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Influence of seed invigoration treatments over growth and seed yield parameters of partially aged seeds of lentil (*Lens culinary* Medik.)

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Abstract
The experiment was conducted at Central Research field of Department of Genetics and Plant Breeding, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (U.P.) during Rabi season 2019-2020, in order to standardize the seed invigoration treatment of Lentil (Variety PL-406). Different invigoration treatment with control (Untreated) were evaluated *viz*., T_0-Control T_1- Indole Butaric Acid @0.5%, T_2-Indole Butaric Acid @1.0%, T_3-Rhizobium Culture @3%, T_4-Rhizobium Culture @5%, T_5-Zinc Sulphate @0.5%, T_6-Zinc Sulphate @1.0%, T_7-Fish Amino Acid @50 ppm, T_8-Fish Amino Acid @75 ppm, T_9-Guava Leaf Extract@50 ppm, T_{10}-Guava Leaf Extract@75 ppm, T_{11}-Panchagavya @50 ppm, T_{12}-Panchagavya @75 ppm. It was found that all the seed treatments showed significance difference with the control except no. of seed per pod. Seed treatment increases the growth and yield of lentil seeds, significantly in field condition. T_8 (Fish amino acid @ 75ppm) followed by T_4 (Rhizobium culture @ 5 %) showed maximum increase in growth and yield of lentil seeds. Seed treatment on field condition gives best result in Fish amino acid @ 75ppm and found to be lowest in Control (untreated). These conclusions are based on the results of six months investigation and therefore further investigation is needed to arrive at valid recommendations. The treatments of lentil crop with Fish amino acid is eco-friendly and economic in use.

Keywords: Seed invigoration, lentil, fish amino acid, rhizobium culture

Introduction
Lentil (*Lens culinaris* Medik.) is a self pollinated crop with very low percentage of natural out crossing. It belongs to the family Leguminoceae, sub family Papillionaceae. The centre of origin of lentil is Central Asia (Vavilov, 1951). Lentil, being rich source of protein, carbohydrate, fat, amino acids, vitamins and minerals, is extensively used in various culinary preparations. The dry and soft seeds are deep fried and used as snacks, combined with cereals for the preparation of bread and cakes. Besan (Dal flour) is used in the preparation of Namkeen and Dhokla. The young pods are used as green vegetables. Although, lentil is primarily a human food, its leaves and stalks have also a feed value, grown as fodder occasionally.

Lentil is the third most important pulse crop of North India (Singh *et al.*, 2014) which is mainly grown as rain-fed crop in Uttar Pradesh, Uttarakhand, Madhya Pradesh, Jharkhand, Bihar and West Bengal. Lentil plays an important role in the diet of developing world. Lentils have the second highest ratio of protein per calorie of any legume, after soybean (Mudryj and Aukema, 2014). Lentil provide a variety of essential nutrients to a person's diet, containing high levels of protein (20-30%), minerals (2-5%), vitamin B9 and prebiotic carbohydrates (Thavarajah *et al.*, 2008) [19]. Lentil is typically rich in micronutrients and has the potential to provide adequate dietary amounts, especially for iron (Fe), zinc (Zn), and selenium (Se) (Thavarajah *et al*., 2015). Lentil is having the lowest content of lectins and trypsin inhibitors among legumes. It contains phytonutrients like flavonoids, tannins, phytic acid, phytosterols, which has anti-inflammatory, antioxidant, and anticancer effects (Ezzat *et al*., 2012) [6].

The botanical features of *Lens culinaris* (cultivated lentil) can be described as annual bushy herb, slender almost erect or sub erect, much-branched, softly hairy; stems slender, angular, 15-75 cm height (Duke, 1981; Muehlbauer *et al*., 1985). Ten to sixteen leaflets are subtended on the rachis (40-50 mm); upper leaves have simple tendrils while lower leaves are mucronate (Muehlbauer *et al*., 1985). "The leaves are alternate, compound, pinnate, usually ending in a tendril or bristly; leaflets 4-7 pairs, alternate or opposite; oval, sessile, 1-2 cm long; stipules small, entire; stipules absent; pods oblong, flattened or compressed, smooth, to 1.3 cm long, 1-2-seeded; seed biconvex, rounded, small, 4-8 mm × 2.2-3 mm, lens-shaped, green, greenishbrown or light red speckled with black; the weight of 100 seeds range from 2 to 8 g; cotyledons red, orange, yellow, or green, bleaching to yellow, often showing through the testa, influencing its apparent colour" (Kay, 1979; Duke, 1981; and Muehlbauer *et al*., 1995). Flowers are small, pale blue, purple, white or pink, in axillary 1-4-flowered racemes; 1-4 flowers are borne on a single peduncle and a single plant can produce upto 10-150 peduncles each being 2.5-5 cm long (Muehlbauer *et al*., 1985). Flowering proceeds acropetally. Germination is hypogeal and this keeps the developing seedlings below ground level which reduces the effects of freezing and other desiccating environmental conditions (Muehlbauer *et al*., 1985).

The time taken by the seed from sowing to the seedling establishment is of prime importance having obvious impact on plant growth and development, final yield and post-harvest quality of seeds thus playing a vital role in successful crop production. As generally described, the seed germination phenomenon consists of three phases; during imbibitions process water is absorbed by the seed with little metabolic activity (Phase-I), in lag phase very little water absorption occurs but considerable metabolic activity takes place (Phase-II), whereas in the next phase (Phase-III) water absorption increases along with the growth of radicle resulting in emergence. The duration of phase-III is of crucial importance because on the initiation of embryo growth the germination is considered complete. During germination, the seed is exposed to different environmental stresses such as extreme temperature, soil crust formation, excessive moisture, drought stress, salinity, insects and diseases that may cause a reduction or complete destruction of seed germination and seedling emergence phenomenon (Ashraf and Foolad, 2005).

Material and Methods

The experimental was carried out to study the “Influence of seed invigoration treatments over morphological and seed quality parameters of partially aged seeds of lentil (*Lens culinary* Medik.)”. Experiment conducted at the department of genetics and plant breeding, SHUATS Prayagraj. The detail of the material used and techniques adopted during the course of the investigation are Different invigoration treatment with control (Untreated) were evaluated viz., T_0-Control T_1- Indole Butaric Acid @0.5%, T_2-Indole Butaric Acid @1.0%, T_3-Rhizobium Culture @3%, T_4-Rhizobium Culture @5%, T_5-Zinc Sulphate @0.5%, T_6-Zinc Sulphate @1.0%, T_7-Fish Amino Acid @50 ppm, T_8-Fish Amino Acid @75 ppm, T_9-Guava Leaf Extract@50 ppm, T_{10}-Guava Leaf Extract@75 ppm, T_{11}-Panchagavya @50 ppm, T_{12}-Panchagavya@75ppm.

Results and Discussions

The data on plant height recorded at maturity stages are presented in Table2.The results indicate the periodic increase in average plant height and also significant effect of various treatments. Significant and highest plant height was recorded with the treatment T_8 (Fish amino acid @ 75ppm) with 31.5 cm. followed by T_4 (Rhizobium culture @ 5 %) with 30 cm. Minimum plant height was observed under T_0 (control) with 26 cm. at harvesting stage.

The most important yield-components the number of pods per plant was found to influence significantly due to various treatments as exhibited in Table 2. The results indicate the periodic increase in average branches and also significant effect of various treatments. Significant and highest number of pods per plant (69.36) was recorded with the treatment T_8 (Fish amino acid @ 75ppm) followed by T_4 (Rhizobium culture @ 5 %) with 68.6. Minimum number of pods per plant (37.37) was observed under absolute control T_0 at harvesting stage.

The number of seed did not differ significantly due to different seed invigoration treatments as revealed from Table 2. It ranged from 1.06/pod in T_0 control to 1.14/pod in T_8 (Fish amino acid @ 75ppm) treatment.

The effect of seed invigoration treatment on seed yield per plant was found to be significant Table 2. The highest seed yield up to 3.03 g/plant was recorded in T_8 (Fish amino acid @ 75ppm) followed by T_4 (Rhizobium culture @ 5 %) with 2.98 g/plant. The overall picture is that the T_8 treatment raised the seed yield per plant by 0.71 g in comparison to control T_0 which resulted in the lowest seed yield (2.32 g/plant).

Table 1: Analysis of variance of 10 growth and seed yield parameters of lentil

S. No.	Characters	Mean sum of square		
		Replication (df=2)	Treatment (df=12)	Error (df=24)
1	Field emergence	0.322	6.302*	0.142
2	Plant height	9.589	19.585*	1.232
3	Number of primary branches	0.007	0.645*	0.022
4	Number of pod per plant	1.248	341.825*	1.281
5	Number of seed per pod	0.000	0.002	0.003
6	Seed yield per plant	0.054	0.129*	0.017
7	Seed yield per hectare	2694.872	59147.009*	380.983
8	Seed index	0.005	0.136*	0.005
9	Biological yield	2533.259	205318.678*	528.507
10	Harvest index	0.037	3.777*	0.044

* Significant at 5% level of significance.

It is evident from the data that the application of seed treatment significant improvement in seed index. The maximum seed index (2.99 g) was registered with T_8 (Fish amino acid @ 75ppm) followed by T_4 (Rhizobium culture @ 5 %) with 2.88 g. The treatment T_0 control resulted least seed index 2.25 g.

A critical examination of data shows that the seed yield significantly increased with the application of different seed invigoration treatments. The data on seed yield as influenced by different seed invigoration treatments is presented in Table 2. Among the seed treatments, highest seed yield was recorded in T_8 (Fish amino acid @ 75ppm) with 1230kg/hac., followed by T_4 (Rhizobium culture @ 5 %) with1180 kg/hac. lowest was recorded in T_0 (control) with 726kg/hac. of seed yield.

Minimum taken days to anthesis (43.33) was recorded by **T_{11}**-Ascorbic Acid (50 ppm) @ 60 DAS followed by **T_6**- SA (10 ppm) @ 45 DAS (43.43), **T_9**- Chitosan (0.5%) @ 60 DAS

(44.00) and **T_8**- DAP (2%) @ 60 DAS (44.07). Maximum taken days to anthesis was recorded by T_0 – Control (46.02). The positively effect of spraying treatment on days to anthesis was found to be non-significant and similar finding observed by Bhat *et al.*, (2011); Patel and Vyas, (2007) and Purbey and Sen, (2005).

Minimum taken days to 50% flowering (46.00) was recorded by **T_6**- SA (10 ppm) @ 45 DAS followed by **T_2**- DAP (2%) @ 45 DAS (46.67), **T_9**- Chitosan (0.5%) @ 60 DAS (47.00) and **T_5**- Ascorbic Acid (50 ppm) @ 45 DAS (47.33). Maximum taken days to 50% flowering were recorded by T_0 – Control (50.67). The positively effect of spraying treatment on days to 50% flowering was found to be significant and similar finding observed by Beena and Mercy, (2003) and Kataria *et al.*, (2003).

Minimum taken days to maturity (86.67) was recorded by T_6- SA (10 ppm) @ 45 DAS followed by T_9- Chitosan (0.5%) @ 60 DAS (87.33), T_2- DAP (2%) @ 45 DAS (88.00) and T_{10}- Moringa leaf extract (3%) @ 45 DAS (88.33). Maximum taken days to maturity was recorded by T_0 – Control (90.00). The positively effect of spraying treatment on days to maturity was found to be significant and similar finding observed by Das *et al.*, (1996); Patel, (2006); Purbey and Sen, (2005) and Khalifa *et al.*, (2012).

Observed maximum seed yield per plant (90.76 gm) was recorded by T_6- SA (10 ppm) @ 45 DAS followed by T_9- Chitosan (0.5%) @ 60 DAS (89.80 g), T_2- DAP (2%) @ 45 DAS (86.53 g) and T_{11}- Ascorbic Acid (50 ppm) @ 60 DAS (83.75 g). Minimum seed yield per plant was recorded by T_0 – Control (63.90 gm). Seed yield per plot (756.30 gm) found to be highest in T_6- SA (10 ppm) @ 45 DAS followed by T_9- Chitosan (0.5%) @ 60 DAS (741.68 g), T_2- DAP (2%) @ 45 DAS (709.10 g) and T_{11}- Ascorbic Acid (50 ppm) @ 60 DAS (698.77 g). Minimum seed yield per plot was recorded by T_0 – Control (516.05 gm). The positively effect of spraying treatment on seed yield was found to be significant and similar finding observed by Aftab *et al.*, (2011); Hesami *et al.*, (2012); Krishnamoorthy and Madalageri, (2000); Rohamare *et al.*, (2013) and Prasad *et al.*, (2003).

Biological yield (1356.53 gm) was observed highest in T_9- Chitosan (0.5%) @ 60 DAS followed by T_{11}- Ascorbic Acid (50 ppm) @ 60 DAS (1352.61 g), T_6- SA (10 ppm) @ 45 DAS (1339.48 g) and T_2- DAP (2%) @ 45 DAS (1338.94 g). Minimum biological yield was recorded by T_0 – Control (1199.37 gm). The positively effect of spraying treatment on biological yield was found to be non-significant and similar finding observed by Ezz El-Din and Khalil, (2004); Naidu and Swamy, (1995) and Giannakoula *et al.*, (2012).

Maximum harvest index (56.68%) was recorded by T_6- SA (10 ppm) @ 45 DAS followed by T_9- Chitosan (0.5%) @ 60 DAS (54.95%), T_2- DAP (2%) @ 45 DAS (53.31%) and T_7- Urea (2%) @ 60 DAS (1338.94 g). Minimum harvest index was recorded by T_0 – Control (43.05%). The positively effect of spraying treatment on harvest index was found to be significant and similar finding observed by Gomaa, (2001); Narra *et al.*, (2010); Farooqi *et al.*, (1999) and; Rohamare *et al.*, (2013).

A critical examination of data shows that the biological yield significantly increased with the application of different seed invigoration treatments. The data on biological yield as influenced by different seed invigoration treatments is presented in Table 2. Among the treatments, highest biological yield was recorded in T_8 (Fish amino acid @ 75ppm) with 2766kg/hac., followed by T_4 (Rhizobium culture @ 5 %) with 2704.31kg/hac. while, lowest was recorded in T_0 (control) with 1933.15 kg/hac. of biological yield.

This is the economic (seed) yield expressed as the percentage of total biological yield in terms of dry matter. The harvest index differs significantly due to application of different seed invigoration treatments presented in Table 2. Among the seed treatments, highest harvest index was recorded in T_8 (Fish amino acid @ 75ppm) with 41.53%, followed by T_4 (Rhizobium culture @ 5 %) with 41.50 % while, lowest was recorded in T_0 (control) with 37.60 % of harvest index.

Table 2: Mean performance of 10 growth and seed yield parameters of lentil

Treatment	Field emergence	Plant height (cm)	No of primary branches	No of pod per plant	No of seed per pod	Seed yield per plant (gm.)	Seed yield per hac. (Kg./hac)	Seed index (gm.)	Biological yield (Kg./hac)	Harvest index (%)
T_0	67.833	26.000	6.467	37.373	1.067	2.320	726.667	2.253	1,933.157	37.607
T_1	71.250	26.533	7.357	41.937	1.070	2.510	836.667	2.393	2,115.813	38.517
T_2	69.527	27.100	7.473	47.493	1.117	2.560	966.667	2.453	2,253.260	40.247
T_3	72.613	27.000	7.627	53.517	1.117	2.690	1,053.333	2.767	2,397.943	40.740
T_4	71.790	30.500	7.840	68.600	1.130	2.980	1,180.000	2.860	2,562.380	41.507
T_5	71.460	26.600	7.387	47.633	1.117	2.810	1,120.000	2.743	2,253.733	40.263
T_6	72.093	28.600	7.600	63.320	1.113	2.520	1,103.333	2.743	2,644.147	39.157
T_7	72.410	26.100	7.233	53.467	1.117	2.520	1,116.667	2.733	2,704.310	40.393
T_8	73.497	31.500	8.000	69.367	1.143	3.030	1,230.000	2.997	2,766.677	41.537
T_9	71.757	21.800	6.900	41.200	1.067	2.477	1,136.667	2.757	2,361.700	40.623
T_{10}	72.330	23.700	7.500	55.100	1.110	2.587	1,110.000	2.433	2,439.033	40.680
T_{11}	71.427	28.100	6.567	41.053	1.070	2.650	970.000	2.770	2,049.133	39.943
T_{12}	70.697	25.500	6.933	43.733	1.070	2.467	1,016.667	2.657	2,142.134	39.563
Grand Mean	**71.43**	**25.5**	**6.93**	**43.73**	**1.07**	**2.46**	**1043.59**	**2.65**	**2355.64**	**40.05**
C.D.	0.630	1.885	0.244	1.922	N/A	0.153	33.088	0.026	39.148	0.377
SE(m)	0.215	0.642	0.083	0.655	0.021	0.052	11.269	0.009	13.333	0.128
SE(d)	0.303	0.908	0.118	0.926	0.030	0.074	15.937	0.013	18.855	0.181
C.V.	0.520	4.141	1.974	2.221	3.342	3.445	1.870	0.583	0.980	0.555

Conclusion

The present study was undertaken to "Influence of seed invigoration treatments over growth and seed yield parameters of partially aged seeds of lentil (*Lens culinary* Medik.)". From the present study, it can be concluded that the effect of treatments showed significant variation for growth, yield and its attributes.

It is concluded that the Lentil aged seeds treated with the different treatment, among the 13 treatments T_8 (Fish amino acid @ 75ppm) followed by T_4 (Rhizobium culture @ 5 %) found the best treatments, significantly increased the growth and yield characters. Among 13 treatments the T_0 absolute control showed minimum results in all characters studied.

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