

## **Beneficiary effect of kalmegh-extract for improving seed storage, viability and vigour some economically important crops**

<sup>1</sup>Anindya Santra and <sup>1</sup>\*Sabyasachi Kundagrami

<sup>1</sup>Department of Genetics and Plant Breeding, Institute of Agricultural Science  
Calcutta University, 51/2, Hazra Road, Kolkata-19

### **Abstract**

Kalmegh (*Andrographis paniculata*) is a very well known and popular medicinal plant used in both homoeopathic and ayurvedic system for a long time successfully as antiinflammatory, antibacterial, antiperiodic, antipyretic, antithrombotic, antiviral, hypoglycemic, hepatoprotective. It has proved its efficacy against colon cancer even. It's such potential to treat different human diseases influenced to attempt a research programme to find out whether there is any effect of kalmegh extract against store grain pest and maintenance of seed vigor and viability in storage for some economically important crops like paddy, lentil, moong and gram. Three concentrations of treatment solution developed following the dilution process described in Homoeopathic Pharmacopeia of India from kalmegh leaves. Freshly harvested seed lots of the above crop seeds treated with the treatments by soaking drying method and kept in cloth bags in three replications along with two control treatments for six months in godown. Such experiment is done during two successive years and from the observation and calculated results it was revealed that crude kalmegh extract was most effective against store grain pest that gradually becomes weaker in dilutions. On the other hand, dilutions improved germination and related parameters in seed lings after storage in respect of control.

**Keywords:** Kalmegh , medicinal plant , storage , germination, seed vigour, viability

---

### **Introduction**

Agriculture is facing the dual challenges of increasing crop production and climate change. Rising temperature, drought, salinity, floods, desertification and weather extreme are adversely affecting agriculture especially in developing world (IPCC, 2007). Most of the predicted population growth to 2030 will be in developing countries (Population Reference Bureau, 2011) and more than half of the work force engaged in agriculture in the third world countries is prone to more damage by climate change. Thus, there is need to improve crop productivity under changed climate, abiotic stresses and to meet the needs of increasing world populations. Nature always stands as a golden mark to exemplify the outstanding phenomena of symbiosis. In the developed countries as the people are becoming aware of the potency and side effect of synthetic drugs, there is an increasing interest in the natural product remedies with a basic approach towards the nature (Yasmeen, 2011). Throughout the history of mankind, many infectious diseases have been treated with herbals. The rise of seed treatments is more than a market opportunity in the eyes of Craig Lindholm, the marketing manager for

seed treatments at BASF U.S. Crop Protection, sees the opportunity to help farmers to protect the yield (The Science behind Seed Treatments, Feb 2008). The search for safe and effective naturally occurring antioxidants is now focused on edible plants, especially spices and herbs (Nakatani, 1997). The aqueous extract obtained from *Andrographis paniculata* leaves showed more phenolic content and antioxidant potential as compared to extract from other parts such as stem and fruits (Arash *et al.*, 2010). Chowdhury and Mandal, 2012 reported that dry and wet seed treatments wet seed treatments has resulted in better vigor and viability. Pre-storage dry physiological treatments with a pharmaceutical formulation, crude plant materials and a mid-storage wet treatment (soaking-drying) showed significant improvement in post-storage germinability over untreated control in wheat (De *et. al.*, 2003). Seed invigoration treatments for improved storability and field performance of rice (*Oryza sativa* L.) were reported by Kundagrami *et. al.* 2008. Patra *et. al.* 2012 and Mandal *et al.* 2011 reported that mid-storage dry treatment with aspirin and neem leaf powder has been suggested to the rice growers for improved storability, field performance and productivity. Sengupta *et. al.*, 2005 also reported pre-storage dry seed invigoration treatments of high-vigour onion are suggested for the improvement of storability and field performance. Basu and co-workers (Pal and Basu 1993) reported that dry seed treatment with crude plant preparation such as red chilli powder (0.5g/kg), turmeric (1g/kg), neem and vitex leaf powder (2g/kg) are effective in slowing down seed deterioration, improve germinability and field emergence and productivity. Plant phenolic compounds are also known for their function as antioxidants due to their free radical scavenging capabilities (Wattenberg *et. al.* 1980; Fauconneau *et. al.* 1997) which will be beneficial for excess water stress.

Kalmegh (*Andrographis paniculata*) is a very well known and popular medicinal plant used in both homoeopathic and ayurvedic system for a long time successfully as anti-inflammatory, antibacterial, antiperiodic, antipyretic, antithrombotic, antiviral, hypoglycemic, hepatoprotective. It has proved its efficacy against colon cancer even (Puri *et. al.* 1993). Kalmegh has antioxidant property that reduced ageing of seed and improved seed storage duration as well as seed vigor and viability (Deepak *et. al.*, 2014; Arash *et. al.* 2010). Under this background current programme was undertaken to find out whether the effect of kalmegh extract against store grain pest and maintenance of seed vigor and viability in storage for some economically important crops like paddy, lentil, moong and gram.

### Materials and methods

In this segment of investigation different management strategies were examined to mitigate the effect of ethanolic Kalmegh extract and its subsequent dilutions over target crops seeds in storage and germination performance. Materials used and methods followed are discussed here. Harvested fresh seeds of Paddy (*Oryza sativa*) variety Nangalmunda, Lentil (*Lens culinaris*) variety Purulia Local, Moong (*Vigna radiata*) variety PM2 and Gram (*Cicer arietinum*) var. Mahamaya2 were collected and dried up in the seed dryer properly to attain the moisture content 8% -10%. Then treatments were applied to the seeds.

Freshly harvested seeds of the above crops collected during their respective period of harvesting, like Paddy in November, Lentil in April, Moong in June and Gram in April. Five treatments were prepared including the two controls- treatment I or control one with no

treatment and treatment II in 65% alcohol. Freshly prepared 65% alcohol extract of Kalmegh leaves was taken as treatment III, 10% dilution of treatment III as treatment IV and 10% dilution of treatment IV as treatment V. Seeds were soaked by the above treatment solution for 1 hour and then immediately dried by air blower and blotting paper assuring complete absence of moisture. Treated seeds were kept in cloth bags in three replications, in each replication there were five cloth bags and each cloth bag contains 50 seeds; kept in open air godown for six months. After storage seed lots were tested for pest infection following the concept proposed by Wheeler, 1969.(Table 1)

a) Table 1: Scale taken for calculation of pest attack (seeds affected by pests)

Rating	Observation
0	No incidence
1	Less than 1%
3	1-5%
5	6 – 25 %
7	26-50%
9	51-100%

b) Calculation

$$\% \text{ of pest attack index} = \frac{\text{Sum of individual pest attacked seed rating} \times 100}{\text{Number of seed assessed} \times \text{maximum infection index}}$$

Other than seed storability the vigor and viability of the seed lots observed after germination by checking germination percentage (Total no. of seeds germinated x100/Total no. of seeds plated for germination), seedling root and shoot length, seedling vigor index(seedling root length + seedling shoot length) X germination, Abdul Baki and Anderson, 1973), seedling fresh and dry weight.

## Results and Discussions

After setting up the experiment the observed data computed, calculated and statistically analyzed. The results are as follows.

Effect of Kalmegh extract on Paddy seeds (Table 2) shown positive effects in consecutive years. The treatment conditions reduced % of disease or pest infection but the effect gradually disappeared as the treatment solution was diluted. % of germination improved in treatment III and IV but decreased in treatment V. All other germination related parameters were also positively affected by treatments; especially seedling vigor index was increased very high.

Table 2. Effect of Kalmegh extract on store grain pest, germination &amp; seedling vigor of Paddy seeds ( in two years)

TREATMENT	PARAMETER																				
	% of affection			% of germination			Seedling root length (cm.)			Seedling shoot length(cm.)			Seedling vigour			Seedling fresh weight (gm.)			Seedling dry weight (gm.)		
	I	II	Mean	I	II	Mean	I	II	Mean	I	II	Mean	I	II	Mean	I	II	Mean	I	II	Mean
<b>I. Control I</b>	60.4	58.3	59.35	76	69	72.5	8.8	8.5	8.65	9.6	8.9	9.25	1398.4	1200.6	1299.5	0.032	0.031	0.031	0.008	0.007	0.0075
<b>II. Control II</b>	60	59	59.5	74	68.5	71.25	8.5	8.5	8.5	9.3	9	9.15	1317.2	1198.7	1257.9	0.03	0.03	0.03	0.008	0.007	0.0075
<b>III. Crude extract</b>	38.2	35.5	36.85	100	100	100	11	11.4	11.2	9.4	9.0	9.2	2040	2040	2040	0.035	0.033	0.034	0.010	0.008	0.009
<b>IV. 2X level of dilution</b>	48	51.1	49.5	90	95	92.5	8.4	8.9	8.65	10.2	9.9	10.05	1674	1786	1730	0.034	0.04	0.037	0.009	0.01	0.0095
<b>V. 3X level of dilution</b>	59.5	56.4	57.95	71	70	70.5	9.2	10.1	9.65	9.4	9.6	9.5	1320.6	1379	1349.8	0.032	0.033	0.0325	0.008	0.007	0.0075
<b>CD</b>	1.68	1.66		2.75	0.72		0.80	0.57		0.51	0.71		1.95	6.95		0.001	0.001		0.0009	0.0008	

Effect of Kalmegh extract on Lentil seeds (Table 3) shown positive effects in successive years. The treatment conditions reduced % of disease or pest infection but the effect gradually disappeared as the treatment solution was diluted. % of germination improved best in treatment IV and then treatment V and III. All other germination related parameters were also positively affected by treatments, specially seedling vigor index was increased very high. Treatment type III was best in all aspects.

Table 3. Effect of Kalmegh extract on store grain pest, germination &amp; seedling vigor of Lentil seeds ( in two years)

TREATMENT	PARAMETER																				
	% of affection			% of germination			Seedling root length(cm.)			Seedling shoot length(cm.)			Seedling vigour			Seedling fresh weight (gm.)			Seedling dry weight (gm.)		
	I	II	Mean	I	II	Mean	I	II	Mean	I	II	Mean	I	II	Mean	I	II	Mean	I	II	Mean
I. Control I	57.7	56	56.85	50	55	52.5	8.86	8.66	8.76	8.4	8.2	8.3	863	927.3	895.15	0.07	0.08	0.075	0.0015	0.0013	0.0014

<b>II. Control II</b>	56.9	56	56.45	50	55	50	8.8	8.5	8.65	8.3	8.2	8.25	8.55	918.5	886.75	0.07	0.09	0.08	0.0015	0.0014	0.00145
<b>III. Crude extract</b>	18.4	21.2	19.8	60	62	61	9.09	8.9	8.995	7.9	7.5	7.7	1019	10168	10179	0.123	0.99	0.556	0.0017	0.0018	0.00175
<b>IV. 2X level of dilution</b>	26.2	25.5	25.85	80	80	80	11.6	10.75	11.175	9.2	9.6	9.4	1664	1628	1646	0.13	0.14	0.135	0.0026	0.0028	0.0027
<b>V. 3X level of dilution</b>	56.4	52.3	54.35	80	60	70	11.9	12.1	12	8.8	8.4	8.6	1656	1230	1443	0.135	0.138	0.1365	0.0030	0.0030	0.0030
<b>CD</b>	1.08	1.08		3.67	1.55		0.19	0.294		0.33	0.28	0.534	6.83	6.173		0.006	0.006		0.0004	0.0001	

Effect of Kalmegh extract on Moong seeds (Table 4) shown positive effects in successive two years. The treatment conditions reduced % of disease or pest infection but the effect gradually disappeared as the treatment solution was diluted like previous crops. % of germination improved in all treatments upto 100%. All other germination related parameters were also positively affected by treatments; especially seedling vigor index was increased very high. Treatment type V was best in all aspects.

Table 4. Effect of Kalmegh extract on store grain pest, germination & seedling vigor of Moong seeds ( in two years)

TREATMENT	PARAMETER																				
	% of affection			% of germination			Seedling root length (cm.)			Seedling shoot length (cm.)			Seedling vigour index			Seedling fresh weight (gm.)			Seedling dry weight (gm.)		
	I	II	Mean	I	II	Mean	I	II	Mean	I	II	Mean	I	II	Mean	I	II	Mean	I	II	Mean
<b>I. Control I</b>	54.6	56.1	55.35	70	68	69	9.8	9.5	9.65	10.2	9.9	10.0	1405	1319.2	1359.6	0.43	0.34	0.385	0.03	0.019	0.0245
<b>II. Control II</b>	54.5	56.2	55.35	70	69	69.5	9.9	9.5	9.7	10.1	10	10.0	1405	1345.5	1372.7	0.43	0.33	0.385	0.03	0.019	0.0245
<b>III. Crude extract</b>	40	41.3	40.65	100	100	100	10.8	10.1	10.45	11.2	10.9	11.0	2200	2100	2150	0.44	0.41	0.425	0.04	0.035	0.0375
<b>IV. 2X level of dilution</b>	43.1	45.5	44.3	100	100	100	9.4	9.0	9.2	12.1	11.78	11.94	2150	2078	2114	0.39	0.35	0.37	0.041	0.04	0.0405
<b>V. 3X level of dilution</b>	58	54.3	56.15	100	100	100	11.6	11.4	11.5	11.16	11.0	11.08	2232	2240	2236	0.40	0.43	0.415	0.029	0.03	0.0295
<b>CD</b>	1.81	0.82		1.43	0.23		0.217	0.51		0.28	0.526		24.23	16.6		0.23	0.02		0.0033	0.0038	

Effect of Kalmegh extract on Gram seeds (Table 5) shown positive effects in successive two years study. The treatment conditions reduced % of disease or pest infection but the effect gradually disappeared as the treatment solution was diluted. % of germination improved best in treatment IV and then treatment V but treatment III reduced the % of germination. All other germination related parameters were also positively affected by treatments, specially seedling vigor index, seedling root and shoot length were increased very high. Treatment type IV and V were best in all aspects.

Table 5. Effect of Kalmegh extract on store grain pest, germination & seedling vigor of Gram seeds ( in two years)

TREATME NT	PARAMETER																				
	% of affection			% of germination			Seedling root length (cm.)			Seedling shoot length(cm.)			Seedling vigour index			Seedling fresh weight (gm.)			Seedling dry weight (gm.)		
	I	II	Mean	I	II	Mean	I	II	Mean	I	II	Mean	I	II	Mean	I	II	Mean	I	II	Mean
I.Control I	65.7	60.1	62.9	74	72	73	6.33	6.55	6.44	14	15	14.5	1504.42	1551.6	1528.1	0.353	0.34	0.347	0.12	0.1	0.11
II.Control II	65.5	60.5	62.9	75	71	73	6.3	6.45	6.35	14	16	15	1522.5	1593.9	1558.2	0.353	0.34	0.347	0.15	0.1	0.125
III.Crude extract	30.6	30.1	30.35	69	70	69.5	14.6	14.1	14.35	10.2	10	10.1	1711.2	1687	1699.1	0.701	0.8	0.75	0.3	0.36	0.33
IV.2X level of dilution	33.5	30.31	31.905	85	84	84.5	16.1	15.3	15.7	12.9	11.4	12.15	2465	2242.8	2353.9	0.825	0.7	0.78	0.25	0.28	0.265
V.3X level of dilution	62.88	60	61.44	80	80	80	17.2	15.9	16.55	13.2	15.4	14.3	2432	2504	2468	0.883	0.8	0.85	0.34	0.35	0.345
CD	1.44	2.66		3.06	1.58		0.182	0.161		0.977	0.577		5.174	11.60		0.027	0.06		0.028	0.019	

Irrespective of crop effect of kalmegh extract treatment (Table 6) it was very clear Crude extract or treatment III was most effective against % of pest or disease affection than other diluted treatments suggesting effect of ethanolic extract treatment of Kalmegh leaf extract in this aspect gradually became weaker as the solution diluted. On the other hand, dilutions improved germination and related parameters than crude extract, like treatment IV proved best for seed germination but in case of other parameters it was evident that efficacy of treatments increased over control as the treatment was more and more diluted. Treatment II i.e. the second control or only 65% alcohol did not show any significant variation in performance over control or the 'no treatment seeds'.

Table 6. Effect of Kalmegh extract on store grain pest and seedling vigor based on Paddy, Lentil, Mung, and

Gram seeds ( in two years)

TREATMENT	PARAMETER																			
	% of affection					% of germination					Seedling root length (cm.)					Seedling shoot length(cm.)				
	Paddy	Lentil	Mung	Gram	Mean	Paddy	Lentil	Mung	Gram	Mean	Paddy	Lentil	Mung	Gram	Mean	Paddy	Lentil	Mung	Gram	Mean
<b>I. Control I</b>	59.35	56.85	55.35	62.9	58.61	72.5	52.5	69	73	66.75	8.65	8.76	9.65	6.44	8.3	9.25	8.3	10.05	14.5	10.525
<b>II. Control II</b>	59.5	56.45	55.35	62.9	56.3	71.25	50	69	73	65.81	8.5	8.65	9.7	6.35	8.3	9.15	8.25	10.05	15	10.612
<b>III. Crude extract</b>	36.85	19.8	40.65	30.35	31.912	100	61	100	69.5	82.62	11.2	8.995	10.45	14.35	11.248	9.2	7.7	11.05	10.1	9.512
<b>IV. 2X level of dilution</b>	49.55	25.85	44.3	31.905	37.90	92.5	80	100	84.5	89.25	8.65	11.175	9.2	15.781	11.1	10.05	9.4	11.94	12.15	10.885
<b>V. 3X level of dilution</b>	57.95	54.35	56.15	61.44	61.44	70.5	70	100	80	80.12	9.65	12	11.53	16.55	12.432	9.5	8.6	11.08	14.3	10.87

  

TREATMENT	PARAMETER														
	Seedling vigour index					Seedling fresh weight (gm.)					Seedling dry weight (gm.)				
	Paddy	Lentil	Mung	Gram	Mean	Paddy	Lentil	Mung	Gram	Mean	Paddy	Lentil	Mung	Gram	Mean
<b>I. Control I</b>	1299.5	895.15	1359.6	1528.1	1270.58	0.031	0.075	0.385	0.34	0.207	0.0075	0.0014	0.0245	0.11	0.035
<b>II. Control II</b>	1257.9	886.75	1372.7	1558.2	1268.88	0.03	0.08	0.385	0.34	0.208	0.0075	0.0014	0.0245	0.12	0.0352
<b>III. Crude extract</b>	2040	1017.9	2150	1699.1	1726.75	0.034	0.5565	0.425	0.755	0.44	0.009	0.00175	0.0375	0.33	0.0945
<b>IV. 2X level of dilution</b>	1730	1646	2114	2353.9	1960.975	0.037	0.135	0.37	0.785	0.331	0.0095	0.0027	0.0405	0.265	0.0794
<b>V. 3X level of dilution</b>	1349.8	1443	2236	2468	1874.2	0.0325	0.1365	0.415	0.855	0.359	0.0075	0.003	0.0295	0.345	0.0962

The treatment was made in such process following the homoeopathic system as per the Homoeopathic Pharmacopea of India. Alcoholic extract was preferred over aqueous to avoid soaking injury as the alcohol evaporates fast and to get better extract because the active ingredients come out better in organic solvents. Different dilutions have variable effects suggested by various scientists like Ma *et. al.* (2011). Kalmegh itself is least pest infected crop

even in seed storage condition suggesting potent ability as biopesticide, therefore its extract carrying the same ingredients can protect other crop seeds making a coating over the seeds after treatment. Diluted treatment condition suggests minimized active ingredient content that becomes lesser effective as pest protector, like homoeopathy prefers crude medicine for external use and dilution for intake. The above mentioned research also showed antifungal effect of Kalmegh. As Seed invigoration treatments with crude plant materials have the potential role to improve germinability, seed viability and seed vigour of many economically important crop (Kundagrami *et. al.*, 2008, Patra *et. al.*, 2012, Mandal *et al.* 2011, Sengupta *et. al.*, 2005, Pal and Basu 1993, De *et. al.*, 1998), so it has a good promise to use kalmegh extract against store grain pest in storage as well as to improve germinability, seed vigour and viability.

### Conclusion

In the present experiment the effect of kalmegh extract against store grain pest and maintenance of seed vigor and viability in storage for some economically important crops like paddy, lentil, moong and gram were undertaken. Three concentrations of treatment solution developed following the dilution process described in Homoeopathic Pharmacopeia of India from kalmegh leaves. Freshly harvested seed lots of the above crop seeds treated with the treatments by soaking drying method and kept in cloth bags in three replications along with two control treatments for six months in godown. Such experiment is done during two successive years and from the observation and calculated results it was revealed that crude kalmegh extract was most effective against store grain pest that gradually becomes weaker in dilutions. On the other hand, dilutions improved germination and related parameters in seed lings after storage in respect of control.

### References

- [1] Abdul - Baki A. and Anderson JD (1973). Viability and leaching of sugars from germinating seeds by textile, leather and distillery industries. *Indian Journal of Environment Protection*, Vol 11 pp 592 – 594, 1073
- [2] Arash RK, Philip A and Muniandy S (2010). Antioxidant potential and content of phenolic compounds in ethanolic extracts of selected parts of *Andrographis paniculata*. *J.medicinal Plant Res.*, 4(3): 197-202.
- [3] Ahmed N and Sultana K (1984). Fungitoxic effect of garlic on treatment of jute seed. *Bangladesh Journal of Botany*, 13(2): 130-136.
- [4] Chowdhury R and Mandal AK (2012). Efficacy of Seed Treatments on the Storability of High-Medium-Vigour *Andrographis* seeds (*Andrographis paniculata* L.). *Indian Agriculturist*, 56 (1&2): 27-31.
- [5] De BK, Mandal, A K and Basu, R N (2003). Seed invigoration treatments on different seed sizes of wheat (*Triticumaestivum* L.) for improved storability and field performance. *Seed Science and Technology*, 31: 379-388.
- [6] Deepak S, Pawar A and Shinde P 2014, Study of antioxidant and antimicrobial activities of *Andrographis paniculata*. *Asian Journal of Plant Science and Research*, 4(2):31-41.
- [7] Fauconneau B, Waffo F, Huguet L, Barrier A, Decendit B and Merillon JM (1997). Scavenger and antioxidant properties of astringin and phenolic compounds extracted from *Vitisvinifera* cell cultures. *Life Sci.*, 61:2103-2108.
- [8] IPCC. (2007). Climate change 2007: The physical science basis—Contribution of working group I to the fourth assessment report of the Intergovernmental Panel on Climate Change. [http://www.ipcc.ch/publications\\_and\\_data/ar4/wg1/en/contents.html](http://www.ipcc.ch/publications_and_data/ar4/wg1/en/contents.html).



- [9] Kundagrami S, De BK and Mandal AK ( 2008). Post-harvest seed invigoration treatments for improved storability and field performance of rice (*Oryza sativa* L.). *Crop Research*, 35: 317-322.
- [10] Ma L, Wu H, Bai R, Zhuo L, Yuan X and Hou D (2011). Phytotoxic effects of *Stellera chamaejasme* L. extracts. *African Journal of Agricultural research*, 6(5): 1170-1176.
- [11] Mandal AK, Patra S, Mallick RB and Guha P (2011). Seed invigoration treatment in rice (*Oryza sativa* L.) for improved storability and comparative efficacy of treatment on field performances in System of Rice Intensification and Conventional method. *Indian Agric.*, 55(3&4): 121-128.
- [12] Nakatani, N (1997). Antioxidants from spices and herbs. Natural antioxidants: chemistry, health effects, and applications. AOCS Press Champaign. In F. Shahidi (ed.): 64-75
- [13] Pal P and Basu RN (1993). Effect of powdered red chilli, turmeric and neem leaf on pre- and post-storage germinability of wheat seed, *Indian Agriculturist*. 37: 266-71
- [14] Patra S, Guha P, Biswas PS and Mandal, AK (2012). Mid-storage seed invigoration treatments in rice (cv. Satabdi) for extended storability and comparative study on field performances by employing conventional and system of rice intensification method. *Indian Biologist*, 44 (2): 29-37
- [15] Population Reference Bureau (2011). World Population Growth, 1950–2050. Washington, DC. USA. [popref@prb.org](mailto:popref@prb.org).
- [16] Puri A, Saxena R, Saxena RP, and. Saxena KC (1993). Immunostimulant agents from *Andrographis paniculata*. *J. Natural Products*, 56(7):995-99.
- [17] Sengupta AK , De BK and Mondal, AK (2005). Pre-storage seed invigoration treatments for the maintenance of vigour, viability and field performance of high-vigour onion seed (*Allium cepa* L.). *Seed Sc. Technol.*, 33: 753-760
- [18] Wattenberg LW, Coccia JB and Lam LKT (1980). Inhibitory effects of phenolic compounds on bezo (a) pyrene-induced neoplasia. *Cancer Res.* ,40: 2820-2823
- [19] Yasmeen, A (2011). Exploring the Potential of Moringa (*Moringaoleifera*) Leaf Extract as Natural Plant Growth Enhancer. A thesis submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy In Agronomy, Department Of Agronomy, University Of Agriculture, Faisalabad, Pakistan.