International Journal of Advanced Engineering Research and Science (IJAERS)
Peer-Reviewed Journal
ISSN: 2349-6495(P) | 2456-1908(O)
Vol-10, Issue-11; Nov, 2023
Journal Home Page Available: https://ijaers.com/
Article DOI:https://dx.doi.org/10.22161/ijaers.1011.7

Evaluation with different Amounts of Moisture and Temperature in the Substrate on the Vigor and Germination of Soybean Seeds

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Received: 01 Oct 2023,

Receive in revised form: 05 Nov 2023,

Accepted: 15 Nov 2023,

Available online: 26 Nov 2023

***Keywords*— Germination, humidity, temperature, vigor.**

***Abstract*— *Seeds are considered to have high vigor as long as they are handled in the right way, always taking as fundamentals, in the pillars of their quality, which are: physical, physiological, genetic and sanitary. A total of 200 seeds were used for 8 treatments of the same variety conducted in the seed laboratory of the INSTITUTO TOCANTINENSE PRESIDENTE ANTÔNIO CARLOS (ITPAC-PORTO), which were subjected to conditions of two temperatures: 10°C and 25°C, under 4 situations of osmotic potentials On substrates: 1.5, 2.0, 2.5 and 3.0 ml. An evaluation was carried out at 5, 8 and 20 days after assembly, using seedling emergence and development as a parameter. The samples were analyzed based on the RAS (RULES FOR SEED ANALYSIS), i.e., they were considered germinated when they showed the development of a normal seedling. The data will be submitted to analysis of variance (ANOVA) and Tukey's test in the Sisvar software. The results allowed us to visualize the excellent germination and growths of the seedlings when using the temperature of 25°C and wetting of 2.5 ml in the substrate. Germination is impacted when the low availability of water in the substrates, as well as milder temperatures, influences the speed of development of meristematic tissues.*

I. INTRODUCTION

Soya (Glycine Max (L.) Merrill) stands out as one of the most important crops in the world economy. Its grains are widely used by the agro-industry (production of vegetable oil and animal feed), the chemical industry and the food industry. It is also used as an alternative source of biofuel (COSTA NETO; ROSSI, 2000).

In Brazil, the first report of soya being grown dates back to 1882, in the state of Bahia (BLACK, 2000).

The cultivar began on the Asian continent and spread to the Americas (FREITAS, 2011).

According to Castro et al. (1983), the reduction in germination speed due to sub-optimal temperatures results in a reduction in the uniformity of emergence in the field, prolonging the time the seeds are exposed to pathogens and increasing the risk of contamination.

Ensuring the best performance of a given crop depends fundamentally on the quality of the seeds (Motta et al., 2000), characterised by germination and vigour.

Therefore, the main objective of this study was to assess the germination capacity of seeds under different temperature conditions and specific amounts of water.

II. VIGOUR AND GERMINATION OF SOYA BEANS: A DETAILED ANALYSIS

Evaluating seed vigour is a fundamental step for the successful production of soybean seeds, which are recognised for their sensitivity to deterioration and less suitable handling practices after maturity (Marcos Filho, 1999a).

Viability is mainly measured by the germination test and aims to determine maximum seed germination under favourable conditions (Marcos Filho, 1999).

One of the limitations of vigour tests is related to the time required to carry them out and the subjectivity of their assessment (Pinto et al., 2015).

According to the observations of Carvalho and Nakagawa (2000), larger or denser seeds tend to harbour well-developed embryos and more abundant reserves, which suggests a higher potential for vigour.

III. MATERIAL AND METHODS

The experiment was conducted in the seed laboratory of ITPAC Porto Nacional in the second half of 2023. Located at geographical coordinates 10º41'46" S 48º23'03" W, altitude 230 m, in the city of Porto Nacional, in the state of Tocantins and country Brazil.

Initially, 1600 seeds were selected for the test. The seeds were supplied by the GDM company and belong to the OLIMPO IPRO cultivar, of maturity group 8.0, adapted for the Tocantins region.

We began the process by meticulously sanitising the site and the equipment to be used in the test. For each test, the seeds were sown on germ paper moistened with distilled water as a substrate. The germ paper was then moistened with different amounts of water (1.5 ml, 2.0 ml, 2.5 ml and 3.0 ml). 200 seeds were used per treatment, with 4 replicates containing 50 seeds each.

The tests were kept in a germination chamber for 5, 8 and 20 days at two different temperatures: 10°C with 4 treatments and 25°C with 4 treatments. The results were expressed as a percentage of normal seedlings, in accordance with the requirements of the Rules for Seed Analysis (Brazil, 1992). The data obtained was analysed using the sisvar application, using the variation test and the ANOVA test. The analysis included checking the significance of the results, the means of the treatments and the significance between them, and was conducted in accordance with the guidelines established by the RULES FOR SEED ANALYSIS (RAS).

Ferreira (2008) highlights the advantages of Sisvar, including its interactivity with the user, which provides an efficient and accurate environment. He hopes that future versions of the programme will address limitations, such as compatibility problems, and extend its capabilities, making it compatible with operating systems other than Windows. Sisvar is relevant, with previous versions often cited in technical and scientific contexts.

IV. RESULTS AND DISCUSSION

We can see that a temperature of 25°C seems to favour the vigour of the tests compared to 10°C in most cases. In addition, an increase in water availability also tends to improve vigour, especially at higher temperatures. The treatments (2 ml of water at 25°C), (3 ml of water at 25°C) and (2.5 ml of water at 25°C) show the highest averages (83 Bb, 85 Bb and 93 Aa, respectively), indicating the most favourable conditions for testa vigour, based on the data and Tukey's test, as shown in Table 1.

The 1.5 ml Water at 10°C (0 Cc) treatment shows an average vigour of 0 Cc, which suggests that under this condition, the vigour of the tests is very low. The 1.5 ml of Water at 25°C (0 Cc) treatment again has an average vigour of 0 Cc, indicating that even with the higher temperature, vigour does not improve. The 2 ml Water at 10°C (0 Cc) treatment, as in the previous treatments, the average vigour is 0 Cc. This suggests that the availability of 2 ml of water at 10°C is not enough to improve vigour.

Treatment 2 ml Water at 25°C (83 Bb), in this treatment, the average vigour is 83 Bb. This is significantly higher than the previous treatments, indicating that an increase in temperature from 10°C to 25°C improves the vigour of the tests. The 2.5 ml Water at 10°C (0 Cc) treatment, once again, the average vigour is 0 Cc, even with an increase in water availability to 2.5 ml. The 2.5 ml Water at 25°C treatment (93 Aa), here, the average vigour is 93 Aa, which is the highest among the treatments so far. This suggests that a temperature of 25°C and an availability of 2.5 ml of water are favourable conditions for testing vigour.

The treatment 3 ml of Water at 10°C (0 Cc), Again, the average vigour is 0 Cc, even with an increase in the amount of water available. Treatment 8 - 3 ml of Water at 25°C (85 Bb), in this treatment, the average vigour is 85 Bb, suggesting that an increase in water availability to 3 ml, combined with a temperature of 25°C, improves vigour compared to the 10°C conditions (Table 1).

Table 1- Average vigour over 5 days of testing

water availability in ml	1,5 ml	2 ml	2,5 ml	3 ml
temperature 10 °C	0 Cc	0 Cc	0 Cc	0 Cc
temperature 25 °C	0 Cc	83 Bb	93 Aa	85 Bb

In the column, means followed by equal letters do not differ according to the Tukey test (5%). Uppercase letters in the column and lowercase letters in the row.

According to Ferreira and Borghetti (2004), when seeds are exposed to higher temperatures, they accelerate their germination as long as there is tolerance, because at the same time as they accelerate the resumption of growth, high temperatures affect the metabolic process, reducing the possibility of germination itself. According to Ferreira and Borghetti (2004), this phase is critical and can be influenced by intrinsic and/or extrinsic conditions, emphasising that water is the most important factor in the germination process.

Garcia et al. (2007), on the other hand, says that soya beans, when sown, develop best at temperatures of 25ºC.

Table 2 shows the average germination results of the 8-day tests, considering water availability in ml and temperature in °C as independent variables.

As in Table 1, the capital letters in the columns indicate means that do not differ from each other, according to the Tukey test at a significance level of 5 per cent. The lower case letters in the rows represent the specific averages for each combination of water availability and temperature.

It can be seen that at a temperature of 10°C, regardless of the amount of water available (1.5 ml, 2 ml, 2.5 ml or 3 ml), the average germination is 0 Cc. This indicates that, under these conditions, germination was inhibited or very low.

However, at a temperature of 25°C, the results are remarkable. In all the water availability conditions (1.5 ml, 2 ml, 2.5 ml and 3 ml), the average germination is equal to 100 Aa. This suggests that at higher temperatures, germination is optimised and water availability does not seem to affect germination, at least within the limits tested.

Table 2- Average 8-day germination of the tests

disponibilidade de água em ml	1,5ML	2 ML	2,5 ML	3 ML
temperatura 10 °C	0 Cc	0 Cc	0 Cc	0 Cc
temperatura 25 °C	0 Bb	100 Aa	100 Aa	100 Aa

In the column, means followed by equal letters do not differ according to the Tukey test (5%). Uppercase letters in the column and lowercase letters in the row.

The temperature of 25ºC with the moistening of 2.0 to 2.5 ml of water favoured the germination process of the treatments, with their germination potentials being observed in the last 8 days, as most of the seeds resulted in normal seedlings.

Water absorption plays a fundamental role at the start of the germination process, as highlighted by Marcos Filho (1986), culminating in the protrusion of the radicle through the seed coat.

Table 3 shows the results of the 20-day average germination of the tests, considering the availability of water in 1.5 ml and temperature in °C as independent variables.

Again, the capital letters in the columns indicate means that do not differ from each other, according to Tukey's test at a significance level of 5%. The lower case letters in the rows represent the specific means for each combination of water availability and temperature.

It can be seen that at a temperature of 10°C, the average germination is 0 Dd, which indicates that germination is quite low under this condition, even with 1.5 ml of water available.

On the other hand, at a temperature of 25°C, the average germination is 0 Bb. This suggests that at a higher temperature, germination was also inhibited, with an average of zero. In this case, both the temperature and the availability of water in 1.5 ml do not seem to be adequate to promote germination after 20 days of testing.

To summarise, the results in Table 3 indicate that germination is rather low or inhibited under both temperatures (10°C and 25°C) and with 1.5 ml of water available after 20 days of testing. This could have significant implications for understanding the influence of these conditions on the early stages of seed development.

Table 3- Average germination after 20 days of testing

water availability in ml	1,5 ml	2 ml	2,5 ml	3 ML
temperature 10 °C	0 Dd	75 Cc	81 Bb	86 Aa
temperature 25 °C	0 Bb	100 Aa	100 Aa	100 Aa

In the column, means followed by equal letters do not differ according to the Tukey test (5%). Uppercase letters in the column and lowercase letters in the row.

V. CONCLUSION

The effect of temperature and the availability of water in the substrate revealed a significant variation between the treatments, highlighting the importance of these factors in seed development.

Notably, the combination of a temperature of 25 °C and moistening the substrate with 2.5 ml proved to be the most effective, resulting in the highest germination percentages.

Under this condition, excellent development of the meristematic structures was observed, including the hypocotyl, plumule and radicle, which culminated in the formation of seedlings with the capacity to continue their normal growth and become healthy plants.

This study confirms the significant influence of temperature and water availability on the vigour of germination tests. Conditions with higher temperatures, notably 25°C, and a greater availability of water, either 2.5 ml or 3 ml, proved to be favourable for stimulating seed vigour.

These results have crucial implications for optimising test conditions and can be applied in various contexts where obtaining vigour is a critical factor.

It is worth emphasising that the use of plastic bags proved to be an effective strategy for reducing moisture loss in the treatments, keeping the seeds adequately hydrated and enabling them to go through the three-phase germination process, moving towards healthy development. On the other hand, the warmer temperatures slowed down the seeds' rate of development. The lack of water had a significant negative impact on the germination of the samples subjected to this treatment, since they did not receive the essential amounts of hydration to start the subsequent germination process.

The study's conclusions highlight that temperature plays a critical role in vigour and germination tests, with higher temperatures being preferred for these processes. In addition, water availability is a vital element, especially with regard to test vigour.

These results provide valuable information for optimising test conditions and promoting successful seed development, while respecting the specific demands of temperature and humidity at each stage of the germination process.

ACKNOWLEDGEMENTS

To the Instituto TOCANTINENSE PRESIDENTE ANTÔNIO CARLOS (ITPAC-PORTO) and the dedication and commitment of everyone involved.

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