academicresearchJournals

Vol. 8(6), pp. 619-629, August 2020
DOI: 10.14662/ARJASR2020.032

ISSN: 2360-7874
http://www.academicresearchjournals.org/ARJASR/Index.htm

Academic Research Journal of Agricultural Science and Research

Full Length Research

Effect of Priming on Seed Germination of Korerima [*Aframomum corrorima* (Braun) P.C.M. Jansen] Genotypes

Hassen Seid[1], Wassu Mohammed [2], Abebe Atilaw[3]

[1]Tepi National Spices Research Center, P.O.Box 34, Tepi, Ethiopia
[2] Department of Plant Science, College of Agriculture and Environmental Science, Haramaya University, Haramaya
[3] Ethiopian Institute of Agricultural Research, Addis Ababa, Ethiopia
Corresponding author's E-mail:- hassenseid49@yahoo.com
E-mail: wassmoha@yahoo.com
E-mail: abeatilaw@gmail.com

Accepted 15 June 2020

This study was conducted to evaluate the effect of seed priming on seed germination of korerima genotypes. Two genotypes were used to assess the effect of priming on seed quality potential in CRD with three replications in factorial arrangement of six priming materials (distilled, tap water, cow urine, gibberellins acid, potassium di-hydrogen phosphate, potassium nitrate) and three priming durations at Tepi National Spices Research Centre in 2016-2017. Analysis of variance results revealed that the presence of significant differences among genotypes for all characters. Unprimed seed of genotypes seed germination percentage and speed of germination ranged from 48.33% to 73.33% and 2.83 to 4.45, respectively. Priming had improved the seed germination potential significantly of the two korerima genotypes (093/00 and 059/03) with varied magnitude in which seed germination and speed of germination of primed seeds improved by about 11.62 to 41.99% and 1.16 to 3.57, respectively. The percentage of normal seedlings increased by about 5.61 to 18.24%, while fresh ungerminated and dead seeds significantly reduced by about 14.33 to 15.87 and 1.75% to 4.59%, respectively, as compared to unprimed seeds. Generally, primed seeds with gibberellins acid and cow urine were significantly improved the seed quality of korerima than other priming materials.

Keywords: korerima, gibberellins, cow urine, priming, seed germination and speed of germination.

Cite this article as: Hassen S., Wassu M., Abebe A (2020). Effect of Priming on Seed Germination of Korerima [*Aframomum corrorima* (Braun) P.C.M. Jansen] Genotypes. Acad. Res. J. Agri. Sci. Res. 8(6): 619-629

INTRODUCTION

Korarima [*Aframomum corrorima* (Braun) P.C.M. Jansen] is herbaceous, perennial and aromatic species classified in the monocotyledonous family Zingiberaceae and belongs to the genus Aframomum. The chromosomes of korarima were observed to be small in size and their diploid number was found to be 2n= 2x=48 (Surawit and Wondyifraw, 2013). The plant consists of an underground rhizome, a pseudo stem, and several broad leaves and morphologically it resembles Elettaria species. Mature korarima plant can reach a height of 1-2 m. It sets seed after 3-5 years of planting depending on the planting materials used and it continue to bear seeds for a number of decades (Eyob, 2009).

Korerima is propagated both by seeds and rhizome Girma *et al.,* 2008). It grows in lower strata of natural forests and it needs 55 to 63% shade level for its proper development. It grows in areas located in altitudes ranging from 1000 to 2300 m.a.s.l. and receiving 1500 mm or more rainfall per year Girma *et al.,* 2008).

The formal survey carried out in southern Ethiopia indicated farmers are not encouraged to cultivate korerima due to seed germination takes prolonged time to emerge (one to two months), poor establishment of plants in the field due to large proportion of ungerminated seeds and lack of improved varieties with improved agronomic practices (Eyob *et al*., 2009).

The germination of korerima is not fast and/or many seeds do not germinate due to the presence of some kind of dormancy, possibly associated with its hard seed coat like the seeds of Elettarias species. The presence of low food reserve in the seed endosperm might be a reason for the very slow growth of korarima seedlings.

Research is essential on way of shortening prolonged period of seed germination and increase the proportion of germinated seeds of korerima to improve the productivity the crop. Seed priming is a procedure that partially hydrates seed, followed by drying of seed, so that germination processes begin, but radicle emergence does not occur. It includes soaking seed in water or osmotic solution, and inter-mixture with porous matrix material (Amarnath *et al.* 2015). The application of some seed treatments to make the hard seed coat of korerima permeable to water and/or gases was reported (Amarnath *et al.* 2015). Improvement of seed quality by seed priming may be a simple and easy approach to enhance seed performance and agricultural productivity. For most crops, the mean yield increases due to priming range from zero to more than 200% with an overall average increase of 30% (Harris, 2009). Though, priming of seeds in most of crops has an advantage, but little work (one experiment) has been done on korerima seeds (Eyob, 2009). However, this study did not include all possible seed priming materials that could be easy accessible to farmers. Therefore, this research was initiated with the objective of to assess the effect of priming on seed germination of korerima.

MATERIALS AND METHODS

Description of the Study Area

The experiment was conducted at Tepi National Spice Research center during 2013-2015 at nursery condition. It is located in Southwest of Ethiopia, SNNP Regional State at an elevation of 1200 m.a.s.l and it situated at Latitude of 7^0 10' 54.5'' N and with a Longitude of 35^0 25' 04.3-28.2'' E of Ethiopia. The research station receives average rainfall of 1559 mm annually with maximum and minimum temperatures of 29.7^0cand 15.5^0c, respectively.

Experimental Materials, Treatments and Design

Experimental treatments and design

Fully ripened red capsules of korerima seeds were harvested, extracted from the capsules and immediately washed with tap water to remove mucilage. Then, uniform and healthy seeds were selected and prepared for different seed treatments. One hundred (g) seeds of each genotype for each replication was subjected for six priming treatments viz., Distilled water; KNO_3 (0.2%); KH_2PO_4 (0.5%); GA_3 200 ppm; Cow urine 10%; Tap water and three priming durations (3 hrs., 6 hrs. and 9 hrs.). The experiment was conducted as 2 (genotypes) x 6 (priming materials) x 3 (priming durations) factorial using completely randomized design (CRD) with three replications and a total of 36 treatments. After the completion of the required seed treatments, for each treatment 100 seeds were sown in sand soil using germinating box and kept at room temperature in seed technology laboratory.

Treatments:

1. Distilled water
2. KNO_3 (0.2%);
3. KH_2PO_4 (0.5%)
4. Gibberellins acid (GA_3) 200 ppm;
5. Cow urine (10%)
6. Tap water

Preparation of priming solution

1. Soaking dried seed in distilled water: (50 g of korerima seeds was taken and soaked in 200 ml of tap water
2. GA_3 (200 ppm): It was prepared by dissolving 500 mg of GA_3 in distilled water and volume was made up to 1000 ml
3. KNO_3 (0.2%): It was prepared by dissolving 2 g of KNO_3 in distilled water and volume was made up to 1000 ml
4. KH_2PO_4 (0.5%): It was prepared by dissolving 5 gm of KH_2PO_4 in distilled water and volume was made up to 1000 ml
5. Cow urine (10%): It was prepared by dissolving 25 ml of cow urine in distilled water and volume was made up to 225 ml
6. Soaking dried seed in tap water: (50 g of korerima seeds was taken and soaked in 200 ml of tap water.

Standard germination (%):-

Standard germination test was done for collected korerima genotypes seed using completely randomized design (CRD) under laboratory condition. As the germination standard is not available for this crop, hence the seed were tested in the laboratory as per procedure of *Coriandrum sativum* because korerima have similar seed size with *Coriandrum sativum*. Based on *Coriandrum sativum* seed testing standard, four hundred seeds of korerima were tested into four replications. The first and final counts were taken on 14^{th} and 28^{st} days after seeds sown. The result of the standard Germination test was setup with four replications (100 seeds on in each replication on plastic bag) as per ISTA working guide.

$$Germination\ percentage = \frac{Number\ of\ Normal\ Seedlings}{Total\ Number\ of\ Seeds\ Swon} * 100$$

Speed of germination:

Speed of germination test was determined with a similar procedure to the standard germination test but the number of germinated seeds were counted and removed every day until there was no further germination (ISTA, 2016) working guide.

$$\frac{n1}{1} + \frac{n2}{2} + \cdots + nx/x = N$$

Where: $n1 \ldots nx$ are the number of seed germinated on day 1 to day $x1$…… x is the number of days.

Seedling Vigor Test:-

Seed vigor index I and II were determined as per (ISTA, 2016) by taking 10 randomly selected normal seedlings at the final counting date from each treatment in the standard germination test. The seedling length of the samples (shoot and root length) were measured using a standard ruler. Dry weight (after oven dried $80^{o}C$ for 24 and cooled down for 30 minutes on silica gel) was weighted on a sensitive balance. Vigor Index I and II were then determined by the following formulae (ISTA, 2016). Seed vigor index I = GP x SL and Vigor index II = GP x SDW (g). Where: GP germination percentage, Sl- seedling length, SWD- seedling dry weight

Data analysis

The collected data were processed and analyzed using SAS computer software Version 9.2 (SAS, 2009). The analysis of variance (ANOVA) was employed for each parameters in order to identify the difference among the factors of storage method and period. The significant differences among the treatments were compared using Fisher's Least Significance Difference (LSD) at < 5 % probability level.

RESULTS AND DISCUSSION

Effect of priming on seed quality of korerima

Analysis of variance

Standard germination (%), speed of germination, seedling length (cm), seedling dry weight (g), seedling vigor index I, seedling vigor index II, normal seedling, abnormal seedling, fresh ungerminated and dead seed were considered to assess the effect of priming on seed quality of two korerima genotypes.

The priming of seeds had significant effect on all the seed quality characters, and also, duration of priming had significant effect on all the seed germination quality characters except seedling length, seedling dry weight, seedling vigor index I and seedling vigor index II. However, the effect of genotypes was significant only on seedling length and seedling vigor index I. The interaction effects of genotype * priming material had significant effects on all the seed germination quality characters except seedling vigor index I and seedling vigor index II. Interaction effects of priming material * duration of priming had significant effects on all the seed germination quality characters except seedling length and seedling dry weight which was insignificant. However, the genotype x duration of priming interaction had significant effect on seedling vigor index I and seedling vigor index only. The three way interaction (genotype * priming * duration of priming) had significant effect on standard germination percentage, speed of germination, seedling vigor index I and seedling vigor index II (Appendix Table 1).

The results of the present study indicated that seed priming had significant and positive effect on different aspects of vigor indices improvements, such as seed germination, growth and biochemical parameters. Seed priming significantly enhanced seed germination quality of korerima irrespective of genotypes. The response of crop for different seed treatments were interpreted in terms of germination percentage, seedling dry weight, speed of germination, seed vigor, seedling length, root length, shoot length test. The results of the present study is in agreement with Amarnath *et al*. (2015) stated that seed priming increase the percentage, germination rate, and decreased abnormal seedlings in sunflower plants. Mahmoodi *et al.* (2012) pointed out gibberellins acid had the effect of improving germination that are in agreement with the results of this study.

Interaction effect of genotype * priming * duration of priming

The genotype, 59/03 interacted with GA_3 of priming for six hours duration and the same genotype interacted with priming of CU (cow urine) for three hours exhibited significantly highest seed germination percentage of 91.66 and 86.67%, respectively. However, this genotype interacted with cow urine for nine hours duration gave significantly highest speed of germination (6.48). In contrast, 093/00 interacted with KH_2PO_4 for nine hours duration had significantly lowest seed germination percentage (56.6%) and speed of germination (3.64), respectively, (Table 2).

The results of the present study indicated that seed priming improved seed physiological quality significantly, meanwhile, korerima seed primed with GA_3 and cow urine showed better seed germination percentage than other seed treatments on two korerima genotypes. In addition, seed priming with cow urine showed the highest speed of germination than other priming materials and the unprimed ones.

Amarnath *et al*. (2015) reported that significantly maximum increase in total germination percentage and speed of germination occurs by treating seeds with coconut water followed by cow urine, while lowest germination was observed with unprimed control treatment.

Genotype, 93/00 interacted with cow urine of priming for three hours duration revealed significantly highest seedling vigor index I of 579.3, but the same genotype interacted with priming of KH_2PO_4 for nine hours duration had significantly lowest seedling vigor index I of 324.03 (Table 2).

The results of the present study indicated that seed priming improved seedling vigor I significantly, meanwhile, korerima seed primed with cow urine and GA_3 showed better seedling vigor I than other seed treatments of the two korerima genotypes. The current finding is in close agreement with Amarnath *et al.* (2015) also confirmed that, maximum increase in seedling length, seedling fresh and dry weight, and vigor index I and II occurs by Coconut water (40.28 cm) followed by Cow Urine (39.53 cm) while lowest seedling length (28.16 cm) was observed with unprimed control treatment in sorghum. Ansari *et al.* (2013) reported that all the priming treatments showed improved vigor index I as compared to non-primed seeds which was due to increased shoot and root length of seedlings from primed seeds and so much more vigorous than from un primed seeds, which support this finding positively.

The highest vigor index II (79.57) was obtained from

genotypes 059/03 primed with cow urine for three hours, while the lowest vigor index II (66.36) was recorded from genotype 093/00 seeds primed with KH_2PO_4 for nine hours. Seeds of 059/03 primed with GA_3 also resulted the second highest vigor index II (78.95) value next to cow urine (Table 2).

The present result indicated that seed priming significantly improved vigor index II of korerima seeds as compared with unprimed ones (Table 15). The present study is in agreement with the results of Ansari *et al.* (2013) reported that highest seedling vigor index II, were attained from treated seeds with 25 ppm of GA_3.

Interaction effect of genotype * priming on seed quality

The genotype 93/00 interacted with cow urine revealed significantly highest seedling length of 6.67 (cm), in contrast genotype 59/03 interacted with distilled water had significantly lowest seedling length of 5.57 (cm). In addition, priming of 059/03 seeds interacted with cow urine increased significantly seedling dry weight 0.33 (g), while seeds of korerima treated with KH_2PO_4 of the same genotype gave lowest seedling dry weight of 0.28 (g). The priming of 059/03 seeds with GA_3 gave significantly highest normal seedling but significantly lowest normal seedling obtained from priming of 093/00 seeds with KH_2PO_4 (Table 3).

The present study indicated that, seed priming improved seed germination as compared to unprimed seeds in both genotypes. Normal seedlings were highly increased in korerima genotypes in all seed treatments in which seeds primed with GA_3 followed by cow urine gave the maximum number of normal seedlings. In korerima genotypes, untreated seeds had lower proportion of normal seedlings which revealed seeds were less vigorous to be used for planting (Table 16). The current finding is in close agreement with Amarnath *et al.* (2015) reported that maximum increase in seedling length occurs by Coconut water followed by Cow Urine while lowest seedling was observed with unprimed control treatment on sorghum. Mahmoudi *et al.* (2012) also investigated the effect of hormone primed on germination and seedling growth of lettuce in which significant differences were evident among seed samples treated with different concentrations of GA_3. The seeds of mountain rye primed with 25 ppm of GA_3 had highest normal seedling percentage (NSP) and seedling vigor index (Ansari *et al.,* 2013).

The priming of 059/03 seeds interacted with cow urine significantly lower the number of abnormal seedling while the priming of the same genotype seeds with KH_2PO_4 gave significantly highest number of abnormal seedlings (Table 3).

The current study showed that, seed priming potentially decreased the number of abnormal seedling occurrence but its effect depends on the interaction of genotypes and the priming material types used. It was observed a general trend that the amounts of abnormal seedlings were reduced in seeds primed with cow urine and GA_3 as compared to other seed treatments. This result is in agreement with Amarnath *et al* (2015) in sorghum observed that seed priming with GA_3 and cow urine minimized the occurrence of abnormal seedling.

Fresh ungerminated seeds were highly reduced when seeds of 093/00 and 059/03 korerima genotypes were primed with cow urine and GA_3, respectively, whereas, maximum number of fresh ungerminated seeds was observed in primed seeds of 093/00 with KH_2PO_4, (Table 16). The lowest numbers of dead seeds were obtained from the primed seeds of 059/03 with GA_3 and cow urine but the same genotype seeds primed with KH_2PO_4 had significantly highest number of dead seed (Table 3).

From this finding it is possible to conclude that seed priming was significantly reduced the occurrence of number of fresh ungerminated and dead seeds in which the magnitude of priming effect depends on the interaction of genotypes and the priming material types. Satish and Basave(2005) suggested seed priming minimized the proportion of fresh ungerminated and dead seeds during seed germination by shorting the dormancy period of the eggplant seeds. Amarnath *et al.* (2015) observed the low occurrence of fresh ungerminated and dead seeds in seeds of sorghum treated with GA_3.

Generally, seed priming significantly improved the seed quality of the two korerima genotypes (093/00 and 059/03) with varied magnitude of improvement in which the germination and speed of germination of seeds improved by about 11.62% to 41.99% and 1.16 to 3.57, respectively. The normal seedlings increased by about 5.61% to 18.24%, while fresh ungerminated and dead seeds significantly reduced by about 14.33 to 15.87%% and 1.75% to 4.59%, respectively, as compared to unprimed ones (Table 3).

Interaction effect of priming materials * duration of priming on seed quality

Interaction effects of priming materials with duration of priming had significantly increased normal seedlings proportions and reduced the amount of abnormal seedlings proportions. The maximum number of normal seedlings were recorded from seeds primed with both GA_3 (73%) and cow urine (72.5%) for six and three hours

priming durations, respectively. In contrast, the minimum number of normal seedlings were registered from seeds primed with both KH_2PO_4 (43%) and tap water (45%) for nine and three hours priming, respectively. The minimum number of abnormal seedlings were registered from seeds primed with GA_3 (17%) and cow urine (17%) for six and three hours durations, respectively. In contrary, the maximum number of abnormal seedlings (35.5%) was observed when korerima seeds primed with tap water for nine hours duration (Table 4).

The present finding is in accordance with Amarnath et *al*. (2015) in sorghum, Bahari, *et al.* (2012) and Ansari et *al.* (2013) in mountain rye reported normal seedling percentage (NSP) and seedling vigor index (SVI) were increased in seeds treated with cow urine and 25 ppm of GA_3. The latter authors also reported the amounts of abnormal seedlings were reduced from treatment cow urine and 25 ppm of GA_3.

The minimum numbers of fresh ungerminated and dead seeds were registered from seeds primed with GA_3 for six hours. In contrast, the maximum number of fresh un-germinated and dead seeds were observed when korerima seeds primed with KH_2PO_4 (23) for nine hours duration. Generally, priming with GA_3 and cow urine had reduced the amount of fresh ungerminated and dead seeds as compared to other seed priming treatments. Umair *et al.* (2010) and Kausar, M. *et al*. (2009), Liopa, A. *et al*. (2011), Nasri, N. *et al*. (2012), Umair, M., *et al.* (2010), observed that osmo-priming like KH_2PO_4 has reduced germination percentage while it increased the amount of fresh and dead seed in mung bean. Amarnath *et al*. (2015) similar result reported in sorghum (sorghum.

CONCLUSIONS

As result of this study, it could be concluded that seed priming significantly improved the seed quality of the two korerima genotypes (093/00 and 059/03) with varied magnitude of improvement in which the germination and speed of germination of seeds improved by about 11.62% to 41.99% and 1.16 to 3.57, respectively. The normal seedlings increased by about 5.61% to 18.24%, while fresh ungerminated and dead seeds significantly reduced by about 14.33 to 15.87%% and 1.75% to 4.59%, respectively, as compared to unprimed ones. Priming seeds with GA_3 and cow urine were improved the seed quality of korerima more than priming seeds with distilled water; KNO_3 (0.2%); $KH2PO_4$ (0.5%), tap water and also further research is needed in order to obtain more conclusive results.

REFERENCES

Amarnath, B. H., Chaurasia A. K., Arvind, K., Niranjana, C., Vivekanad, V. and Ashish, K. 2015. Effect of priming with botanicals and animal waste on germination and seedling vigour in sorghum (*Sorghum bicolor* L.) seeds. *Advances in Applied Science Research,* 6(10):73.

Ansari, O., Azadi, M.S., Sharif-Z., F., Younesi, E. 2013. Effect of hormone priming on germination characteristics and enzyme activity of mountain rye (*Secale montanum*) Seeds under drought stress conditions. *Journal of stress physiology & biochemistry*, vol. 9 no. 3 2013, pp. 61-71 ISSN1997-0838.

Armin, M. Asgharipour M. and M. Razavi-Omrani. 2010. Effect of seed priming on the Germination and Seedling growth of watermelon (*Citrullus lanatus). Advances in Environmental Biology*. 4(3):501-505.

Bahari, A., Sharif-Zadeh, F., Ardekani, M.2012. Effect of priming treatments on germination characteristics and seedling establishment *Bromuvs tumentlus* germination under drought and cold. Finishing a master 260 pages.

Eyob Seyifu, 2009. Promotion of seed germination, subsequent seedling growth and in vitro propagation of korerima *(Aframomum corrorima* (Braun) P.C. M. Jansen). *Journal of Medicinal Plant Resources*, 3: 652-659.

Eyob Seyifu, Tsegaye A. and Appelgren, A. 2009. Analysis of korerima (*Aframomum corrorima* (Braun) P.C.M. Jansen) indigenous production practices and farmbased biodiversity in southern Ethiopia. Genetic Resources Crop Evolution, 56: 573-585.

Girma Hailemichael, Digafie Tilahun, Edossa Etissa, Belay Yemanebirhan and Weyessa Garedew. 2008. Spices research achievements, revised edition, Ethiopian Institut of Agricultural Research, Addis Ababa, Ethiopia.

ISTA. 2016. International Seed Testing Association. International rule for seed testing. Bassersdorf, Switzerland.

Kausar, M., T. Mahmood, S.M.A. Basra and M. Arshad. 2009. Invigoration of low vigor sunflower hybrids by seed priming. *International Journal of Agricultural Biology.* 11: 521–528.

Liopa, A., Zakynthinos, G., Varzakas, T., Nickolaos Xynias. 2011. Effect of NaCl and GA3 on seed germination and seedling growth of eleven medicinal and aromatic crops. *Journal of Medicinal Plants Research* 5(17): 4065-4073.

Mahmoudi, H., Zargouni, H., Tarchoune, I., Baatour, O., Nasri, N., Ben Massoud, R., Zaghdoudi, M., Abidi, W., Huang, J., Hannoufa, A., Lachaâl, M., Ouerghi, Z.

2012. Combined effect of hormonal priming and salt treatments on germination percentage and antioxidant activities in lettuce seedlings. African *Journal of Biotechnology*, 11(45): 10373-10380.

Nasri, N., Mohamoudi, H., Baatour, O., Mrah, S., Kaddor, R. and Lacha, M. 2012. Effect of exogenous gibberellic acid on germination, seedling growth and phosphatase activities in Lettuce under salt stress. *Africa Journal Biotechnology* 11:11967-11971.

SAS Institute Inc. 2009. Statistical Analysis Systems, version 9.2 Cary, North Carolina,

Surawit, W. and Wondyifraw Tefera. 2013. In Vitro Chromosome Doubling in Korerima [*Aframomum corrorima* (Braun) P.C.M. Jansen] Using Colchicine and Oryzalin. Asetsart J. (Nat. Sci.) 47: 684 - 694.

TNSRC (Tepi National Spices Research Centre). 2016. National research strategy for spices plants. Tepi, Ethiopia. Ethiopia.

Umair, M., Ali, S., Bashir, K. and Hussein, S. 2010. Evaluation of different seed priming techniques in mung bean (*Vigna radiata* L.). *Soil and Environment*. 29(2):181-186

APPENDICES

Table 1. Mean squares from analysis of variance for seed quality characters as affected by seed priming of two korerima genotypes evaluated at Tepi

Seed quality character	Genotype (1)	Priming (5)	duration (2)	Genotype*Priming (5)	Genotype*Duration (2)	Priming * duration (10)	Genotype* priming*duration (10)	Error (72)	CV (%)
Standard germination (%)	2.1^{ns}	958**	129**	101***	17.4ns	233**	39.3**	21.75	6.26
Speed of germination	0.04ns	5.4***	1.15**	0.6***	0.18ns	1.18**	0.26**	0.13	7.48
Seedling length (cm)	3.83**	0.99**	0.11ns	0.19*	0.34ns	0.06ns	0.20ns	0.36	9.79
Seedling dry weight (g)	0.001ns	0.004**	0.001ns	0.0003*	0.002ns	0.003ns	0.002ns	0.007	8.97
Seedling vigour index I	19460.8*	62610.9**	4738.2ns	537.1^{ns}	4804.4**	9072.7**	2281.2*	3478.7	12.83
Seedling vigour index II	8.18ns	161**	7.21ns	11.2^{ns}	0.12**	22.1**	6.10*	7.97	12.33
Normal seedling	1.02ns	469.7***	63.4**	4.7***	8.5.ns	114.2**	19.3*	10.66	9.27
Abnormal seedling	0.18ns	86.3***	11.6**	9.1***	1.56ns	20.9**	3.53ns	1.95	12.83
Fresh un-germinating seed	2.67ns	241.4***	33.1**	18.3***	2.39ns	51.58**	11.24ns	7.15	15.36
Dead seed	1.61ns	31.2**	3.65*	4.3***	1.15^{ns}	8.34**	1.98ns	7.61	7.7

ns, * and **, insignificant, significant at P<0.05 and P<0.01, respectively, CV (%) = coefficient of variation in percent, Numbers in parenthesis represent degree of freedom

Table 2. Interaction effect of genotype * priming * duration of priming on seed germination in korerima

Genotype	Priming	Duration of Priming (hrs.)	Standard Germination (%)	Speed of germination	Seedling vigor index I	Seedling vigor index II
093/00	Distilled water	3	71.60f-h	4.64g-k	462.42c-i	71.37f-k
		6	73.30e-h	4.56g-k	437.25e-k	70.77f-m
		9	73.30e-h	4.64g-k	436.77e-k	71.90e-k
	Potassium nitrate	3	81.60b-d	5.40b-e	513.97a-d	73.7c-j
		6	70.00g-j	5.42b-e	476.38b-h	73.27c-j
		9	60.00kl	4.83f-j	380.55h-l	67.95k-m
	Potassium di hydrogen phospha te	3	66.60h-k	4.50g-l	411.20e-k	70.27g-m
		6	60.00kl	4.05l-n	378.70i-l	67.40km
		9	56.60 l	3.64n	324.03l	66.36m
	Gibberellins acid	3	81.60b-d	5.24b-f	544.77a-d	74.04c-i
		6	85.00a-c	5.68b	525.68a-d	74.67b-g
		9	83.33bc	5.61bc	564.67ab	76.33a-d
	Cow urine	3	85.00a-c	5.61bc	579.30a	77.57a-c
		6	83.33bc	5.70b	553.67a-c	77.81a-c
		9	80.00b-e	5.31b-f	527.60a-d	76.09a-e
	Tap water	3	65.00i-k	4.24j-m	439.67e-k	69.50h-m
		6	68.30g-j	4.51g-l	442.45e-j	73.62c-j
		9	80.00b-e	5.36b-e	514.38a-d	74.39b-h
059/03	Distilled water	3	66.60h-k	4.05l-n	385.57h-l	69.94h-m
		6	70.00g-j	4.40i-ml	393.17h-l	70.63g-k
		9	78.33c-f	4.83f-j	450.20d-j	73.49c-j
	Potassium nitrate	3	75.00d-g	5.01d-h	452.80d-j	72.15d-k
		6	81.60b-d	5.50b-e	532.17a-d	73.78c-j
		9	66.60h-k	4.38i-m	392.00h-l	69.83h-m
	Potassium di hydrogen phospha te	3	71.60f-h	4.56g-k	409.23f-k	61.54e-k
		6	73.30e-h	4.93e-i	406.00g-l	71.36f-k
		9	63.30kl	3.91l-n	365.52j-l	68.23k-m
	Gibberellins acid	3	85.00a-c	5.59b-d	505.18a-f	77.71a-c
		6	91.66a	6.40ab	564.85ab	78.95ab
		9	81.60b-d	5.60b-d	493.07a-f	76.26a-d
	Cow urine	3	86.67ab	5.75b	544.75a-d	79.57a
		6	68.30g-j	5.06c-g	474.67b-i	75.32b-f
		9	71.60f-h	6.48a	467.98c-i	74.10c-h
	Tap water	3	60.00kl	3.90mn	344.99kl	69.37j-m
		6	66.60h-k	4.310j-m	409.33f-k	71.08f-k
		9	73.30e-h	4.60g-k	438.82e-k	73.61c-j
	CV (%)		6.18	4.18	9.83	9.84
	LSD P<(5%)		7.59	0.59	96..001	4.59

Means with the same letter are not significantly different, LSD = least significant difference

Table 3. Interaction effect of genotype * priming on seed germination in korerima

Genotype	Priming	Seedling length (cm)	Seedling dry weight (g)	Normal seedling	Abnormal seedling	Fresh ungerminated seed	Dead seed
093/00	Distilled water	6.12b	0.29bc	50.9b-d	22.00b-d	17.77a-c	11.4abc
	KNO_3	6.13b	0.29bc	52.1b-d	22.33b-d	15.44b-e	10.1b-d
	KH_2PO_4	6.02bc	0.29bc	42.7e	23.66a-c	21.66a	16.5a
	GA_3	6.56ab	0.29bc	58.3ab	19.00de	12.10de	4.6de
	Cow urine	6.67a	0.32ab	59.9ab	19.03de	10.07de	4.4de
	Tap water	6.55ab	0.31ab	49.7c-e	21.33c-e	18.10a-c	10.7a-d
059/03	Distilled water	5.57d	0.30bc	50.1c-e	21.50c-e	18.27a-c	9.8b-d
	KNO_3	6.13b	0.29bc	52.1b-d	22.66a-d	16.44a-d	8.1b-e
	KH_2PO_4	5.66cd	0.28c	48.6c-e	25.83a	18.99a-c	11.5abc
	GA_3	6.03bc	0.31ab	60.27a	20.83c-e	10.40e	3.2e
	Cow urine	6.27ab	0.33a	58.2ab	18.33e	13.77c-e	7.3c-e
	Tap water	5.95bcd	0.31ab	46.6de	20.00de	20.55ab	12.7ab
CV (%)		7.63	8.34	9.33	9.33	7.89	7.33
LSD ($P<0.05$)		0.41	0.018	7.63	3.28	5.23	6.19

Means with the same letter(s)are not significantly different, LSD = least significant difference , CV (%)= coefficient of variation, $KNO_{3=}$ Potassium nitrate, $KH_2PO_{4=}$ Potassium di hydrogen phosphate, $GA_{3=}$ Gibberellins acid

Table 4. Interaction effect of priming materials * duration of priming on seed germination

Treatment		Seed germination test parameter			
Priming material	Duration of priming (hours)	Normal seedling	Abormal seedling	Fresh ungerminating seed	Dead seed
Distilled water	3	49.00fg	22.00b	21.00a-c	12.00cd
	6	51.00f	22.00b	19.00c-e	12.00cd
	9	54.00e	24.00b	18.00d-f	8.00ef
Potassium nitrate	3	56.00de	24.00b	16.00fg	8.00ef
	6	58.00cd	25.00ab	14.00gh	7.00e-g
	9	48.00g	20.00b	21.00a-c	15.00a-c
Potassium di hydrogen phosphate	3	49.00fg	22.00b	20.00b-d	12.00cd
	6	48.00g	21.00b	20.00b-d	14.00bc
	9	43.00h	19.00b	23.00a	18.00a
Gibberellins acid	3	59.00bc	26.00ab	14.00gh	5.00fg
	6	73.00a	17.00bc	10.00j	4.00g
	9	59.00bc	26.00ab	13.00hi	6.00fg
Cow urine	3	72.50a	17.00bc	11.00ij	5.00fg
	6	57.00cd	25.00ab	13.00hi	8.00ef
	9	54.00e	24.00b	17.00ef	8.00ef
Tap water	3	45.00h	20.00b	22.00ab	16.00ab
	6	54.00e	24.00b	16.00fg	9.50de
	9	48.00g	35.5.00a	22.00ab	12.00cd
CV (%)		9.8	8.5	7.85	8.66
LSD (P>0.05)		2.97	11.23	2.97	3.07

Means with the same letter are not significantly different, LSD = least significant difference, CV (%)= coefficient of variation.