

Effect of seedling age on germination characteristics of Mung bean seeds (*Vigna radiata* L.)

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Abstract

An experiment was conducted on mung bean germination in a greenhouse belonging to the research station of the Department of Horticulture and Landscape Engineering at the College of Agriculture, University of Diyala, in the agriculture season of 2025 to obtain optimal germination characteristics for mung bean seeds and some vegetative traits of the seedlings, and the reflection of this effect after transplanting to the permanent field to overcome the damages of saline soil during germination. Seeds were sown in cork trays with a capacity of 196 seedlings using peat moss as the germination medium. A completely randomized design (CRD) was used. The experiment included one factor, seedling ages (3, 4, and 5 weeks), and was performed with three replicates. The trays were placed inside an unheated greenhouse in accordance with the common local method of seedling production. Data collection began after the emergence of the first seedling and continued daily until germination stopped in all treatments. The results showed that 21-day-old seedlings had the shortest average for germination period, at 6.33 days, followed by 28-day-old seedlings at 9.66 days, while 35-day-old seedlings had the highest average for germination period at 12.33 days. 21-day-old seedlings also had the lowest average for germination rate, at 5.91 days.seed⁻¹, followed by 28-day-old seedlings at 7.61 days.seed⁻¹, compared to 35-day-old seedlings, which had the highest average for germination rate at 8.50 days.seed⁻¹. Furthermore, 21-day-old seedlings achieved the highest average for germination uniformity, at 10.29 seeds per day¹, followed by 28-day-old seedlings at 8.71 seeds.day⁻¹, while 35-day-old seedlings recorded the lowest average in this trait, reaching 7.84 seeds.day⁻¹. 21-day-old seedlings showed the highest increase in average germination vigor, reaching 7.40 g fresh weight.seedling⁻¹, followed by 28-day-old seedlings with 5.80 g fresh weight.seedling⁻¹, compared to 35-day-old seedlings which recorded the lowest average for this trait at 3.50 g fresh weight.seedling⁻¹. Regarding stem and root length, 35-day-old seedlings showed the highest increase in average length for both, reaching 9.18 and 8.36 cm, respectively, followed by 28-day-old seedlings, which recorded 7.56 and 6.55 cm, while 21-day-old seedlings showed the lowest average, reaching 5.67 and 4.43 cm, respectively. Seedlings age did not have a significant effect on the percentage of germination and the number of leaves.

Keywords. Mung bean, seedling age, germination characteristics

Introduction

Mung beans (*Vigna radita* L.) are a summer crop belonging to the legume family (Fabaceae). They are considered a strategic and industrial crop in most producing countries. The area cultivated with mung beans worldwide is estimated at approximately 7.3 million hectares, with a global production of 5.3 million tons. The average yield is approximately 721 kg/ha¹,

where mung beans are cultivated for various purposes. Their seeds are used for human consumption due to their high protein content (up to 29%) and their richness in the amino acid lysine; they also contain riboflavin and minerals [15]. Mung bean seeds unsuitable for human consumption can be used for livestock feed, as 1.5 tons are equivalent to one ton of soybean meal. Furthermore, the green parts of the crop are

used after harvest as green manure, improving the physical and chemical properties of the soil. Mung beans are characterized by their short life cycle and ability to fix atmospheric nitrogen [12,13]. However, they are intolerant of high soil salinity, as their successful cultivation requires soil salinity of less than 3 millimhos.cm⁻¹ (approximately 1500 parts per million) [5]. [18] indicated that the critical threshold for mung beans against salinity, at which productivity begins to decline, is approximately 1.8 dS/m². Furthermore, salinity is one of the most serious environmental factors affecting salt-sensitive legume crops, including mung beans; it leads to crop yield losses exceeding 70% and causes significant negative effects on plant physiology and performance, resulting in stunted growth, impaired metabolism, and ultimately, plant death [10]. The age of the seedling plays an important role in the growth and yield of the mung bean crop, as the vegetative and physiological characteristics of the seedlings vary according to their age, which directly affects their efficiency when transferred to the permanent field. [4] indicated that transferring 30-day-old maize seedlings from the greenhouse to the permanent field reduced the vegetative growth period compared to other seedling ages, which positively impacted the early flowering date and increased the yield and its components compared to the traditional method, which delayed the flowering date. Although transplanting technology has not been used for mung bean crops in Iraq and globally, it has been applied to other field crops to treat the problems contributing to reduced yields in Iraq, where studies have shown increased production in maize [4], sunflower [3], cotton (with the successful planting of a winter crop afterward, [1], and sugarcane [2]. Therefore, this study aims to determine the optimal seedling age for mung bean based on its clear impact on germination and vegetative characteristics and how this impact is subsequently

reflected (upon transplanting to the permanent field) in achieving the highest yield and best quality.

Materials and Methods

An experiment was conducted in 2025 on mung bean cultivation in the greenhouse of the Horticulture and Landscape Engineering Department, College of Agriculture, University of Diyala, located in Baquba District at 45° longitude and 33° latitude.

Seedling Production

To evaluate the response of mung bean to the transplanting method and determine its success, mung bean seeds (Figure 1) were sown in cork trays with a capacity of 196 seedlings using peat moss as the germination medium inside a greenhouse (Figure 2) using a completely randomized design (CRD). The experiment included one factor: seedling age, with three treatments (3, 4, and 5 weeks) and three replicates, resulting in nine experimental units. The trays were placed inside an unheated plastic greenhouse, following a common local method for seedling production, and were sterilized with the fungicide Topsin (Figure 3). Data collection started as soon as the first seedling appeared and continued every day until all treatments had stopped germination.

Characteristics studied

Germination tests

The following germination tests were studied:

1. Germination Period (days)

This represents the number of days required for seed germination. Germinated seeds were counted each day, starting from the sixth day after planting, when the first seedling appeared, until germination stopped completely on the eighteenth day after planting.

2. Germination percentage

This was calculated using the following equation:

$$\text{Germination \%} = \frac{(\text{Number of germinated seeds})}{(\text{Total number of seeds})} \times 100$$

3. Germination Rate (days.seed⁻¹)

This was calculated using the following equation:

Germination Rate

$$= \frac{\text{Total (Number of germinated seeds every germination period)}}{\text{Total number of germinated seeds at the end of the germination period}}$$

4. Uniformity of germination (seed.day⁻¹)

This is an important characteristic of seedlings, as whenever seedlings are uniformity in their growth, which means they germinate at the same time, they are uniform in length, thickness, and growth vigor, and all are ready for planting in the permanent field without any seedlings remaining that are unsuitable for planting at the specified time (Figure 4). Germination uniformity was calculated according to the following equation [11].

Germination uniformity =

$$\frac{\text{Total number of seeds germinating at the end of the germination period}}{\text{Number of days from sowing to germination failure}}$$

5. Germination vigor (g fresh weight.seedling⁻¹)

The germination vigor test was conducted to distinguish vigorous seeds from weak seeds (Figure 5), i.e., to distinguish seeds capable of producing vigorous plants if suitable conditions were provided during their cultivation in the field. Germination vigor was determined by calculating the average fresh weight of the seedlings before

transplanting them to the permanent field [11].

Vegetative Characteristics

Before transplanting (10a) seedlings to the permanent field (Figure 6), the following vegetative characteristics were studied.

1. Stem length (cm)

Measured from the point of contact of the stem with the soil surface to the end of the main stem using a graduated ruler.

2. Root length (cm)

Measured after removing all peat moss from the roots and placing them on a wide surface, then measuring their length using a graduated ruler.

3. Number of Leaves

The total number of leaves was calculated for the same seedlings whose stem and root lengths were measured.

Statistical analysis

The obtained data were statistically analyzed according to the analysis of variance (ANOVA) method for a completely randomized design (CRD) using the SAS statistical software (2001). The least significant difference (LSD) test was chosen to differentiate between the means of the treatments for significant differences at a probability level of 5% [16].



Figure 1. Mung bean seeds used in the greenhouse experiment

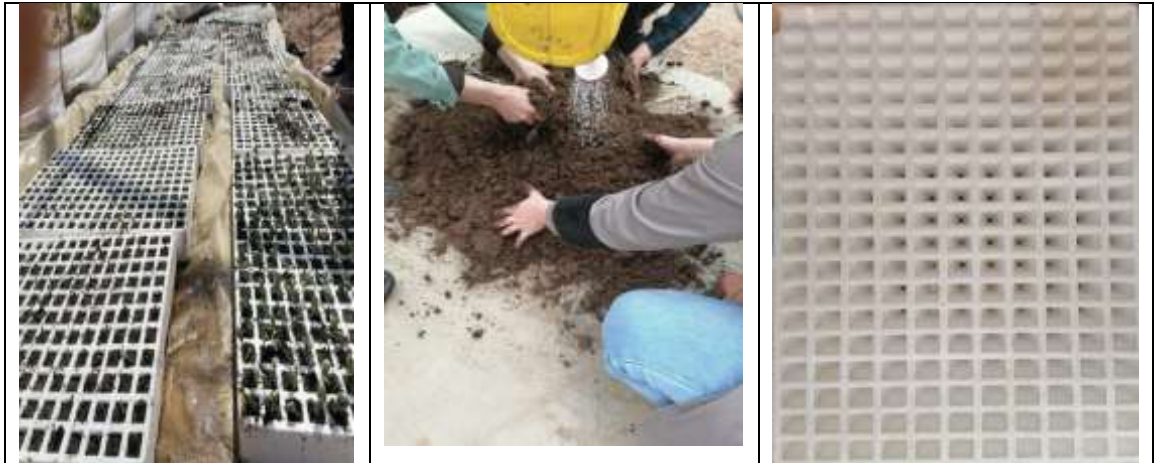


Figure 2. The cork trays and peat moss used in the experimental treatments



Figure 3. Sterilization of used cork trays with the fungicide (Topsin)



Figure 4. Variation in germination uniformity of mung bean seeds according to different seedling age treatments



Figure 5. Mung bean seed germination vigor at different time intervals

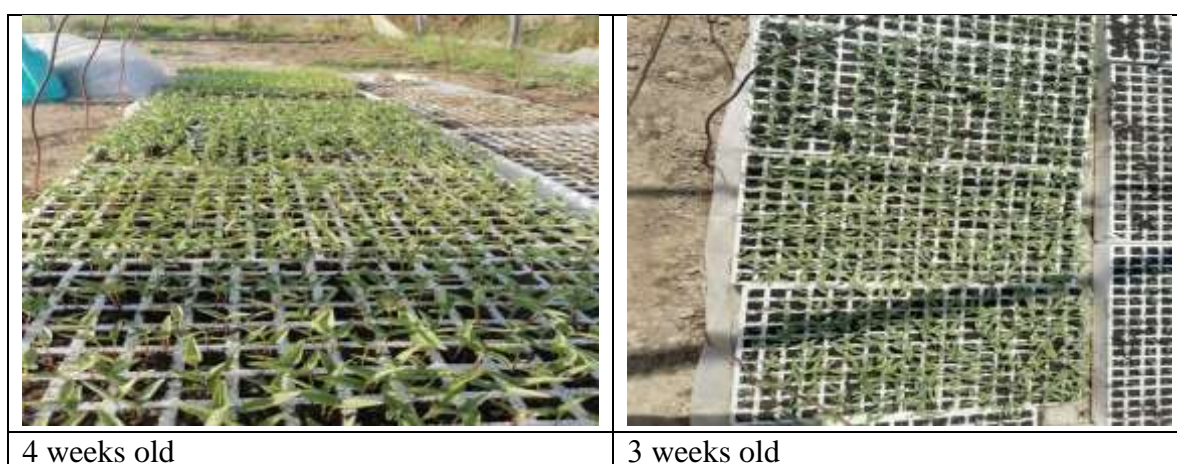


Figure 6. Mung bean seedlings of different ages

Results and discussion

Germination tests

1. Germination Time (days)

The data in Figure (7) indicates significant differences in average germination time between seedling ages. Seedlings grown on March 10th (21 days old) had a lower average germination time of 6.33 days, while seedlings grown on February 24th (35 days old) had a higher average of 12.33 days. The lower average germination time recorded on March 10th is attributed to the higher temperatures at that time, where the temperature is a key factor influencing physiological and biological processes

within the plant, such as photosynthesis, water absorption, nutrient transport, enzyme activity, and other processes. It has been observed, according to van't Hoff's law, that the rate of chemical reactions doubles with each 10°C increase in temperature. [9] explained that rising temperatures up to 30°C led to a clear increase in the germination rate of mung bean seeds, while lowering the temperature to 10°C caused a decrease in the germination rate. This indicates that moderately high temperatures improve the physiological processes associated with germination.

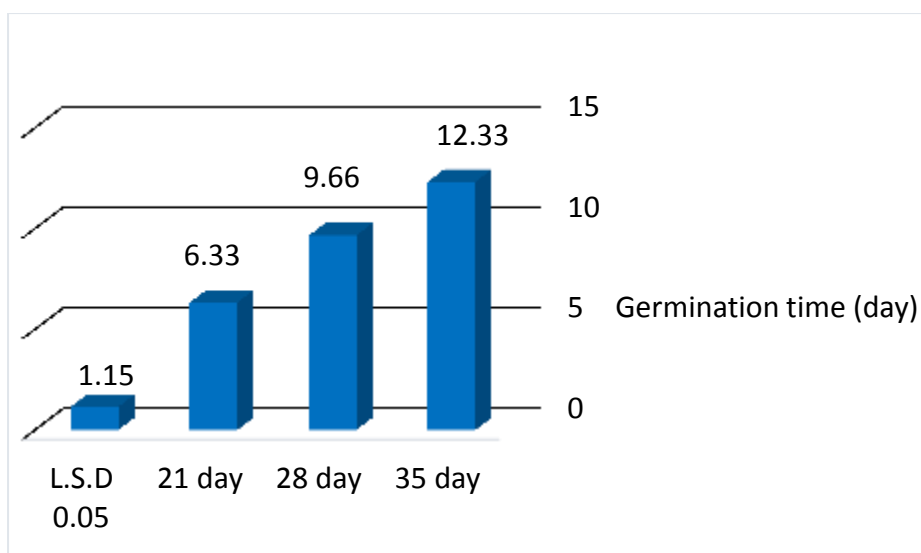


Figure 7. Effect of seedling age on average germination time (days) of mung bean seeds before transplanting from greenhouse to permanent field

2. Germination percentage (%)

The data in Figure 8 indicate no significant differences in the average germination percentage between seedling ages.

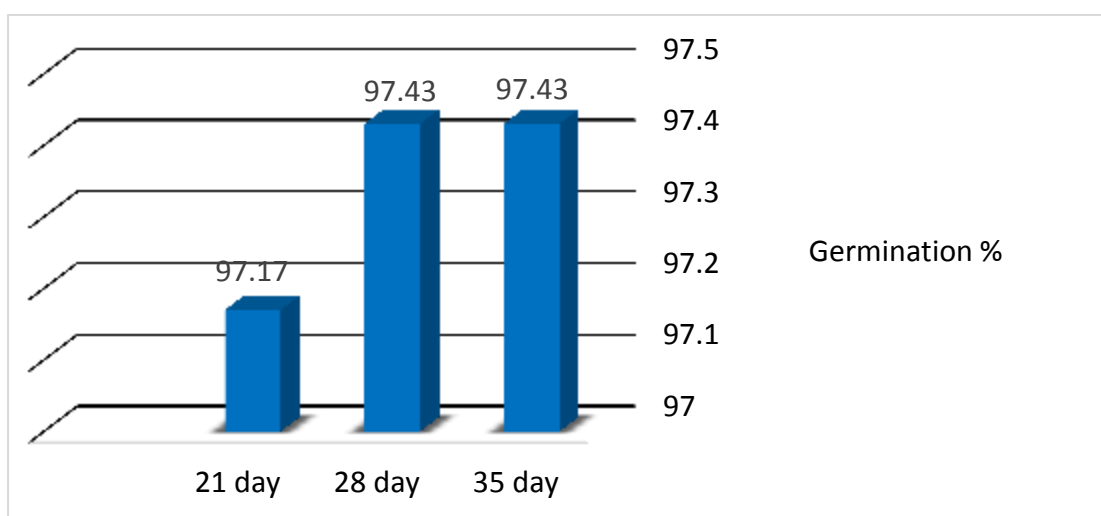


Figure 8. Effect of seedling age on the average percentage (%) of mung bean seeds before transplanting from the greenhouse to the permanent field

3. Germination rate (days.seed⁻¹)

The results in Figure 9 show significant differences in average germination rate between seedling ages. The 21-day-old seedling (planted on March 10) achieved an earlier germination rate of 5.91 days.seed⁻¹, while the 35-day-old seedling (planted on February 24) showed a delayed average germination rate of 8.50 days.seed⁻¹. The reason for the lower average germination

speed recorded by the 21-day-old seedling is attributed to the higher temperature during seed planting, where the temperature is a major factor affecting seed physiological processes, particularly germination, as it influences the rate of enzyme activity responsible for analyzing stored materials and converting them into energy for growth. [14] observed that at optimal temperatures, enzymes reach their

highest efficiency, leading to rapid germination, while at lower temperatures, enzyme activity decreases, weakening metabolic reactions and slowing germination. This increase in germination

rate corresponds to a decrease in germination time, as there is an inverse relationship, where factors that reduce germination time accelerate the germination rate [6].

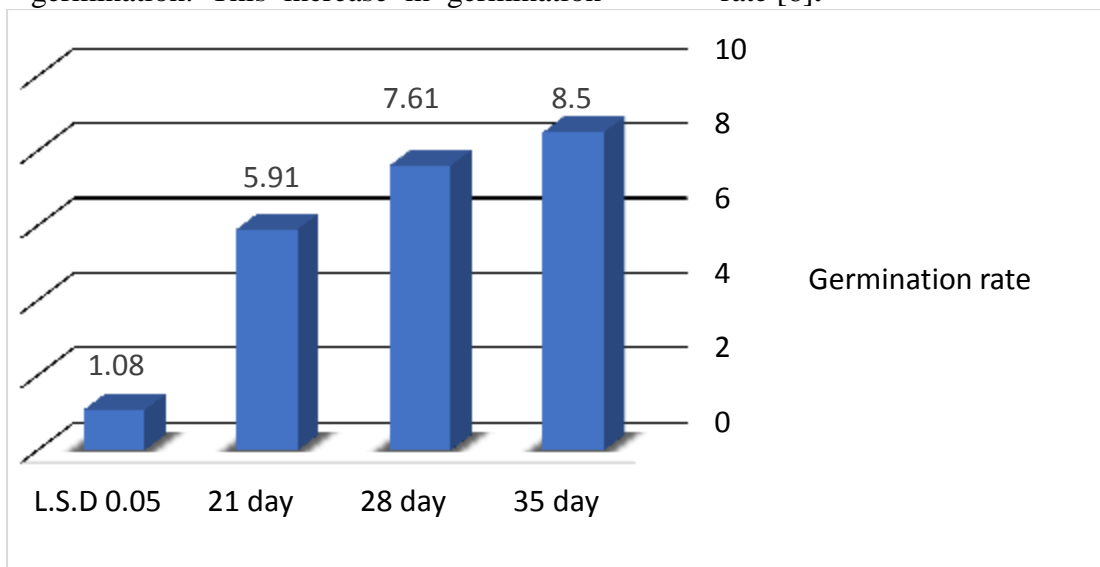


Figure 9. Effect of seedling age on average germination rate (days.seed⁻¹) of mung bean seeds before transplanting from greenhouse to permanent field.

4. Germination uniformity (seeds.day⁻¹)

Figure 10 shows significant differences in germination uniformity between seedling ages. Seedlings grown at 21 days old (planted on March 10) showed an increase in the average germination uniformity, reaching 10.29 seeds.day⁻¹, while seedlings grown at 35 days old (planted on February 24) showed a decrease, reaching 7.84 seeds.day⁻¹. The superior germination uniformity observed in the 21-day-old seedlings is likely due to the gradual increase in temperature at this age, which led to increased physiological activity in the seedlings within the greenhouse. This was

accompanied by longer light exposure, as light plays a crucial role in regulating seed germination [7]. Metabolic reactions and enzyme activity cause variations in germination time. Low temperatures slow down seed metabolism, limiting growth, while high temperatures accelerate metabolism, consuming the energy needed for seed growth. According to the principles of enthalpy, as temperature rises, water energy and diffusion pressure increase, stimulating metabolic and enzymatic activity within the seed, which leads to the seeds becoming moistened more quickly, accelerating germination [8].

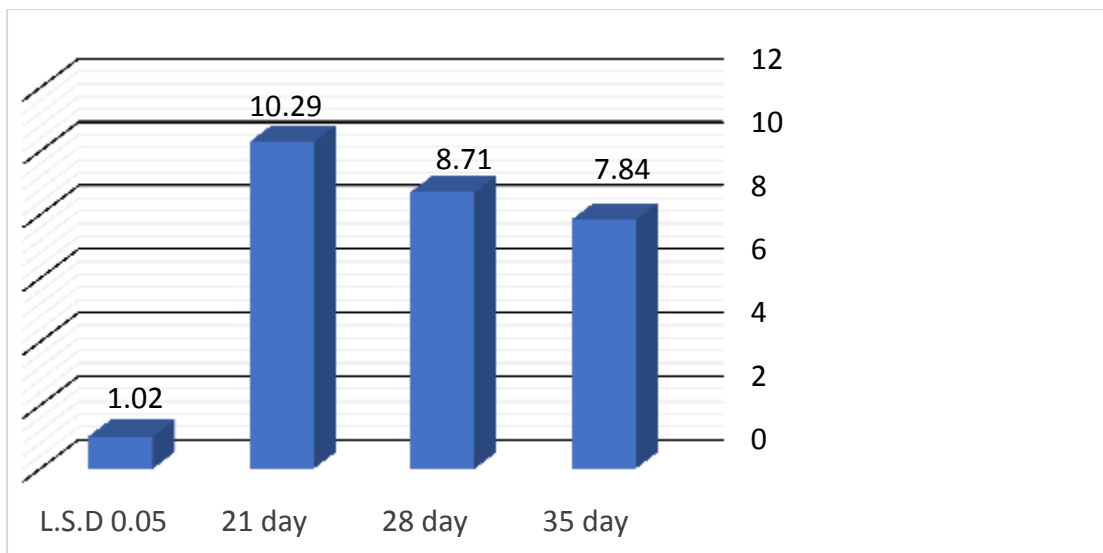


Figure 10. Effect of seedling age on average germination uniformity (seed.day⁻¹) of mung bean seeds before transplanting from greenhouse to permanent field

5. Germination vigor (g fresh weight.seedling⁻¹)

Figure 11 shows significant differences in germination vigor between seedling ages. The 21-day-old seedling (planted on March 10) exhibited the highest average germination vigor, reaching 7.40 g fresh weight.seedling⁻¹, while the 35-day-old seedling (planted on February 24) showed the lowest average germination vigor, at 3.50 g fresh weight.seedling⁻¹. The reason for recording the highest average

germination rate at 21 days is due to its superiority in all germination characteristics (germination time, germination rate, and germination uniformity) compared to 35 days. This is attributed to the availability of optimal environmental conditions within the greenhouse, including moderate temperature and appropriate light intensity, which stimulated the physiological processes of the seeds and positively impacted germination rate.

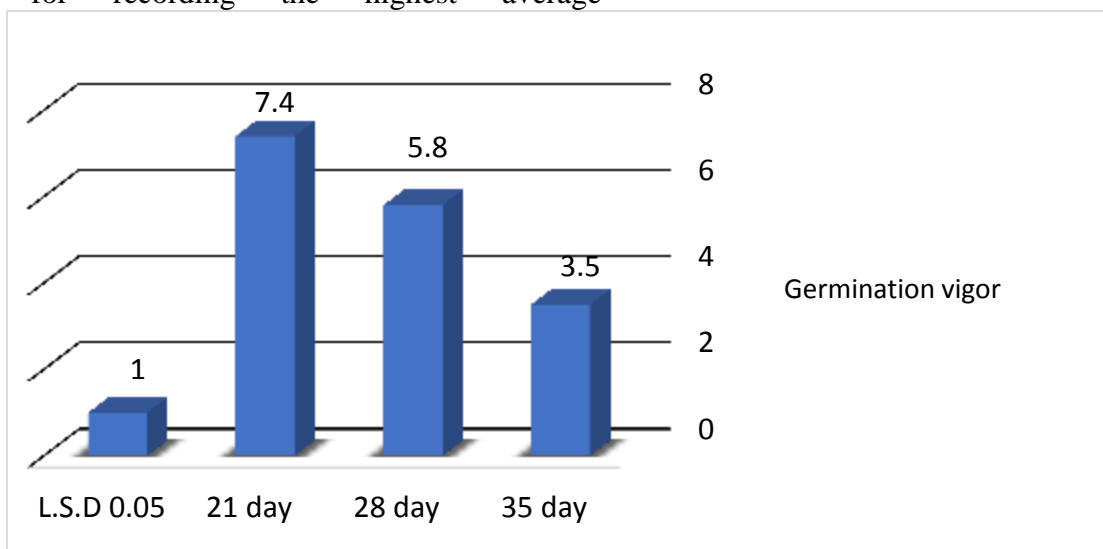


Figure 11. Effect of seedling age on average germination vigor (g fresh weight seedling⁻¹) before transplanting from greenhouse to permanent field.

Vegetative Characteristics

1. Root length (cm)

Figure 12 shows significant differences in root length between seedlings of different ages. The 35-day-old seedling showed the highest average root length, reaching 8.35 cm, followed by the 28-day-old seedlings at 6.55 cm, while the 21-day-old seedlings recorded the lowest average root length at 4.43 cm. The increase in average root length

at 35 and 28 days is attributed to the longer growing period in the greenhouse until transplanting to the permanent field. During this time, water and nutrients were utilized for growth, and photosynthesis continued for a longer period, resulting in the production of larger quantities of nutrients, and some of which were translocated to the roots. These factors combined may have contributed to the increased root length.

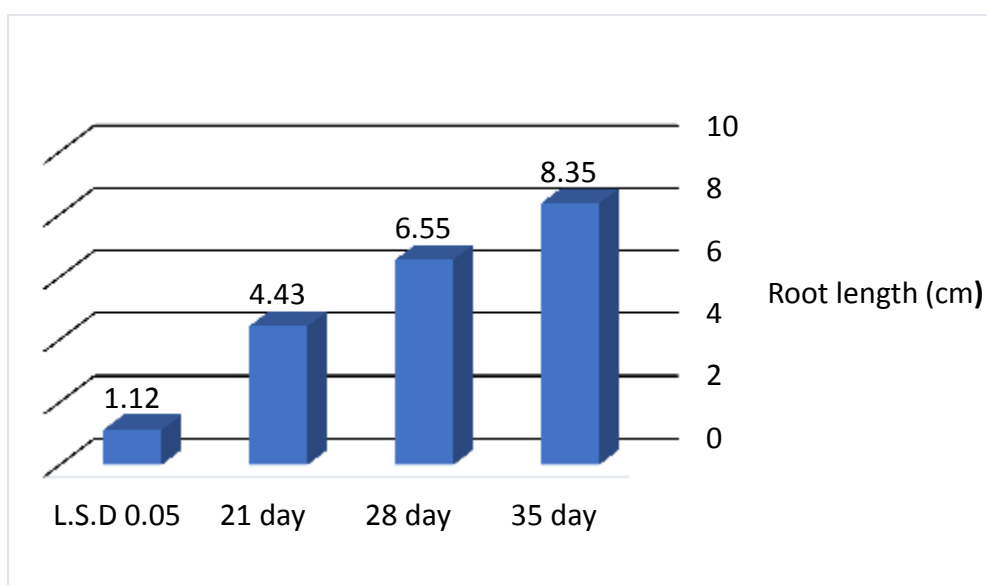


Figure 12. Effect of seedling age on average root length (cm) of mung bean crop before transplanting from greenhouse to permanent field

2. Stem length (cm)

Figure 13 shows significant effects of seedling age on average stem length. Seedlings aged 35 days showed the highest average stem length of 9.18 cm, followed by seedlings aged 28 days at 7.56 cm, while seedlings aged 21 days showed the lowest average stem length at 5.67 cm. The

increase in average stem length at 35 and 28 days is likely due to the significant role of these treatments in producing the highest average root length (Figure 12). Several studies have indicated a highly significant positive correlation between stem height and root length [17].

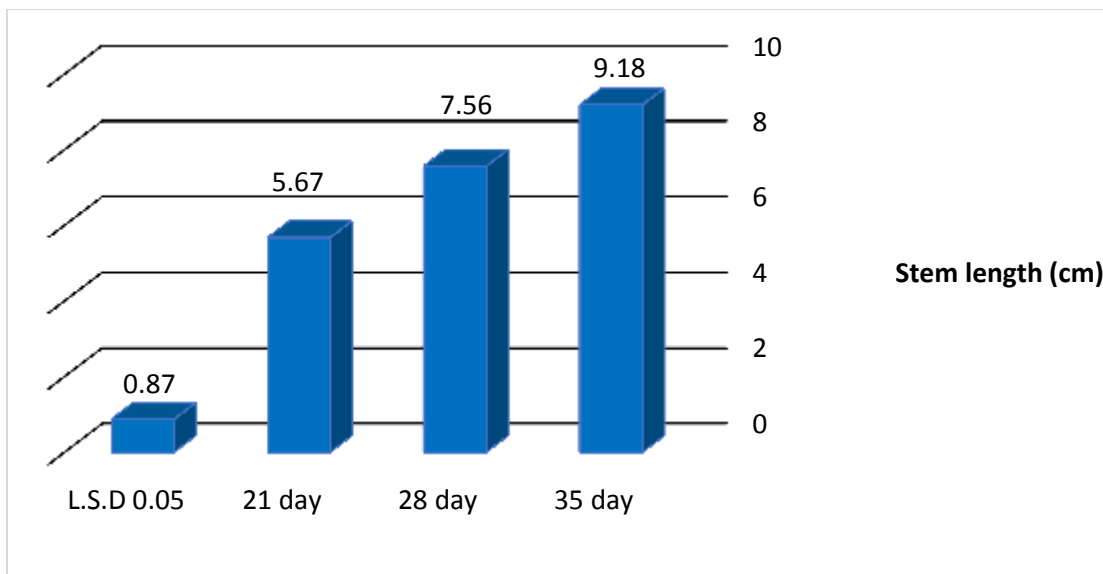


Figure 13. Effect of seedling age on average stem length (cm) of mung bean crop before transplanting from greenhouse to permanent field.

Number of leaves per seedling

The results in Figure 14 show no significant differences in the average number of leaves between seedling ages.

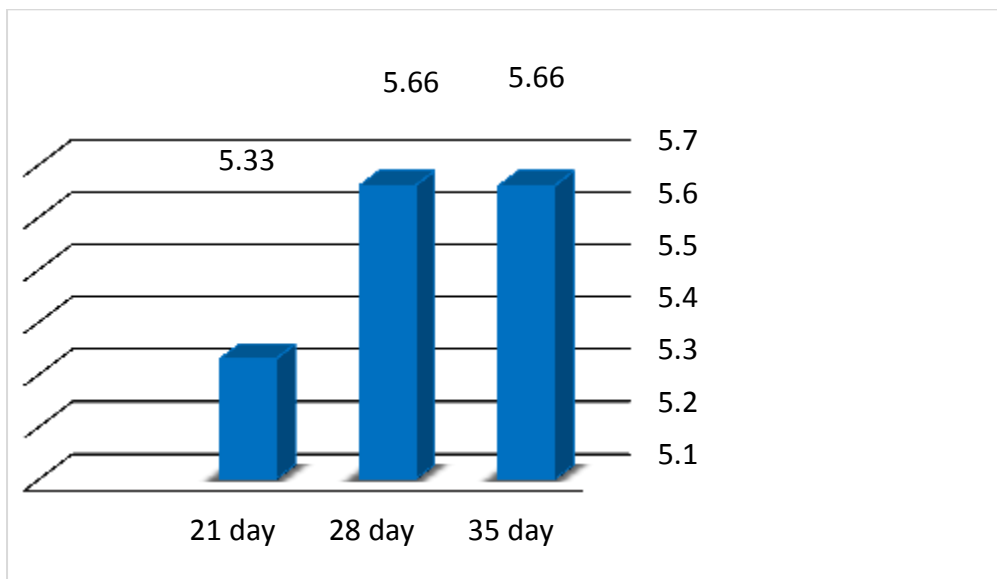


Figure 14. Effect of seedling age on average number of leaves per seedling of mung bean before transplanting from greenhouse to permanent field

Conclusion

Can be concluded from the current experiment that we should rely on 21-day-old seedlings instead of other ages, as they recorded optimal

germination characteristics represented by a short germination period, increased rate and uniformity of germination, and the highest

germination vigor of the seedling, thus achieving the highest characteristics that make it dominant and resistant to environmental

factors when transferred to the permanent field.

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1.

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