Original Research Article

"Effect of seed hardening on seed germination and morphological parameters in Linseed (*Linumusitatissimum*L.)"

ABSTRACT

Give a brief on seed hardening and the problem you intend to solve?The experiment was carried out for "Effect of seed hardening on seed germination and morphological parameters in Linseed (*Linumusitatissimum*L.)" during rabi season in the year 2022 at Field Experiment Centre, Department of Genetics and Plant Breeding, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology And Sciences, Prayagraj, Uttar Pradesh on linseed crop. The experiment was laid out in Randomized CompleteBlock Design(RCBD) with 13 treatments and 3 replications. T_0-Control, T_1-NAA-25 ppm, T_2-NAA-50 ppm, T_3-NAA-150 ppm, T_4-KCl-25 ppm, T_5-KCl-50 ppm, T_6-KCl-150 ppm, T_7-KNo_3-25 ppm, T_8-KNo_3-50 ppm, T_9-KNo_3-150 ppm, T_{10}-$CaCl_2$-25 ppm, T_{11}-$CaCl_2$-50 ppm, T_{12}-$CaCl_2$-150 ppm were the treatments. Linseed seeds were treated with NAA, KCl, KNo_3 and $CaCl_2$ with different concentrations (25 ppm,50 ppm and150 ppm) for 5 hours and after sowing growth, yield and yield parameters were observed. Main objectives are to determine the effect of seed hardening on seed germination and morphological characters of Linseed and to find out suitable concentration for seed hardening in Linseed. It was noticed that T_9-KNo_3-150 ppm treatment performed better when compared with other treatments, Was it significantly different and at what significant or probability level?where as minimum was observed in control. The highest field emergence(92.20%), plant height(74.34 cm), number of primary branches(3.87), number of secondary branches(23.53),seeds per capsule(8.13), seed yield per plant(3.42) and harvest index(25.38 %) showing better results when treated with treatment (T_9)-KNo_3-150 ppm for 5 hours and followed by Treatment(T_{11}) $CaCl_2$-50 ppm. Very less days(72) required for 50 % flowering and maturity(111.67) was observed in treatment T_9 when compared with other treatments. It concluded that T_9(KNo_3-150 ppm) ~~found~~was superior in all the growth and yield parameters in linseed.What is your recommendation?

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Keywords: Seed hardening, Field emergence, Biological yield, NAA, KCl, KNo_3 and $CaCl_2$

INTRODUCTION

Linseed (*Linumusitatissimum* L.) (2n = 30) is a major Rabi oilseed crop and one of the oldest crops grown. It is an annual, self-pollinating plant species of the Linaceae family known as "Alsi" that is thought to have originated in southwest Asia, specifically in India **(Vavilov, 1935 and Richharia, 1962)**. It is a member of the Linaceae family, which contains 14 genera and over 200 species. Linum derives its name from "lin" or "thread," and Usitatissimum is a Latin word that means "most useful." When used as an oilseed, it is also known as flaxseed or linseed, and when used for fibre, it is known as fibre flax or simply flax (in Europe).

In 2021 world linseed production is 3.34 million tonnes and cultivated area is 41,42,449 ha**(FAO,2021).**In 2022 India Linseed production was 1 lakh tonnes and productivity is 574 kg/ha **(ICAR 2022).**At the end of fiscal year 2023, India is estimated to produce nearly 140 thousand metric tons of linseed **(Statista, 2023).**Major linseed producing states are Madhya Pradesh, Chattisgarh, UP, Maharashtra, Bihar, Odisha, Jharkhand, West-Bengal, Nagaland and Assam.

Nutrients per 100 g of edible flaxseed contains Protein 6.5 g, Fat 20.3 g, Minerals 37.1g, Crude fiber 2.4 g, Total dietary fiber 4.8 g, Carbohydrates 24.5 g, Energy 28.9 kcal, Potassium 530mg, Calcium 750mg, Phosphorous 170mg. (**Soni *et al*., 2016).** As a percentage of total fat, flax seeds contain 54% omega-3 fatty acids (mostly ALA), 18% omega-9 fatty acids (oleic acid) and 6% omega-6 fatty acids (linoleic acid); the seeds contain 9% saturated fat, including 5% as palmitic acid. Flax seed oil contains 53% 18:3 omega-3 fatty acids (mostly ALA) and 13% 18:2 omega-6 fatty acids(**Soni*et al*., 2016).**

Flax seeds are a good source of several vitamins and minerals. They are Thiamine essential for normal metabolism and nerve function, Copper essential mineral and important for growth, development, and various functions**,** Molybdenum essential trace mineral is abundant in seeds, grains, and legumes,Magnesium that has many functions in our body and Phosphorus usually found in protein-rich foodsand contributes to bone health and tissue maintenance Ref.

Hardening of seeds to required chemicals enables the plants to overcome the specific stresses. This process actually hardens the protoplasm (by osmoregulation), which enables the seeds to absorb more water under favourable situations to maintain its viability under unfavourable conditions. Hardening of seeds resulted in the absorption of more water due to increase in the elasticity of cell wall and development of a stronger and efficient root system **(Krishnasamy and Srimathi, 2001)**.

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Naphthalene acetic acid (NAA) is a synthetic plant growth regulator and a type of auxin, which is a class of plant hormones that play a crucial role in regulating various aspects of plant growth and development.Calcium chloride can be used as a seed coating material to improve the seed's resistance to stress conditions, such as drought and salinity. Coating seeds with a calcium chloride solution helps protect the seeds during early growth stages and enables better establishment of the seedlings.Potassium nitrate can stimulate seed germination by breaking seed dormancy. Dormancy is a natural state that prevents seeds from germinating under unfavorable conditions, such as extreme temperatures or moisture levels. By treating seeds with potassium nitrate, farmers can help break this dormancy and promote faster and more uniform germination.Potassium can help plants to withstand to environmental stresses such as drought, salinity, and temperature fluctuations. Treating seeds with potassium chloride may enhance the ability of seedlings to withstand adverse conditions.Ref

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Materials and Methods:

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the experimental material for present investigation comprised of 13 treatments was conducted in Randomized Block Design(RBD)?with 3 Replications.

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Treatment details:

T_1-NAA-25 ppm (5hrs), T_2-NAA-50 ppm(5hrs), T_3-NAA-150 ppm(5hrs), T_4-KCl-25 ppm(5hrs), T_5-KCl-50 ppm(5hrs), T_6-KCl-150 ppm(5hrs), T_7-KNo_3-25 ppm(5hrs), T_8-KNo_3-50 ppm(5hrs), T_9-KNo_3-150 ppm(5hrs), T_{10}-$CaCl_2$-25 ppm(5hrs), T_{11}-$CaCl_2$-50 ppm(5hrs), T_{12}-$CaCl_2$-150 ppm(5hrs) along dry seed with distilled water as control.

Treatment preparation:

25 ppm solution: Measure out 2.5 mg of NAA, KCl, $KNo_3$and $CaCl_2$and add them to 100 ml volumetric flask separately. Then add water and dilute to 100 ml solution. Soak the seeds in these solutions for 5 hours before sowing.

50 ppm solution: Measure out 5 mg of NAA, KCl, $KNo_3$and $CaCl_2$and add them to 100 ml volumetric flask separately. Then add water and dilute to 100 ml solution. Soak the seeds in these solutions for 5 hours before sowing.

150 ppm solution: Measure out 5 mg of NAA, KCl, KNo_3 and $CaCl_2$ and add them to 100 ml volumetric flask separately. Then add water and dilute to 100 ml solution. Soak the seeds in these solutions for 5 hours before sowing.

Seed sowing and germination: Give source of seed, sowing media, number of seeds per treatment per replicate, care of crop or cultural practises, period of experiment and year

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In the present investigation, data of the following pre and post- harvest data was recorded asField emergence(%), Plant height, Number of Primary branches, Number of Secondary branches,Days to 50% flowering, Days to Maturity (Days), Number of seeds per capsule, Seed yield per plant(g) and Harvest index (%).

RESULTS AND DISCUSSION:

Field emergence(%): Seed hardening is one of the pre-sowing seed treatment techniques which shows the significant positive effect on the field emergence in Linseed. Maximum emergence was observed in treatment T_9 with 92.20% and followed by treatment T_{10} and T_{11} with 91.10%. Potassium nitrate can stimulate seed germination by breaking seed dormancy.

Plant height(cm)(90 DAS): Seed hardening is one of the pre-sowing seed treatment techniques which shows the significant positive effect on the plant height in Linseed. maximum plant height was observed in treatment T_9 with height of 74.34 cm and followed by treatment T_{11} with 67.33 cm.

Number of primary branches: Seeds treated with NAA which is a class of plant hormones that play a crucial role in regulating various aspects of plant growth and development. Along with the NAA, remaining treatments are also increased the primary branches in linseed. Treatment T_9 showed the maximum primary branches with 3.87 followed by T_{11} with 3.40 primary branches per plant.Remaining all the treatments showed significant performances over the control.

Number of secondary branches: Treatment T_9 with KNo_3-150 ppm(5hrs) showed significant increase in the secondary branches of linseed with the value of 23.53 and followed by treatment T_{11} with value of 21.87 in this experiment.Potassium nitrate and Calcium chloride can be used as a seed coating material to improve the seed's resistance to stress conditions and improves the seedling establishment and increase the branching number.

Days to 50 % flowering: Treatment with KNo_3-150 ppm(5hrs) takes minimum days(72) for flowering after sowing followed by treatment T_{10} and T_{11} takes 74 days for flowering after sowing. Maximum days for flowering was taken by control. Seed hardening treatments mainly NAA and $CaCl_2$ play a crucial role in regulating various aspects of plant growth, development and flowering.so seed hardening reduced the days for flowering and useful for early development of crop.

Days to maturity: Seed hardening treatments like KNo_3, KCl and NAA causes early flowering which results early maturity of crop that can reduce the crop duration. Treatment T_9 required minimum days for maturity(111.67) followed by T_7 with 112.67 days for maturity but control takes 123.33 days for maturity.

Number of seeds per capsule: Seeds treated with NAA regulating various aspects of plant growth and development. Along with the NAA, remaining treatments are also increased seed per capsule in linseed. Treatment T_9 showed the maximum seeds per capsule with 8.13 followed by T_{11} with 7.67 seeds per capsule. Remaining all the treatments showed significant performances over the control.

Seed yield per plant (g):Seed hardening is one of the pre-sowing seed treatment techniques which shows the significant positive effect on the seed yield in Linseed. maximum yield was observed in treatment T_9 with 3.42 g and followed by treatment T_{11} with 3.07 grams per plant. all the seed hardening treatments increase the seed yield over the control.

Harvest Index (%): Treatment T_9 with KNo_3-150 ppm(5hrs) showed significant increase in the economic yield as well as biological yield of linseed. Treatment T_9 showed the maximum harvest index with the value of 25.38% and followed by treatment T_{12} with value of 24.38% in this experiment. Potassium nitrate and Calcium chloride can be used as a seed coating material to improve the seed's resistance to stress conditions and improves the seedling establishment.as a result seed hardening increased all the parameters significantly when compared with the nontreated seeds.

Table 1. Mean performances of different seed hardening treatments on growth and yield parameters in Linseed (*Linumusitatissimum*L)

Treatment	Field emergence(%)	Plant height (90DAS) (cm)	Number of primary branches	Number of secondary branches	Days to 50% flowering	Days to maturity	Number of seeds per capsule	Seed yield per plant (g)	Harvest Index (%)
T0	83.30	58.47	2.53	15.27	81.67	123.33	6.00	2.61	21.57
T1	84.40	63.39	3.07	18.53	81.00	117.00	6.73	2.95	23.83
T2	89.96	65.27	3.33	19.20	77.67	117.00	6.20	2.96	22.92
T3	86.60	63.53	2.93	18.93	80.00	115.33	6.53	2.95	23.64
T4	84.40	62.67	3.13	17.93	77.00	118.33	6.40	2.99	24.33
T5	85.53	60.73	3.13	16.93	77.00	115.00	6.80	2.79	22.04
T6	**84.40**	60.05	2.67	15.40	81.33	121.67	6.13	2.63	21.59
T7	87.73	63.51	3.00	16.40	77.33	112.67	6.40	2.82	22.53
T8	91.06	61.19	3.20	16.93	79.00	115.67	6.33	2.82	23.26
T9	**92.20**	74.34	3.87	23.53	72.00	111.67	8.13	3.42	25.38
T10	91.10	60.53	3.13	16.33	74.00	116.67	6.20	2.68	21.76
T11	91.10	67.33	3.40	21.87	74.00	113.00	7.67	3.07	23.60
T12	88.86	65.06	3.13	20.80	79.00	118.00	6.73	3.06	24.38
Grand Mean	87.74	63.54	3.12	18.31	77.77	116.56	6.63	2.90	23.16
S.E(m)	1.96	1.64	0.14	1.01	1.86	1.77	0.25	0.08	0.79
C.V	3.88	4.80	7.79	9.53	4.14	2.63	6.60	4.85	5.97
C.D*	5.73	4.48	0.41	2.94	5.43	5.17	0.74	0.24	2.32

*indicates significant at 5 % level of significance??? Where is it?.

There are no p values shown inside the table

Separate germination and morphological parameters in different tables

CONCLUSION

It is concluded that from the present investigation of seed hardening, treatments with KNo_3, NAA, KCl and $CaCl_2$ showed significant increase in the growth and yield parameters of Linseed. The treatment KNo_3-150 ppm(T_9) found superior in field emergence, plant height, number of primary branches, number of secondary branches, seeds per capsule, seed yield and harvest index followed by treatment(T_{11}) in all parameters. By reducing the seed dormancy with NAA treatments field emergence rate increased. Through $CaCl_2$ seed treatment, establishing strong seedling that can increased the seed yield under stress condition. KNo_3 treatment increas~~ing~~ged the crop growth and branches number hence~~that~~ increas~~ed~~ing the seed yield. Thus seed hardening treatment in linseed increases the growth and yield parameters significantly compared with the~~than~~ control. What is your recommendation?

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