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NATURAL FORMULATION AND CHEMICAL AS PRE-SOWING SEED TREATMENT AFFECTING SEED QUALITY OF FINGER MILLET (*ELEUSINE CORACANA* L. GAERTN)

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ABSTRACT

Eleusine coracana (L.) (Gaertn) or finger millet, also known as Ragi in Hindi language is a popular and traditional nutri-cereal / millet of the Seraj area in wet temperate of Himachal Pradesh. Locally called as *koda or kodra*, its cultivation is taken up in the kharif season by raising a nursery instead of direct field sowing in the wet temperate Himalayas. In this research study indigenous finger millet seeds were presoaked for 12 and 24 hours respectively in distilled water, different treatments of gibberellic acid (20 ppm, 40 ppm, 60 ppm, 80 ppm and 100 ppm) and one Beejamrit formulation (collected locally). Seed and seedling characters viz., field emergence percentage, seedling length, dry weight and seedling vigour index- length were recorded under the seed germination test. The treatment combinations 60 ppm GA_3 + 12 hrs soaking showed higher germination percentage (96.00%), seedling length (10.50 cm) and seedling vigour index. The treatment combination Beejamrit + 12 hrs soaking were at par with the best treatment combination. Seed germination promoting chemical GA_3 had significantly improved the initial growth of the seedling. The natural formulation Beejamrit was also equally good in boosting the seedling emergence as well as its physical characters. These treatment combinations can invigorate or enhance the seed quality thus boosting crop production of finger millet in the long run in the wet temperate high hills of Himalayas.

Key word : Gibberellic acid, Beejamrit, Finger millet, Seed germination, Seed soaking.

Introduction

Finger millet [*Eleusine coracana* (L.)] popularly is also known as *koda* in the higher hills of the wet-temperate zone of Himachal Pradesh. An energy and carbs-rich Nutri- cereal finger millet contains amino acid tryptophan which lowers appetite and helps in keeping weight in control (Satyarthi *et al*., 2018). *Ragi* (Hindi), is a traditional and non-commercial kharif millet crop that has lost a place in subsistence terraced cereal farming in the high hills due to more popular cereal crops and other cash crops such as potato, peas and cauliflower prevalent in this area. Due to the conducive climate for off-season vegetable production in Seraj valley, folks here dedicate the majority of the land holdings for the production of high-value crops, whereas, low fertile and wastelands are utilized for sowing of the finger millet (Thakur *et al*., 2023). Under the Himalayan regions in the country, Himachal Pradesh acquired 2nd place with 28% area under millets (1997-2016) (Bhat *et al*., 2019). But millets here are grown on poor soils and major portion of the area is fed to livestock as green fodder. The major area under millets is occupied by ragi followed by *kangni* (foxtail millet) , *cheena* (proso millet), *swank* (little millet) and *katai* (kodo millet) and state productivity of *ragi*is 1037 kg/ha (Sood *et al*., 2023). Finger millet cultivation is practiced as a direct sown as well as a transplanted kharif crop in the Seraj valley. Seeds are sown in nursery at the end of April month and transplanted in June. The rainfed crop is direct sown in the month of June. The positive impact of seed invigoration treatment; seed soaking is foreknown. Seed soaking is done with various chemical and natural formulations and its duration varies. According to Baskin and Baskin (2004) the members of family Poaceae exhibit varying degrees of dormancy in caryopsis, spikelets or glumes, impermeable seed coats and as a result of chemical inhibitors found in the glumes or seed coat. Seed treatment as seed soaking can prove to be beneficial to break down seed dormancy and improve seedling germination (Sridhar and Kumar, 2013). Gibberellins is a large family of plant growth hormones synthesized from geranyl diphosphate in plants and it stimulates cell division and expansion (Camara *et al*., 2018). Gibberellic acid-3 (GA_3) acts as a natural plant growth regulator, especially for stem elongation, seed germination, and increased fruit size.GA_3improves seed germination (Devi *et al*., 2021) upon seed treatment at a certain concentration and duration. External application of GA_3 enhanced seed germination as a result of stimulation of synthesis and production of enzyme hydrolases (Wang *et al*., 2019) further strengthening the build-up of essential seedling characteristics (Dheeravathu *et al*., 2023). Beejamrit, an important component of natural farming is an age-old low-cost natural formulation made from dairy excreta and forest soil supplemented with limestone (Sagar *et al*., 2018). This biostimulant is plunged with free living nitrogen fixers, phosphate solubilizers and indolic contents (Mukherjee *et al*., 2022). Cow dung, one of the ingredients in beejamrutha has been shown to include naturally occurring beneficial microorganisms, primarily bacteria, yeast, actinomycetes, photosynthetic bacteria, and some fungus (Swaminathan, 2005). The bacterial isolates of beejamrit promotes seed germination (Sreenivasa *et al*., 2010), seedling length and vigour besides ancient Indian treaties including the *Charak Samhita*; *Sushru*; *Vagbhaatand Nighantu*; *Ratnakar*, among others have described its usage in sustainable agriculture (Vyankatrao, 2019). The treated seeds sown as nursery-raised crops provide a kick-start to the crop establishment in the field. Hence, the early-developed seedlings have a chance for field transplanting preventing it from untimely rains at the farmer's field. Finger millet is a climate-resilient crop (Patel *et al*., 2023) know well to tolerate drought and heat stress. It performs well in both irrigated and rainfed conditions. Pre sowing treatment of seeds with chemicals and natural formulations have preferentially an impact on any seed to perform well in unfavorable weather to meet the demand of good agricultural practices. Taking into consideration the availability of meager research studies on this crop in the high hills of Himachal Pradesh the research methodology was decided to study the effect of chemical and natural formulation on the seed quality of finger millets in the wet temperate high hills of Himachal Pradesh.

Materials and Methods

Experimental design

The research experiment carried out in *Kharif* season in laboratory of Colllege of Horticulture and Forestry, Thunag, Mandi, Himachal Pradesh (India) in the year 2023 consisted of 7 seed treatments and control and 2 seed soaking duration. Treatments included seed soaking in GA-3 at different concentrations (C1 = 20 ppm, C2 = 40, ppm, C3 = 60 ppm, C4 = 80 ppm and C5 = 100 ppm), C6 = Beejamrit (collected locally) and C7 = distilled water, where as control was used where seed were not soaked in any solution. 2-3 g seeds were soaked in the aforementioned solutions for 12 hrs (T_1) and 24 hrs (T_2), respectively. It was laid out in Factorial Completely Randomized Design (FCRD) in the laboratory with the control used as a non factorial treatment and analyzed accordingly. For each treatment seed quality parameters were recorded as mentioned under. According to ISTA (International Seed Testing Association, Zurich) guidelines (Anonymous, 2013) four hundred seeds were taken and put for germination in between paper method in four replications to conduct the test, *viz*. germination (%), seedling length (cm), seedling dry weight (mg) (Anonymous, Seed Net India; Tonapi *et al*., 2011). Further, its seedling vigour index was evaluated using the procedure of Abdul Baki and Anderson (1973).

Statistical analysis

Statistical package used for data analysis is MS Excel. Shapiro-Wilk test was used to check the normality of the data. Acceptance of hypothesis for Shapiro- Wilk test proved that the data was normally distributed. After fulfilling the assumptions of ANOVA, Two factor analysis i.e. factorial analysis with additional treatment (control) was used to test the performance of main effects and interactions. Tukey's HSD test was used for multiple comparisons, to find means that are significantly different from each other.

Results and Discussion

The final germination percentage value of finger millet seeds treated with chemical and natural formulations ranged from 73 to 96 per cent (Fig. 1). Maximum percent germination (96.00%) was observed in the treatment combination (60 ppm GA-3 seed soaking+12 hrs) and the treatment combination (Beejamrit seed soaking + 12 hrs) was statistically on par with the highest value. In terms of individual treatment, 60 ppm GA-3 (C3) seed soaking performed well in terms of germination with 93.33% germination and it was statistically at par with Beejamrit as seed soaking (C6) treatment that recorded

78.50% germination. The factorial treatment *i.e.* 12 hrs as seed soaking duration was superior over 24 hrs seed soaking duration in terms of germination (86.30%) parameters. Both GA-3 60 ppm as well as Beejamrit treated seeds performed well as compared to the seeds that were untreated or soaked in distilled water (Table 1). These results are in concordance with Balaguera *et al* (2009), who found that in tomato GA-3 seed soaking before sowing improved seed germination and other seed quality characters. Seed soaking in GA-3 eliminated the mechanical constraints in the endosperm cells endogenously thus aiding in third phase of germination *i.e.* radicle protrusion. A soaking duration of 12 hrs fetched higher germination percentage instead of a longer duration of seed soaking as per the stuy conducted by Chavan *et al* (2019) in agar wood. Chemical-treated agar wood seeds showed better germination than the untreated ones asthe removal of chemical inhibitors such as phenols through leaching, which made seed coat to swell and become soft for the easy passage of water into the cotyledons (Chavan *et al*., 2019). In addition to increasing cell wall flexibility and improving water absorption, GA-3 may play a role in the activation of cytological enzymes, which could explain the increased germination rate with GA-3 (Padma *et al.*, 2013). Beejamrit solution is an excellent source of indolic compounds including IAA (Mukharjee *et al.*, 2022) and Beejamrit seed soaking increased coleoptile and radicle length in chickpea seeds (Vaishnavi *et al*., 2021). There could be a correlation between the components and microorganisms connected with Beejamrita treatment and its superior efficacy. According to Natrajan (2007) and Sreenivasa (2010), Beejamrita is rich in both macro and micronutrients, numerous vitamins, growth-promoting substances including indole acetic acid (IAA) and gibberellic acid (GA) and advantageous microbes. Compared to water soaking, beejamrita seed soaking (12 hrs) showed promising results as seed primers to boost germination and seedling growth of different vegetables (Fernando and Ekanayake, 2022). Some other research analogous to the present study results are found in black gram (Bhargavi *et al*., 2019), ridge gourd (Kumari *et al*., 2021) and agarwood (Chavan *et al.*, 2019).

The observation seedling length (root length + shoot length) ranged over a value of 8.33cm to 10.50 cm (Fig. 2). Maximum seedling length of 10.50 cm was found in treatment combination (60 ppm GA-3 seed soaking+12 hrs). Also among treatments maximum seedling length 9.94 cm was observed in treatment C3and treatment C6 was on par with the highest value with seedling length of 9.42 cm. However, there was a non-significant effect of soaking duration on the seedling length. There was no significant interaction of soaking duration for the seedling length Gibbrellic acid as a naturally occurring growth hormone is associated with hypocotyl elongation (Akazawa *et al.*, 1990; Swain and Singh, 2005), active amylase breaking down to make available carbohydrates into simpler sugar, making nutrients and energy more readily available to the faster-growing seedlings (Rout *et al*., 2017). Hence, comparing the GA-3 treatments to

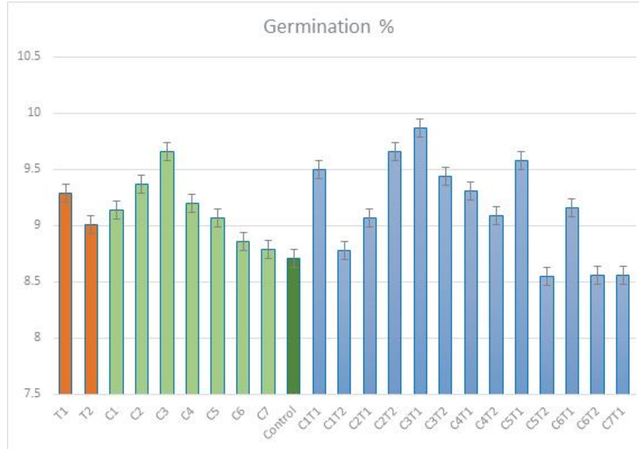

Fig. 1 : Effect of natural formulation and chemical on seed germination percentage.

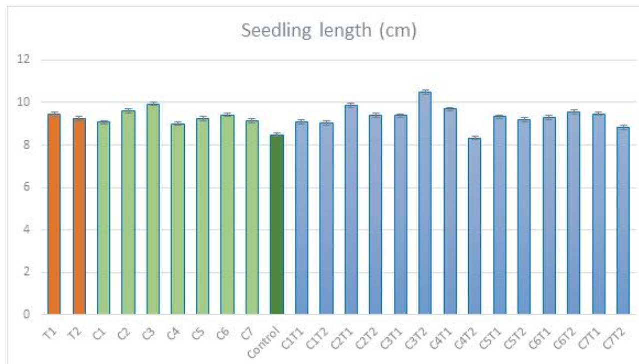

Fig. 2 : Effect of natural formulation and chemical on seedling length.

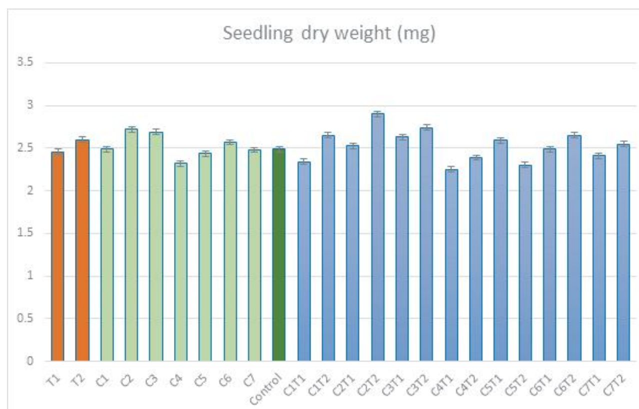

Fig. 3 : Effect of natural formulation and chemical on seedling dry weight.

Table 1 : Effect of natural formulation and chemical on seed quality characters.

Treatments	**Germination (%)	Seedling length (cm)	Seedling dry weight (mg)	SVI-I
T_1	9.29 (86.30)[b]	9.45[b]	2.46[a]	816.80[b]
T_2	9.01 (81.25)[a]	9.26[a]	2.60[b]	757.43[a]
SEM	0.37	0.25	0.18	78.55
CD	0.26	NS	0.11	46.41
C1	9.14 (83.50)[cd]	9.07	2.49[bc]	759.47
C2	9.37 (87.73)[d]	9.62	2.72[ef]	845.32
C3	9.66 (93.33)[e]	9.94	2.69[ef]	918.38
C4	9.20 (84.59)[cd]	9.01	2.32[a]	764.61
C5	9.07 (82.18)[c]	9.26	2.44[b]	765.09
C6	8.86 (78.50)[b]	9.42	2.57[d]	748.72
C7	8.79 (77.21)[a]	9.15	2.48[bc]	708.23[a]
SEM	0.16	1.70	0.08	267.38
CD	0.87	0.18	0.07	37.84
C1T1	9.50 (90.15)[bc]	9.09[ab]	2.34[ab]	823.11[cd]
C1T2	8.78 (77.10)[ab]	9.04[ab]	2.65[abc]	695.83[abc]
C2T1	9.07 (82.31)[ab]	9.86[bcd]	2.53[ab]	814.43[c]
C2T2	9.66 (93.32)[bc]	9.39[bc]	2.90[c]	876.21[cde]
C3T1	9.87 (96.00)[c]	9.38[bc]	2.63[bc]	901.21[cde]
C3T2	9.44 (89.20)[bc]	10.50[d]	2.74[bc]	935.55[de]
C4T1	9.31 (86.59)[b]	9.69[bc]	2.25[a]	839.25[cde]
C4T2	9.09 (82.62)[ab]	8.33[a]	2.39[ab]	689.97[ab]
C5T1	9.58 (91.79)[bc]	9.33[bc]	2.59[b]	853.31[bcde]
C5T2	8.55 (73.10)[a]	9.19[b]	2.30[ab]	676.87[a]
C6T1	9.16 (84.00)[ab]	9.30[bc]	2.49[ab]	784.00[bcde]
C6T2	8.56 (73.24)[ab]	9.55[bc]	2.65[bc]	713.44[abcd]
C7T1	8.56 (73.28)[ab]	9.48[bc]	2.41[ab]	702.32[abcd]
C7T2	9.01 (81.25)[ab]	8.82[abc]	2.55[ab]	714.13[abcd]
SEM	0.20	0.25	0.07	31.35
CD	0.68	0.78	NS	122.78
Control	8.71 (75.89)	8.49	2.49	651.60
SEM^	0.11	0.21	0.01	33.80
CD^	NS	0.78	NS	122.78

*Control- non factorial, ** Square root transformation, SVI-I = Seedling vigour index- length, NS = Non Significant, ^ = non factorial versus rest.

the control, the seedling growth was effectively increased.Similar results were reported by Bahrani and Pourreza, 2012 in wheat seeds kept in gibberellic acid solution (1 m Mol GA) for 6 hrs, where upon treatment the hypocotyle length increased over the control. These results conform with the findings of Ali *et al.* (2021) in Soghum and Paikra *et al.* (2021) in Papaya. As a natural formulation seed soaked (over a duration) with Beejamrit have promising effect on seedling length producing higher seedling length and root volume in maize and finger millet (Jha *et al.*, 2020) and better seedling length over control in field pea (Chandra and Chaurasia, 2021). In present study. Beejamrit treatment produced on par seedling length with GA_3. Beejamrit improves seedling length as seed treatment over control (Fernando and Ekanayake, 2022) completely rejuvenates the seed (Burra and Menon, 2021) and IAA presents in this natural formulation is involved in the root and shoot development (Nirmale and Ulape, 2020).

There was a non-significant difference among the treatment combinations for seedling dry weight. Among the individual treatments seedling dry weight ranged from 2.32 to 2.72 mg with highest seedling dry weight of 2.72 mg was observed in the treatment C2 (40 ppm GA-3 seed soaking) followed by 2.69 mg in C3 (60 ppm GA-3 seed soaking) (Fig. 3). The treatment 24 hrs seed soaking duration recorded higher seedling dry weight (2.60 mg).GA_3 promotes cell division and nutrient intake, which accelerates seedling growth and increases fresh and dry weight (Paikra *et al.*, 2021) upon soaking seeds of papaya cv. Red Lady in the aqueous solution of GA_3 100 ppmfor 12 hrs. There was a parallel increase in fresh and dry weight of maize seedling (Cetinkaya *et al.*, 2021) along the seedling height with application of GA_3 as seed treatment for 24 hrs. In another finding soaking seeds in GA 80 ppm for 12 hours produced higher seedling dry weight in Rangpur lime as an after effect of finer translocation of photosynthetic products to sink that renders a better seedling growth and increased auxin levels that stimulated more root initiation (Dilip *et al.*, 2017). Similar results upon GA_3 seed treatment were produced by Hota *et al.* (2018) in Jamun, Chauhan *et al.* (2019) in Oats and Jafri *et al.* (2015) in Sunflower.

Seedling vigour index ranged from 676.87 to 935.55 among the treatment combination. The treatment combinations C3T2 (60 ppm GA-3 seed soaking +24 hrs) showed better performance in the seedling vigour with maximum SVI-I of 935.55 over others and it was statistically on par with C6T1 (Beejamrit+12 hrs seed soaking) (784.00) (Beejamrit seed soaking + 12 hrs) (Fig. 4). Maximum (918.38) SVI- I was recorded in the C3 followed by C2 and C6 was statistically at par with the highest at SVI- I of 748.72. A seed soaking duration of 12 hrs improved the seedling vigour as it recorded the SVI- I value of 816.80 as compared to 24 hrs seed soak and also as compared to no soaking *i.e.* control. The higher seedling vigour index

Fig. 4 : Effect of natural formulation and chemical on seed vigor Index (SVI).

(SVI-I) in the aforesaid treatment and treatment combination may be attributed to their higher value of germination and seedling length as discussed earlier. According to Paikra *et al*. (2021) the endogenous GA_3 levels of the seedling were insufficient hence, when the seeds were treated with GA_3 externally there was an improvement in growth thereby aiding in the invigouration of plant physiological processes promoting higher seedling vigour index. A seed soaking treatment with 150 ppm GA_3 for 12 hrs duration promotes higher SVI- I in soybean as compared to the control (Seyit and Sahane, 2022). These findings are in concordance with the results of Singh *et al.* (2019) in custard apple; Shihab and Hamza (2020) in sorghum and Kabilan *et al*. (2022) in chilli. The on-par treatment Beejamrit produced more vigour seedling than the control due to more germination percentage and seedling length as per the results of Bhargavi *et al.* (2019) in black gram seeds.

Conclusion

The present study reveals that never the less, *Eleusine coracana* is a drought-hardy crop, but a seed invigoration treatment provides an edge to the seeds of this crop to perform well upon sowing. In the present case, both GA-3 as chemical seed soaking and Beejamrit as a seed soaking in natural formulations proved to be beneficial in improving the seed quality traits. GA-3 @ 60 ppm was the optimum dose as compared to very low and very high concentration *viz*., 20 ppm and 100 ppm in producing higher seed quality characteristics. GA-3 is a chemical seed treatment and will add to the price of seed production, whereas Beejamrit is locally prepared and readily available at the farmer's field. So, farmers can opt for it as a more sustainable approach. This will be an advantage to the farmers for an early start to its nursery as well in hills, where the nursery may be ruined by untimely rains.

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