Current Journal of Applied Science and Technology

39(10): 68-78, 2020; Article no.CJAST.56936
ISSN: 2457-1024
(Past name: British Journal of Applied Science & Technology, Past ISSN: 2231-0843, NLM ID: 101664541)

Physiological and Biochemical Assesement of Chickpea and Lentil Grown in Different Agroclimatic Zones of Bihar

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Authors' contributions

This work was carried out in collaboration among all authors. Author KR designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors VK and SBK managed the analyses of the study. Authors AK, RRK and AK managed the literature searches. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/CJAST/2020/v39i1030629
Editor(s):
(1) Dr. Orlando Manuel da Costa Gomes, Lisbon Accounting and Business School (ISCAL), Lisbon Polytechnic Institute, Portugal.
Reviewers:
(1) Bruno Oliveira Lafetá, Federal Institute of Minas Gerais, Brazil.
(2) Necat Togay, Mugla S.K. University, Fethiye ASMK Vocational High School, Turkey.
Complete Peer review History: http://www.sdiarticle4.com/review-history/56936

Original Research Article

Received 05 March 2020
Accepted 11 May 2020
Published 19 May 2020

ABSTRACT

The present study was conducted to evaluate the seed quality of chickpea (cv. PG-186) and lentil (cv. HUL-57) seed samples collected from randomly selected districts of different agroclimatic zones of Bihar. The seed quality was assessed based on their physiological (seed moisture, seed germination, seedling length, vigour index, etc.) and biochemical enzymes (SOD, POX and CAT) parameters. Based on the physiological and biochemical evaluation, the chickpea seed sample collected from the Sheikhpura district was found significantly high quality (96.3% germination percentage) among all, while seeds collected from Begusarai (76.7%) and Darbhanga (77.7%) districts exhibited lowest germination percentage. The germination and vigour of lentil seed

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revealed that the sample of Patna district was having the highest germination percentage (98.7%) while seeds collected from Katihar and Rohtas district exhibited lowest germination percentage (66% and 74.3% respectively). In the case of biochemical analysis of both chickpea and lentil seed samples, higher SOD, POX and CAT activities were observed in seeds in which the highest germination percentage was recorded. On the basis of the results of chickpea and lentil seed samples, the seed lots were categorized into high, mid and low vigour. Among chickpea, the seed samples of Sheikhpura, Patna, Munger, Bhagalpur, Lakhisarai, and Jehanabad were categorized as high vigour; while seeds of Darbhanga and Begusarai district were categorized as low vigor. Similarly, in case of lentil the seed samples of Patna, Munger, Bhagalpur, Sheikhpura, Lakhisarai, and Khagaria were categorized as high vigour; while seeds of Rohtas and Kathiahr district were categorized into low vigor. This study will be helpful to the farmers and pulses growers in order to enhance the seed quality for getting higher production in respective districts.

Keywords: Chickpea; germination; lentil; seed quality; seed vigour; antioxidant enzymes.

1. INTRODUCTION

Pulses are the major source of dietary protein for millions of people particularly in developing countries, and thereby play an important role in mitigating protein malnutrition [1]. However, year-to-year fluctuations in pulse production and productivity get affected not only due to stresses but also due to the lack of availability of quality seeds. The productivity of pulses in the Bihar state is significantly more preponderant than overall India productivity. Chickpea and Lentil are the major pulses grown in the state. Lentil (*Lens culinaris* L.) is an important rabi pulse crop of Indo Gangetic Plain which is being grown on an area of about 1.5 m ha with an annual production of 1.0 m tonnes [2]. While, Chickpea also gain significant value in the state with good productivity (1000 kg/ha) as compared to the national average of 841 kg/ha [3]. Despite the huge potential and the comparative advantage, the production of chickpea in the state has experienced a major setback, owing to a drastic decline in the area under the crop by about 60% till 2011 due to socio-economic reasons [4].

Among pulse crops grown in Bihar, lentil is the only pulse crop whose cropped area increased by 20,000 hectares. Its production is still greater than all India average (991 kg/ha). But in reference to chickpea in Bihar, the area has declined from 2.45 lakh in 1975-76 to 0.56 lakh hectare in 2010-11 although productivity has increased from 550 kg/ha to 1000 kg/ha during the same period, even after 2003, the area has been in declining trend due to growing popularity and public policy emphasis on Rice-Wheat system [3].

Even though the productivity of these two pulse crops is significantly higher, but still the production is not at par due to the non-availability of quality seeds to the pulses growers. Quality of seeds gets deteriorated during storage, and thus affects the production. Farmers store their seeds in different ways such as i) tin, ii) plastic dram, iii) earthen pot, iv) jute bag with polythene lined, v) polythene bag, vi) bamboo dol, and vii) sac [5]. The concern for quality seed production of pulses has been considered for a long time but there is no literature regarding the assessment of the quality of seed of pulse crop at the district level of Bihar. The loss in the seed quality not only affects the economy of marginal and small farmers and breeders but also affects production and productivity. In order to enhance the seed quality, the first and foremost thing is to assess the quality of seeds. So, in this research, the physiological and biochemical assessment of the two most popular varieties of pulse crops namely chickpea and lentil was carried out to assess the quality of seeds.

2. MATERIALS AND METHODS

2.1 Seed Sample Collection from Different Agro-Climatic Zones of the State

Seed samples of chickpea (cv. PG-186) and lentil (cv. PG-186) were collected from 15 districts of Bihar, which was randomly selected from each zone of State. Seed sample was collected in clean, moisture-free polythene bags from farmers of various districts with the help of Krishi Vigyan Kendras (KVKs) of respective districts. The details of sample collection are given in Table 1.

2.2 Physiological Evaluation of Collected Seed Samples

The laboratory evaluation of collected seed samples was done and the physiological

parameters namely final germination percentage (FGP), seedling length (cm), seedling dry weight (g), vigour index I and vigour index II was studied. Seeds were kept for standard germination test (rolled paper towel method) in a seed germination chamber at a constant temperature of 20±2ºC and relative humidity of 90-95% following the method prescribed by International Seed Testing Association, 2015 for chickpea and lentil crop. Three replications of 50 seeds were placed between two layers of moist paper towel and placed in the seed germinator maintained at 20°C [6]. To know the germination potential and germination rate, the first and final count was taken on the 5th and 8th day respectively. Germination percentage was calculated based on a number of normal germinated seeds out of all tested seeds at the final count of the test.

To further study seedling length and seedling vigour, ten normal seedlings were picked up randomly from each replication of the germination test on the final count day. The root length was measured from the cotyledonary node to the tip of the primary root and shoot length was measured from the cotyledonary node to the tip of the apical bud. The seedling length was calculated by adding both root and shoot length of an individual seedling. The mean seedling length was calculated by averaging the seedling length of ten normal seedlings and expressed in centimeters. All ten seedlings together were kept in wax paper and dried in a hot air oven maintained at 80±1ºC temperature for 17 hours. The dry weight of the seedlings was recorded and expressed in grams. The mean values were used for computing the vigour indices using the following formula [7]:

Vigour Index I = Germination (%) × Total seedling length (cm)

Vigour Index II = Germination (%) × Seedling dry weight (gm)

2.3 Biochemical Evaluation of Collected Seeds Samples

2.3.1 Estimation of catalase enzyme activity

The catalase (CAT) activity was estimated according to the procedure described by Aebi [8] with some modification. 3 ml of reaction mixture contained 1 ml of 0.1 M phosphate buffer (pH 7.0), 0.3 ml of 30% H_2O_2 (v/v) and 100 µl of enzyme extract. The final volume was adjusted by adding sterile distilled water. The reaction was initiated with the addition of crude enzyme and the consumption was determined by changes in optical density at 240 nm. The optical density was measured for 0 min and 3 min on UV-Vis Spectrophotometer. The extinction coefficient of the catalase enzyme is 36 M-1 cm-1 and enzyme activity was expressed as µM/mg protein/min. The catalase activity was calculated using the following formula:

$$\text{Catalase activity} = \frac{\Delta A}{t} + \frac{1}{\varepsilon} + \frac{1}{protein\ conc.(mg\ protein/ml)} \text{x1000}$$

Where ΔA=Change in absorbance in 10mm path length

t=time

ε=Molar coefficient of H_2O_2

Table 1. Sample collection from different Agro-climatic zones of Bihar

SN	Agro-climatic zone	Name of district	Geographical location
1.	Agro-climatic zone I (North West Alluvial Plain Zone)	1. KVK, Madhubani	26.35°N 86.0°E
		2. KVK, Darbhanga	26.4°N 85.72°E
		3. KVK, Begusarai	25.42°N 86.1°E
2.	Agro-climatic Zone II (North East Alluvial Zone)	4. KVK, Purnea	25.9°N 87.4°E
		5. KVK, Saharsa	25.87°N 86.6°E
		6. KVK, Khagaria	25.5°N 86.47°E
		7. KVK, Katihar	25.54°N 87.56°E
3.	Agro-climatic zone IIIA (South East Alluvial Zone)	8. KVK, Sheikhpura	25.1°N 85.85°E
		9. KVK, Munger	25.38°N 86.46°E
		10. KVK, Lakhisarai	25.18°N 86.04°E
		11. KVK, Bhagalpur	25.23°N 87.04°E
		12. KVK, Banka	24.88°N 86.9°E
4.	Agro-climatic zone IIIB (South West Alluvial Zone)	13. PRC, Mokama, Patna	25.4°N 86.02°E
		14. KVK, Rohtas	24.62°N 83.91°E
		15. KVK, Jehanabad	25.15°N 84.83°E

2.3.2 Estimation of Peroxidase enzyme activity

Peroxidase (POX) activity was assayed as described by Putter [9] with some modifications. The assay mixture of 3 ml contained 1.5 ml of 0.1 M phosphate buffer (pH 7.0), 1 ml freshly prepared 10 mM guaiacol, 0.1 ml enzyme extract and 0.1 ml of 12.3 mM H_2O_2 and finally makeup volume 3 ml with distilled water. Initial absorbance was read at 436 nm and then increase in the absorbance was noted at the interval of 30 sec on the UV-Vis spectrophotometer. The extinction coefficient of peroxidase is 25.2 mM-1 cm-1 and the enzyme was expressed as µM/mg protein/min.

$$\text{Peroxidase activity} = \frac{\Delta A}{t} + \frac{1}{\varepsilon} + \frac{1}{protein\ conc.\ (mg\ protein/ml)}$$

Where ΔA=Change in absorbance in 10mm path length
t=time
ε=Molar coefficient of H_2O_2

2.3.3 Estimation of Superoxide dismutase enzyme activity

The Superoxide dismutase (SOD) activity was estimated by recording the decrease in absorbance of the enzyme as described by Dhindsa et al. [10] with some modification. 3 ml of reaction mixture containing 1.5 ml of 0.1 M phosphate buffer, 0.2 ml of 200 mM Methionine, 0.1 ml of 3 mM EDTA, 0.1 ml of 2.25 mM NBT, 0.1 ml of 1.5 M sodium carbonate, 1 ml of distilled water and 0.05 ml of enzyme samples. The reaction was started by adding 0.1 ml 60 µM Riboflavin and placing the tubes below a light source of two 15 W fluorescent lamps for 15 min. The reaction was stopped by switching off the light and covering the tubes with black cloth. Absorbance was recorded at 560 nm. One unit of enzyme activity was taken as the quantity of enzyme which reduced the absorbance reading of samples 50 % in comparison with tubes lacking enzymes. The enzyme activity was expressed as U/µg protein.

$$\text{SOD activity} = \frac{1}{Protein\ conc.\ (in\ \mu g)}\ x\ \frac{Ac - At}{Ac\ x\ 0.5}$$

Where, Ac=O.D. of control (Without enzyme)
At= O.D. of test (With enzyme)
0.5=50% reduction of activity

2.3.4 Statistical analysis

The results were presented as mean values ± standard error of the three replicates. Data were statistically analyzed using OPSTAT software. The significant difference between means was calculated by one way ANOVA ($p \leq 0.05$).

3. RESULTS

The physiological evaluation of collected chickpea and lentil seed samples were carried out as per standard methods prescribe by ISTA, 2015 [6] and vigour index by Abdul-Baki and Anderson [7]. The results of the physiological evaluation of chickpea and lentil seed samples are provided in Tables 2 and 4. The results of the physiological evaluation of chickpea seeds reveal that the 100 seed weight of collected seed samples were varied in the range of 16.8 gm to 22.8 gm. The seed moisture content in all the varieties was at par as per standard and ranged from 8.2 to 11.6% (Table 2). Further seed germination and seed vigour study revealed that the chickpea seeds of Bhagalpur, Lakhisarai, Munger, Sheikhpura, Jehanabad, and Patna exhibited more than 90% germination among which seeds of Sheikpura district recorded highest germination percentage (96.3%) while seeds collected from Begusarai (76.7%) and Darbhanga (77.7%) district exhibited lowest germination percentage. A moderate germination percentage of 86.3% and 88% were recorded from the seeds of Banka and Rohtas district respectively. The seedling length of the seeds was ranged from 11.6 cm to 20.8 cm. Sheikpura sample recorded the highest seedling length while seeds of Begusarai recorded the lowest seedling length. The lowest seedling length indicated the low quality of seeds. Similarly vigour index I and II were recorded highest in Sheikhpura samples while it was lowest in Begusarai and Darbhanga samples.

The results of the physiological analysis of lentil seed samples are tabulated in Table 4. Similarly in the physiological analysis of lentil seed samples revealed that the 100 seed weight of lentil ranged from 1.5-2.3 gm with the moisture content of ranging about 5-9%. Further seed germination and seed vigour study revealed that the lentil seeds of Bhagalpur, Lakhisarai, Munger, Sheikhpura, and Patna exhibited more than 90% germination among which seeds of Patna district recorded highest germination percentage (98.7%) while seeds collected from

Table 2. Physiological evaluation of chickpea seed sample

Name of district	100 Seed weight (g)	Seed moisture content (%)	Germination (%)	Seedling length (cm)	Seedling dry weight (g)	Vigour index I	Vigour index II
1. Begusarai	20.1±0.208	11.6±0.136	76.7±0.595	11.6±0.425	1.04±0.010	888±22.929	79±0.333
2. Darbhanga	22.8±0.322	10.0±0.084	77.7±0.997	13.5±0.149	1.01±0.026	1050±26.836	78±2.404
3. Banka	17.3±0.145	8.3±0.035	86.3±1.226	15.9±0.253	1.07±0.017	1370±6.884	93±2.333
4. Bhagalpur	22.6±0.289	8.2±0.060	92.7±2.048	20.0±0.377	1.76±0.012	1850±15.189	163±2.646
5. Lakhisarai	16.8±0.145	8.5±0.157	91.3±3.652	18.5±0.718	1.45±0.036	1688±8.690	133±1.764
6. Munger	18.2±0.404	9.5±0.086	92.0±0.010	19.8±0.369	1.63±0.019	1819±34.020	150±1.856
7. Sheikhpura	18.3±0.291	9.2±0.057	96.3±1.423	20.8±0.127	1.87±0.035	2005±6.833	180±4.359
8. Jehanabad	18.2±0.379	9.8±0.056	91.3±1.777	17.7±0.088	1.44±0.020	1620±36.088	132±3.712
9.Mokama, Patna	19.0±0.173	7.5±0.440	95.3±0.880	20.4±0.385	1.81±0.009	1942±50.120	172±1.453
10. Rohtas	18.0±0.058	9.7±0.000	88.0±1.021	16.8±0.260	1.24±0.020	1482±37.672	109±0.334
CD (5 %)	1.46	0.85	4.93	1.07	0.07	80.2	7.6
CV (%)	3.38	4.01	3.24	3.57	2.75	3.23	3.47

Values are expressed as means±SE of three replicates

Katihar and Rohtas district samples exhibited lowest germination percentage (66% and 74.3% respectively). A moderate germination percentage (80-89%) lentil seeds of Begusari, Darbhanga, Madhubani, and Purnea district. The seedling length of the seeds was ranged from 11.6 cm to 20.8 cm. Seed samples of Patna district also recorded the highest seedling length (26.4 cm) while seeds of Katihar recorded lowest seedling length(16.9 cm). The lowest seedling length indicated the low quality of seeds. Similarly, vigour index I and II were recorded highest in Patna district samples while it was lowest in samples collected from Katihar and Rohtas district.

The results of biochemical analysis in chickpea and lentil of three antioxidative enzymes namely, peroxidase, catalase and superoxide dismutase are depicted in Tables 3 and 5. The activities of these biochemicals were found directly correlated to the seed quality. In case of chickpea, the highest activities of POX (14.507 µM/mg protein /min), CAT (10.409 µM/mg protein /min) and SOD (19.79 U/mg protein) were found in the sample of Sheikhpura district which was having highest germination percentage, while lowest activities of these three enzymes were observed in Begusarai and Darbhanga seed samples (Table 3). Similarly, in case of lentil, the highest activities of POX (13.79 µM/mg protein /min), CAT (10.08 µM/mg protein /min) and SOD (11.89 U/mg protein) were found in the sample of Patna district which was having highest germination percentage, while lowest activities of these three enzymes were observed in Katihar seed samples (Table 3).

On the basis of the results of the physiological assessment (seed germination percentage) of chickpea and lentil seed samples, the seed lots were categorized into high, mid and low vigour. Among chickpea, the seed samples of Sheikhpura, Patna, Munger, Bhagalpur, Lakhisarai, and Jehanabad were categorized into high vigour; seeds of Rohtas and Banka district categorized in Mid Vigour while seeds of Darbhanga and Begusarai district were categorized into low vigor (Table 4). Similarly, in the case of lentil, the seed samples of Patna, Munger, Bhagalpur, Sheikhpura, Lakhisarai, and Khagaria were categorized into high vigour; seeds of Begusarai and Madhubani district categorized in Mid Vigour while seeds of Rohtas and Katihar district were categorized into low vigor (Table 7).

Table 3. Biochemical evaluation of chickpea seed sample

SN	Name of District	Peroxidase (µM/mg protein /min)	Catalase (µM/mg protein /min)	Superoxide Dismutase (U/mg protein)
1.	Begusarai	8.403±0.058	7.161±0.231	**15.95±0.265**
2.	Darbhanga	8.322±0.120	4.559±0.153	16.62±0.252
3.	Banka	10.087±0.231	6.808±0.379	16.21±0.173
4.	Bhagalpur	12.700±0.115	9.652±0.252	17.32±0.088
5.	Lakhisarai	11.962±0.231	5.329±0.115	15.99±0.153
6.	Munger	10.135±0.176	7.601±0.219	17.94±0.173
7.	Sheikhpura	14.507±0.153	10.409±0.173	19.79±0.153
8.	Jehanabad	10.891±0.116	6.353±0.208	18.48±0.173
9.	Mokama, Patna	11.224±0.233	7.350±0.306	16.46±0.265
10.	Rohtas	10.185±0.231	6.620±0.321	17.20±0.116
CD (5 %)		0.526	0.736	0.565
CV		2.826	5.974	1.914

Values are expressed as means±SE of three replicates

Table 4. Categorization of collected chickpea seed samples

High Vigour (>90 % GP)	Mid Vigour (80-90 % GP)	Low Vigour (<80 % GP)
Sheikhpura	Rohtas	Darbhanga
Patna	Banka	Begusarai
Bhagalpur		
Munger		
Jehanabad		
Lakhisarai		

Table 5. Physiological evaluation of lentil seed sample

Name of districts	100 Seed weight (g)	Seed moisture content (%)	Germination (%)	Seedling length (cm)	Seedling dry weight (g)	Vigour index I	Vigour index II
1. Begusarai	2.1±0.058	7.85±0.035	89.0±0.529	21.9±0.203	0.90±0.003	1952±30.665	81±0.882
2. Darbhanga	1.6±0.033	7.64±0.036	83.7±1.414	19.0±0.267	0.84±0.003	1592±58.612	70±1.667
3. Madhubani	1.8±0.058	7.94±0.154	87.3±2.222	22.3±0.186	0.89±0.007	1950±55.806	78±2.082
4. Khagaria	2.3±0.033	7.95±0.093	90.7±0.668	22.3±0.231	0.91±0.009	2022±24.907	82±1.202
5. Katihar	1.5±0.033	8.06±0.035	66.0±0.698	16.9±0.426	0.79±0.009	1112±30.965	52±1.333
6. Purnea	1.7±0.033	4.83±0.194	84.7±1.043	20.7±0.426	0.91±0.009	1751±10.149	77±1.856
7. Bhagalpur	2.2±0.033	7.43±0.253	92.0±0.611	23.6±0.186	0.94±0.006	2167±22.014	87±1.202
8. Lakhisarai	1.9±0.058	8.76±0.034	92.0±1.229	24.8±0.467	0.94±0.003	2285±69.245	87±1.202
9. Munger	2.3±0.033	8.08±0.061	93.0±1.092	25.0±0.338	0.95±0.007	2326±46.307	89±0.882
10. Sheikhpura	1.8±0.033	8.08±0.070	91.3±2.011	23.9±0.376	0.93±0.003	2187±59.821	85±1.856
11.Mokama, Patna	2.1±0.058	8.50±0.119	98.7±2.721	26.4±0.371	0.98±0.003	2606±47.158	97±0.577
12. Rohtas	2.2±0.058	8.11±0.121	74.3±1.975	17.4±0.203	0.82±0.006	1292±64.108	61±2.309
CD (5 %)	0.142	0.547	4.625	0.949	0.021	138.003	4.577
CV	3.255	3.2	3.14	2.542	1.368	4.203	3.428

Values are expressed as means±SE of three replicates

Table 6. Biochemical evaluation of lentil seed sample

SN	Name of District	Peroxidase (µM/mg protein /min)	Catalase (µM/mg protein /min)	Superoxide dismutase (U/mg protein)
1.	Begusarai	11.78±0.153	8.45±0.208	8.79±0.120
2.	Darbhanga	10.48±0.115	6.79±0.145	9.55±0.120
3.	Madhubani	10.85±0.208	7.39±0.133	10.06±0.240
4.	Khagaria	12.30±0.265	6.80±0.058	8.92±0.120
5.	Katihar	9.48±0.115	5.66±0.252	6.16±0.145
6.	Purnea	11.23±0.203	7.40±0.115	8.17±0.120
7.	Bhagalpur	10.44±0.058	6.76±0.208	7.48±0.120
8.	Lakhisarai	11.19±0.115	6.49±0.120	10.68±0.173
9.	Munger	9.77±0.258	6.80±0.0.219	10.83±0.273
10.	Sheikhpura	10.12±0.208	7.38±0.233	9.16±0.173
11.	Mokama, Patna	13.79±0.153	10.08±0.219	11.89±0.233
12.	Rohtas	10.88±0.231	7.70±0.120	8.30±0.120
CD (5 %)		0.539	0.526	0.505
CV		2.879	4.227	3.246

Values are expressed as means±SE of three replicates

Table 7. Categorization of collected lentil seed samples

High vigour (>90 % GP)	Mid vigour (80-90 % GP)	Low vigour (<80 % GP)
Patna	Begusarai	Rohtas
Munger	Madhubani	Katihar
Bhagalpur		
Lakhisarai		
Sheikhpura		
Khagaria		

4. DISCUSSION

Seed quality attributes include germination (percentage, rate, and uniformity), dormancy, seed and seedling vigor (germination/growth under stress conditions), seedling dry weight, and normal embryo and seedling morphology, as well as the ability to develop into a healthy plant. Seed quality is a limiting factor affecting not only germination capacity but also emergence potential, field stand, uniformity, seedling growth and finally crop productivity. The significance of seed quality is more pronounced under different environmental conditions [11]. In our present results, significant differences in all physiological parameters were observed in chickpea and lentil seed samples collected from different agroclmatic zones of this state. According to the Indian Minimum Seed Certification Standards (IMSCS), chickpea seed has 85% standard germination percentage considered as the best quality seeds. In the present study, we have categorized the seeds as high, mid and low vigour on the basis of physiological and biochemical and assessments and observed the significant differences among different seed lots. A significant variation in 100 seed weight of chickpea was observed which may be due to the seed moisture content and variation in harvesting time. Full viability and germination of seed cannot be attained until the seed reaches full maturity. Seed maturation is an important phase that controls final seed quality [12].

Several researchers have studied the seed germination parameters in pulse crops like chickpea [13,14], lentil [15] as well as pigeonpea [16] under adverse environmental conditions. However, the assessment of seed quality collected from different agroclimatic zones have not been documented yet. The diverse agroclimatic conditions in field during seed development and maturation affect vigor, viability, test weight, appearance, and storability of seed. The rate of aging is also strongly influenced by preharvest and post harvest environmental factors such as temperature, relative humidity, seed moisture content. According to Rajjou and Debeajoun [17], the seeds deteriorate during storage, and thus lose vigor, become more sensitive to stresses during germination and eventually unable to germinate. The seeds which maintain high vigor may be considered high-quality seeds, and the use of high-quality seeds will help farmers and pulses growers in order to obtain higher production. In order to improve seed quality, this was our initial approach to assess the seed quality of pulse crops grown in different agroclimatic zones of the state and we have observed significant influence of agroclimatic conditions on seed quality both in chickpea and lentil.

The antioxidant enzymes activity viz POX, CAT and SOD were found significantly higher in high vigour seeds in both chickpea and lentil. Seeds also get exposed to various environmental stresses during storage which may result in free radical toxicity by enhanced production ROS [17,18]. The antioxidative defense enzymes protect the cell membrane against the oxidative damage. In order to control free radical-induced cellular damage, seeds have developed a detoxification mechanism. Superoxidase dismutase along with catalase act as an enzymatic oxidant detoxification system and thus help to maintain the quality of seeds [16,19]. SOD activities have also been associated with the protection of plant tissues from SO_2 injury in plants [20]. Peroxidase catalyzes the oxidation of a wide variety of electron donors with the help of H_2 and helps in scavenging the endogenous H_2O_2. Removing the highly toxic H_2O_2 produced during dismutation is essential for the cell to avoid inhibition of the enzymes [16].

The present study revealed that the high vigour seeds of chickpea and lentil were having the highest germination percentage as well as a good antioxidant defense mechanism. The quality of mid vigor and low vigor seeds may be enhanced using several seed priming methods [11,21]. Seed priming will help to enhance the quality of seeds and further for the successful crop establishment in order to obtain higher production.

5. CONCLUSIONS

Seed quality is an important factor for the successful establishment of the crop and achieving higher production. Even though, the productivity of chickpea and lentil in the state of Bihar is comparatively higher but unable to achieve the self-sufficiency in production due to some environmental factors as well as unavailability of quality seeds. This research work was aimed to assess the seed quality of the popular grown variety of chickpea and lentil in Bihar state. Seed samples were collected from different agroclimatic zones of Bihar and physiological and biochemical analyses were carried out. Our results exhibit that the chickpea seed sample of the Sheikhpura district was having the highest germination percentage and higher antioxidant enzyme activities. Similarly, in

the case of lentil, the result revealed that the sample of Patna district was having the highest germination percentage (98.7%) and higher antioxidant enzyme activities. The higher seed quality attributes to cope against adverse environmental conditions and leads to successful crop establishment and higher production & productivity. This study will help to pulses growers of Bihar in order to assess their seed quality and enhancing the quality of seeds using different priming techniques.

ACKNOWLEDGEMENT

Authors are sincerely thanks to SERB-DST, New Delhi for funding the research project.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sdiarticle4.com/review-history/56936