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# THE EFFECT OF THE STOMP AQUA HERBICIDE ON THE GERMINATION IN *ZEA MAYS*

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**Abstract:** Maize occupies a leading position in highly cultivated plants due to features that make it relatively easy to grow. Weed control started a century ago when a few inorganic compounds such as sulfuric acid, copper salts and sodium chlorate were used. In 1940, the herbicid activity of 2,4- dichlorophenoxyacetic acid was detected. Corn is one of the most important crop plants in agriculture and the economy, with Romania occupying the lead. A large proportion of corn production is prevented by the weeds it is competing with, and for the reason that manual plowing is not always a safe method, but also because it takes longer, it is concluded that herbicides are a better alternative to weed control. The purpose of this study was to study the influence of different herbicide concentrations on germ of the seed material in maize (*Zea mays* L. convar. *saccharata* var. *rugosa*). The herbicide pendimethalin inhibits germination of corn caryopsis, thus a lower number of sprouted caryopsis was recorded for the herbicide-treated variants.

**Keywords:** *Zea mays* L. convar. *saccharata* var. *rugosa,* Stomp Aqua herbicide, germination faculty, roots, stems and coleoptilum measurements.

## INTRODUCTION

As cereals are the most important crop plants used as a food source for the population and cereal production in most countries is below 200 kg/inhabitant/year, the amount deemed to be optimal is 500-700 kg/inhabitant/year, there is a need to increase annual cereal production and improve crop quality. In this respect, there is a need to continuously improve the biological factor and production technologies, as well as to improve the quality of the harvest.

Maize occupies a leading position in highly cultivated plants due to features that make it relatively easy to grow: is resistant to drought, has a low number of pests, can provide a high number of hybrids (currently only hybrids being cultivated), can be cultivated in monoculture for several years, the crop can be fully mechanized, valorised water and fertilizers (organic and mineral), large yields can be achieved and harvesting is done without the danger of shaking. Many researchers studied the variate aspects of maize because of its industrial importance (Mihalescu *et al*., 2008, Mihalescu *et al*., 2009, 2010; Blidar *et al*., 2012; Tripon and Blidar, 2016)

For the selection of the seed material, the main characteristic to be taken into account, in both agricultural and research practice, is the determination of germination capacity and germination energy, these parameters providing information on the degree and speed of germination, therefore on the quality of the seed.

However, some low-level weeds are beneficial because they provide food and habitat for a number of beneficial organisms on maize (Millinngton *et al*., 1990), but when weeds pass above a certain threshold, they significantly reduce the production and quality of corn crops (Cussans, 1968).

Weed control started a century ago when a few inorganic compounds such as sulfuric acid, copper salts and sodium chlorate were used. In 1940, the herbicid activity of 2,4- dichlorophenoxyacetic acid was detected.

It is important to manage weeds efficiently in order to obtain optimum returns in corn crops (Bird *et al*., 2003). Due to weeds, farmers and their families spend more than 50% of their working time on manual weed-growing (Fasil *et al.,* 2006; Ellis *et al.,* 1993; Akobundu, 1996), therefore, it has been concluded that chemical herbicide control is an alternative to manual plowing because its faster, less costly (Chikoye *et al.,* 2005) and provides better control against (Johnson *et al.*, 1997; Toloraja *et al*., 2001; Khan and Haq, 2004; Juhl, 2004).

Some researchers reported that it is important to use herbicides and weed control in corn crops to achieve a more qualitative and much higher crop (Becker and Staniforth, 1981; Jehangeri *et al.*, 1984; Abid et al., 1991). Similarly other researchers such as Owen (1993), Miller and Libby (1999), have suggested, in support of which others also come, saying that the yield of corn crops has increased significantly with the help of herbicides and that they have reduced the density of weeds (Ali et al., 2003), with 65-90% of the entire population (Nadezem *et al.*, 2006).

Although herbicides are very effective in weed control, their excessive use has led to weed resistance to herbicid modes of action (Wrubel and Gresse, 1994).

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This is the reason when herbicides are used as the only weed control tool, combined with little or no in the diversity of agronomic practices (Beckie *et al.*, 2004).

Both glyphosate and glufosinate have been and are still very used in weed control, and as a result a wide range of weeds that have become resistant to them (Burke *et al.*, 2008).

Plant species resistant to glyphosate, in particular the *Amaranthus spp*. species, have become a real problem worldwide in all areas where maize and cotton are grown. In several maize cultivation areas in the USA several atrazine-resistant weed species have been documented. Atrazine can be applied both pre-emerging and post-emerging; it can be applied alone or in combination with one or more herbicides (Walsh *et al.*, 2012).

The development of herbicide-resistant weeds, reduces the abundance and diversity of plants in agro-systems, and this raises concerns about the environmental impact of herbicides (Rotches-Ribalta *et al.*, 2015). When spraying plants with herbicides in crop fields, sublethal doses can reach non-target plants in adjacent habitats through drift, run-off and/or volatilisation (Boutin *et al.*, 2014).

The success of weed control methods depends on many factors, yet the timing of application and the stage of culture are the most important factors in chemical control (Hoverstad et al., 2004). The time of application of herbicides is very important for the proper control of weeds and the efficacy of herbicides can be increased (Vandini *et al.*, 2005).

### Reasons for carrying out the study

Corn is one of the most important crop plants in agriculture and the economy, with Romania occupying the lead. A large proportion of corn production is prevented by the weeds it is competing with, and for the reason that manual plowing is not always a safe method, but also because it takes longer, it is concluded that herbicides are a better alternative to weed control.

The purpose of this study was to study the influence of different Stomp Aqua herbicide concentrations on germination of the seed material in maize (*Zea mays* L. convar. *saccharata* var. *rugosa*), this herbicide being recommended by the manufacturer for control of monocotyledonous and dicotyledonous weeds (https://www.agro.basf.ro/ro/produse/overview/Stomp%C2%AE-Aqua.html). Our question was how much the Stomp Aqua maize crop affects, especially germination and development of caryopsis.
This has made us choose a pre-emerging herbicide.

## MATERIALS AND METHODS

The materials utilised were: maize caryopsis, plastic casseroles, cotton wool floppy disks, herbicide, water, ruler. The biological material used for this study consisted of carefully selected corn caryopsis without bruising and being whole, these seeds belong to the variety *Zea mays* L. convar. *saccharata* var. *rugosa*.

Stomp Aqua is a pendimethalin-based herbicide that combats annual monocotyledonous weeds and some annual dicotyledonous species (https://www.agro.basf.ro/ro/produse/overview/Stomp%C2%AE-Aqua.html).

The caryopsis were placed in transparent plastic casserole 18 cm long, 9 cm wide and 3 cm high. Cotton wool floppy disks have been used as a growing substrate. The variation of the substrate was initially made with 50 ml of tap water, the moisture has been continuously controlled, wetting as many times as needed. The experiment was repeated four times, and that is why 12 casserole (three casserole each repeat) were prepared. 100 caryopsis were placed in each casserole, so in an experiment we used 300 caryopsis each.

In the blank variant, the selected maize caryopsis were not treated with the herbicide solution and different concentrations of the Stomp Aqua herbicide were used for the other two experimental variants.

The following variants result:

- V1 - where caryopsis have not been treated with a herbicide, this is the blank variant,
- V2 - where caryopsis have been treated with a herbicide solution, with the concentration recommended by the manufacturer, i.e. 8 ml of herbicide per 1 liter of water,
- V3 - where caryopsis have been treated with a herbicide solution, in duplicate of that recommended by the manufacturer, i.e. 16 ml of herbicide per 1 liter of water.

The caryopsis were treated with herbicide for 24 hours, after which only tap water was administered to them. The casseroles were placed in natural light and at an average temperature of 24 to 25 °C.

The experimental data from the study have been processed and entered in tables on the basis of which representative graphs were made for the comparison of experimental results. A series of images were performed during the study, the most representative of which were entered below.


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**Fig.1.** Fitting the experiment with caryopsis of *Zea mays* L.convar. *saccharata* var. *rugosa* (original image)

**Fig. 2.** Measurement of the stem (original image)

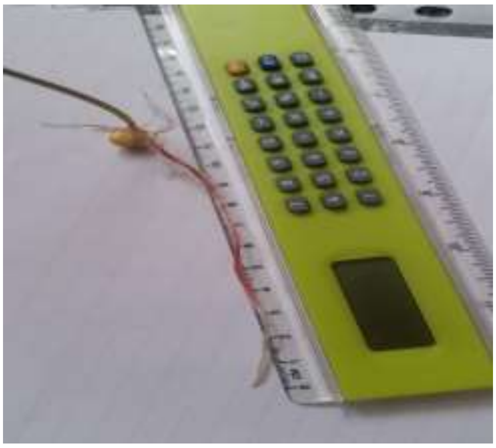


**Fig. 3.** Measurement of the root (original image)

## RESULTS AND DISCUSSIONS

The experiments have been monitored for 16 days at 3-day intervals during which macroscopic observations have been performed. At 3, 6, 9, 12 and 15 days observations were noted and analyzed, following: germination faculty, root length and stem length.

**Table 1.**

The values of germination faculty (GF) and germination energy (GE) in *Zea mays* L.convar. *saccharata* var. *rugosa*

| Variants. | V1 | | V2 | | V3 | |
|---|---|---|---|---|---|---|
| Number of days | Number of germinated / total | GF(%) | Number of germinated / total | GF(%) | Number of germinated / total | GF(%) |
| 3 z | 59 | 59% | 50 | 50% | 46 | 46% |
| 6 z | 85 | 85% | 77 | 77% | 70 | 70% |
| 9 z | 93 | 93% | 86 | 86% | 77 | 77% |
| 12 z | 93 | 93% | 86 | 86% | 77 | 77% |
| 15 z | 93 | 93% | 86 | 86% | 77 | 77% |
| | GE=68 | | GE=56 | | GE=50 | |

V1 (blank) - caryopsis have not been treated with a herbicide; V2 - caryopsis treated with 8 ml of Stomp Aqua herbicide solution in 1 liter of water; V3 — caryopsis treated with 16 ml Stomp Aqua herbicide solution in 1 liter of water

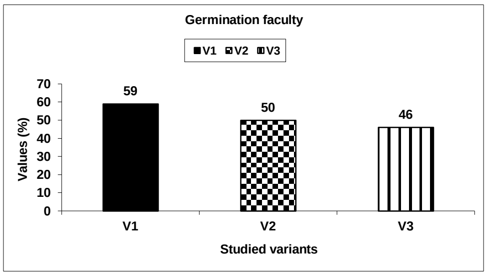
### At 3 days after the experimental set-up

**In the first variant (V1- blanck variant)**: out of the total of 100 maize caryopsis put to germinate, the embryonic root was present at 59 caryopsis, with the germination capacity at this experimental variant being the highest, i.e. 59 %. The roots were up to 20 mm long, with an average of 11.5 mm and a yellowish-white color being one/plantlet. The coleoptilum was present only in some caryopsis, with pink color and an average length of 5 mm. The presence of mould on the growing sublayer in the form of dark gray spherical islands has been noted.

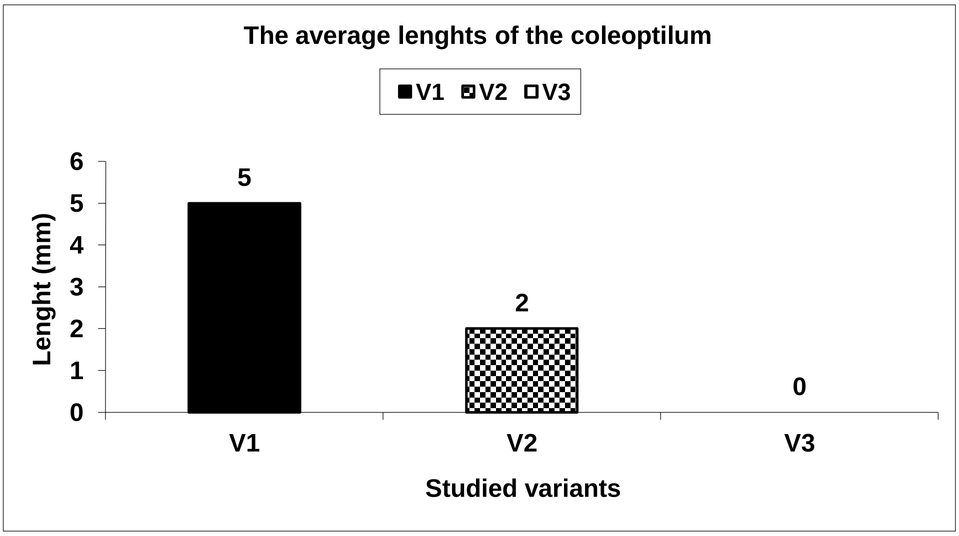
**In the second variant (V2)**: of the total of 100 caryopsis, 50 caryopsis sprouted, the germination capacity is 50%. The stems were 7 mm in average length and yellowish-white color, being one per plantlet. The coleoptilum was present in some caryopsis and was an average length of 2 mm. The presence of mould is not noted.

**In the third variant (V3)**: of the total of 100 caryopsis, 50 caryopsis sprouted, the germination faculty reached the lowest value in the whole batch, i.e. 46%. Note the length of the newly formed root as the lowest and the mean length is only 5 mm. Because of the high concentration of the herbicide that is at a high concentration, coleoptilum is not present in this variant; the presence of mould is also not noted.

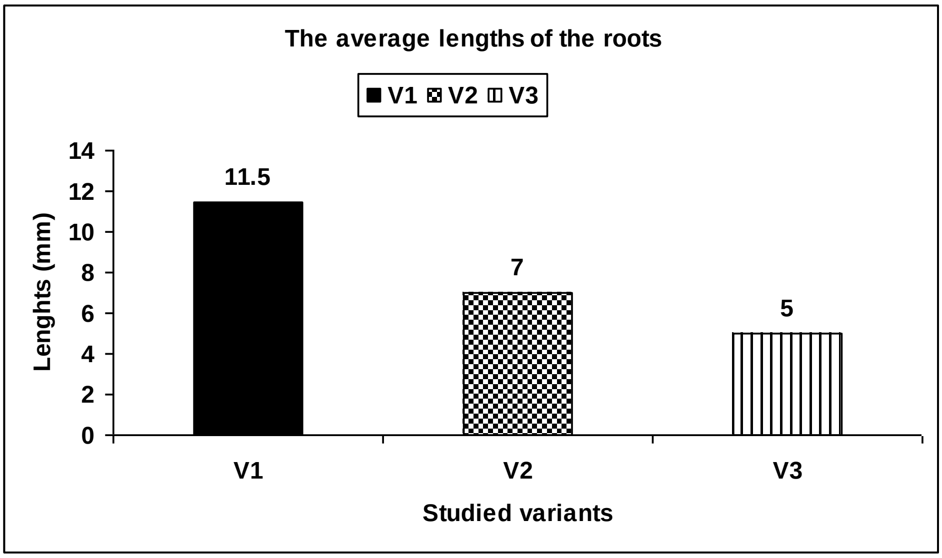
In none of the experimental variants whose cariopse has been treated with a herbicide, the presence of mould was not noted, but at all the high degree of germ cell disease was found.




**Graph. 1.** Comparative graph of the germination dynamics of *Zea mays* L. convar. *saccharata* var.*rugosa*, noticed on the 3rd observation day




**Graph. 2.** Comparative graph of the length of the coleoptilum / stems measured on the 3rd observation day




**Graph. 3.** Comparative graph of the length of the roots measured on the 3rd observation day

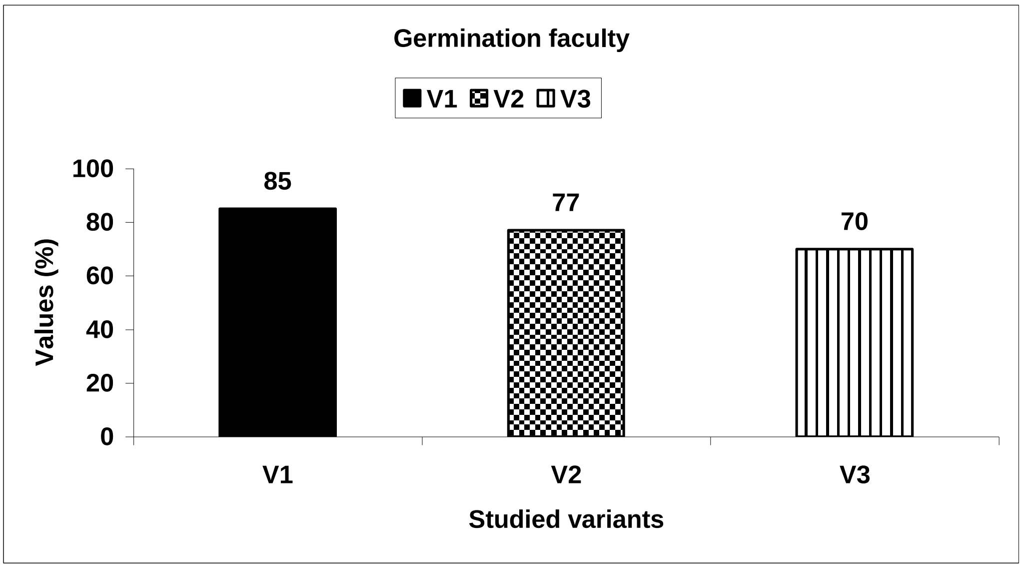
### At 6 days after the experimental set-up

**In the first variant (V1)**: out of the total of 100 cariopse, there are 85 sprouted cariopse this time, as on day 3 of the observations, the highest value in this lot. Embryonic stems are an average size of 23 mm and the average of the coleoptilum is 17 mm. Both root and coleoptilum have developed at a rapid rate from day 5, when the root mean length was respectively 13 mm and 9 mm the mean coleoptilum. On the growing substrate, there is a mould that has started attacking the surrounding caryopsis, and 8 of them are affected.

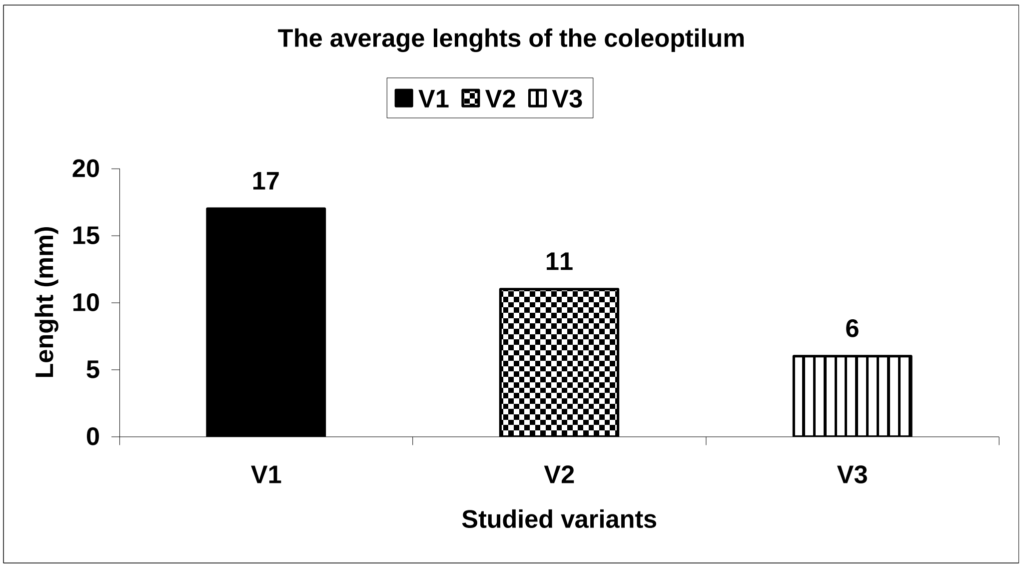
**In the second variant (V2)**: of the total of 100 cariopse, 77 are germinated, but due to the fact that these cariopes have been treated with 8 ml herbicide solution in one liter of water, it has led to the growth of both root and coleoptilum as the blank caryopsis, this gives the mean root length of 11 mm and the coleoptilum, 15 mm. On this date, the presence of mould on the growing substrate in the form of a dark gray spherical islands, and which attacked 9 cariopse.

**In third variant (V3)**: of the total of 100 caryopsis, 70 are germinated. As with variant 2, the root and coleoptilum have a slower growth compared to the control variant, which has not been treated with a herbicide solution. The stems are an average size of 6 mm and the coleoptilum is an average size of 9 mm. Although the herbicide concentration used on the substance with which caryopsis has been treated, 16 ml in 1 liter of water, does not inhibite the development of mould, thus, the presence of mould in the form of dark gray spherical islands and which attacked 7 of the caryopsis is noted on the growing substrate.

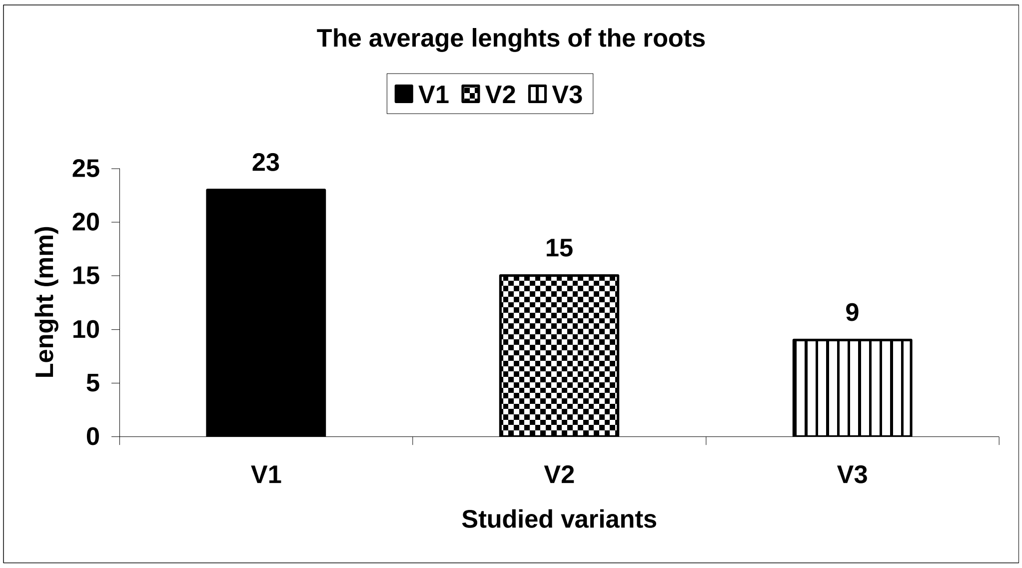
The germination energy was recorded on the 4th day of all experimental variants, where at variant 1 it was 68%, at variant 2 it was 56% and at variant 3 the value was 50%. It is noted that its value decreases with the increase in the herbicide concentration.




**Graph. 4.** Comparative graph of the germination dynamics of *Zea mays* L. convar. *saccharata* var. *rugosa*, noticed on the 6th observation day




**Graph. 5.** Comparative graph of the length of the coleoptilum / stems measured on the 6th observation day



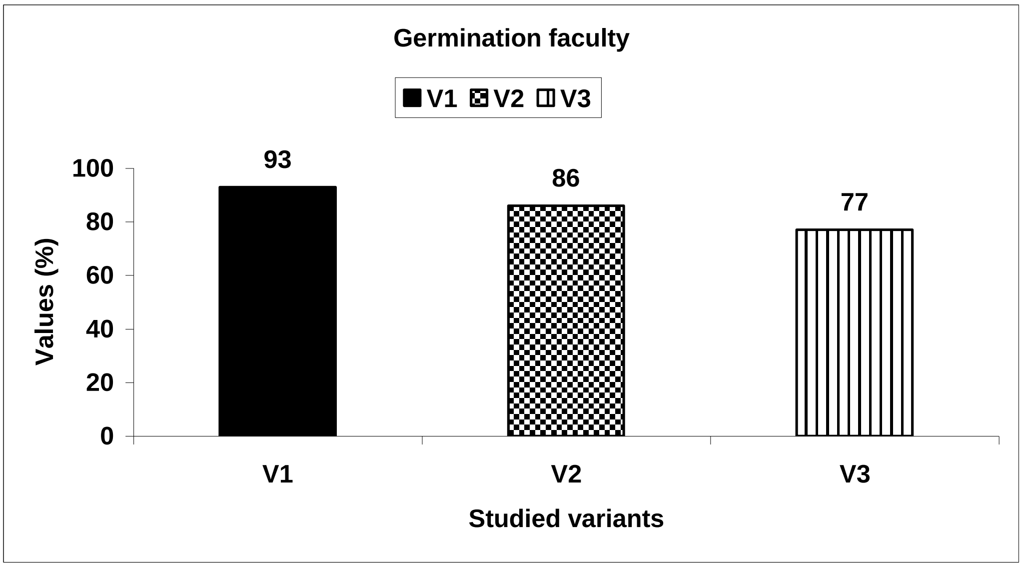

**Graph. 6.** Comparative graph of the length of the roots measured on the 6th observation day

### At 9 days after the experimental set-up

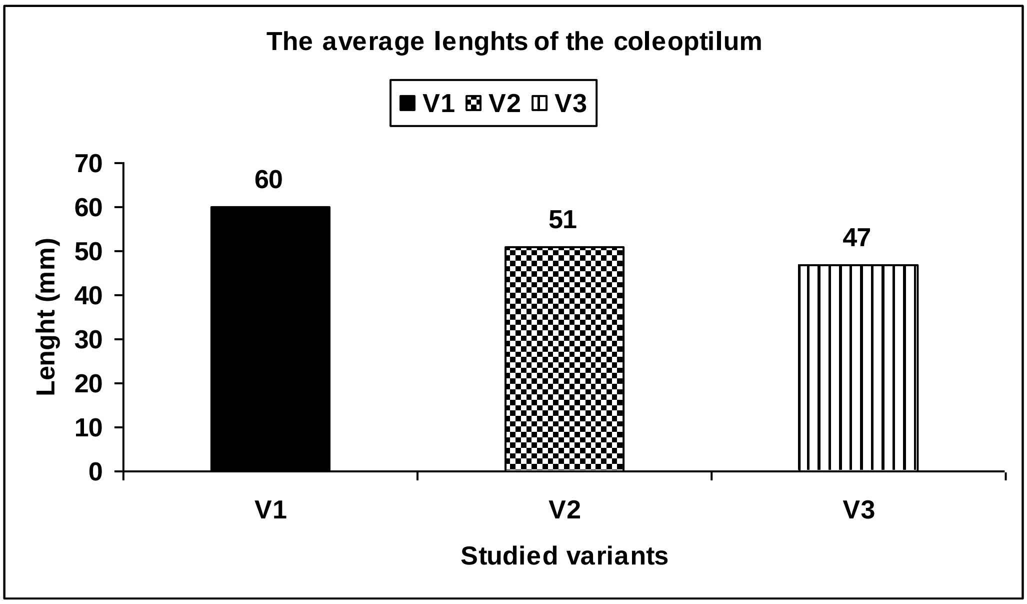
**At the first variant (V1):** 93 caryopsis of the total 100 which have been germinated at the time of the assembly of the experiment, are germinated on this date. The germination faculty reached 93%, being the highest of the 3 variants (Table 1). At this option we can talk about plantlets, since the first leaf penetrated the coleoptilum, the largest size of the stalk was 126 mm, and the average size was 60 mm and the color was dark green, some plantlets with cherry-colored areas toward the base. This tree has several largest roots of 120mm size and the length average was 51 mm, the largest size so far encountered and the color is yellowish to some plantlets.

**In the second variant (V2)**: at this variant, the germination faculty was 86%, while 86 caryopsis of 100 were germinated. Also, in this variant it is noted that the first leaf has penetrated the coleoptilum to several plantlets, with the average stem size being 51 mm, the color being dark green, having yellowish-white roots, but on some plantlets, the roots are to the cherry, and the root mean size of the root was up to 25 mm. Several caryopsis stopped from development due to the mold present on the substrate and which attacked them.

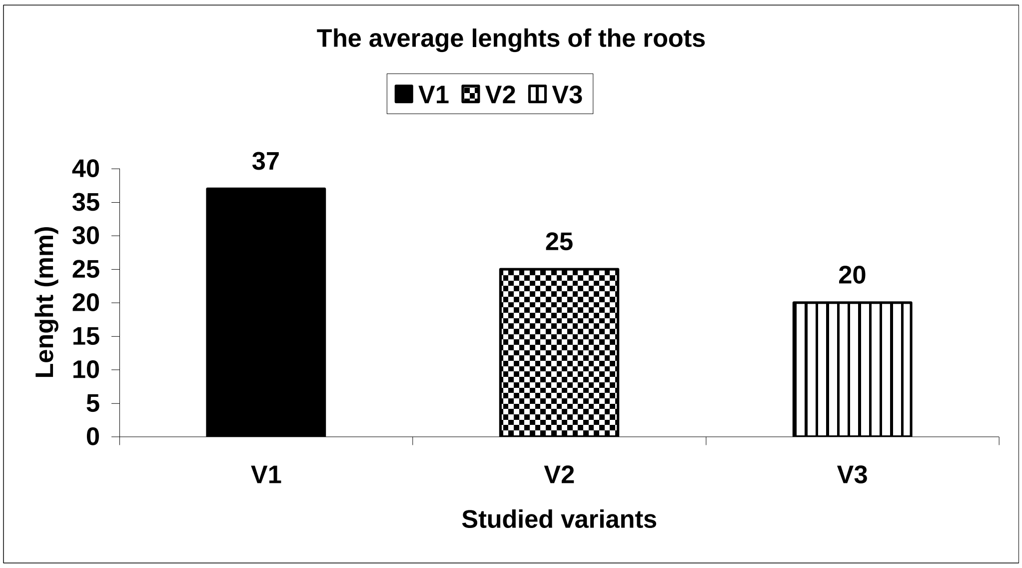
**In the third variant (V3):** at this date 77 cariopse are germinated, the germination capacity being 77 % and the lowest value found at this time of the 3 experimental variants.We are still talking about choleopril, because the first leaf has not yet penetrated the coleoptionil, although there is an attempt to get out. Coleoptilum has an average size of 47 mm, and the roots have 20 mm; also, having yellowish-white, and some red area towards the base the roots.




**Graph. 7.** Comparative graph of the germination dynamics of *Zea mays* L. convar. *saccharata* var.*rugosa*, noticed on the 9th observation day




**Graph. 8.** Comparative graph of the length of the coleoptilum / stems measured on the 9th observation day



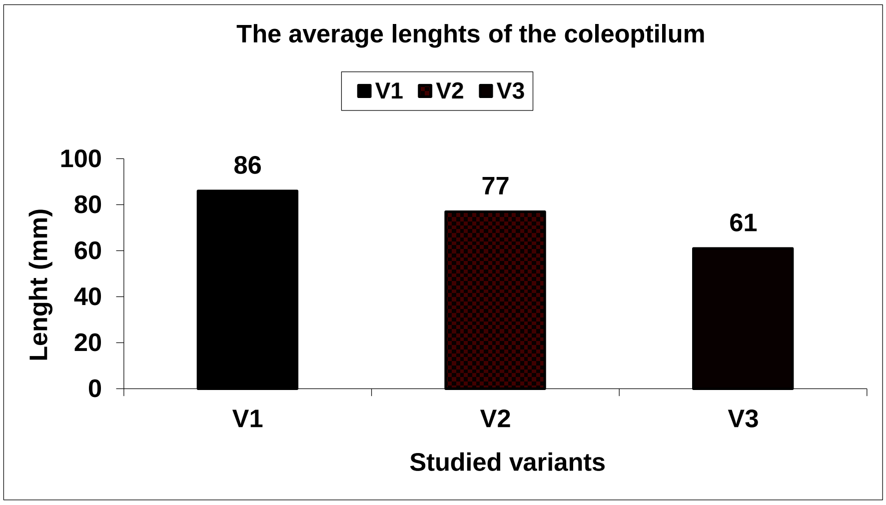

**Graph. 9.** Comparative graph of the length of the roots measured on the 9th observation day

### At 12 days after the experimental set-up

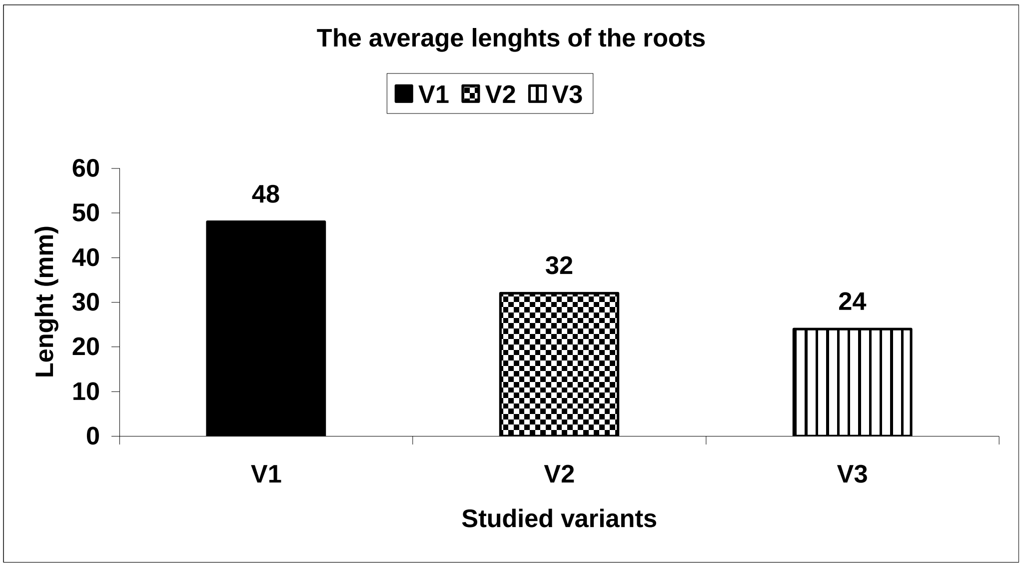
In the first variant (V1): from the 9th of the day of the experimental installation, no caryopsis has sprouted, so the germination stopped and we obtained a germination capacity of 93%. The plantlets are well developed with stems up to 188 mm in size, the average length of which is 86 mm; and the root of the most developed plantlets have been up to 130 mm in size with an average length of 48 mm. The mould is present on the whole surface of the substrate and has attacked not less than 23 caryopsis. Among the caryopsis attacked by mould are those that have not sprouted at all, but there are also a few caryopsis that have sprouted just that the stage of development has stopped in coleoptilum.

In the second variant (V2): at this time it is noted that no more caryopsis is germinated in addition to those sprouted up to 9 a day, as is the blank version, so the germination remains 86 %. The plantlets have root-length of an average size of 77 mm and the stems are of an average size of 32 mm. In most of the stems are dark green with cherry areas, but there are plantlets where the color of the stems is light green. The mould is present on almost all the surface of the substrate, attacking most of the caryopsis, some of them have not developed and have remained at the coleoptilum stage, or at most the first leaf has penetrated the coleoptil, but just that not enough to be able to speak of a developed plantlets.

**In the third variant (V3):** it has been noted, just as the other two versions, have not sprouted any more caryopsis, so, the germination faculty is of 77%, as in the 9th day. The average length of the stems is 61 mm, dark green, some o them are light green and the roots-lenght average is 24 mm long, most of them are pink. The mould is present on more than half the surface of the substrate and has attacked almost all the caryopsis.The most affected caryopsis stopped out of development, some even at the coleoptilum stage.




**Graph. 10.** Comparative graph of the length of the coleoptilum / stems measured on the 12 observation day



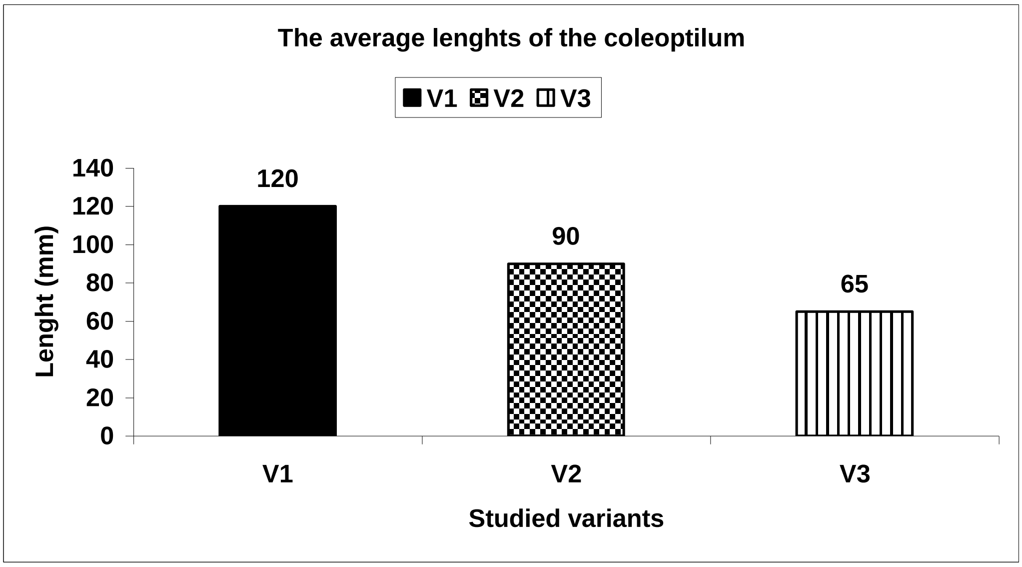

**Graph. 11.** Comparative graph of the length of the roots measured on the 12 observation day

**At 15 days after the experimental set-up**

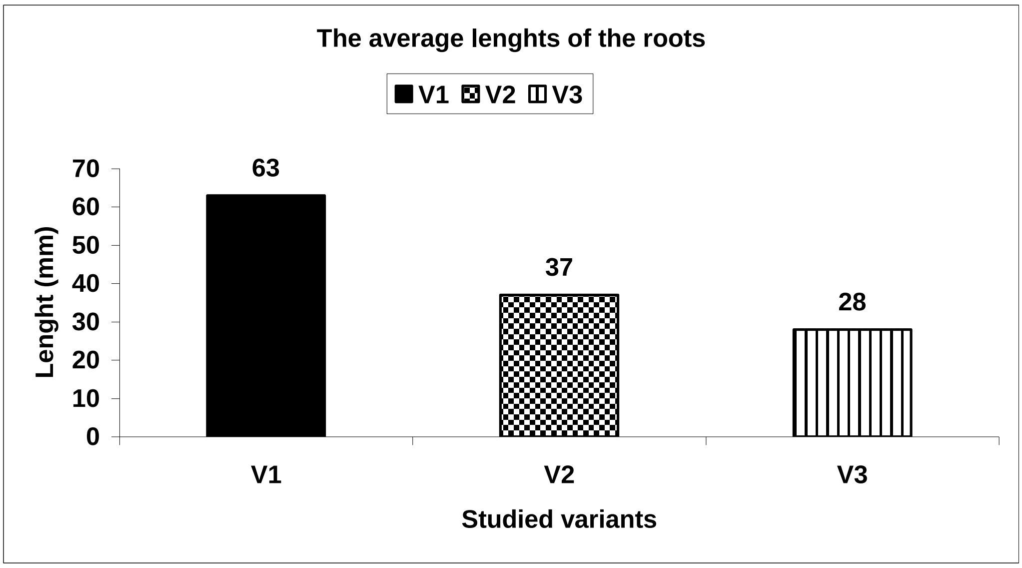
**In the first variant (V1):** at this observation date, most of the plantlets are highly developed, the stems are up to 225 mm in size, the average being of 120 mm. We observed some fully cherry-colored stems with several leaves (5 leaves/tree) and the roots mean size was 63 mm. Some root growth is strongly attacked by light grey mould, which has covered the whole surface of the substrate and because of which several caryopsis are no longer seen.

**In the second variant (V2):** at this observation date, although the plantlets are much more developed than in the previous observation, compared to the blank version, a smaller dimension of the stem size is recorded, having an average length of 90 mm and a root length of 37 mm. Most of the plantlets have 2 leaves each.

**In the third variant (V3):** at this observation date, it is noted that both the size of the stems and the roots is much smaller compared to the blank variant, but also variant 2, which is 65 mm average for the stems and 28 mm for roots. Although the size of the plantlets is smaller than the other two variants, they have developed 1-2 leaves in each plantlet.




**Graph. 12.** Comparative graph of the length of the coleoptilum / stems measured on the 15th observation day




**Graph. 13.** Comparative graph of the length of the roots measured on the 15th observation day

Many authors found that the correct application of herbicides has a positive influence on field crops (Mikova and Stoimenova, 2006; Korpanov *et al*, 2010; Simic *et al.*, 2008, 2010, 2012).

In 2012, Khan et al. observed low weed biomass after the application of pre-emerging herbicides to maize cultivation, and in 2013, Khatam reported a low weed density that has been specifically treated with the aid of a herbicide for fast toxicity and efficiency of weed in corn crops. Many researchers have found that herbicides have a great influence on reducing weed biomass (Khan *et al.*, 2009; Gul *et al.*, 2011), who have achieved much higher biological yield due to effective control of weeds through application of herbicides.

From an environmental point of view, the most significant impact of herbicides is that of a change in plant diversity composition or sublethal effects causing changes in plant development, growth and morphology (Boutin et al., 2004). The severe sublethal effect of biomass (Riemens *et al.*, 2008, 2009), reproduction (Boutin *et al.*, 2014; Riemens *et al.*, 2008; Olszyk *et al.*, 2015) and plant physiology (Ivanov, 2013) have been reported in several studies, in particular in the greenhouse experiments and field situations (Hensley *et al.*, 2013). Only a few studies investigated the effect of herbicides on germination and plant growth (Tanveer *et al.*, 2009).

Maize (*Zea mays* L.), soya (*Glycine max* L.) Merr.) and cotton (*Gossypium hirsutum* L.) contain a modified gene 5-enolpyruvi-shikima-3-phosphate synthetically, which gives resistance to glisophate. The use of glisoft-resistant crops, the reduction of traditional herbicides and cultivation practices, has created a selective advantage for glisofat-resistant weeds (Culpepper, 2006; Owen, 2008).

Pendimethalin is a pre-emerging selective herbicide on soil surface, with or without incorporation into soil, which is part of the dinitroaniline group (Devine *et al.*, 1993) being used extensively to control weeds from cotton, soya, tobacco, maize, etc (Smith *et al.*, 1995; Lin *et al.*, 2007). According to Moosavi *et al.* (1995), the Stomp (pendimethalin) herbicide controls 77 of the grasses' weeds and 69 of the weeds in the maize crop.

It has been found that the use of pendimethalin prior to cultivation or before the growth of the crop results in growth inhibition. The reason for such inhibition is due to a change in cell division steps which are necessary to separate the chromosomes and to form the cell wall (Parka and Soper, 1977; Appleby and Valverde, 1988).

The treatment with pendimethalin herbicide reduces the primary root length and the number of lateral roots, this is due to the fact that the root is the first directly in contact with pendimethalin in the soil. Smith (2006) found that this herbicide has significantly inhibited weed growth as well as crop growth. It has been found that plants treated with herbicides under the dinitroaniline group develop the swelling and fragility of the stems or hypocotilum of the seed, and the color is dark green (Parka and Soper, 1977).

Phytotoxicity and severe symptoms reported by literature refer to reduced or inhibited germination, length of root and small stem (Sinha *et al.*, 1996). In this study this was observed in both experiments; thus, for herbicide-treated variants, lower values were recorded than for blank variants, both in terms of germination capacity and in terms of stem length and root length.

Several reports have shown that herbicides have adverse effects on maize germination, such as Nehru *et al.* (1999) have observed that the pendimethalin and trifluralin herbicides severely affect the germination and growth of maize and beans.

Rajashekar and Shivashankara (2010) have studied the effect of pendimethalin on the maize crop from which it resulted that with the increase in herbicide concentration the germination percentage, the length of the radiculas decreased sharply.The same authors in 2009 studied the effect of pendimethalin on the soybean crop, from which they observed the same.

Our results are correlated with what the authors have said, in terms of germination, so higher concentrations of the herbicide pendimethalin have inhibited the germination of caryopsis.

## CONCLUSIONS

The following can be concluded from the experiments carried out and from the results obtained:

1. According to the literature, the herbicide pendimethalin inhibits germination of corn caryopsis, thus a lower number of sprouted caryopsis was recorded for the herbicide-treated variants.

2. With the increase in the herbicide concentration, the growth of choleoptera is slowingwe believe that the herbicide has a negative influence.

3. There has been a significant difference in rooting growth between the control and the treated variants, so we believe that the herbicide has negative effects on germination and plant growth.

## AUTHORS CONTRIBUTIONS

Conceptualization, T.I.M.; M.L.M.; and T. V.; methodology, T.I.M.; T.V..; data collection T.I.M.; M.L.M.; T.V. data validation, T.I.M.; M.L.M.; T.V.; data processing T.I.M.; M.L.M.; T.V.; writing—original draft preparation, T.I.M.; T.V.; writing—review and editing, T.I.M.; T.V.

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## CONFLICT OF INTEREST

The authors declare no conflict of interest.

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