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Effect of Botanical Seed Enhancement Treatment on Seed Yield and Quality in Ragi Cv. TRY 1

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ABSTRACT

The present investigation 'effect of various seed enhancement treatments on seed yield and quality in ragi cv. TRY 1' was carried out at Department of Genetics and Plant Breeding, Faculty of Agriculture, Annamalai University Tamil Nadu. The seeds of ragi cv. TRY 1 were given with various pre sowing botanical seed enhancement treatments i.e. Pungam leaf extract @ 10%, Arappu leaf extract @ 10%, Vasambu rhizome extract @ 10%, Prosopis leaf extract @ 10%, Adathoda leaf extract @ 10%, Papaya leaf extract @ 10%, Moringa leaf extract @ 10%, Thulasi leaf extract @ 10%, Neem leaf extract @ 10% along with control. All the pre sowing treatment seeds were evaluated for the initial quality characteristics. The Moringa leaf extract @ 10% pre sowing treatment registered significantly higher values for initial seed qualities and lower EC. In field evaluation, Moringa leaf extract @ 10% pre sowing treatment seeds recorded higher growth, physiological and growth parameters.

Key words: Ragi, Botanical seed enhancement, Seed quality, Seed yield

Finger millet (*Eleusine coracana* (L.) Gaertn.) belongs to family Graminae (Poaceae), is said to have derived its name from Greek goddess of cereals Eleusine (Chalam and Venkateswaralu 1965). Finger Millet is the fourth most important millet crop in the world. Finger millet variously called as chodi, bird's foot, nagli, mandua, ragi, madua, marawah in different regions is one of the important millet crops of India. It is rich in carbohydrate value (72%), which is in the form of non–starch polysaccharides and dietary fibre, which helps, in lowering cholesterol and slow release of glucose to the blood stream during digestion. High quality seeds play an important role in successful crop production. Rapid germination and emergences are essential for successful crop establishment, for which seed priming could play an important role. Seed priming is a pre-sowing. Botanical seed priming is a common practice followed to improve seed performance with respect to uniformity of germination and rate of germination (De-Lespinay *et al.* 2010). It is the process of regulating germination by managing the temperature and seed moisture content, in order to maximize the seed's potential.

The ragi seed is having distinct morphological features. It is a small seeded grain; its kernel is not having a true caryopsis but a utricle. The use of high quality seeds is one of the most important elements in increasing agricultural production in any farming system. Seed enhancement may be defined as post-harvest treatments that improve germination and seedling growth or facilitate the delivery of seeds and other inputs/materials required at the time of sowing smoothly (Nagaraju *et al.* 2018). Botanical seed priming process had potential advantages over simple seed coating. Seed priming often results in more rapid and uniform seedling emergence and may be useful under adverse soil conditions. Many researchers have shown the ability of different botanicals in combining adverse climatic condition also help the seed to show its potentials (Masuthi *et al*. 2015). Applications of nutrients to the dryland is a problematic one, by giving the nutrients to the seed itself as presowing treatment will improve the viability and vigour of the seed and that will give good yield (Vijaya 1996). Botanical seed treatment is derived from natural sources based on botanical ingredient. It is liquid, natural seed treatment and root growth promoter formulation. It also stimulates indigenous microbes in the root zone. It proven to be reliable performer in low and high rainfall areas and in all soil types. It is also one of the lowest financial investments through which a grower can make to maximize productivity and improve the bottom line. With this background, the study was undertaken in ragi cv. TRY 1 to study the effect of various botanical seed enhancement treatment on seed yield and seed quality.

MATERIALS AND METHODS

The present investigations was carried out at the Department of Genetics and Plant Breeding, Faculty of Agriculture, Annamalai University to study the effect of the pre sowing botanical seed treatment on seed yield and quality in ragi. Freshly harvested bulk seeds of ragi cv. TRY 1 were graded and imposed with the following pre sowing seed treatments.

Treatment details

T_0 – Control
T_1 – *Pungam* leaf extract @ 10% seed hardening
T_2 – *Arappu* leaf extract @ 10% seed hardening
T_3 – *Vasambu* rhizome extract @ 10% seed hardening
T_4 – *Prosopis* leaf extract @ 10% seed hardening
T_5 – *Adathoda* leaf extract @ 10% seed hardening
T_6 – *Papaya* leaf extract @ 10% seed hardening
T_7 – *Moringa* leaf extract @ 10% seed hardening
T_8 – *Thulasi* leaf extract @ 10% seed hardening
T_9 – *Neem* leaf extract @ 10% seed hardening

The fresh leaves of Pungam (*Pongamia pinnata*), Arappu (*Albizia amara*), Vasambu (*Acorus calamus*), Prosopis (*Prosopis juliflora*), Adathoda (*Adathoda vasica*), Papaya (*Carica papaya*), Moringa (*Moringa oleifera*), Thulasi (*Ocimum tenuiflorum*) and Neem (*Azadirachta indica*) were collected separately and dried under shade. The shade dried leaves were powdered using mortar and pestle. Then exactly weigh ten gram of leaf powder using weighing balance and dissolved in 100 ml of distilled water, which was measured already in the beaker to make 10% leaf extract. The leaf extract was filtered by using muslin cloth to remove unwanted materials and leaf debris. The seeds were soaked in equal volume of (1:1) leaf extract for 4 hours along with water. The soaked seeds were dried back to original moisture content.

The treatments were evaluated for seed quality parameters viz. speed of germination (Maguire 1962), germination (%), root length (cm), shoot length (cm), dry matter production (mg) as per the procedure of ISTA, (1999), seedling vigour index I, seedling vigour index I (Abdul-Baki and Anderson 1973) and EC I, electrical conductivity (d sm^{-1}) (Presley 1958), dehydrogenase activity (Kittock and Law 1968) and protein content (%) (Alikhan and Youngs 1973). The above treated seeds were also evaluated for their field performance. Field trial was conducted by adopting randomized block design with three replications. The plot size was 3×5 m^2. The crop was raised with the spacing of 25×15 cm and recommended package of practices for ragi were followed. The following observations were recorded and the following growth parameters i.e. field emergence (%), plant height (cm), days to 1^{st} flowering, days to 50% flowering, number of tillers $plant^{-1}$, chlorophyll content, gas exchange parameters, number of productive, length of the earhead (cm), weight of the earhead $plant^{-1}$ (g), weight of earhead $plot^{-1}$ (kg), weight of earhead ha^{-1} (kg), seed yield $plant^{-1}$ (g), seed yield $plot^{-1}$ (kg), seed yield ha^{-1} (kg), harvest index, seed recovery (%) and 1000 seed weight were recorded. All the data were analyzed statistically with appropriate tools and expressed as mean values as per the method of Panse and Sukhatme (1985).

RESULTS AND DISCUSSION

Botanical seed treatment is extracted from naturally occurring sources based on botanical ingredients. It is a liquid formulation, which is effective against problems that occur in cold wet soils especially limited disturbance and no-till operations and areas of low moisture. It has synergistic effect on early and uniform seed germination and enhance tolerance to pest and disease during early crop stage. It controls soil and seed-borne fungal disease. Seed priming has presented promising and even surprising results for many seeds including legume seeds (Knypl and Khan 1981). The direct benefits of seed priming in all crops are faster emergence, more and uniform stands, less need to re-sow, more vigourous plants, better drought tolerance, earlier flowering, earlier harvest and higher seed yield (Balaji and Sathiya Narayanan 2019). In the laboratory analysis the 10% moringa leaf extract hardened seeds recorded higher seed qualities viz. speed of germination, germination percentage, root length, shoot length and dry matter production. The above mentioned treatment was recorded 18.8, 17.5, 26.7, 51.06 and 50.5 percentages higher than control respectively with the above mentioned characters (Table 1). This treatment also recorded higher values for seed qualities viz. vigour index I, vigour index II, total dehydrogenase activity and protein content. It recorded 60.3, 59.2, 30 and 5.7 percentage higher than control respectively with the above mentioned characters (Table 2). The seed hardened with MLE @ 10% recorded low EC of 7 dSm^{-1} when compared to control and others. Similar results were reported by Basra *et al*. (2011) in maize, Azra *et al*. (2013) in wheat and Abohassan and Abusuwar (2017) in legumes.

Table 1 Effect of botanical seed enhancement treatment on various seedling quality in ragi cv. TRY 1

Treatment	Speed of germination	Germination (%)	Root length (cm)	Shoot length (cm)	Dry matter production (mg seedling^{-10})
T_0	21.20	80 (63.45)	7.10	4.70	2.79
T_1	24.20	91 (72.64)	8.60	6.70	3.60
T_2	23.80	90 (71.99)	8.40	6.40	3.60
T_3	22.40	85 (67.32)	7.60	5.50	3.10
T_4	24.70	92 (73.61)	8.80	6.90	4.10
T_5	22.10	83 (65.67)	7.50	5.30	3.00
T_6	21.70	82 (65.01)	7.20	5.00	2.90
T_7	25.20	94 (76.17)	9.00	7.10	4.20
T_8	22.70	86 (68.15)	7.80	5.80	3.50
T_9	23.40	88 (69.78)	8.00	6.00	3.50
Mean	23.14	87.10 (68.82)	8.00	5.94	3.43
SED	0.7379	2.7833	0.2545	0.1887	0.1080
CD(P=05)	1.5422	5.8172	0.5320	0.3944	0.2257

Figures in parenthesis are arcsin transformation values

Table 2 Effect of botanical seed enhancement treatment on other seedling quality in ragi cv. TRY 1

Treatment	Vigour Index I	Vigour Index II	Electrical conductivity (dSm^{-1})	Total dehydrogenase activity (OD value)	Protein content (%)
T_0	944.00	231.00	9.10	0.40	9.91 (18.34)
T_1	1392.30	327.60	7.23	0.49	10.34 (18.75)
T_2	1332.00	324.00	8.18	0.47	10.29 (18.70)
T_3	1113.50	263.50	9.02	0.43	10.13 (18.55)
T_4	1444.39	357.20	7.12	0.51	10.40 (18.81)
T_5	1062.40	249.00	9.04	0.42	10.07 (18.50)
T_6	1000.40	237.80	9.09	0.41	10.02 (18.45)
T_7	1513.39	367.80	7.00	0.52	10.48 (18.88)
T_8	1169.60	301.00	8.83	0.44	10.19 (18.61)
T_9	1232.00	308.00	8.36	0.46	10.26 (18.68)
Mean	1220.39	296.69	8.29	0.45	10.20 (18.63)
SED	38.8683	9.4480	0.2723	0.0136	0.041
CD(P=05)	81.2347	19.7463	0.5692	0.0284	0.082

Figures in parenthesis are arcsin transformation values

The application of moringa leaf extract has also effectively improved seed germination and seedling vigour as compared to untreated control (Fuglie 1999). The effectiveness in seedling quality of moringa leaf extract priming is due to the fact that its leaves are a rich source of zeatin, ascorbic acid, Ca, and K (Foidl *et al*. 2001), which regulates the seed germination and seedling establishment related metabolism. The higher concentration of calcium and other mineral contents in *M. oleifera* leaves might be responsible for promoting seed emergence rate and plant vigour (Anjorin *et al*. 2010). MLEs contain major and minor nutrients, amino acids, vitamins, and cytokinins, auxins, and abscisic acid (ABA) like growth substances (Foidl *et al*. 2001). It is well known for its miraculous nutritional and medicinal properties. Leaves of tree are extremely rich in vitamins (A, B, C), essential minerals (K, Ca, Fe), antioxidants (Ascorbate, Phenolics), proteins and growth hormone zeatin (Foidl *et al*. 2001). Hence, its leaf extract either prepared in 80% ethanol or in water contains growth-enhancing substances and can be used as natural source of growth promoter (Fuglie 2001). The seed primed with MLE cause fine adjustment of cytokinin levels within the plant is needed to achieve the optimal growth of shoots and vigour (Gan and Amasino 1995). The above hardened seeds were also evaluated under field condition, the growth parameter, gas exchange, yield parameter and seed yield parameters were observed. It revealed that the 10% moringa leaf extract hardened seeds recorded higher values for the growth parameters viz. field emergence, plant height and number of tillers plant $^{-1}$ which were 23.3, 12.5 and 59.3 percentage higher than the control respectively with the above mentioned characters (Table 3). It recorded early days to 1st flowering and days to 50% flowering parameters which was 45.80 and 60.20 days respectively when compared to control and other treatments (Table 3).

MLE is a rich source of PGR hormone, zeatin, ascorbic acid, Ca, and K (Foidl *et al*. 2001), which are involved in several plant growth and development processes. Fuglie (2001) confirmed that this cytokinin (CK) related hormone increases crop growth when primed with fresh moringa leaves extract. The improvement in growth and yield of crop at seed hardened with MLE might be due to the presence of growth promoting substances as well as nutrient elements in moringa as suggested by many reseachers (Abdalla 2013).

The growth and yield enhancement was due to presence of zeatin, a cytokinin in moringa leaves (Fuglie 1999). The MLE efficacy might also be due to a higher zeatin concentration in *Moringa oleifera* leaves (5–200 µg g–1 of fresh weight) as reported by Fuglie (1999) or due to higher or enhanced mobilizations of metabolites/ inorganic solutes to germinating plumule, which results in enhanced growth (Taiz and Zeiger 2006). The MLE priming was effective due to other growth promoting factors, which are a rich source of antioxidants, calcium, potassium, and iron (Barciszweski 2000); the major ones are ascorbate, carotenoids, phenols, and flavonoid (Iqbal and Bhanger 2006). Basra *et al*. (2011) reported an increase in the emergence potential and phenolic content in seedlings. The increase in phenolic contents due to MLE priming might be attributed to a higher content of vitamin C in MLE.

Table 3 Effect of botanical seed enhancement treatment on various growth parameters in ragi cv. TRY 1

Treatment	Field emergence (%)	Plant height (cm)	Days to 1st flowering	Days to 50% flowering	Number of tillers plant^{-1}
T_0	77 (61.35)	92.90	52.30	65.90	3.20
T_1	92 (73.70)	103.60	46.10	62.30	4.70
T_2	90 (71.99)	100.80	48.40	62.50	4.50
T_3	85 (67.32)	98.70	49.30	64.40	3.80
T_4	93 (74.71)	104.10	46.70	61.40	4.80
T_5	83 (65.67)	96.50	49.50	64.70	3.60
T_6	81 (64.26)	93.40	51.60	65.50	3.40
T_7	95 (77.56)	104.60	45.80	60.20	5.10
T_8	87 (69.01)	99.20	48.70	63.70	4.10
T_9	89 (70.69)	99.50	48.50	63.40	4.30
Mean	87.20 (69.32)	99.33	48.69	63.40	4.15
SED	1.6160	1.8293	0.9176	1.1823	0.0773
CD(P=05)	3.3936	3.8415	1.9270	2.4828	0.1623

Figures in parenthesis are arcsin transformation values

Moringa leaf extract (MLE), is rich in some antioxidants, i.e., proline, phenols, flavonoids, and ascorbic acid, as well as some osmoprotectants, i.e. amino acids and soluble sugars. In addition, it is rich in phytohormones such as indole-3-acetic acid, gibberellins and cytokinins. The application of moringa leaf extract as seed primer has been found to act as growth enhancer due to the presence of zeatin, ascorbates, carotenoids, phenols, antioxidants, and essential plant nutrients (Yasmeen *et al*. 2013), and have critical role for the promotion of cell division, cell elongation, and chlorophyll biosynthesis (Taiz and Zeiger 2010) and enriched content of growth promoting hormones like auxins and cytokinines (Moyo *et al*. 2011) might have contributed to the acceleration in growth characters through rapid cell division, cell multiplication and enlargement. Similar results were reported by Basra *et al*. (2011) in maize, Azra *et al*. (2013) in wheat, and Abohassan and Abusuwar (2017) in legumes. The physiological parameter such as chlorophyll content, photosynthesis, transpiration, intercellular CO_2 concentration and stomatal conductance also higher in Moringa leaf extract seed @ 10% hardening treatment which was 17.5, 52.9, 56.7, 15.6 and 60 percentages higher than control respectively with the above mentioned characters (Table 4). The Moringa leaf contains appreciable amounts of specific plant pigments with demonstrated potent antioxidant properties such as the carotenoids (lutein, alpha-carotene, beta-carotene, and xanthin) and chlorophyll (Owusu 2008). Moreover, the leaves of moringa have several macroelements such as Mg (Yameogo *et al*. 2011) a constituent of chlorophyll, both of which would account for the increase in the amount of chlorophyll a and chlorophyll b in crop plants. Also, seed fortification with MLE may stimulate earlier cytokinin formation thus preventing premature leaf senescence and resulting in more leaf area with higher photosynthetic pigments (Rehman and Basra 2010).

The moringa leaf extract, which increased chlorophyll content in plant leaves. The effectiveness of MLE might also be attributed to higher protein and antioxidants in addition to mineral contents (especially calcium and potassium) in moringa leaves (Foidl *et al*. 2001) that helps in the metabolic processes. This report corroborates those of Gingula *et al*. (2005) that increased leaf area and photosynthetic capacity was associated with increase nitrogen on the cells and tissue growth. Adequate growth factors supply can help delay leaf senescence thereby maintaining the leaf green pigment and functionality for a longer period. Cytokinins are vital hormones found in MLE and have been reported to cause increased cell division by stimulating the process of mitosis. Increased mitosis results in plant growth and the formation of shoots and buds as well as development of fruits and seeds (Schmulling 2002).

The enhanced accumulations of both total protein and chlorophyll in response to treatments with Moringa leaf were due to the high protein, sugar and starch content of the entire *moringa oleifera* plant (Abdalla 2013). This could be as a result of effect of Moringa leaves is rich in Zeatin and can be used as a natural source of cytokinin. The leaves also contain ascorbates carotenoids, phenol, potassium and calcium, which will help enhance the synthesis of biochemicals in plants which have plant growth promoting capability and are being applied as exogenous plant growth enhancers (Foidl *et al*. 2001). Moringa is rich in zeatin, ascorbate and minerals including potassium, which plays a key role in delaying senescence under less than optimum conditions (Basra *et al*. 2011). This corresponds to improved chlorophyll contents and physiological parameters by priming with MLE. In MLE, cytokinins have critical role for promotion of cell division, cell elongation, chlorophyll biosynthesis, and modification in apical dominance in plants (Tiaz and Zeiger 2010). These results support our hypothesis that ML contains growth hormones and cytokinins (Ali *et al*. 2011). Cytokinins can enhance yield (Barciszewski *et al*. 2000). Similar results were reported by Basra *et al*. (2011) in maize, Azra *et al*. (2013) in wheat, and Abohassan and Abusuwar (2017) in legumes.

Table 4 Effect of botanical seed enhancement treatment on various physiological parameters in ragi cv. TRY 1

Treatment	Chlorophyll content (mg g^{-1})	Pn (mg CO_2 $m^{-1}S^{-1}$)	Tr (mg H_2O CO_2 $m^{-1}S^{-1}$)	Ci (mol/mol)	CS (mol/mol. S)
T_0	1.94	22.76	5.30	293.7	0.30
T_1	2.20	33.77	8.18	330.2	0.43
T_2	2.17	33.49	7.66	328.5	0.41
T_3	2.09	28.36	6.52	310.3	0.36
T_4	2.24	34.57	8.25	335.2	0.45
T_5	2.05	26.54	6.27	305.6	0.33
T_6	2.03	24.78	5.76	298.7	0.31
T_7	2.28	34.81	8.31	339.7	0.48
T_8	2.12	31.68	7.25	319.7	0.38
T_9	2.15	32.56	7.48	322.80	0.40
Mean	2.12	30.33	7.09	318.4607	0.38
SED	0.0670	0.9724	0.2259	10.1735	0.0124
CD(P=05)	0.1400	2.0324	0.4721	20.0625	0.0259

Pn – Photosynthetic rate, Tr – Transpiration rate, Ci – Intercellular CO_2 concentration and CS – Stomatal conductance

The seed hardened with MLE @ 10% was also recorded the yield attributes character such as number of productive tillers $plant^{-1}$, earhead length, earhead weight $plant^{-1}$, earhead yield $plot^{-1}$ and earhead yield kg ha^{-1}. It recorded 55.1, 58.3, 56.06, 25.10 and 18.3 percentage higher than control respectively with the above mentioned characters (Table 5). This treatment was also recorded the higher seed yield parameters such as seed yield $plant^{-1}$, seed yield $plot^{-1}$, seed yield kg ha^{-1}, harvest index, seed recovery % and 1000 seed weight were also 60.5, 17, 21.4, 15.3, 25.3 and 28.5 percentage higher than control respectively with the above mentioned characters (Table 6). Similar results were reported by Basra *et al*. (2011) in maize, Azra *et al*. (2013) in wheat and Abohassan and Abusuwar (2017) in legumes.

Table 5 Effect of botanical seed enhancement treatment on various yield parameters in ragi cv. TRY 1

Treatment	Number of productive tillers $plant^{-1}$	Ear head length (cm)	Ear head weight (g $plant^{-1}$)	Ear head yield (kg $plot^{-1}$)	Ear head yield (kg/ha)
T_0	2.90	4.80	6.60	3.34	2359
T_1	4.20	7.30	9.80	4.15	2673
T_2	4.00	6.80	9.50	4.13	2631
T_3	3.50	5.80	8.50	3.87	2461
T_4	4.30	7.40	10.10	4.17	2743
T_5	3.20	5.40	7.80	3.56	2432
T_6	3.00	5.20	7.30	3.45	2366
T_7	4.50	7.60	10.30	4.18	2793
T_8	3.60	6.10	8.90	3.92	2562
T_9	3.90	6.70	9.30	3.96	2598
Mean	3.71	6.31	8.81	3.87	2561.80
SED	0.0692	0.1173	0.1661	0.0729	47.2010
CD(P=05)	0.1453	0.2464	0.3487	0.1532	99.1222

This can be attributed to the moringa leaf aqueous extract content of high minerals and hormones which are directly/indirectly involved in fruit growth and development process and consequently increase number of fruit/tree (Abdalla 2013). This increase in fruit weight, length and diameter fruit weight, length and diameter are ascribed to the high level of potassium and zinc in moringa leaf aqueous extract. Potassium improves seed quality by enhancing the formation and translocation of carbohydrates from the shoot to storage organs (seeds) and carbohydrate enzymes (Ramezani and Shekafandeh 2011). It might be attributed to the content of moringa extract from proteins, vitamins such as A, B_1, B_2, B_3, C and E, β carotene, phenolic, sugars, and minerals such as calcium, magnesium, sodium, iron, phosphorus and potassium and several hormones as auxin, gibberellins and cytokinins which regulate internal mechanism for controlling seed setting and abscission of ovaries (Talon and Zeevaart 1992). The increased root-to-shoot ratio from MLE priming may be attributed to cell wall extension and increased metabolic activities at low water potential (Afzal *et al*. 2002). Zinc is precursor of tryptophan which is involved in synthesis of indole acetic acid that is required for fruit growth and development (Zekri and Obreza 2009). In addition to, the high content of cytokinin-like substances, which plays a vital role in cell division and expansion, thus finally increased the seed yield. Iftikhar (2009) observed increased emergence and vigorous plant development in maize seeds primed with MLE due to the presence of Ca, K, ascorbic acid, and cytokinin hormone. The increase in yield of MLE primimg was probably due to the presence of high endogenous levels of cytokinin-like substances (zeatin, kinetin, etc.) resulting in the increase in size of fruit and number of fruit per plant. The zeatin, a cytokinin related hormone in the extract, which was responsible for the improved growth and yield as suggested by some researchers (Mvumi *et al*. 2013).

Table 6 Effect of botanical seed enhancement treatment on various seed yield parameters in ragi cv. TRY 1

Treatment	Seed yield/plant (g)	Seed yield/plot (kg)	Seed yield (kg/ha)	Harvest index	Seed recovery (%)	1000 seed weight (g)
T_0	3.80	1.47	950	0.13	54.50 (47.58)	2.10
T_1	5.80	1.70	1150	0.15	65.30 (53.91)	2.60
T_2	5.40	1.69	1148	0.15	64.60 (53.50)	2.50
T_3	4.50	1.56	1122	0.14	60.30 (50.95)	2.40
T_4	6.00	1.71	1152	0.15	66.70 (54.76)	2.60
T_5	4.10	1.55	1028	0.14	57.20 (49.13)	2.30
T_6	3.90	1.53	1015	0.13	55.10 (47.93)	2.20
T_7	6.10	1.72	1154	0.15	68.30 (55.74)	2.70
T_8	4.80	1.67	1130	0.14	61.60 (51.71)	2.40
T_9	5.20	1.68	1138	0.14	62.70 (52.36)	2.50
Mean	4.95	1.62	1098.70	0.14	61.63 (51.78)	2.43
SED	0.0915	0.0298	20.6484	0.0039	1.1429	0.0446
CD(P=05)	0.1921	0.0527	43.3617	0.0082	2.4001	0.0936

Figures in parenthesis are arcsin transformation values

From the aforementioned investigation effect of various botanical seed enhancement treatments on yield and quality seed production in ragi cv. TRY 1. revealed that moringa (*Moringa oleifera*) leaf extract @ 10% hardened seeds recorded the higher seed yield and quality when compared to other treatments and control. It is also on par with the treatment in which the seeds hardened @ 10% Prosopis leaf extract.

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