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Effects of Temperature and Water Purity on Germination and Yield of Mungbean Sprouts

(Kesan Suhu dan Ketulenan Air Bagi Percambahan dan Hasil Kecambah *Mungbean*)

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ABSTRACT

Mungbean (Vigna radiata *L. Wilczek*) *is a popular pulse crop, producing protein-rich food and nitrogen-rich residues. Mungbean sprouts were grown at different temperature levels of 10, 20 and 30°C in various water purities of 30 (distilled water), 100, 400, 700 and 1000 TDS (ppm). After keeping them in the germination chamber for 72 h, the percentage of germination, stem length and yield along with proximate composition were determined. The temperature was kept as main factor and water purity as the second. The experiment was replicated four times and the data obtained were analyzed using two factorial completely randomized design. The results showed that both the factors had significant* ($p \leq 0.05$) *effect on the germination, stem length, yield as well as proximate composition. A temperature of 30°C and water with high purity of 30 TDS resulted in high emergence (69%), stem length (3.14 cm) and yield (70.1 g) as compared to the other treatments. Minimum germination (2.1%), stem length (0.11 cm) and yield (12.11 g) were recorded in samples kept at low temperature of 10°C and water purity with 1000 TDS. The mungbean seeds showed a very low plasticity to water purity, and that they were very susceptible to water impurities. It is concluded that, to prepare sprouts from mungbeans, it is necessary to germinate mungbean seeds them in water having high purity and temperature of 30°C for maximum germination, stem length and yield.*

Keywords: Germination; mungbeans; sprouts; stem length; yield

ABSTRAK

Mungbean *(*Vigna radiata *L. Wilczek) ialah tanaman popular pulse, menghasilkan makanan kaya protein dan sisa yang kaya dengan nitrogen. Cambah* Mungbean *telah berkembang pada suhu yang berbeza iaitu 10, 20 dan 30°C dalam pelbagai ketulenan air 30 (air suling), 100, 400, 700 dan 1000 TDS (ppm). Selepas disimpan dalam bilik percambahan selama 72 jam, peratusan percambahan, panjang batang dan hasil komposisi proksimat telah dikenal pasti. Suhu penyimpan merupakan faktor utama manakala ketulenan air adalah faktor yang kedua. Uji kaji ini diulang kali sebanyak empat kali dan data yang diperoleh dianalisis menggunakan dua reka bentuk faktoran yang rawak. Keputusan menunjukkan bahawa kedua-dua faktor mempunyai kesan signifikan* ($p<0.05$) *untuk percambahan, panjang batang, hasil serta komposisi proksimat. Suhu 30°C dan air dengan ketulenan yang tinggi 30 TDS menghasilkan kemunculan tinggi (69%), panjang batang (3.14 cm) dan hasil (70.1 g) berbanding rawatan lain. Percambahan minimum (2.1%), panjang batang (0.11 cm) dan hasil (12.11 g) direkod dalam sampel yang disimpan pada suhu rendah 10°C dan ketulenan air dengan 1000 TDS. Benih* mungbean *menunjukkan keplastikan yang sangat rendah terhadap ketulenan air dan mudah terdedah kepada pencemaran air. Kesimpulannya, untuk mencambah benih* mungbean*, ia perlu dicambah di dalam air yang berketulenan tinggi serta suhu 30°C untuk percambahan, panjang batang dan hasil yang maksimum.*

Kata kunci: Hasil; cambah; mungbean*; panjang batang; percambahan*

INTRODUCTION

Mungbean (*Vigna radiata* L. Wilczek), belonging to family Fabaceae, is a legume crop well-known in developing countries like India, Pakistan and Bangladesh. Being a rich and cheap source of proteins, mungbean is widely used as vegetable in developing world as it measure up to animal sources. The seeds have high nutritional value with high proteins, fibers, resistant starch and phytonutrients making them rich in antioxidants to reduce aging (Ronald et al. 2016). Mungbean is also used against chronic diseases like cancer, diabetes and cardiac diseases, and it is considered to be essential for myelination by oligodendrocytes within te brain (Chen et al. 2012).

Mungbean has been consumed in many forms like fried, boiled, powdered and sprouted. However, mungbean sprout is the most nutritious form as it contains 200% more protein as compared to other consumable forms. The nutritional value per 100 g of mungbean sprout is that it contains 7 g protein, 18 g carbohydrate, 24 g fat, 0.026 g sodium, 0.06 g potassium, 0.02 g iron, 0.029 g calcium, 103.5 calories of energy and other important vitamins (Hanumantha et al. 2016).

One of the most important benefits of sprouting mungbeans is that it helps in the elimination of the anti-nutrient agent called phytic acid. Phytic acid is a well-known anti-nutrient that is present in other forms of mungbeans. This agent inhibits some of our important digestive enzymes that digest proteins and carbohydrates, including amylase, trypsin and pepsin. Thus sprouted mungbeans have higher digestibility as they are devoid of phytic acid. It also has increased absorption of vitamins, iron, zinc, magnesium and other minerals. Due to unique quality, mungbean sprouts are very famous and have high demand. However, sprouting requires certain specific conditions. The most important of which is favorable temperature in the range of 25-30°C. Furthermore, it requires water free from any dilution and proper light (Islam et al. 2017).

Sprouts grow well in hot and humid weather, but the demand of sprouts increases in winter season when the condition is not favorable for sprouting. This increases demand of mungbean sprouts during winter and compels the hotels and suppliers to explore alternative ways of having fresh mungbean sprouts in winter. Although freezing or storage helps, it has the disadvantage of causing brownish discoloration in the sprouts. The growers try to grow sprouts in winter, but it fails to achieve the required yield and quality because mungbean seeds are sensitive to environmental condition. Special oven is nowadays also supplanted for this purpose, but the percent of sprouts emergence and yield is still very low (Maninder et al. 2017). The present study emphasizes on the impact of temperature and water purity on the percent of emergence and yield of mungbean sprouts.

Materials and Methods

The study was conducted in food processing laboratory in the Department of Agricultural Mechanization, Faculty of Crop Production Sciences, University of Agriculture, Peshawar, Pakistan. Mature and high quality seeds of hybrid variety Golden (locally grown) were purchased. Some of these were tested for imbibition in favorable conditions (30°C in distilled water) to see if the seeds were alive. Golden variety was chosen as it is known to be the most protein containing mung bean variety in Pakistan. In addition, to ensure quality research, clean, uniformed and undamaged seeds were selected for the experiment.

Sterilization of the Samples

All the seeds were soaked for 2 min in a 0.1% mercuric chloride solution to sterilize them. Then all the samples were put in Petri dishes containing different aqua solutions having different levels of purity ranging from 30 to 1000 TDS (total dissolved solids). Distilled water having 50 TDS was used as a control while four different solutions of 100, 400, 700 and 1000 ±5 TDS (ppm) were prepared for comparison. All the samples were tested three times with the electric conductivity meter (Water Filter Man, HM-S1, USA) to ensure accuracy. All the samples were put in germination chambers whose psychometric conditions were set according to the experiment. Each sample consisted of 100 seeds in a Petri dish replicated four times. All the samples were provided with 20 mL of the prepared solutions every 12 h.

Psychometric Conditions of the Germination Chambers

Three different setups were created in the germination chamber (PERCIVAL, 75ft3, USA) and the temperature was set at 20, 30 and 40°C with a precision of +1°C for separate experiments. The humidity remained in the ranges of 87.11-85.51%, 75.22-71.19% and 67.53-61.94% in the germination chamber during the experiment. All the samples were kept for 72 h, and approximately 12 h of light (42000 Lux) was provided inside the chamber. These conditions are almost equal to the ones provided by the supplanted oven in the industries for sprouting.

Statistical Analysis

Experiments were laid out in completely randomized design with four replications. Temperature having three levels (10, 20 and 30ºC) was kept as first factor while water purity having five levels (50, 100, 400, 700, 1000 TDS) was kept as the second factor. Analysis of variance and statistical comparisons were made with M Stat C at 95% confidence level (Gomez & Gomez 1984). Data on germination (%), sprout length (cm) and sprout yield (g) were recorded when mung bean achieved 90% visual germination (Figure 1).

FIGURE 1. Sprouted mungbeans

Results and Discussion

Emergence of Seeds to Sprout

Percentage emergence of mungbean seeds, after the period of 72 h in the germination chamber, was recored (Figure 2). The statistical analysis of the data showed that both the temperature and water purity had significant (p<0.05) effect on the percent of emergence of the mungbean seeds. When the temperature was kept constant, the germination percentage had a negative relationship with the water purity/TDS (Figure 2). R^2 value of 0.927 showed 92%

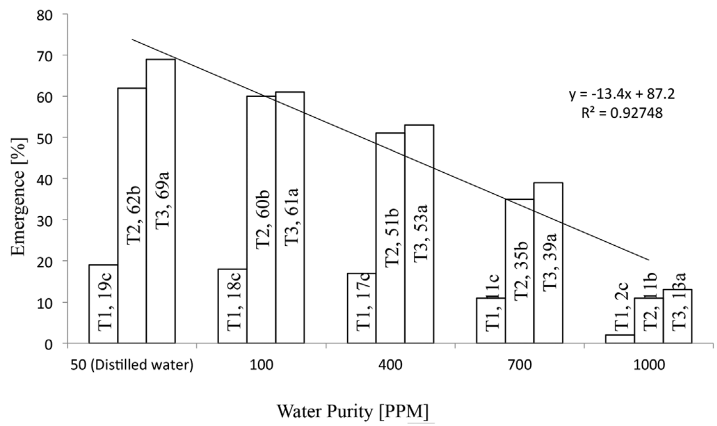

FIGURE 2. Emergence (%) of mung bean seeds affected (Duncan's multiple range test at p<0.05) by different temperatures and water purity levels

of variation in percent of emergence due to the change in water purity/TDS. At 50 TDS and 40°C, the percent of emergence was much higher (69%) than all the treatments. On the other hand, the lowest percent of emergence (2%) was found in the treatment having 1000 TDS at 10°C. Khattak et al. (2007) stated that water purity is very necessary for mungbean seeds and lentil seeds to germinate properly. Decrease in purity of water will increase the TDS causing an adverse effect on the germination of mungbean seeds. Vinod and Reddy (2015) also reported the results in accordance with the findings of our experiments. They indicated that purified or distilled water without any impurity would increase germination percentage of mungbean seeds.

The means of emergence with the temperature levels showed a significant effect on the percent of emergence (Figure 3). Furthermore, percent of emergence of sprouts had a positive relationship with level of temperature. Penas et al. (2008) stated that the temperature range of 10-40°C had a positive relationship with the percent of emergence. Population growth of different pathogens also decreased with increase in temperature. This is due to the fact that at high temperature (>30°C) the growth of microorganisms begins to decrease. Increasing temperature will control the growth of micro organisms.

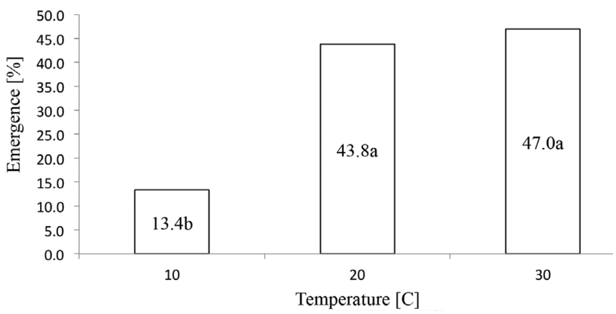

FIGURE 3. Means of emergence (%) of mungbean seeds affected (Duncan's multiple range test at p<0.05) by different temperature levels

The means of emergence with the water purity level showed a significant effect on the percent of emergence (Figure 4). Percentage emergence of sprouts had a negative relationship with the water purity. This is due to the fact that as osmotic pressure increases with the increase in water TDS, it causes a change in the nutrient contents of the media or water quality significantly affecting the seed emergence as well as its growth. Vijay and Abhishek (2009) reported that water turbidity increases osmotic pressure outside the roots on mungbean which makes it difficult for the seeds to germinate. The same phenomena were recorded in this experiment. It may be possible that adequate amount of nutrient stores and the artificial media or solution exist for compensation of differing nutrient levels. However, availability of nutrients and seed reserves are not most favorable, and nutrient solutions positively responded to the seed emergence. Seedling emergence decreased with increase of TDS (Chen et al. 2012).

STEM LENGTH OF SPROUTS

The stem length of sprouts (Figure 5) showed a significant effect from different levels of temperature and water purity/TDS. Stem length of sprouts was significantly affected by the water purity/TDS. There was a negative relationship between stem length and water purity/TDS. There was no obvious difference of stem length among the different treatments at early stages. By extending the time, the first treatment having 50 TDS showed faster growth at constant temperature. At 50 TDS and temperature of 30°C, the longest stem length was observed. However, by decreasing temperature the length of sprout stems declined. As a result, at 10°C, the shortest stem length was recorded (Figure 5). At 1000 TDS, the shortest stem length among all the treatments was recorded.

The results showed that there was a positive relationship between temperature and stem length with an R^2 value of 0.896 (Figure 6). The lowest stem length (2.47 cm) was found at a temperature of 10°C. A slight difference (0.22 cm) was found between the stem length treated at 10 and 20°C. The largest stem length (3.14 cm)

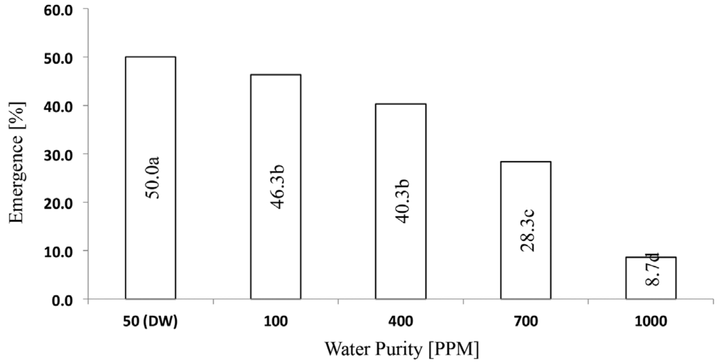

FIGURE 4. Means of emergence of mungbean seeds affected (Duncan's multiple range test at $p<0.05$) by different water purity levels

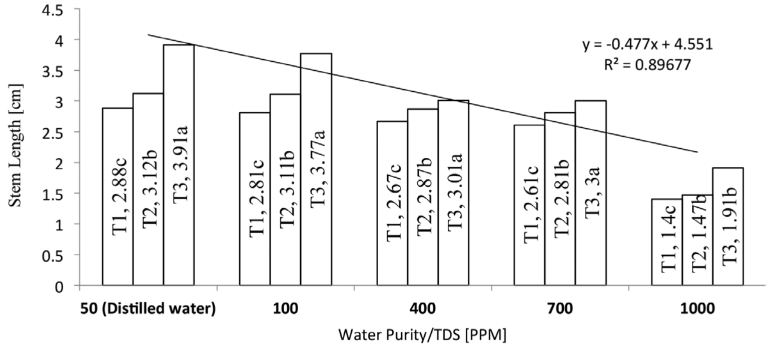

FIGURE 5. Stem length of mungbean seeds affected (Duncan's multiple range test at $p<0.05$) by different temperatures and water purity levels

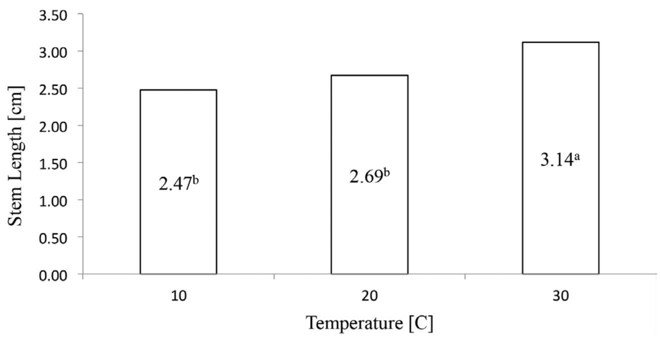

FIGURE 6. Means of stem length (cm) of mungbean seeds affected (Duncan's multiple range test at $p<0.05$) by different temperature levels

was found at a temperature of 30°C. Hence, it is concluded that stem length of sprouts was significantly affected by the temperature.

Panuccio et al. (2014) stated that the increase in the mineral contents in the solution or media decreased the development of sprout stem. Seed emergence, growth, development and survival depended on the type of media or solutions. The high amount of ions produced osmotic and ionic stresses. Osmotic stress occured in the root or radical while ionic stress developed when higher amount of unavoidable ions accumulated in the cells. These high amounts of ions affect the plant enzymes, resulted in reduced energy production and other physiological processes.

The results showed that there was a negative relationship between stem length and water purity/TDS with R^2 of 0.88 (Figure 7). The highest stem length (3.12 cm) was found at 50 TDS. 50 and 100 TDS were found highly significant while poor significance was found at 1000 TDS. There was a minor difference found between the stem length treated with 400 and 700 TDS. It is concluded that the stem length was significantly affected by the water purity/ TDS. Lal and Shanmugasundaram (2001) reported the same results in favour of our experiment that mungbean subjected to water with high impurity has a reduction in the stem length.

YIELD OF SPROUTS

The yield of mungbean sprouts was significantly affected by the treatments (Figure 8). The highest average yield (70.14 g) was found by applying 50 TDS at 30°C. A smaller difference (1.03 g) in yield of sprouts was found between 50 and 100 TDS at 30°C. All the lowest yields were found by applying 1000 TDS media. At 10, 20 and 30°C the average yield recorded were 12.2, 34.4 and 40.98 g, respectively. If the temperature was kept constant, the yield of sprouts would show a negative relationship with the water purity/TDS.

The type of media or nutrients provided to plants or seeds showed a significant difference than that of control. Some type of nutrients accelerated the growth and yield of selected plants or seedlings while other inhibited the growth or declined the yield. Some nutrients increased or decreased the pH of the solution which led to the decrease in the yield of seedling and plant growth. The solution with pH7 showed a good response in increasing growth and yield of sprouts or seedling or even plant growth. There was a direct relationship between TDS and pH value in a solution. In the same way, the solution having high TDS showed decline growth and yield. It may be summarized that there was a negative relationship between TDS and growth or yield (Bouchard et al. 2007; Islam et al. 2017).

The results showed that there was a positive relationship between the yield of sprouts and temperature with an R2 value of 0.887 (Figure 9). The highest average yield (58.96 g) was found in the temperature treatment of 30°C. The lowest average yield (30.08 g) was found in the temperature treatment of 10°C. At 20°C the average yield was 50.73 g. There was a small difference in the average yield between the treatments treated with 20 and 30°C. It is concluded that the yield was significantly affected by the temperature.

The results showed that the yield of sprouts was significantly affected by the water purity (Figure 10). At 50 and 100 TDS, the yield of sprouts was 57.1 g and 56.4 g, respectively. Both the treatments were highly significant in the production of mungbean sprouts. The average difference between these two treatments was 0.68 g. The lowest yield (29.22 g) was found by applying 1000 TDS.

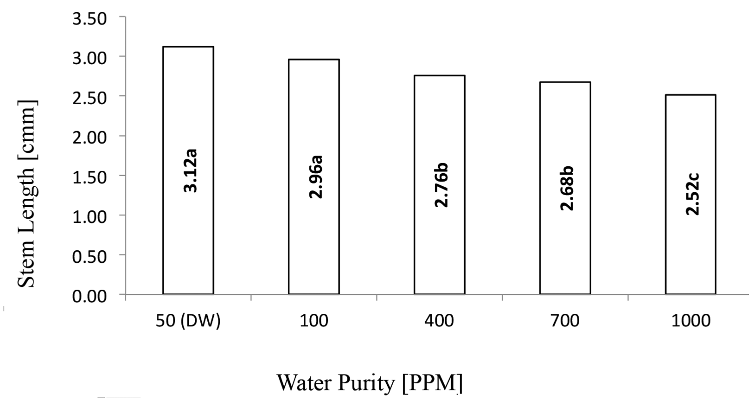

FIGURE 7. Means of stem length of mungbean seeds affected (Duncan's multiple range test at p<0.05) by different water purity levels

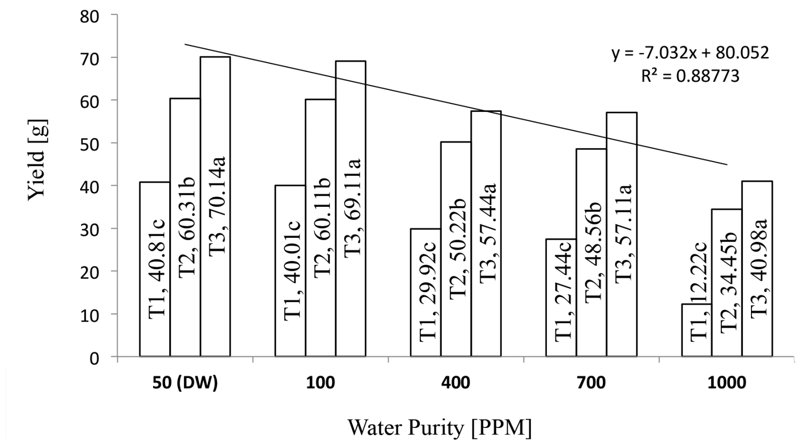

FIGURE 8. Yield of mungbean sprouts affected (Duncan's multiple range test at p<0.05) by different temperatures and water purity levels

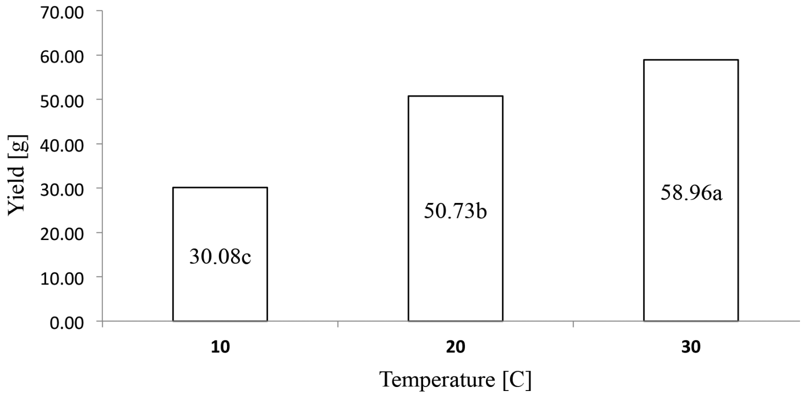

FIGURE 9. Means of yield of mungbean sprouts affected (Duncan's multiple range test at $p<0.05$) by different temperature levels

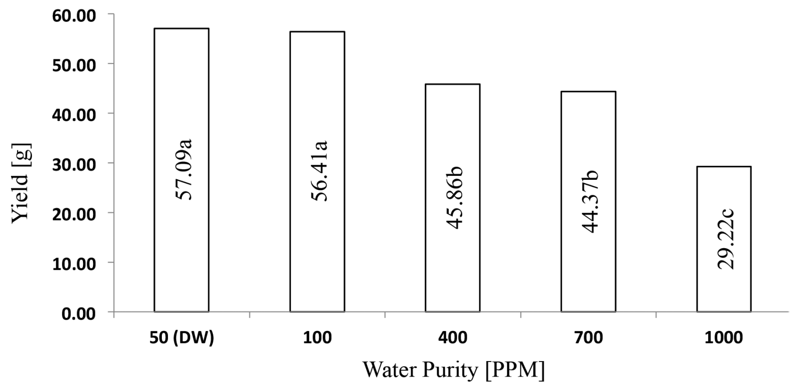

FIGURE 10. Means of yield of mungbean sprouts affected (Duncan's multiple range test at $p<0.05$) by different water purity levels

At 400 and 700 TDS, the average yields obtained were 45.9 and 44.4 g, respectively. Figure 8 shows that there was a negative relationship between yield and water purity. The results are in accordance with the findings of Hanumantha et al. (2016), Lal and Shanmugasundaram (2001) and Vijay and Abhishek (2009), reporting decrease in yield of mungbean sprouts by the effect of water TDS.

CONCLUSION

The results showed that mungbean (*Vigna radiata*) germinates properly in clean or distilled water. Increase in water TDS will cause an adverse effect on mungbean to germinate and produce sprouts. Similarly, temperature also plays a vital role in germination and sprouting of mungbean. It is thus recommended to germinate mungbean at a temperature of 30°C with clean or distilled water having TDS less than 100 ppm to get high quality mungbean sprout with high percent of emergence mungbean seeds.

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