Research Article
Open Access

Effect of acid media on seed germination performance of Swiss-chard (*Beta vulgarise* L.)

Abstract

Objectives: An experiment was designed with the objectives of studying the effect of acidity (pH) on the seed germination performance of Swiss-chard, and to determine the optimal pH level for the highest seed germination.

Methods: The study was carried out in the laboratory of the Department of Horticulture of the University of Wolkite. The treatments were different pH levels (2, 4, 6 and 7) obtained from solutions of citric acid and distilled water in different concentration mixtures. The CRD design was used with three replicates.

Findings: Analysis of variance (ANOVA) showed that all recorded germination parameters (germination rate, mean germination time, germination speed and germination index) were all most significantly different *($p<0.001$)* for different pH levels. The highest seed germination rates (85.33% and 81.33%) were recorded at pH 7 and pH 6 respectively. Similarly the highest mean germination time (13 days and 11 days) and the highest germination speed (3.88/day and 3.7/day) were recorded at pH 6 and pH 7, respectively. However, the lowest seed germination rate (4%), the lowest mean germination time (0.5 days) and the lowest seed germination speed (0.18/day) at pH 2. The highest germination index (100 and 95.42) was recorded at pH 7 and pH 6 respectively while the lowest seed germination index (4.61) was recorded at pH 2. In general pH 7 and pH 6 can give the best results to the highest germination yield of Swiss chard.

Keywords: Swiss chard, pH, germination percent, mean germination time, germination index

Volume 7 Issue 1 - 2023

Birhanu Tsegaye Sisay, Habtam Fentaye
Wolkite University, Welkite, South Ethiopia

Correspondence: Birhanu Tsegaye Sisay, Wolkite University, Welkite, South Ethiopia, Tel +251-965198424, Email birhanutsegay91@gmail.com

Received: March 03, 2023 | **Published:** March 17, 2023

Introduction

Swiss chard (*Beta vulgaris* L.), a leafy biennial vegetable, belonging to the Chenopodiaceae family, is a highly nutritious leafy vegetable and popularly known in many parts of the world for its nutritional properties, all year round availability, low cost and is widely used in many dishes.[1] Its leaves and stalks contain relatively high levels of vitamins A, B, and C, as well as minerals, such as calcium, phosphorus and iron.[2] Cooked leaves yield 20 kcal per 100 g.[3] In Ethiopia, it has been producing around urban and peri-urban areas compared to lettuce and cabbage and little research effort was made before on this vegetable. However, this vegetable has advantages that can contribute significant positive impact on improving food security especially on reducing malnutrition.[4]

The plants of chard were grown on neutral and alkaline soil with different agrochemical characteristics. The quality and quantity of chard depended on soil properties. The content of P, K and Mn in chard depended on its concentration in soil and the chard Ca and Mg were regulated by the content of exchangeable soil Ca and Mg. The opposite trend was noticed between soil pH and chard Mn and Cu content. The yield was in positive significant relationship with available soil.[5] Chemical compositions as well as nutritional value of chard may greatly vary depending on climatic conditions, soil characteristics and nutrient supply as important determinants of quantity and quality of yield of agricultural plants.[6] Swiss chard is a very nutrient demanding crop species. The content of mineral elements, total quality and yield are influenced by the amount, frequency and method of fertilization.[7] Soil characteristics influence nutrient solubility, but also microbial activity and root growth.[8]

Soil acidity had become a serious threat to crop production in most highlands of Ethiopia in general and in the western part of the country in particular. About 40.9 % of Ethiopia is covered by acid soils, 28% by moderately acidic soils (pH 4.5 - 5.5), 13% by strongly acidic soils (pH <4.5).[9] An earlier study estimated that about 41% of arable lands of Ethiopia are affected by soil acidity/Al^{3+} toxicity. But recently the status of most soil in western Ethiopia was became acidic though the degree varied from location to location; severely limiting crop production.[10]

Farmers have been producing Swiss chard in acid affected area in Ethiopia especially in highland areas as well as in urban and around urban areas under both irrigation and rain-fed conditions. No previous investigations were made on the effect of acidity on seed germination performance of swiss chard. Therefore, the current study was designed with the objectives to evaluate the effect of acidity on seed germination of Swiss chard (var. Fordhook Giant) and identify the optimum pH level for the best seed germination and therefore better growth of Swiss chard.

Material and methods

Experimental area

The experiment was conducted in 2021 at Horticulture department laboratory of Wolkite University, Ethiopia. Wolkite University is located about 158 km southwest of the capital city, Addis Ababa, on the way to Jima. Geographically the university is located at 7.8-8.5°N latitude and 37.5-38.7°E longitude with an altitude range of 1300-1400 m.

Description of experimental material

Fordhook Giant variety of swiss chard was used as experimental material. Fordhook Giant has darker green leaves and broader leaf stems. Fordhook Giant is a widely known variety. It is well adapted

to Ethiopian environmental condition.[11] A canned and certified seed of Swiss chard variety was obtained from local agriculture shop.

Treatments and experimental design

The experiment comprised of four levels of acid treatments (pH 2, pH 4, pH 6) and pH 7 (control treatment) which were obtained by mixing citric acid with distilled water in different formation, except for the control treatment which was only distilled water. The treatments were laid out using Completely Randomized Block Design (CRD) with three replications. All the other factors were constant and kept under uniform condition. Treatments were assigned randomly to each experimental petri-dish.

Experimental procedure

Petri-dishes were washed and cleaned and made free from any dirty and oven dried to kill biofilm. Lemon juice was extracted and different pH solutions were formulated along with distilled water in different concentration mixture, and also has varied nutritional constituents as described in the table 1 below. The total ascorbic acid (pH) values found in lemon juice were adjusted using digital pH meter. White single layer of tissue paper was placed on the Petri dishes and a constant 30ml of solution from each pH concentration treatment were added to each Petri dish, and 50 counted seeds of Swiss-chard were placed on the Petri dish and covered. The Petri dishes were placed in growth room under optimum temperature condition for facilitating seed germination of swiss-chard.

Table 1 Nutritional content of lemon per 100g of juice

Name	Amount	Unit
Water	92.3 g	g
Ash	0.21 g	g
Sugars, total including NLEA	2.52 g	g
Sucrose	0.43 g	g
Glucose	0.99 g	g
Fructose	1.1 g	g
Calcium, Ca	6 mg	mg
Iron, Fe	0.08 mg	mg
Magnesium, Mg	6 mg	mg
Phosphorus, P	8 mg	mg
Potassium, K	103 mg	mg
Sodium, Na	1 mg	mg
Zinc, Zn	0.05 mg	mg
Copper, Cu	0.016 mg	mg
Manganese, Mn	0.012 mg	mg
Vitamin C, total ascorbic acid	38.7 mg	mg
Vitamin A, IU	6 IU	IU

Source: USDA, 2019

Data collection

Numbers of germinated seedlings were counted on regular interval and the following germination parameters were computed.

Germination percentage (%): calculated using the following formula by Khan et al.[12]

$$GP = \frac{N_i}{N} * 100$$

Mean germination time (day): was calculated using the following formula.[13]

$$MGT = \sum \frac{ni * di}{N}$$

Germination speed (s) (number/day): was calculated using the following formula developed by Khan et al [12]

$$S = \frac{ni}{Di}$$

Germination index: was calculated according to the following equation,[13]

$$GI = \frac{Germination\ \%\ in\ each\ treatment}{Germination\ \%\ in\ the\ control} * 100$$

Data analysis

The significance of the effect of pH and nutrition on the 4 response variables (germination percent, mean germination time, germination speed and germination index) was determined using Analysis of Variance (ANOVA) of a Completely Randomized Blocks Design (CRD). For each response variable, the validity of normal distribution and constant variance assumptions on the error terms was verified by examining the residuals. Independence assumption was met due to the randomization of the varieties within each block. Since the effect of pH was significant (P-value < 0.05) for the response variables, means comparison was conducted using the LSD method at 5% level of significance. The analysis was computed using the GLM procedure of SAS 9.3.

Results

The analysis of variance (ANOVA) showed that all the recorded germination parameters (germination percent, mean germination time, germination speed and germination index) were highly significantly different ($p<0.001$) for different pH level. In the present study, increased level of acidity was found to adversely affect the germination of Swiss chard.

Germination percent

The highest germination percent (85.33% and 81.33%) was recorded at pH 7 and pH 6, respectively which was followed by pH 4 and the lowest germination (4%) was recorded from lowest pH treatment (pH 2) (Figure 1). This showed that pH had significant effect on seed germination of Swiss chard. Therefore significantly highest germination was recorded at neutral and slight acidic condition. Based on the data, result indicated that germination percentage of Swiss chard seeds was accelerated at neutral pH and pH 6 and decelerated at pH 4 and pH 2. This is because; strong citric acid has inhibiting effect on the radicle as well as hypocotyl germination of swiss-chard. The current result is somewhat in line with other studies on that effect of soil acidity at germination on yields of sweet clover and alfalfa,[14,15] has shown that both crops grew well and produced large yields even on strongly acid soils (pH<4.0) provided that germination occurred in a neutral medium.

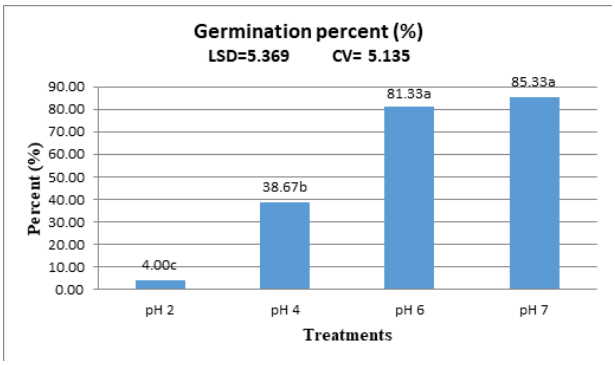

Figure 1 Treatments means and mean comparison for germination percent of swiss-chard.

Citation: Sisay BT, Fentaye H. Effect of acid media on seed germination performance of Swiss-chard (*Beta vulgarise* L.). *Horticult Int J.* 2023;7(1):9–12. DOI: 10.15406/hij.2023.07.00269

Mean germination time

ANOVA showed significant effect of pH on mean germination time of Swiss chard. The highest mean germination time (13 day) was recorded at pH 6 which is in statistical parity with pH 7 (11 day). However, the lowest mean germination time (0.5 day) was recorded at treatment pH 2 (Figure 2). This showed that acidity had effect on germination time. This is because strong acidity can prevent the germination time, and weak acidity and neutral condition will prevail the germination time.

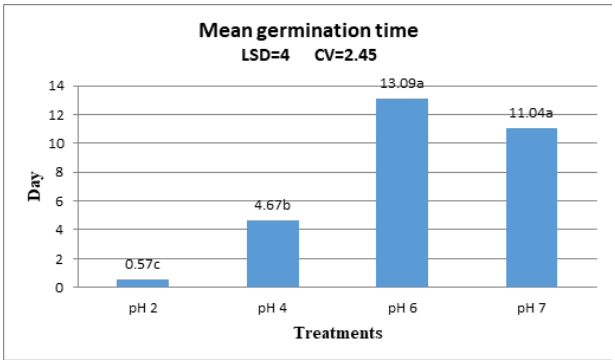

Figure 2 Treatments means and mean comparison for mean germination time of swiss-chard.

Germination speed

The analysis of variance also revealed that pH had highly significant effect on germination speed of Swiss chard. Thus, the highest germination speed (3.88/day) was recorded at pH 7 (neutral) which was not significantly different with treatment pH 6 (3.7/day) which is followed by pH 4 and pH 2. The lowest seed germination speed was recorded at treatment pH 2 (Figure 3). Thus, it can be concluded that neutral and slight acidic growing media can enhance (accelerate) the seed germination speed of Swiss chard.

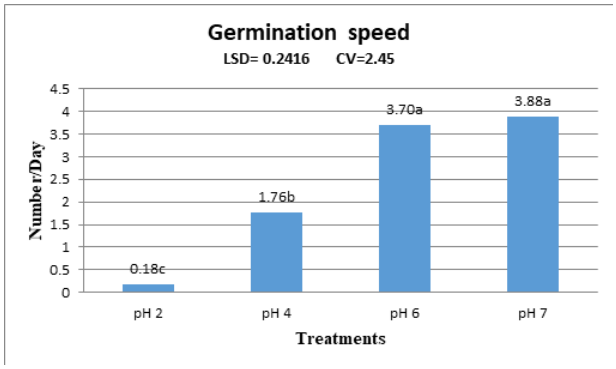

Figure 3 Treatments means and mean comparison for germination speed of swiss-chard.

Germination index

ANOVA showed highly significant different between treatments on seed germination index. The highest germination index (100) was recorded at pH 7 which was not significantly different with pH 6 (95.42). The lowest seed germination index was recorded at treatment pH 2 (4.61) (Figure 4).

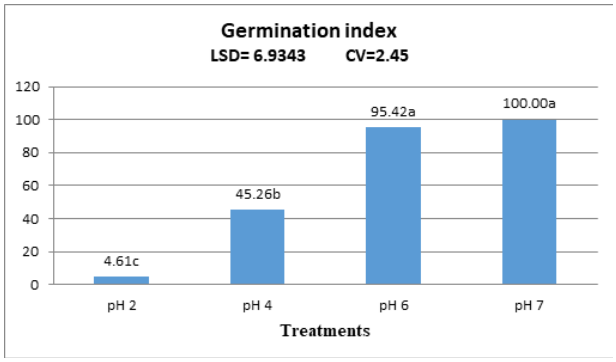

Figure 4 Treatments means and mean comparison for germination index of swiss-chard.

Conclusion

From the current study, we can conclude that both slight acidity (pH 6) and neutral (pH 7) conditions are preferable for Swiss-chard seed germination. This implies that chard production can also be favoured at slightly acidic and neutral condition. However, strong acidity (pH 2 and 4) conditions are not good for the germination and production of Swiss chard. Therefore, it is advisable to amend strong acid soils by adding lime to maintain current soil pH status or increase surface soil pH. The management of acid soils should aim at improving the production potential by the addition of soil amendments to correct the acidity and manipulate the agricultural practices to obtain optimum crop yields.

Acknowledgments

None.

Conflicts of Interest

None.

References

1. Gao ZJ, Han XH, Xiao XG. Purification and characterization of polyphenol oxidase from red Swiss chard (Beta vulgaris subspecies cicla) leaves. *Food Chem*. 2009;117:342–348.
2. Pyo Y, Lee T, Logendra L, et al. Antioxidant activity and phenolic compounds of swiss chard (Beta vulgaris Subspecies Cycla) Extracts. *Food Chem*. 2004;85:19–26.
3. Wyk V, BE. *Food plants of the world, identification, culinary uses and nutritional value*. 1st Edition. Briza Publication. Pretoria:South Africa; 2005.
4. Gebremedhin H, Awgechew H. The response of Swiss chard (Beta vulgaris L.) to nitrogen levels and intra-row spacing in Debre Berhan Central Ethiopia. *Journal of Horticulture and Postharvest Research*. 2019;2(2):105–116.
5. Knežević M, Durović D, Mugoša B, et al. Relationships between parameters of soil and chard (Beta vulgaris L. Var. Cicla L.). *Agriculture & Forestry*. 2014;60(3):275–283.
6. Brito LM, Pinto R, Mourão I, et al. Organic lettuce, rye/vetch, and Swiss chard growth and nutrient uptake response to lime and horse manure compost. *Org Agr*. 2012;2:163–171.
7. Miceli A, Miceli C. Effect of nitrogen fertilization on the quality of Swiss chard at harvest and during storage as minimally processed produce. *J Food Quality*. 2014;37:125–134.
8. Knežević M, Perović N, Radulović M, et al. *Monitoring of soil fertility in Montenegro*. 12th congress of society of soil science of Serbia–status and prospectives of soil protection management and use, book of abstracts, Novi Sad; 2009: 148 p.

9. Debele T, Abdulahi B. *Sustainable land management and agricultural practices research in Ethiopia*. United Nations expert group meeting on SLM and AP, Gothenburg; Sweden: April 2009. 16-17 p.

10. Takala B. Soil acidity and its management options in Western Ethiopia: Review. *Journal of Environment and Earth Science*. 2019;9:(10).

11. Asredie S, Mengist F. *Techniques of cool season vegetable crops seed production*. A guide for seed producers and development practitioners. Amhara regional agricultural research institute (ARARI); 2010

12. Khan MA, Ungar IA. Germination of salt tolerant shrub Suaeda fruticosa from Pakistan: salinity and temperature responses. *Seed Sci Technol*. 1998;26:657–67.

13. Ellis RA, Roberts EH. The quantification of ageing and survival in orthodox seeds. Seed Sci Technol.1981;9:373–409.

14. Karim M A, Utsunomiya N, Shigenaga S. Effect of sodium chloride on germination and growth of hexaploid triticale at early seedling stage. *Japanese Journal of Crop Science*.1992;61:279–284.

15. Haller E. Effect of the germinating seed environment on crop yields. Effect of soil acidity at germination on yields of sweet clover and alfalfa. *Exp Agric*.1983;19:55–66.

Citation: Sisay BT, Fentaye H. Effect of acid media on seed germination performance of Swiss-chard (*Beta vulgarise* L.). *Horticult Int J.* 2023;7(1):9–12. DOI: 10.15406/hij.2023.07.00269