	19.83
V_4	132.68	129.48	136.71	132.96	16.63	16.03	17.71	16.79	27.13	24.22	29.43	26.93
V_5	116.92	115.88	130.44	121.08	13.54	13.34	14.23	13.70	18.64	16.59	20.06	18.43
V_6	123.90	119.41	124.90	122.74	15.76	15.51	15.99	15.75	23.77	23.28	26.46	24.50
V_7	102.73	86.50	103.54	97.59	12.67	11.88	13.56	12.70	19.26	16.41	19.81	18.49
V_8	124.50	121.48	127.48	124.48	17.98	14.63	14.78	15.80	25.70	23.65	28.03	25.80
B mean	118.82	113.80	122.23	118.28	14.90	14.12	14.91	14.64	22.01	20.22	24.18	22.14
	S. Em ±		CD @ 5 %		S. Em ±		CD @ 5 %		S. Em ±		CD @ 5 %	
V	4.13		11.74		0.97		2.77		1.00		2.85	
B	2.53		7.19		0.60		1.69		0.61		1.75	
V×B	2.38		NS		0.56		NS		0.58		NS	

NOTE: NS- Non significant.

B_1- Polymer @ 3 ml kg^{-1}+ *Trichoderma harzianum* @ 10 g kg^{-1}; B_2- Polymer @ 3 ml kg^{-1}+ *Pseudomonas fluorescens* @ 10 g kg^{-1}; B_3- B_1 + B_2; V_1- KRG-33; V_2- TS-3R; V_3-Asha; V_4-BSMR-736; V_5- Maruti; V_6- GRG-152; V_7- Gulyal Local; V_8- GRG-811.

branch number, reflecting the role of enhanced vegetative growth. Similar positive effects of *Trichoderma* and *Bacillus* on plant height, branching and yield were previously reported in legumes by Khan and Ahmad (2015) and Joshi *et al.* (2019).

For phenological traits, TS-3R (99.7 days) and Gulyal Local (102.1 days) reached 50% flowering earliest, while Asha was the latest (129.3 days). Similarly, TS-3R matured the earliest (149.63 days), followed by KRG-33 (152.06 days), whereas Asha took the longest time (190.12 days). These differences highlight that flowering and maturity were primarily genotype-driven, with limited influence of bioagent treatments. The shorter maturity period of TS-3R may be linked to its inherent earliness, while prolonged duration in Asha corresponds with its late maturity class. Such variation in phenology among genotypes is consistent with earlier reports on pigeonpea maturity diversity.

Significant variation was observed in yield attributes among pigeonpea genotypes and bioagent treatments (Table 5). BSMR-736 recorded the highest number of pods per plant (242.83), followed by GRG-811 (228.36) and GRG-152 (221.32), while KRG-33 produced the fewest pods (107.36). Among the bioagent treatments, B3 (polymer + *T. harzianum* + *P. fluorescens*) was most effective (186.08 pods per plant), whereas B2 resulted in fewer pods (161.08). A similar trend was evident in seeds per pod, with BSMR-736 (3.87) and GRG-811 (3.70) recording higher values compared to Gulyal Local (2.97). Across treatments, B3 (3.49) produced more seeds per pod, while B2 (3.21) was the lowest.

Seed yield also differed significantly among genotypes and treatments. BSMR-736 produced the maximum seed yield (52.92 g plant^{-1} and 13.99 q ha^{-1}), followed by GRG-811 (50.77 g plant^{-1}; 13.21 q ha^{-1}) and GRG-152 (49.95 g plant^{-1}; 12.59 q ha^{-1}). In contrast, KRG-33 recorded the lowest yield (32.34 g plant^{-1}; 7.35 q ha^{-1}). Among bioagents, B3 gave the highest yield (49.26 g plant^{-1}; 11.40 q ha^{-1}), which was comparable with B1 (47.03 g plant^{-1}; 10.62 q ha^{-1}), while B2 was the least effective (33.08 g plant^{-1}; 10.03 q ha^{-1}). Although genotype × treatment interactions were statistically non-significant, the combination V4B3 (BSMR-736 + B3) produced the highest yield (59.37 g plant^{-1}; 15.31 q ha^{-1}), whereas V7B2 (Gulyal Local + B2) recorded the lowest (14.84 g plant^{-1}; 5.38 q ha^{-1}).

The superior performance of BSMR-736 may be attributed to its semi-spreading growth habit, which favored greater branching and thus a higher number of pods. This agrees with Baldey (1988), who noted that semi-spreading types in pigeonpea exhibited greater branching plasticity than compact types. Increased pod number was closely associated with more primary and secondary branches, while differences in seeds per pod are largely controlled by genetic and environmental factors. Sujatha and Ambika (2016) and Bony *et al.* (2017) also reported higher pod production under polymer-coated bioagent seed treatments.

Enhanced seed yield under BSMR-736 and B3 is likely due to cumulative effects of increased pods per plant, more seeds per pod and better vegetative growth. Similar findings were reported in soybean (Brooker *et al*., 2007) and pigeonpea (Vinod *et al*., 2014; Ananthi *et al*., 2015; Kumar *et al*., 2017), where polymer seed treatment improved plant growth, branching, pod number and yield. Thilagavathi *et al.* (2007) also demonstrated that combined application of *P. fluorescens* and *T. viride* significantly enhanced seed yield under both glasshouse and field conditions. Although interactions were non-significant statistically, trends clearly indicated that the combination of a responsive genotype (BSMR-736) with synergistic bioagents (B3) produced the highest productivity, as also supported by previous studies (Sushma *et al*., 2018; Heena, 2020; Uzma, 2022).

Following harvest, seed quality parameters varied significantly among pigeonpea genotypes (Table 6).

Table 4: Effect of different bioagents and genotypes on days to 50 per cent flowering and maturity in pigeonpea

Treatment	Days to 50 per cent flowering				Days to maturity			
	B_1	B_2	B_3	Mean	B_1	B_2	B_3	Mean
V_1	104.00	103.00	105.00	104.00	144.89	163.22	148.06	152.06
V_2	101.00	97.70	100.30	99.70	155.01	145.42	148.45	149.63
V_3	131.00	128.00	129.00	129.30	183.13	186.70	200.52	190.12
V_4	126.00	128.00	113.00	122.30	177.32	175.85	189.21	180.79
V_5	115.30	114.30	116.00	115.20	162.87	176.97	172.68	170.84
V_6	109.30	110.30	104.70	108.10	156.15	147.63	160.82	154.87
V_7	102.00	102.70	101.50	102.10	163.56	153.51	156.72	157.93
V_8	121.00	120.00	121.00	120.70	160.61	168.32	167.15	165.36
B mean	113.70	113.00	111.30	112.70	162.94	164.70	167.95	165.20
	S. Em ±		CD @ 5%		S. Em ±		CD @ 5%	
V	4.86		13.85		8.85		25.18	
B	2.98		NS		5.42		NS	
V×B	2.81		NS		5.11		NS	

NOTE: NS- Non significant

B_1- Polymer @ 3 ml kg^{-1} +*Trichoderma harzianum* @ 10 g kg^{-1}; B_2- Polymer @ 3 ml kg^{-1}+ *Pseudomonas fluorescens* @ 10 g kg^{-1}B_3- B_1 + B_2; V_1- KRG-33; V_2- TS-3R; V_3-Asha; V_4- BSMR-736; V_5- Maruti; V_6- GRG-152; V_7- Gulyal LocalV_8- GRG-811.

Table 5: Effect of different bio-agents and genotypes on yield parameters in pigeonpea.

Treatment	Number of pods plant^{-1}				Number of seeds pod^{-1}				Seed yield (g plant^{-1})				Seed yield (q ha^{-1})			
	B_1	B_2	B_1	Mean	B_1	B_2	B_3	Mean	B_1	B_2	B_3	Mean	B_1	B_2	B_3	Mean
V_1	106.5	98.3	35.75	107.36	3.03	2.96	3.37	3.12	35.75	23.48	37.81	32.34	7.23	7.07	7.75	7.35
V_2	174.5	161.1	52.58	177.67	3.14	3.07	3.30	3.17	52.58	40.30	53.29	48.72	12.01	11.77	12.51	12.10
V_3	137.2	134.6	45.61	140.50	3.09	3.02	3.34	3.15	45.61	33.19	47.87	42.22	10.12	9.91	10.73	10.26
V_4	242.3	224.5	56.74	242.83	3.79	3.75	4.06	3.87	56.74	42.65	59.37	52.92	13.62	13.03	15.31	13.99
V_5	133.8	130.5	35.97	135.88	3.26	3.07	3.36	3.23	35.97	27.79	42.81	35.52	8.35	8.17	8.98	8.50
$V\text{-}_6$	216.9	210.2	54.05	221.32	3.54	3.33	3.64	3.50	54.05	40.94	54.86	49.95	12.41	12.25	13.10	12.59
V_7	131.2	117.3	40.16	128.25	2.94	2.88	3.09	2.97	40.16	14.84	42.63	32.55	8.27	5.38	8.85	7.50
V_8	226.8	212.2	55.41	228.36	3.74	3.59	3.77	3.70	55.41	41.45	55.47	50.77	12.98	12.68	13.98	13.21
B mean	171.15	161.08	47.03	172.77	3.31	3.21	3.49	3.34	47.03	33.08	49.26	43.12	10.62	10.03	11.40	10.69
	S. Em ±		CD @ 5%		S. Em ±		CD @ 5%		S. Em ±		CD @ 5%		S. Em ±		CD @ 5%	
V	8.64		24.58		3.74		0.41		3.24		9.24		0.15		0.41	
B	5.29		15.05		2.29		0.25		1.99		5.66		0.09		0.25	
V×B	4.99		NS		2.16		NS		1.87		NS		0.08		NS	

NOTE: NS- Non significant

B_1- Polymer @ 3 ml kg^{-1} + *Trichoderma harzianum* @ 10 g kg^{-1}; B_2- Polymer @ 3 ml kg^{-1} + *Pseudomonas fluorescens* @ 10 g kg^{-1}; B_3- B_1 + B_2; V_1- KRG-33; V_2- TS-3R; V_3-Asha; V_4- BSMR-736; V_5- Maruti; V_6- GRG-152; V_7- Gulyal local; V_8- GRG-811.

Table 6: Seed quality parameters of pigeonpea genotypes after harvest.

Genotypes	Germination (%)	Shoot length (cm)	Root length (cm)	Seedling dry weight (mg/10 seedlings)	Seedling vigour index I	Seedling vigour index II	Electrical conduc -tivity (µS cm^{-1} g^{-1} seed fresh weight)
KRG-33	91.48 (74.09)*	9.39	17.11	191.72	2429	17604	17.18
TS-3R	96.13 (79.42)	9.39	16.19	191.03	2459	18384	12.63
Asha	92.71 (75.06)	8.97	14.94	172.76	2218	16005	15.96
BSMR-736	95.36 (78.74)	9.10	15.39	177.45	2337	16950	15.14
Maruti	90.33 (72.38)	9.54	18.22	196.23	2512	17715	18.37
GRG-152	94.27 (77.29)	8.93	14.02	172.13	2166	16228	15.72
Gulyal local	88.35 (70.44)	8.28	13.23	171.77	1902	15158	19.77
GRG-811	95.63 (79.35)	9.35	16.16	190.50	2440	18243	13.98
Mean	93.03 (75.85)	9.12	15.66	182.95	2308	17036	16.09
S. Em ±	1.71	0.15	0.26	2.69	51.1	413.60	0.27
CD @ 1%	6.48	0.56	0.98	10.21	193.83	1568.88	1.01

*Figures in the parenthesis are arcsine transformed values.

Germination was highest in TS-3R (96.13%) and GRG-811 (95.63%), while Gulyal Local had the lowest (88.35%). Maruti exhibited the greatest shoot (9.54 cm) and root length (18.22 cm), along with the highest seedling dry weight (196.23 mg) and seedling vigour index I (2512). In contrast, Gulyal Local consistently recorded the poorest performance, with the lowest shoot (8.28 cm) and root length (13.23 cm), seedling dry weight (171.77 mg) and vigour index I (1902). Vigour index II followed a similar trend, with TS-3R attaining the highest value (18,384), while Gulyal Local had the lowest (15,158). Electrical conductivity (EC) of seed leachate, an indicator of membrane integrity, was lowest in TS-3R (12.63 µS cm^{-1} g^{-1}) and highest in Gulyal Local (19.77 µS cm^{-1} g^{-1}), confirming that higher solute leakage was associated with poor seed quality.

These differences reflect inherent genetic variability in seed quality traits, where vigorous genotypes such as TS-3R and GRG-811 maintained higher germination, vigour and lower EC, whereas Gulyal Local was relatively more susceptible to deterioration. The positive association between low EC and high vigour indices suggests better membrane integrity and metabolic efficiency in superior genotypes. Similar observations were reported by Kumar *et al.* (2022), who found that polymer-coated seeds expressed higher germination, longer seedlings, greater dry matter accumulation and reduced leachate conductivity under field conditions. In the present study, bioagent treatments and their interactions did not significantly influence seed quality parameters, highlighting that genotypic effects were predominant.

CONCLUSION

The water agar and standard blotter methods were effective in detecting common fungal contaminants in pigeonpea seeds, with infection rates varying across genotypes. BSMR-736 consistently showed the lowest seed infection in both methods, indicating its comparative tolerance. Genotype and bioagent treatments significantly influenced plant height, branching, flowering and yield traits. Notably, BSMR-736, GRG-152, GRG-811 and TS-3R exhibited favorable agronomic performance, while the combined application of polymer coating with *Trichoderma harzianum* and *Pseudomonas fluorescens* enhanced growth and yield attributes more effectively than single treatments. These findings highlight the potential of integrating genotype selection with bioagent seed treatments to improve pigeonpea productivity. Further research is warranted to elucidate the mechanisms of bioagent synergy and optimize their application for sustainable pigeonpea cultivation.

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Disclaimers

The views and conclusions expressed in this article are solely those of the authors and do not necessarily represent the views of their affiliated institutions. The authors are responsible for the accuracy and completeness of the information provided, but do not accept any liability for any direct or indirect losses resulting from the use of this content.

Informed consent

All animal procedures for experiments were approved by the Committee of Experimental Animal care and handling techniques were approved by the University of Animal Care Committee.

Conflict of interest

The authors declare that there are no conflicts of interest regarding the publication of this article. No funding or sponsorship influenced the design of the study, data collection, analysis, decision to publish, or preparation of the manuscript.

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