

Participatory Evaluation of Seed Treatment Techniques to Improve Seed Quality and Yield in Tomato (*Lycopersicum esculentum*) at Wolaita Zone, Southern Ethiopia

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Abstract

The research was conducted using 8 seed treatments which include: 5% HCl, 10% HCl, 5% H_2SO_4, 10%H_2SO_4, Sodium Carbonate (5%), Wood Ash, Hot water treatment & fermentation at 'Mante Gerera' Kebele (Peasant Association) Sodo Zuriya woreda in Wolaita Zone, Southern Ethiopia, in 2011 with the objectives to identify the best seed treatment technique that improves seed quality and subsequent yield in tomato and to disseminate knowledge and skill of seed treatment techniques for farmers and other stakeholders. The experiment was done under laboratory and field condition. The laboratory work focused on seed extraction, treatment and germination. Concerning seed quality, seeds treated with acids have shown better quality in terms of color. The best result was that of HCl treated ones. In case of germination, date of germination and percentage of germination showed statistically significant difference ($p = 0.05$) among treatments. The fast germination (2.33days) was observed in seeds treated with 10% HCl, 5% H_2SO_4 and hot water where as the most delayed one was wood ash treated seeds (4.17 days). The highest germination was obtained by seeds treated with 5% H_2SO_4 (96.67%) and the lowest (63.33%) was that of seeds treated with wood ash. Thus, it can be said that nearly 33% of seeds could be saved by treating seeds with acids. Statistical analysis showed non-significant difference among treatments in plant height. But branch number per plant has showed statistically significant difference ($p = 0.05$) among treatments. The highest branch number per plant (6.67) was recorded by hot water treatment followed by 5% H_2SO_4 (6.50). On the other side, the lowest average branch number per plant (4.78) was recorded by fermentation. The highest mean fruit diameter was observed in seeds treated with 10% HCl (39.2 mm) and 10% H_2SO_4 (38.17mm). Generally better results were observed in acid treatments than nonacid treated seeds. The highest value in fruit yield (516.42 qt/ha) was recorded by 10% H_2SO_4 followed by 5% HCl whose yield recorded was 478.40 qt/ha. The lowest yield (349.79 qt/ha) was recorded by wood ash treatment. Therefore, it is advisable for seed business men to treat with HCl to fetch high market demand than local producers and nearly 33% of seeds could be saved by treating seeds with acids. Thus, it is advisable to treat tomato seeds with acids so as to improve its quality in terms of color, germination date and percentage. It can be generalized that tomato seeds treated with acids are the best in terms quality and fresh fruit yield.

Key words: Mante Gerera, Tomato, acids, wood ash, fermentation, seed extraction, quality, yield

1. Introduction

Tomatoes are the second most consumed vegetable and the most popular fruit vegetables since it has versatile uses in the vegetable recipe in the world. The popularity is because of they are eaten fresh or processed and can be stewed, fried, baked, or used as juice. In addition to this versatility, tomatoes are also nutritional. They are low in calories (20 calories per average size fruit) and an excellent source of iron and vitamins A and C. They also contain small amounts of the B complex vitamins thiamin, niacin, and riboflavin (Chadha, 2006).

Seeds are one of the least expensive but most important factors influencing yield potential. Crop seeds contain all the genetic information to determine yield potential, adaptation to environmental conditions, and resistance to insect pests and disease. Seed produced under controlled condition is likely to be higher yielding and is less likely to harbor pathogen than locally produced seeds (Barsa, 2006; Rice *et al*., 1990). Increasing agricultural production through the use of high quality seed, among other agricultural inputs, has become essential for providing enough food for rising number of people in the world today (Barsa, 2006).

Seed quality is determined by many factors, principally seed purity and germination. However, many other factors, such as the variety, presence of seed-borne disease, vigor of the seed, and seed size are important when considering seed purchase. Seed lots that have low germination also are less vigorous due to seed deterioration. As seeds deteriorate, loss of vigor precedes loss of viability, so seeds with low germination usually will be less vigorous.

Hence, in seed lots with poor germination, those seeds that do germinate often produce weaker seedlings with reduced yield potential (Barsa, 2006; Nemati*et al*., 2010). However tomato production is challenged by several factors among which shortage of improved quality seed is the one. Farmers in the area use and even government offices provide seeds for farmers which are purchased from supper markets without clear understanding of its quality, adaptability and viability as well.

The seed quality of tomato is affected by factors such as seed treatment method, duration and fermentation temperature for seed extraction and fruit maturity. For tomato seed extraction, fruit is placed into a crusher that pulverizes the fruit and separates the gelatinous seed from the remaining fruit tissues by pressing them through screens. The extract containing the gelatinous seed material must still be separated from the remaining pulp in various methods such as fermentation, acid, alkali and hot water treatments (Agrawal, 1994; Nemati *et al*., 2010).

In fermentation methods, the selected ripe fruits are harvested, crushed and allowed for fermentation in non-metallic containers at room temperature for two to three days. The pulps remain in the extract until the gel surrounding the seeds has been degraded by microorganisms. The mixture should be stirred at once or twice a day to maintain a uniform rate of fermentation, also to release the seeds entrapped in the floating pulp and to prevent a fungal growth from starting at the surface of the mass, which can injure or discolour seeds. When fermentation is complete, the good seeds settle down at the bottom and much of the pulp floats at the top, leaving a layer of clear liquid in between. The duration of fermentation process is largely dependent on the temperature. If it is between 24 to 27°C, satisfactory separation of seed and pulp may be achieved within 48 to 72 hrs. In relatively high temperatures (25-30°C) the fermentation is complete in approximately 24 hrs. Excessive fermentation reduces seed quality. Usually the longer the fermentation time and the higher the temperature resulted in the greater reduction in germination (Agrawal, 1994).

In chemical methods, hydrochloric acid, sulphuric acid and sodium carbonate are usually used. The acid treatment methods are often favoured by large commercial producers as it rapidly degrades the gelatinous seed coating resulting in the production of a very bright clean seeds. Efficient breakdown of the gel surrounding the seed and quick cleaning, avoiding of the low and high temperatures problem, eradication of bacterial canker and producing bright looking seed coat are important features of acid treatment method. However, it can be deteriorative on seed quality if application period and concentration are not appropriate. Sodium carbonate accomplishes the same task as hydrochloric acid without the potential danger to workers. However, it darkens the seed coats and makes the seeds less attractive as a commercial product. After seed treatment, the seeds are immediately washed to remove digested materials and any remaining chemicals. This is accomplished by placing the seeds and chemicals in long, slightly angled water troughs that contain a series of riffles at specific intervals (Chadha, 2006; Tindall, 1983).

Hot water treatment is preferred because the bacterial canker pathogen survives inside the seed coat and is not completely eliminated by surface disinfestations using Clorox, acid, or other treatments. It is also permitted for organic tomato production. Tomato seeds should be placed in a loosely woven cotton (e.g. cheesecloth) bag and immersed in a 122 degree Fahrenheit water bath for 25 minutes exactly (Agrawal, 1994; Rice *et al*., 1990).

Supplying of high quality seeds is the basic requirement and it contributes greatly to the success of any crop. As far as tomato is concerned, factors like inadequate seed production technology, absence of suitable varieties and poor post-harvest seed handling resulted in the unavailability of good quality seed became a major problem. The crop is produced in Wolaita area long ago in small plots of land for local markets and house hold consumption. Nowadays, there is highly increasing demand for the crop nearby towns. But farmers in the locality use uncertified seeds because of the crop's perishable nature and due to lack of information on seed extraction and seed treatment of the crop. Therefore, the current study was conducted with the following objectives: to identify the best seed treatment technique that improves seed quality and subsequent yield in tomato, and to disseminate knowledge and skill of seed treatment techniques for farmers and other stakeholders.

2. Materials and Methods

2.1. Description of the Study Area

The research was conducted at Mante Gerera kebele in Sodo Zuriya Woreda, Wolaita Zone, Southern Ethiopia. The particular site is about 18 km away from Wolaita Sodo University in south west direction with an altitude of 1700 masl. The area approximately receives average annual rain fall of about 1212 mm and mean annual temperature of 21^{o}C.

2.2. Treatments & Experimental Design

The experiment was conducted using Randomized Complete Block Design (RCBD) with three replications using the following treatments: 5% HCl, 10% HCl, 5% H_2SO_4, 10%H_2SO_4, Sodium Carbonate (5%), Wood Ash, Hot water treatment & Fermentation. In chemical treatment methods, the respective concentrations of chemicals were used and seeds put in woven cloth were immersed in solution containing chemicals for 30 minutes. The seeds after soaking were washed immediately by pure cold water and allowed to dry under partial shade condition. For hot water treatment, bag containing the seeds were immersed in 122 ^{0}F water bath for 25 minutes. The seeds then were immediately removed and washed by pure cold water and dried. In the fermentation method, the pulp with the seeds was left for fermentation for about 2 days. The seeds then washed immediately by pure cold water and dried. In wood ash treatment, the fresh extracted seeds were washed using wood ash until the gelatinous material was removed away and then the seeds were dried.

Field trial was done using plant spacing of 90 X 30 cm between rows and plants, respectively. Each plot had 5 rows and 10 plants per row. The total plot area was 4.5m X 3.0 m = 13.5m^2 with 24 total plots. The space between each plot was 50 cm and between blocks was 1m. The total area required was (15.5m X 28m) = 434m^2.

2.3. Data Collected

Data on seed quality, vegetative and yield were collected. These include: Seed color, Date of germination, Percentage of germination, Plant height (cm), Number of branches per plant, Number of fruits per plant, Fruit size (diameter) (mm), Marketable fresh yield (kg), Unmarketable fresh yield (kg)and Total fresh yield (kg). For description of the soil of the study area, composite soil sample from 0 – 30 cm soil depth was collected from the experimental field and analyzed for soil texture, pH, available P, total N, and organic carbon.

2.4. Data Analysis

The collected data were analyzed by using statistical software (SAS version 9, 2002) and mean separation was done by LSD at 5% probability.

3. Results and Discussion

3.1. Selected Physioco-Chemical Properties of the Experimental Soil

The selected physical and chemical characteristics of experimental soil were soil pH, soil texture, organic carbon (OC), total nitrogen (TN) and available phosphorus (Av. P) (Table 1).

The textural class of experimental soil was sandy loam. The pH of the site (5.7) was moderately acidic according to Herrera (2005) who classified pH range of 5.6 to 6.2 as moderately acidic. The pH of the soil was suitable for crop in general and for tomato in particular as tomato performs best in soils with moderately acidic soil pH. The organic carbon content of the experimental site was 3.39 % which could be classified as medium range based on the classification made by Landon (1991) who classified as medium range the OC content of 2 to 4 %. The analysis result of available phosphorus content of experimental site was high according to Pushparajah (1997) who classified available P contents of soil in mg kg^{-1} < 11, 11 - 20, 20 – 30 and > 30 as low, medium, high and very high, respectively. The total nitrogen (TN %) content of the experimental site was 0.19 % and based on criteria set by Landon (1991) the N content was low.

3.2. Laboratory Experiment

3.2.1. Seed Quality

3.2.1.1. Seed color

Very bright clean seeds were observed on seeds treated with acids and hot water treatment than others. The most clean and bright seeds were observed by HCl treatments followed by H_2SO_4 and hot water treatments in more or less similar in color. The poorest and dull color was observed by seeds treated with wood ash followed by sodium carbonate. Fermentation has given seed color of medium brightness as compared to acids and hot water treatments

3.2.1.2. Date of Germination (DG)

The analysis indicated that there is a significant difference (p = 0.05) among treatments in date of germination for seeds treated with acids, hot water and fermentation and that of seeds treated with wood ash and Sodium carbonate (Table 2). The result indicated that 10% HCl, 5% H_2SO_4 and hot water treatments showed the fastest germination date (2.33 days). Again the value is followed by 5% HCl, 10% H_2SO_4 and fermentation (2.5 days). However, the most delayed germination was observed in wood ash treatment (4.17days) followed by Sodium carbonate (4.00 days). Moreover, the result indicated that seeds treated with acids, hot water and fermentation did not show significant difference in date of germination.

3.2.1.3. Germination Percentage (GP)

The data analysis indicated that there was significant difference (p = 0.05) among treatments in germination percentage (Table 2). The lowest value was obtained for seeds treated with wood ash (63.33%) and that of the highest value was obtained by seeds treated with 5% H_2SO_4 (96.67%) followed by hot water treatment (95.56%). In general, better result was obtained in seeds treated with acids, hot water and fermentation (>85%) but those seeds treated with Sodium carbonate (76.67%) and wood ash (63.33%) were inferior in germination percentage (see figure)

3.3. Field Experiment

Under field condition Plant height (cm), branch number per plant, fruit diameter (mm), average number of fruit per plant, marketable fresh fruit yield, unmarketable fresh fruit yield and total yield were recorded.

Statistical analysis showed non-significant difference among treatments in plant height. But branch number per plant has showed statistically significant difference (p = 0.05) among treatments. The highest branch number per plant (6.67) was recorded by hot water treatment followed by 5% H_2SO_4 (6.50). On the other side, the lowest average branch number per plant (4.78) was recorded by fermentation.

The average fruit number per plant was not significantly different (p = 0.05) among treatments. However, the highest fruit number per plant (35.67) was recorded by 10% H_2SO_4 while the lowest mean value (30.94) was observed in wood ash treatment (Table 2).

Fruit diameter has shown statistically significant difference (p = 0.05) among treatments. The highest mean fruit diameter (39.2 mm) was recorded by 10% HCl followed by (38.17 mm) in 10% H_2SO_4. The lowest value in fruit diameter (34.57 mm) was observed in fermentation followed by (34.80 mm) in hot water treatment (Table 2). Generally better results were observed in acid treatments than nonacid treated seeds.

Fresh marketable fruit yield has shown significant difference among treatments. The highest value in fruit yield (516.42 qt/ha) was recorded by 10% H_2SO_4 followed by 5%HCl whose value recorded was 478.40 qt/ha. The lowest yield (349.79 qt/ha) was recorded by wood ash treatment. The next lower value (373.46 qt/ha) was recorded by fermentation (Table 2). On average, those seeds treated with acids have relatively better yield than those treated with others.

Unmarketable and total fresh fruit yield did not show significant difference among treatments. However, the highest value in total fresh fruit yield (704.69 qt/ha) was recorded by 10% H_2SO_4 while the lowest total yield (529.84 qt/ha) was recorded by fermentation. Similarly, the total yield that is the sum of both marketable and unmarketable yield did not show significant difference among the treatments (Table 2).

4. Summary and Conclusion

The experiment was conducted under laboratory and field condition. The laboratory work focused on seed extraction, treatment and germination test as well. During laboratory work, training of seed extraction was given for FRG members and DAs (development Agents) and hence important skills about tomato seed extraction and seed treatment techniques have been gained by FRG members.

As far as seed quality is concerned, seeds treated with acids have shown better quality in terms of color. Those seeds treated with HCl & H_2SO_4 of different concentration have shown relatively brighter in color than other treatments. The best result was that of HCl treated ones. Therefore, it is advisable for seed business men to treat with HCl to fetch high market demand than local producers. As far as germination test is concerned, date of germination and percentage of germination showed statistically significant difference among treatments. The fast germination (2.33days) was observed in seeds treated with 10% HCl, 5% H_2SO_4 and hot water where as the most delayed one was wood ash treated seeds (4.17 days). In case of germination percentage, the highest germination was obtained by seeds treated with 5% H_2SO_4 (96.67%) and the lowest (63.33%) was that of seeds treated with wood ash.

Under field condition, plant height (cm), branch number per plant, fruit diameter (mm), average number of fruit per plant, marketable fresh fruit yield, unmarketable fresh fruit yield and total yield was measured. Among these parameters, branch number per plant, fruit diameter (mm) and marketable fresh fruit yield showed statistically significant difference among treatments. Other parameters did not show difference significantly. Better branch number per plant was recorded by hot water treatment followed by 5% $H_2SO_4$and 10% H_2SO_4. The highest mean fruit diameter was observed in seeds treated with 10% HCl (39.2 mm) and 10% H_2SO_4 (38.17mm).Generally better results were observed in acid treatments than nonacid treated seeds. The highest value in fruit yield (516.42 qt/ha) was recorded by 10% H_2SO_4followed by 5% HCl whose value recorded was 478.40 qt/ha. The lowest yield (349.79 qt/ha) was recorded by wood ash treatment.

It can be generalized that tomato seeds treated with hydrochloric acids are the best in terms of quality. The result showed that nearly 33% of seeds could be saved by treating seeds with acids. Thus, it is advisable to treat tomato seeds with acids so as to improve its quality in terms of color, germination date and percentage. For those who are engaged in tomato seed marketing, it is advisable to treat seeds with 5% HCl acid that yielded bright quality color that is very clean and attractive. Though the field work needs repetition to give valid conclusion, based on the current work it is possible to say that acid treated seeds were better in marketable fresh fruit yield. Therefore, it can be concluded that acids are the best options in tomato seed treatment to improve both quality and final fruit yield.

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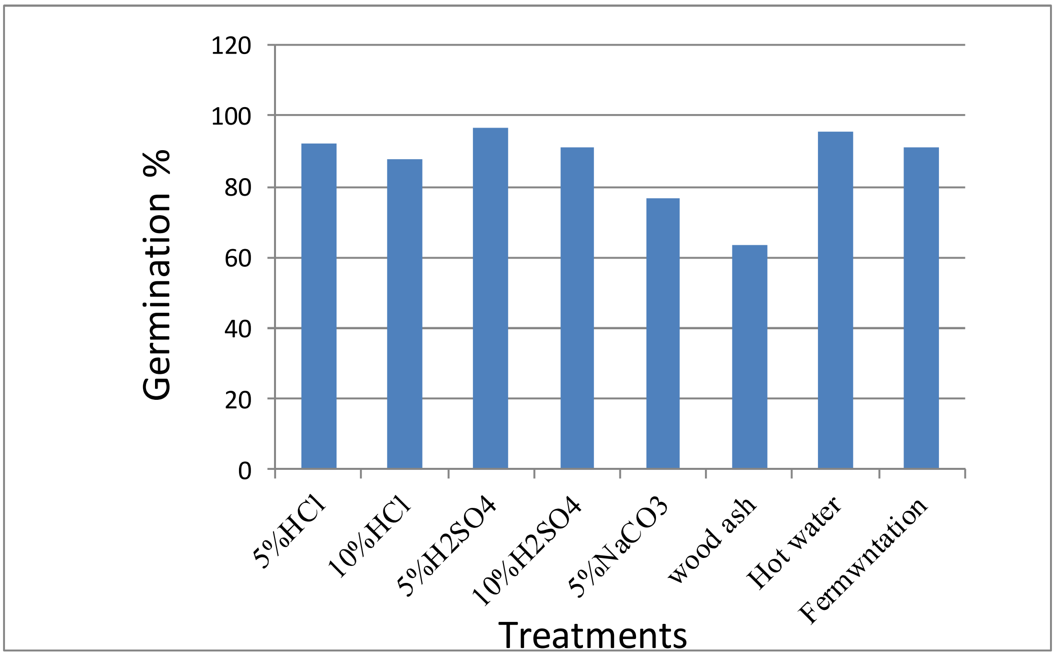
Germination %
120
100
80
60
40
20
0
5%HCl
10%HCl
5%H2SO4
10%H2SO4
5%NaCO3
wood ash
Hot water
Fermwntation
Treatments

Table 1: Selected physioco-chemical properties of experimental soil before sowing.

Soil Texture	pH (H_2O)	OC (%)	TN (%)	Av. P (mg/kg) (Olsen)
Sandy loam	5.7	3.39	0.19	28.94

Table 2: Summarized mean values of traits studied under laboratory and field condition, 2012.

Trt	DG (days)	PG (%)	Ph (cm)	BN	FD (mm)	FN	MY (qt)	UMY (qt)	TY (qt)
1	2.50	92.22	88.69	6.1667	36.93	35.280	478.40	191.36	669.75
2	2.33	87.78	84.61	5.633	39.20	35.277	402.26	187.24	589.51
3	2.33	96.67	87.44	6.500	36.50	34.223	406.38	148.15	554.53
4	2.50	91.11	90.11	6.400	38.17	35.667	516.42	188.27	704.69
5	4.00	76.67	83.05	6.0667	35.27	35.170	476.34	219.14	695.48
6	4.17	63.33	88.11	6.0667	34.57	30.947	349.79	189.30	539.09
7	2.33	95.56	88.00	4.7667	34.80	32.723	400.62	151.24	529.84
8	2.50	91.10	83.94	6.6667	35.77	33.220	373.45	156.38	551.85
mean	2.83	86.80	86.74	6.03	34.06	36.40	425.46	178.88	604.34
LSD	0.55	11.59	ns	0.96	3.47	ns	144.43	ns	Ns

Trt= treatments; DG=date of germination; GP= germination percentage; Ph= plant height (cm);Bn= Branch number/plant; Fn= fruit number/plant; Fd= fruit diameter(mm); My= marketable yield(qt/ha); UMy= unmarketable yield (qt/ha); Ty= total yield(qt/ha).