https://doi.org/10.18406/2316-1817v14n120221682 e-ISSN 2316-1817

Different sources of nitrogen in potato cultivation and the management of common scab

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Received in: 20/12/2021
Accepted in: 23/08/2022

Abstract

Potato (*Solanum tuberosum* L.) is native to South America and is the main vegetable grown in Brazil and worldwide. One of the diseases that can attack potato crops is the common scab, caused by the bacteria *Streptomyces scabies*, which affect roots and tubers. The objective of this research was to evaluate the effect of different sources of cultivation on potato crop in the management of common potato scab. The experimental design was in randomized blocks (DBC) containing five treatments urea (45% N), ammonium sulfate (20% N), protected urea (45% N), organomineral (0.75% N) and control (0% N). N) and four replications, in a total of 20 pots. The bacterium was removed from infected potato tubers and isolated in petri dishes containing YMA (Yeast, Manitol, Agar) culture medium. The bacterium was inoculated into the soil 15 times, seven days before planting. Seeds were distributed in pots with a capacity of 8 L, in a proportion of 2:1 (earth and sand), which were placed in a greenhouse. Fertilizing for planting and coverage was carried out according to the requirements of the crops: fertilization with urea and ammonium sulfate was carried out once at planting and twice at the top dressing; fertilizing with protected urea and organomineral was carried out once at planting and once at the top dressing; and nitrogen fertilization was not performed in the control treatment. The tubers were harvested 90 days after sowing. The variables analyzed were severity (graded) and incidence, counting the number of contaminated tubers, tuber weight yield of each plot, number of leaves, number of stems, and plant height. It was observed that the treatments with urea and ammonium sulfate had a lower percentage of common scab incidence, with an average incidence of 6.74% and 8.42%, respectively, followed by protected urea (8.90%). Urea and ammonium sulfate were efficient in reducing potato scab and increasing tuber production.

Keywords: Nitrogen. *Solanum tuberosum* L. *Streptomyces scabies*.

Introduction

The potato (*Solanum tuberosum* L.) is the main vegetable cultivated in Brazil and worldwide, considering the extension of the cultivated areas and consumption rate. It is the fourth most produced food globally, being the vegetable that yields the most in a smaller area. According to the 2020 Census of the Brazilian Institute of Geography and Statistics (IBGE), 115 thousand hectares of potatoes were planted in Brazil, producing about 3.4 million tons, with average productivity of 29.6 t ha^{-1}.

Frequently, crops have suffered from the presence of different types of pests and diseases caused by fungi, bacteria, viruses, and insects, which leads to significant economic losses. One of the diseases is common scabies, caused by the bacteria *Streptomyces scabies*, which affect potato tubers. In addition to the tropical climate, which favors the emergence of pests and diseases, the low natural fertility of Brazilian soils implies the intensive use of inputs in potato cultivation. The high use of pesticides, fertilizers, and seed tubers, mainly when imported, eventually burdens production (DELEO; CARDOSO, 2014).

Common scab is a bacterial disease that has become widespread in several potato-producing regions of the world (LORIA et al., 1997). It has been considered the fourth most important crop disease in North America (SLACK, 1991).

In Brazil, there is little information about the economic impact of the disease on potato agribusiness. However, Nunes (2002) observed that, depending on the variety cultivated, the losses due to the depreciation of the tubers can reach up to 83%. Fischer et al. (2005) indicate a drastic rise in the number of complaints from producers regarding the boosted incidence of the disease.

One of the reasons for this increase may be the low quality of the propagating material, among which nitrogen (N) stands out. Nitrogen is the most required element in the potato crop (MALAVOLTA, 2006), but it has a high energetic and financial cost.

Plants under nutritional stress are more susceptible to attack by pests and diseases. Although the species is responsive to nitrogen fertilization, its dose for maximum productivity of potato tubers is variable, which makes its management complex, as it depends on factors such as cultivar, seed potato size, history of the area, soil organic matter, soil type, crop management and conduction and volume of rainfall during cultivation (FERNANDES; SORATTO, 2012; ZOTARELLI et al., 2015; CAMBOURIS et al., 2016). Moreover, due to its shallow and poorly developed root system compared to other crops, potato has low efficiency in nitrogen absorption, requiring high amounts of this nutrient (YAMAGUCHI; TANAKA, 1990; GEARY et al., 2015; DARABI et al., 2018; LI et al., 2019).

To control common scab disease, planting in areas infested with the pathogen should be avoided, crops should be rotated, tolerant cultivars used, and planting in alkaline soils should be avoided. Additionally, the soil should receive balanced fertilization with nitrogen and others.

Thus, this research aimed to evaluate the agronomic characteristics and the management of common scab of potato crops with different nitrogen sources.

Material and methods

The research was carried out in Borda da Mata, MG, which has an average altitude of 803 m and average annual rainfall of 1324.7.7 mm. The region's climate is mesotrophic and the average annual temperature is 19°C.

The experimental design used was randomized blocks (RBD), with five treatments (urea, ammonium sulfate, protected urea, organomineral, and control) and four replications, in a total of 20 experimental plots.

Sixty days before the experiment onset, soil samples were taken for analysis. From the results, liming was performed, aiming to reach a base saturation (V) of 60%. Potato tubers of Ágata cultivar were donated by a producer in the region.

The experiment was carried out in plastic pots with eight liters of capacity in the proportion of 2:1, with two parts of ravine earth and one part of sand. The mixture was sieved and fertilized according to the requirements of the crop.

The bacterium was removed from infected potato tubers and isolated in petri dishes containing YMA culture medium (Yeast, Mannitol, and Agar). Subsequently, they were subcultured in 20 plates, with the culture medium remaining for ten days under ambient conditions. The bacterial suspension was prepared in a blender, adding 100 mL of sterile distilled water per plate. Then, the suspension (100 mL) was inoculated into each pot for the first 15 cm.

Seven days after bacteria inoculation, two tubers were placed in each pot. The pots were placed in a greenhouse. Planting fertilization and coverage were performed according to soil analysis. At planting, 6.8 g of Phosphorus (P) and 0.27 g of potassium (K) were applied in each plot.

The urea treatment was performed once at planting and twice at top dressing, with 0.35 g of urea per pot at planting and 1.33 g per pot at the first topdressing fertilization, which was carried out 15 days after planting. The second topdressing fertilization, 30 days after planting, was made with 1.33 g per pot.

The application of ammonium sulfate occurred once at planting and twice at top dressing, with 0.8 g per pot at planting, 3 g at the first top dressing, carried out 15 days after planting, and 3 g at the second top dressing, performed 30 days after planting.

The treatment with protected urea was carried out once at planting and once at top dressing, with 0.35 g per pot at planting and 1.33 g at the first fertilization, carried out 15 days after planting. The application of the organomineral treatment was carried out once at planting and once at the top dressing, with 5.3 g per pot at planting and 15.3 g per pot at the top dressing, carried out 15 days after planting. In the control treatment, no nitrogen source was applied.

As for irrigation, soil moisture was kept below field capacity, especially during tuberization, because excessive irrigation may favor soil diseases, such as common scabies. The water demand depends mainly on climatic conditions and the cultivation system. Thus, the total crop need, including soil water evaporation, varies from 250 mm to 550 mm and can exceed 600 mm for long-cycle cultivars in hot, dry regions. The tubers were harvested 90 days after planting.

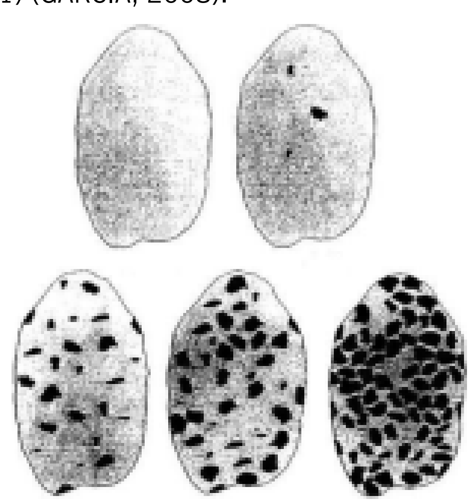
The variables analyzed were percentage of incidence and severity, tuber weight yield of each plot, number of leaves, number of stems, and plant height. The percentage of bacterial incidence was evaluated by the number of infected tubers per pot, dividing the number of diseased tubers by the total number of tubers in each pot, multiplied by 100.

The severity was indicated through grades, which represent a certain percentage of the surface of each tuber with symptoms of common scab, based on the diagrammatic scale of five degrees, described by James (1971): 1 – tuber without disease symptoms; 2 – tuber with up to 12.5% of the area with symptoms; 3 – tuber between 12.5% and 25% of the area with symptoms; 4 – tuber between 25% and 50% of the area with symptoms; and 5 – tuber with more than 50% of the area with symptoms.

Counting leaves and stems was performed 40 days after the emergence of symptoms; all units of leaves and stems were counted in each plot. Height was measured 40 days after the emergence of symptoms with a millimeter ruler.

The tuber yield in each plot was also evaluated by weighing each one after the removal of the soil. The statistical data analysis was carried out through the SISVAR program (FERREIRA, 2000). The means obtained were evaluated by analysis of variance, considering a significance level of 5% for the F test. When significant, the results corresponding to the treatments were transformed and compared using the Scott Knott test (5% probability).

Figure 1 – Representation of the common scab severity scale of potato tubers, adapted from James (1971) (GARCIA, 2008).



Results and discussion

The average results regarding the percentage of incidence and severity of common potato scab submitted to different treatments are shown in Table 1. There was a significant difference ($P < 0.05$) between treatments for incidence and severity.

There was a significant difference between the control and the other treatments regarding the percentage of severity, as shown in Table 1. However, treatments with urea, ammonium sulfate, protected urea, and organomineral were similar and had higher incidence.

Table 1 shows a lower incidence of common scab in potato tubers when urea and ammonium sulfate were applied at 6.74% and 8.42%, respectively. The other treatments, such as control, protected urea, and organomineral were not different. The lower incidence of urea and ammonium sulfate may be due to the rapid solubilization of their components, causing a lowering of soil pH. Studies by Saha et al. (1997), Yoshida et al. (1997), and Sturz et al. (2004) indicated that the application of fertilizers that reduce soil pH, such as urea and ammonium, manganese or aluminium sulfates, obtained satisfactory results in controling potato scab.

Soil fertilization can also be related to its pH decrease. The ammonium sulfate fertilizer decreases the pH of the soil and increases the concentration of soluble aluminium, reducing the incidence of scab by up to 50% (MIZUNO; YOSHIDA; TADANO, 2000).

The pH factor is correlated with the incidence of scabs (BITTENCOURT et al., 1985; LEVICK et al., 1985), ranging from 6.0 to 8.0, where the disease occurs with greater intensity. Values lower than six favour the occurrence of the disease, although, according to Bittencourt et al. (1985), scabs can occur in soils with a pH from 5.0 to 6.0. Alkaline soils influence the outbreak of potato common scab, however maintaining or reducing soil pH to values less than 5.2 generally reduces scab and can be a control tool if combined with the right type of soil, with the right amount of moisture and with tolerant cultivars (LAMBERT; POWELSON; STEVENSON, 2005).

According to Nascimento et al. (2013), the volatilization of various types of urea and ammonia coatings is higher than the sources of ammonium nitrate and ammonium sulfate. Gagnon et al. (2012) found better performance of polymer-coated urea only in rainy years, and in the dry year, there was no benefit in using controlled-release fertilizer.

The organomineral represents a major challenge for organic fertilization related to the availability of nutrients -mainly nitrogen- throughout the crop cycle (BARRETO et al.,

Table 1 – Mean values of severity (%) and incidence of infected potato tubers submitted to different nitrogen treatments.

Treatments	Incidence (%)	Severity (%)
Control	9,67 a	5,16 a
Urea	6,74 b	3,14 b
Ammonium sulfate	8,42 b	4,04 b
Protected Urea	8,90 a	3,72 b
Organomineral	9,11 a	3,64 b
Means	8,57	3,94
p-value	*0,00001	*0,00209

Means followed by different lowercase letters in the column differ by the Scott Knott test at 5% probability.

2016). The management of organic fertilizer is complicated when it comes to the forms of nitrogen available to plants, as it is conditioned by mineralization, and only a part of the organic-N is mineralized in the year it is applied (MALLORY et al., 2010).

Thus, replacing fertilizers with mineral compositions strictly by organic compounds can significantly decrease yield. There is a necessary time frame for the change from conventional systems to organic ones. The time frame depends on the adaptation of the ecological systems to the new conditions. Eventually, over the years, the availability of nutrients through organic fertilization becomes natural once the system comes into balance (FEIDEN, 2001).

The average results regarding the number of leaves, number of stems, plant height (cm), and production of potato tubers (g) submitted to different nitrogen treatments are shown in Table 2. There was a significant difference ($P < 0.05$) between treatments for plant height and tuber production.

Table 2 exposes that the treatments with urea and ammonium sulfate provided higher plants. The other treatments had no significant differences between them.

There was a significant increase in tuber production when treated with urea and ammonium sulfate. A significant difference was found for protected urea. Lower values were identified for the other treatments, such as control and organomineral. Probably, the reduction of tubers occurred due to the low content of nitrogen available in the organomineral, compared to ammonium sulfate and urea.

Nitrogen is an essential nutrient all living organisms require, and its lack often limits primary production in aquatic and terrestrial ecosystems. It is needed in large quantities as it is an essential component of proteins, nucleic acids, and other cellular constituents (VIEIRA, 2017).

Studies reveal that nitrogen is one of the elements necessary for plant growth, being the second most extracted nutrient by the potato crop (around 3 to 5 kg of nitrogen per ton), and it governs plant development, stimulating the growth of the aerial part. Thus, its lack may be the factor that limits potato productivity (COELHO et al., 2010), which explains the lower production value of the control treatment, in which this nutrient was not made available to the plant.

Conclusion

Urea and ammonium sulfate were efficient elements for reducing the common scab of potatoes.

Table 2 – Values for the number of leaves, number of stems, plant height, and final production of potato tubers submitted to different nitrogen treatments.

Treatments	Number of leaves	Number of stems	Height (cm)	Production (g)
Control	1,95	4,72	13,25 b	66,18 c
Urea	2,09	4,89	16,75 a	122,76 a
Ammonium sulfate	1,95	4,72	16,00 a	116,62 a
Protected Urea	2,00	5,02	14,25 b	82,43 b
Organomineral	1,91	4,71	13,00 b	71,83 c
Means	1,98	4,81	14,65	91,96
p-value	0,0567	0,9153	*0,0011	*0,00001

Means followed by different lowercase letters in the column differ by the Scott Knott test at 5% probability.

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