The Bioscan 16(1): 27-32, 2021
AN INTERNATIONAL QUARTERLY JOURNAL OF LIFE SCIENCES
www.thebioscan.com

SEED PRIMING WITH OIL CAKE EXTRACT IMPROVES THE GERMINATION OF BHENDI

R. VIJI[1], V. MANONMANI[1], N.VINOTHINI[2],R. K. BHAVYASREE [3] AND T. POOVARASAN [1]
[1]Dept. of Seed Sci. Tech,[3]Centre for Plant Breeding and Genetics
Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu – 641 003
[2] Faculty of Agricultural Sciences, SRM Institute of Science and Technology, Deemed University,
Kattankulathur,Tamil Nadu - 603 203
e-mail: ns.vinothini93@gmail.com

KEYWORDS
Oil cake
Priming
Bhendi
Germination

Received on :
25.11.2020

Accepted on :
05.01.2021

***Corresponding author**

ABSTRACT
Seed priming with organic nutrients is now focused on using a macro or micronutrient enriched seeds. A study was conducted to evaluate the effect of seed priming with oil cake extracts on physiological seed quality parameters *viz*., speed of germination, germination per cent, root and shoot length, dry matter production and vigour index. Studies were carried out in bhendi cv. CO 1 to identify the suitable oil cake extracts and optimizing the concentration for seed priming for improving germination and vigour of bhendi. The extracts of oil cakes *viz.*, groundnut, sesame, coconut, cotton and neem were used as seed priming agents for conducting the experiment. To optimize the concentration of oil cake extracts for seed priming treatment, the various concentrations *viz*., 5, 10, 15 and 20 % of each oil cake extracts were prepared and used. Among the different oil cake extracts, bhendi seeds primed with sesame oil cake extract 5 % was identified as the best suitable seed priming agent. In bhendi, sesame oil cake extract 5 % registered highest per cent of speed of germination, root and shoot length, dry matter production and vigour index over nonprimed seeds 73.6,4.5, 16.6, 31.2,35.2 and 33.3 %, respectively).

INTRODUCTION

The seed is a basic input in agriculture in which 25 % yield increase can be achieved by quality seeds. Quality seed is the key for successful agriculture which demands every seed should readily be germinable and produce a vigorous seedling ensuring high yield. Better germination and vigour of the seedlings are the main basic foundations for the success of stand establishment of any crop plant. Various seed quality enhancement technologies including priming, coating and conditioning of the seeds are applied to improve germination and emergence in seeds of many crops (Arif *et al*., 2008; Taylor *et al*., 1998; Yanglem *et al*., 2016).

Seed priming is a technique in which seeds are soaked in solutions of low water potential that initiates pre-germinative metabolic activity but prevents radical protrusion (Ashraf and Foolad, 2005; Bradford, 1986; Farooq *et al*., 2006; Janmohammadi *et al*., 2008; Mcdonald, 2000). However, the beneficial effects of seed priming have been well documented in many research-based published data include early germination and improves germination rate (Bradford, 1986; Ghassemi-Golezani *et al*., 2008; Jett *et al*., 1996; Taylor and Harman, 1990).

Seed priming with organic nutrients is now recently focused by using a macro or micronutrient enriched seeds as reported by Rehman *et al*. (2012) and Mirshekari *et al*. (2012). Generally, nutrients are delivered to plants as soil applications, fertigation or foliar spray (Johnson *et al*., 2005; Roberts, 2008). Applying nutrients as a seed treatment, through seed coating and seed priming is another option which avoids the aforementioned risks (Farooq *et al*., 2012). The use of micronutrient enriched seeds (seed priming) has been reported to be a better strategy in overcoming micronutrient deficiencies. Priming the seeds with micronutrients makes them able to rapidly imbibe water and revive metabolism and germination. Then results in a higher germination rate (Rowse, 1996), improved stand establishment increased drought and pest tolerance, and ultimately higher yields (Harris *et al*., 1999).

The efficacy of different oil cakes and certain nematicides applied as seed coating was determined. The oil cakes not only reduced the population of plant parasitic nematodes and fungi, which may partly be due to higher concentration of phenols in plants, but also promoted the growth of the tomato plant. Neem seed cake as such was found unsuitable as a wholesome animal feed due to the bitterness and hence widely utilized as a fertilizer and insect repellent and insecticide. The cake contains 5.2 % N, 1.1 % P_2O_5 and 1.5 % K_2O (Khan, 1952) and serves as a good manure. The oil-cakes such as mustard, neem, castor, karanj, groundnut, mahua and sesame gave their best to manage the disease in glass house and in field condition as well. Oil cakes to be the best option so far against phytoparasitic nematodes are not only because of its easily availability but also economic feasibility for the growers/farmers entrepreneurship (Sumbul *et al*., 2015). With this background, the current study is formulated to standardize the seed priming treatment with oil

cake extracts for bhendi seeds.

MATERIALS AND METHODS

Genetically pure fresh seeds of bhendi cv. CO 1 seeds were obtained from the Department of Vegetables in Tamil Nadu Agricultural University, Coimbatore formed the base materials for the present investigation. Oil cakes of groundnut, sesame, coconut, cotton and neem were obtained from the oil mill located at Kalveerampalayam, Coimbatore. The laboratory studies were carried out at the Department of Seed Science and Technology, Tamil Nadu Agricultural University, Coimbatore.

The cold-water extract of oil cakes namely groundnut, sesame, coconut, cotton and neem each in 5, 10, 15 and 20 % concentration were prepared by dispensing 5, 10, 15 and 20 g of dried seed cake in 100 ml of distilled water and kept for 4-6 hours with intermittent shaking for every half an hour. Then the oil cake extracts were filtered through fine mesh or muslin cloth. Those oil cake extracts were used as priming agents for conducting the present experiment. Priming treatments were imposed with water and various oil cake extracts *viz*., groundnut, sesame, coconut, cotton and neem. The oil cake extracts of various concentrations were prepared and crop seeds were soaked in an equal volume of solutions for the duration of 12 hours under ambient temperature. After priming, the seeds were removed from the solutions, shade dried at room temperature to bring back to its original moisture content. The nonprimed and primed seeds were evaluated for the physiological parameters. The experiment was carried out with four replications in Completely Randomised Block Design (Viji and Manonmani, 2018).

The number of seeds germinated on each of the days, the speed of germination was calculated. Germination test was conducted by following the procedure outlined in ISTA (2012) with roll towel medium using 4 x 100 seeds in a germination room maintained at 25 ± 2ºC temperature and 95 ± 3 % RH. The seedlings were evaluated at the end of the final count days for bhendi *ie*., after 21 days. Based on normal seedlings, the germination per cent was calculated adopting the following formula and the mean expressed as a percentage.

$$\text{Germination}(\%) = \frac{\text{Number of normal seedings}}{\text{Total number of seeds sown}} X100$$

At the time of germination count, ten normal seedlings were selected at randomly used for measuring the root and shoot length of seedlings. Those selected seedlings are dried under shade for 24 hours and were kept in an oven maintained at 85ºC for 24 hours. After the drying period, the seedlings were cooled in a closed desiccator for 30 minutes and were weighed in a top pan balance and the mean expressed as mg seedlings-10 (Gupta, 1993). Vigour index (VI) was calculated using the method suggested by Abdul-Baki and Anderson (1973) and expressed in the whole number.

Vigour index = Germination (%) x [Root length (cm) + Shoot length (cm)]

RESULTS AND DISCUSSION

The difference in speed of germination was statistically significant for the priming treatments. Among the priming treatments, the seeds primed with sesame oil cake extract 5 % registered higher speed of germination of 9.9 followed by seeds primed with coconut oil cake extract 15 % (9.5). The nonprimed seeds registered delayed germination of 5.7 (Table 2, 3 and 6).

Regarding germination, highly significant differences was noticed due to seed priming treatments. Among the priming treatments, the highest germination of 92 per cent was observed due to seeds primed with sesame oil cake extract 5 % which were on par with coconut oil cake extract 15 % (91 per cent), while the lowest germination of 88 per cent was recorded by nonprimed seeds (Table 2, 3 and 6).

The difference in root length was statistically significant due to priming treatments. Seeds primed with sesame oil cake extract 5 % measured the longest root length of 19.78 cm followed by seeds primed with coconut oil cake extract 15 % (18.46 cm). The nonprimed seeds recorded shortest root length of 15.82 cm (Table 2, 3 and 6).

Highly significant influence was observed for shoot length due to priming treatments. Seeds primed with sesame oil cake extract 5 % outperformed other treatments by recording longest shoot length of 14.17 cm which were on par with cotton oil cake extract 5 % (13.94 cm), whereas the nonprimed seeds recorded the shortest shoot length of 10.80 cm (Table 2, 4 and 6).

Statistically highly significant variation was noticed for dry matter production of 10 seedlings due to priming treatments. The dry matter production registered by the seeds primed with sesame oil cake extract 5 % was more (311.7 mg seedlings-10) followed by seeds primed with coconut oil cake extract 15 % (295.4 mg seedlings-10), while the lowest dry matter production of 230.4 mg seedlings-10 was recorded in nonprimed seeds (Table 2, 3 and 6).

The vigour index was highly significant among the priming treatments. Among the priming treatments, seeds primed with sesame oil cake extract 5 % recorded greater vigour index of 3123 followed by priming with 15 % coconut oil cake extract (2920). The lowest vigour index of 2343 was registered by nonprimed seeds (Table 2, 3 and 6).

The studies on investigating the effect of these oil cake extract as a seed invigourative nutrient are limited. Hence, the studies have been conducted to investigate the effect of oil cake extracts as nutri-priming agent for enhancing seed qualities like germination and vigour. The present study was undertaken to evaluate the efficacy of oil cake extracts as seed priming agent and nutrient for treating different crop seeds for improving its seed quality attributes.

The different oil cakes *viz*., groundnut, sesame, coconut, cotton and neem are used in the present study. Generally, oil cakes contain amino acids also contain crude protein and crude fibre (Sunil *et al*., 2015). In addition to macro and micronutrients are present in various edible and non-edible oil cakes were also reported by Bi (1970); Kuo (1967).

Table 1. Standardization of seed priming with groundnut oil cake extract on physiological traits in bhendi

Priming Treatments	Speed of germination	Germination (%)	Root length (cm)	Shoot length (cm)	Dry matter production (mg seedlings-10)	Vigour index
Nonprimed seed	5.7	88 (69.73)	15.82	10.80	230.4	2343
Hydropriming	8.9	90 (71.57)	17.44	11.97	250.7	2647
5 %	8.8	87 (68.87)	16.53	12.48	269.3	2524
10 %	8.3	88 (69.73)	15.53	12.68	262.8	2482
15 %	8.0	88 (69.73)	15.88	12.63	265.4	2509
20 %	9.0	90 (71.57)	17.95	13.56	273.5	2836
Mean	8.0	89 (70.63)	16.53	12.35	258.7	2557
SEd	0.102	0.885	0.241	0.211	4.395	47.334
CD (P =0.05)	0.214	1.859	0.506	0.443	9.234	99.447

Table 2 : Standardization of seed priming with sesame oil cake extract on physiological traits in bhendi

Priming Treatments	Speed of germination	Germination (%)	Root length (cm)	Shoot length (cm)	Dry matter production (mg seedlings-10)	Vigour index
Nonprimed seed	5.7	88 (69.73)	15.82	10.8	230.4	2343
Hydropriming	8.9	90 (71.57)	17.44	11.97	250.7	2647
5%	9.9	92 (73.57)	19.78	14.17	311.7	3123
10%	9	88 (69.73)	17.81	14.15	277.3	2812
15%	8.8	86 (68.02)	16.16	13.49	272.6	2550
20%	8.8	86 (68.02)	17.2	12.3	255.9	2537
Mean	8.5	88 (69.73)	17.37	12.81	266.4	2669
SEd	0.132	1.078	0.241	0.132	3.459	40.683
CD (P =0.05)	0.277	2.265	0.505	0.277	7.267	85.474

Table 3: Standardization of seed priming with coconut oil cake extract on physiological traits in bhendi

Priming Treatments	Speed of germination	Germination (%)	Root length (cm)	Shoot length (cm)	Dry matter production (mg seedlings-10)	Vigour index
Nonprimed seed	5.7	88 (69.73)	15.82	10.8	230.4	2343
Hydropriming	8.9	90 (71.57)	17.44	11.97	250.7	2647
5%	9	89 (70.63)	17.81	13.48	273.8	2785
10%	9.2	90 (71.57)	18	12.81	262.6	2773
15%	9.5	91 (72.54)	18.46	13.63	295.4	2920
20%	9.1	88 (69.73)	17.06	13.33	282.2	2674
Mean	8.6	89 (70.63)	17.43	12.67	265.9	2690
SEd	0.065	0.687	0.243	0.183	3.363	39.223
CD (P =0.05)	0.136	1.444	0.511	0.385	7.065	82.405

Table 4: Standardization of seed priming with cotton oil cake extract on physiological traits in bhendi

Priming Treatments	Speed of germination	Germination (%)	Root length (cm)	Shoot length (cm)	Dry matter production (mg seedlings-10)	Vigour index
Nonprimed seed	5.7	88 (69.73)	15.82	10.8	230.4	2343
Hydropriming	8.9	90 (71.57)	17.44	11.97	250.7	2647
5%	9	92 (73.57)	18.11	13.94	271.9	2949
10%	9	91 (72.54)	16.58	12.98	257.4	2690
15%	8.8	90 (71.57)	15.89	12.42	249.8	2548
20%	8.6	89 (70.63)	15.22	13.1	255.7	2520
Mean	8.3	90 (71.57)	16.51	12.54	252.7	2616
SEd	0.153	1.066	0.207	0.178	4.117	30.419
CD (P =0.05)	0.321	2.239	0.435	0.374	8.65	63.909

Even though, the nutrient content present in the oil cake extracts and its effect on plant growth and productivity through soil application as manure is well established, the invigourative effect of oil cake extracts on seed germination and vigour potential as seed priming agent is the ever first attempt in the seed science research. Hence, the effort has been made to explore the effect on extracts of oil cakes as seed invigourative nutrient for improving seed quality attributes like germination and vigour which ultimately lead to the growth and yield of the crops (Som *et al*. (1992) in brinjal, Patel (1993) in pearl millet crop. Priming with nutrient solutions also improves plant growth and productivity. Similar work was reported by (Harris *et al*., 2007; Johnson *et al*., 2005; Kalita *et al*., 2002: Rai and Basu, 2014; Sarmadi *et al*., 2014).

The extracts of above oil cakes with the concentrations of 5,

Table 5: Standardization of seed priming with neem oil cake extract on physiological traits in bhendi

Priming Treatments	Speed of emergence	Germination (%)	Root length (cm)	Shoot length (cm)	Dry matter production (mg seedlings^{-10})	Vigour index
Nonprimed seed	5.7	88 (69.73)	15.82	10.8	230.4	2343
Hydro Priming	8.9	90 (71.57)	17.44	11.97	250.7	2647
5%	8.5	88 (69.73)	15.8	10.97	264.9	2356
10%	9.1	91 (72.54)	18.09	12.77	268.4	2808
15%	9	90 (71.57)	16.66	11.92	255.9	2572
20%	8.6	88 (69.73)	15.76	11.48	265.3	2397
Mean	8.3	89 (70.63)	16.6	11.65	255.9	2520
SEd	0.134	0.832	0.246	0.138	2.683	36.056
CD (P = 0.05)	0.281	1.748	0.516	0.289	5.636	75.751

Table 6: Influence of seed priming with different oil cake extracts in bhendi

Priming Treatments		Speed of germination	Root length (cm)	Shoot length (cm)	Dry matter production (mg seedlings-10)
Nonprimed seed		5.7	15.82	10.8	230.4
Hydropriming		8.9	17.44	11.97	250.7
Oil cake extract		9	17.95	13.56	273.5
Groundnut	20%				
Sesame	5%	9.9	19.78	14.17	311.7
Coconut	15%	9.5	18.46	13.63	295.4
Cotton	5%	9	18.11	13.94	271.9
Neem	10%	9.1	18.09	12.77	268.4
Mean		8.7	17.95	12.98	271.7
SEd		0.147	0.198	0.139	4.258
CD (P = 0.05)		0.306	0.411	0.29	8.854

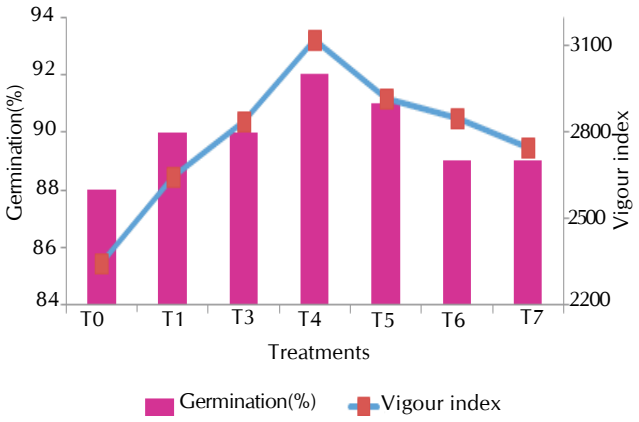

Figure 1: Seed priming influence on germination (%) and vigour index of bhendi

10, 15 and 20 % of each used for carrying out the seed priming experiment. Among the different concentrations, groundnut oil cake extract 20 %, sesame oil cake extract 5 %, coconut oil cake extract 15 %, cotton oil cake extract 5 % and neem oil cake extract 10 % outperformed other treatments by recording maximum germination per cent and seedling vigour of above crop seeds used in the present study (Table. 6). Generally, seed germination entails three distinct phases: (i) imbibition, (ii) lag phase and (iii) radicle growth and emergence. The purpose of priming is to prolong the lag phase, which allows some pregerminative physiological and biochemical processes to take place but prevents germination (Bradford, 1986).

In the lag phase of seed germination, before growth, metabolic processes in addition to repair occur during priming, such as changes in tissue morphology (Argerich and Bradford, 1989). Induction of repair mechanisms for damage on DNA, RNA, proteins or membranes may be involved. It is known that DNA repair is initiated within a few minutes after dry seeds or embryos have started to imbibe water (Osborne, 1982). Repair of DNA may occur at reduced water availability as well (Ashraf and Bray, 1993).

The present study revealed that in bhendi seeds treated with sesame oil cake extract 5 % outperformed then other treatments by an increase in per cent of the speed of emergence, root and shoot length and dry matter production over nonprimed seeds (73.6, 16.6, 31.2 and 35.2 % respectively) (Table. 6). In bhendi, the treatment with sesame oil cake extract 5 % outperformed other treatments by an increase in per cent of germination and vigour index over nonprimed seeds (4.5 and 33.3 % respectively) (Fig. 1). Priming the seeds with various oil cake extracts makes them able to rapidly imbibe water and revive metabolism and germination because of the presence of nutrients in plenty (N, P, K, protein, carbohydrates, antioxidants, vitamins and minerals) which might be the reason for the improvement of the seed quality attributes of seed germination and vigour potential in bhendi. This report is supported with the findings in maize (Viji and Manonmani, 2018) where the seed priming with sesame oil cake extract found to be increased early germination, germination per cent, root and shoot length and vigour index. Similar results were also reported by Chavan *et al*. (2014) in soybean and Parmar *et al*. (2016) in custard apple that the primed seed produced higher germination and other seed quality parameters.

Ashraf and Rauf (2001) reported that final germination per cent, fresh and dry weight of bhendi seed increased by seed priming significantly. Copeland (1976) observed that most seeds imbibed in water and sown in a moist environment,

germinate faster than untreated seeds. The results of the present experiment conform with the findings of Harris *et al*. (1999) and Rowse (1996). The suitable oil cake extract for seed priming of bhendi seeds is sesame oil cake extract 5 per cent.

REFERENCES

Abdul-Baki, A. A. and Anderson, J. D. 1973. Vigor determination in soybean seed by multiple criteria. *Crop science*. **13(6):** 630-633.

Argerich, C. A. and Bradford, K. J. 1989. The effects of priming and ageing on seed vigour in tomato. *J. Experimental Botany*. **40(5):** 599-607.

Arif, M., Jan, M. T., Marwat, K. B. and Khan, M. A. 2008. Seed priming improves emergence and yield of soybean. *Pakistan J. Botany*. **40(3):** 1169-1177.

Ashraf, M. and Bray, C. 1993. DNA synthesis in osmoprimed leek *(Allium porrum* L.) seeds and evidence for repair and replication. *Seed Science Research*. **3:** 15-23.

Ashraf, M. and Foolad, M. 2005. Pre sowing seed treatment - A shotgun approach to improve germination, plant growth, and crop yield under saline and non saline conditions. *Advances in Agronomy*. **88:** 223-271.

Ashraf, M. and Rauf, H. 2001. Inducing salt tolerance in maize (*Zea mays* L.) through seed priming with chloride salts: Growth and ion transport at early growth stages. *Acta Physiologiae Plantarum*. **23(4):** 407-414.

Bi, G. 1970. Animal feed from local products and by-products in the British Caribbean.

Bradford, K. J. 1986. Manipulation of seed water relations via osmotic priming to improve germination under stress conditions. *Horticultural Science*. **21:** 1105-1112.

Chavan, N. G., Bhujbal, G. B. and Manjare, M. R. 2014. Effect of seed priming on field performance and seed yield of soybean [*Glycine max* (L.) Merill] varieties. *The Bioscan.* **9(1):** 111-114.

Copeland, L. 1976. Seed and seedling vigor. Principles of seed science and technology. Minneapolis: *Burgess*.PP. 149-1184.

Farooq, M., Barsa, S. M. and Wahid, A. 2006. Priming of field-sown rice seed enhances germination, seedling establishment, allometry and yield. *Plant growth regulation*. **49(2):** 285-294.

Farooq, M., Wahid, A. and Siddique, K. H. 2012. Micronutrient application through seed treatments: a review. *J. soil science and plant nutrition*. **12(1):** 125-142.

Ghassemi-Golezani, K., Aliloo, A., Valizadeh, M. and Moghaddam, M. 2008. Effects of hydro and osmo-priming on seed germination and field emergence of lentil(Lens culinaris Medik.). *Notulae Botanicae Horti Agrobotanici Cluj-Napoca*. **36(1):** 29.

Gupta, P. 1993. Seed vigour testing. Handbook of seed testing, quality control and research dev., New Delhi. PP. 242-249.

Harris, D., Joshi, A., Khan, P., Gothkar, P. and Sodhi, P. 1999. On-farm seed priming in semi-arid agriculture: development and evaluation in maize, rice and chickpea in India using participatory methods. E*xperimental Agriculture.* **35(1):** 15-29.

Harris, D., Rashid, A., Miraj, G., Arif, M. and Shah, H. 2007. 'On-farm'seed priming with zinc sulphate solution-A cost-effective way to increase the maize yields of resource-poor farmers. *Field Crops Research*. **102(2):** 119-127.

ISTA. 2012. International rules for seed testing. International Seed Testing Association, Basssersdorf, Switzerland.

Janmohammadi, M., Dezfuli, P. M. and Sharifzadeh, F. 2008. Seed invigoration techniques to improve germination and early growth of inbred line of maize under salinity and drought stress. *Gen. Appl. Plant Physiol*. **34(4):** 215-226.

Jett, L. W., Welbaum, G. E. and Morse, R. D. 1996. Effects of matric and osmotic priming treatments on broccoli seed germination. *J the American society for horticultural science*. **121(3):** 423-429.

Johnson, S., Lauren, J., Welch, R. and Duxbury, J. 2005. A comparison of the effects of micronutrient seed priming and soil fertilization on the mineral nutrition of chickpea (*Cicer arietinum*), lentil (Lens culinaris), rice (*Oryza sativa*) and wheat (Triticum aestivum) in Nepal. Experimental Agriculture. **41(4):** 427-448.

Kalita, U., Suhrawardy, J. and Das, J. 2002. Effect of seed priming with potassium salt and potassium levels on growth and yield of direct seeded summer rice (*Oryza sativa* L.) under rainfed upland condition. *Indian J. Hill Farming*. **15:** 50-53.

Khan, A. 1952. Manure and its sources from oil cakes. *J. Sci. Club* (India). **5:** 14-16.

Kuo, L. H. 1967. Animal Feeding Stuffs compositional data of feeds and concentrates (Part 3). *The Malaysian Agricultural J*. **46(1):** 63-70.

Mcdonald, M. B. 2000. Seed priming. Seed technology and its biological basis. Sheffield Academic Press Ltd., Sheffield, UK. PP. PP.287-325.

Mirshekari, B., Baser, S., Allahyari, S. and Hamedanlu, N. 2012. On-farm seed priming with Zn + Mn is an effective way to improve germination and yield of marigold. *African J. Microbiology Research*, **6(28):** PP**.** 5796-5800.

Osborne, D. J. 1982. Deoxyribonucleic acid integrity and repair in seed germination: the importance in viability and survival. The Physiology and Biochemistry of Seed Devêlopment, Dormancy and Germination. PP.435-463.

Parmar, R. K., Patel, M. J., Thakkar, R. M. and Tsomu, T. 2016. Influence of seed priming treatments on germination and seedling vigour of custard apple (*Annona squamosa* l.) cv. Local. *The Bioscan*. **11(1):** PP. 389-393.

Patel, B. 1993. Response of wheat (*Triticum aestivum* L.) cv. GW-496 to organic, inorganic and bio-fertilizers under middle gujarat conditions. M.Sc (Ag.) Thesis, Gurajat Agricultural University, Anand.

Rai, A. K. and Basu, A. K. 2014. Pre-sowing seed bio-priming in okra: response for seed production. *The Bioscan*. **9(2):** 643-647.

Rehman, H. U., Aziz, T., Farooq, M., Wakeel, A. and Rengel, Z. 2012. Zinc nutrition in rice production systems: a review. *Plant and Soil*. **361(2):** 203-226.

Roberts, T. L. 2008. Improving nutrient use efficiency. *Turkish J. Agriculture and Forestry*. **32(3):** 177-182.

Rowse, H. 1996. Drum priming-a non-osmotic method of priming seeds. *Seed Science and Technology*. **24:** 281-294.

Sarmadi, R., Asli, D. E. and Eghdami, A. 2014. Effect of seed priming by potassium nitrate on nodulation of common bean (*Phaseolus vulgaris* L.). *Int. J. Farm. Alli. Sci.* **3(3):** 312-316.

Som, M. L., Hashim, H., Mandak, A. K. and Matty, T. K. 1992. Influence of organic manures on growth and yield of brinjal. *Crop Research*. **5(1):** 80-84.

Sumbul, A., Rizvi, R., Mahmood, I. and Ansari, R. A. 2015. Oil-cake amendments: useful tools for the management of phytonematodes. *Asian J. Plant Pathology*. **9:** 91-111.

Sunil, L., Appaiah, P., Kumar, P. P. and Krishna, A. G. 2015. Preparation of food supplements from oilseed cakes. *J. Food Science and Technology*. **52(5):** 2998-3005.

Taylor, A. and Harman, G. 1990. Concepts and technologies of selected seed treatments. *Annual Review of Phytopathology*. **28(1):** 321-339.

Taylor, A., Allen, P., Bennett, M., Bradford, K., Burris, J. and Misra,

M. 1998. Seed enhancements. *Seed Science Research*. **8(2):** 245-256.

Viji, R. and Manonmani, V. 2018. Influence of seed priming with oil cake extracts on quality parameters of maize seeds. *Madras Agricultural J.* **105(7-9):** 243-246.

Yanglem, S. D., Ram, v., Rangappa, K., Devi, M., Singh, N., and Singh, A. 2016. Effect of seed priming on germination and initial seedling growth of pea (*Pisum sativum* L.) cultivars. The Bioscan. **11(4):** 2625-2630.