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PLANT PROTECTION | ORIGINAL ARTICLE

Influence of Tuber Seed Size on Susceptibility of Cipira Potato Variety to Aphid (*Myzus persicae*), and Potato Blight and Bacterial Wilt Diseases

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ABSTRACT

Potato (*Solanum tuberosum* L.) is one of the most important tuber crops in the world and it is fourth among food crops after rice, wheat and maize. Potato is widely cultivated for its cheap source of carbohydrates, vitamins as well as minerals. In Cameroon where potato provide a livelihood for most producers, especially in the Western highland, production is challenged by unavailability of appropriate seeds of local varieties or Cameroon improve varieties. Many decades ago, Cipira was released by the Institute of Agricultural Research for Development, Bambui, North West Region, Cameroon as an improved resistant variety. The current study evaluated the performance of Cipira considering seed sizes. Four seed sizes (20mm, 25mm, 30mm and 35mm diameter) were evaluated in a randomized complete block trial in Bambili in 2022 and 2023. Green peach aphid incidence was inversely related to tuber seed sizes ($P < 0.05$). Aphid population abundance was higher from plants with larger diameter. Late blight and bacterial wilt incidence and disease severity index was significantly higher for plants of smaller tuber seed size. Productivity was 8.06 t ha^{-1}, 6.2 t ha^{-1}, 5.7 t ha^{-1} and 5.8 t ha^{-1} from 35mm, 30mm, 25mm and 20mm tuber seed sizes, respectively in 2022. The yield in 2023 was 8.9 t ha^{-1}, 7.8 t ha^{-1}, 7.1 t ha^{-1}, and 6.3 t ha^{-1}, from 35mm, 30mm, 25mm and 20mm, respectively. For improved yield and reduced pest and diseases incidences, Cipira at 30 mm and 35 mm seed sizes are recommended.

1. Introduction

Irish potato (*Solanum tuberosum* L.) is one of the most important tuber crops in the world and it is fourth among food crops after rice, wheat and maize (Naz et al., 2011). It is also ranked as the firth most important industrial crop (Khan et al., 2017). Potato belongs to the family Solanaceae and it has a global distribution (Grun, 1990; Gehan, 2013). Annual production is about 300 million tons from approximately 20 million hectares of arable land (Jasim et al., 2013). This plant is widely cultivated for its cheap source of carbohydrates, vitamins (B_1 and C) as well as minerals from its tubers (Rashid, 1993). 100g of potato tuber is estimated to have 79.9g water, 78 kcal Energy, 16.8g carbohydrates, 2.4g protein, 36.0mg calcium, 49.0mg phosphorus, 31.0mg ascorbic acid, 2.2mg niacin, 1.1mg iron, 0.12mg thiamine and 0.06mg riboflavin (Tamm, 2007).

In Cameroon, potato is cultivated mainly in the highland zones (Altitude: 1000 to 3000m above sea level) and in six of the ten regions of the country, providing a source of income for many. Over 80% of national production comes from the West and North West regions of the country (Fontem et al., 2004). Potato ranks fifth in tons produced among the major staple crops behind cassava, plantain, cocoyam/taro and maize in Cameroon (KTHEISEN, 2009). Production has witnessed a threefold increase in

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the last two decades (FAOSTAT, 2016), driven largely by the ever-increasing domestic demand and a large export market to neighbouring countries such as Gabon, Equatorial Guinea, Chad, Nigeria and Central Africa Republic (Fontem et al., 2004). Although potato production has increased in Cameroon lately, production is still lagging behind due to increasing domestic and export market demands, pest and disease attacks, soil fertility problems and poor irrigation systems (Achiri et al., 2018; Njualem, 2010; Fontem et al., 2004).

Pest and disease remain major limiting factors for potato production (Olanya et al., 2015; Kahar and Konar, 2016; Uwamahoro et al., 2018). Amongst the pest, the green peach aphid *Myzus persicae* (Sulzer) (Hemiptera: Aphididae) is one of the most important sucking pests of potato (Konar et al., 2001; Kahar and Konar, 2016). The green peach aphid is a polyphagous phloem sap- sucking insect with the ability to injure plant tissue during feeding, causing leaf abnormalities such as yellowing, curling and reduction of leaf canopy, and premature senescence of leaves (Beckendorf et al., 2008). Furthermore, the green peach aphid has been largely implicated for the transfer of severe mosaic virus, potato virus Y (PVY) and the potato leaf roll virus (PLRV) with dire consequences on yield (Blackman and Eastop, 2000; Wale et al., 2008; Kahar and Konar, 2016; Kumara et al., 2017). Amongst the diseases late blight and bacterial wilt, caused by *Phytophthora infestans* (Mont.) de Bary and *Ralstonia solancearum*, respectively are the major diseases of potatoes especially in the tropics and subtropics (Olanya et al., 2015; Naffaa et al., 2017; Charkowski et al., 2020; Longwe et al., 2023). The presence of late blight is of great importance due to foliar blight and tuber blight, causing huge losses to potato production (Olanya et al., 2015). *Phytophthora infestans* is also considered a very aggressive potato pathogen since it has a very large genome (~240 Mb) with a complex organization, hence a high adaptability to the host potato and easy to develop resistance to many fungicides (Ivanov et al., 2021). The bacterial wilt has a significant impact on the quality and quantity of potato, and it is a major threat to potato production globally (Uwamahoro et al., 2018; Charkowski et al., 2020; Longwe et al., 2023). This soil born pathogen reduces water and nutrient absorption, leading to wilting as a major symptom and plant death in severe instances (Karim and Hossain, 2018; Khairy et al., 2021). Therefore, monitoring and quantifying these pathogens may enhance management practices of these diseases.

In Cameroon, there has been a consistent decline in availability of seeds of local varieties to farmers as a result of closure of some research centers or their inability to function fully. This has led to the degeneration of Cameroonian improved varieties as a result of continuous use by farmers. This has led to the reduction of seed quality used by farmers. Potato farmers have turned to use poor quality seeds with varying seed sizes for planting, generation in the process a plethora of challenges especially with growth, pests and disease resistance and yield (Njualem et al., 2023).

Some of the varieties cultivated in Cameroon include: Cipira, Tubira, Bambui Wanda, Desire, Cardinal, Banso, Mondial, Spunta and Diamant. The certified local varieties include: Cipira, Tubira, Bambui Wanda, Jacob and Maffo. Banso is a local landrace that has been cultivated since potato cultivation in Nso, North West Region of Cameroon. Cipira, and Jacob are Cameroonian improved varieties which are high yielding, disease resistant and has high dry matter content, released in 1993 (Njualem, 2010). Over two decades now, it is imperative to ascertained their performance vis-à-vis their susceptibility to pest and diseases, and their productivity in the current ever-changing climate conditions. Therefore, this study was designed to provide information on the susceptibility of a Cameroonian improved variety Cipira, planted at different seed sizes, to pest and diseases two decades after release in the western highland zone of Cameroon.

2. Materials and Methods

2.1. Experimental site

A two-year study was carried out in Bambili, North West Region of Cameroon, from the 18th of April 2022 to the 17th of July 2022 and 07th of April 2023 to 30th of July 2023. Bambili is found in Mezam Division in the North West Region of Cameroon. It has an altitude of 1558m and a tropical monsoon climate with an average annual temperature of 30 ^{o}C. Bambili has an annual rainfall of 854mm and average humidity of 84% which are acceptable for potato production. Weather parameters obtained from the Institute of Agricultural Research for Development (IRAD), Bambili, during the study period are reported (Table 1). The soil is generally acidic and rich in organic carbon, with a sandy-loam texture and a total nitrogen of 0.3 to 0.8% (Asongwe et al., 2016).

Table 1. Weather parameters of the study site

Months	Temperature (ºC)		RH (%)		Rainfall (mm)	
	2022	2023	2022	2023	2022	2023
April	19.6	22.75	82.24	74.15	293	143
May	19.1	21.19	87.11	83.90	298	216
June	18.3	20.02	89.30	88.22	332	254
July	17.7	19.08	90.01	90.99	358	367

2.2. Treatments, experimental design and field establishment

The treatments used in the study were seed sizes (diameter of seeds in mm). The tuber seed sizes tested were 20 mm, 25 mm, 30 mm and 35 mm. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications (R). Each replicate consists of four experimental units (plot or hill) to which each treatment was assigned. Each experimental unit or hill measured 6 m x 0.5 m x 0.4 m. The experimental unit was prepared using a handheld hoe. The block/replicate was separated by a path of 1 m.

Organic manure (poultry manure) was applied at planting. The crest of the ridge was opened with hoe and 200g of manure applied on the furrow created. The manure was then mixed and carefully covered with soil. Sprouted seeds of each tuber seed sizes were planted by placing the seed tuber on the furrow at the crest of the ridge. The seeds were planted 30cm between plants and beginning on each ridge at half the planting distance (15cm). Ridges within a block were separated by 80cm. The seeds were planted at a depth of 5cm, covered with soil and properly firmed with hands. A total of 20 seeds were planted per ridge/treatment. Weeding and moulding was done six weeks after planting. Weeds were removed manually and subsequently moulding with a hoe. The experiment was then kept weed free till harvesting. Rainfed irrigation was the source of water. No pesticides were used in this study.

2.3. Data collection

2.3.1. Plant establishment

Plant establishment was assessed 21days after planting. By this time all the plants are expected to have geminated. The number of plants that had emerged and established from the soil was counted and recorded. The plant establishment is reported as a percentage.

2.3.2. Green peach aphid Myzus persicae (Hemiptera: Aphididae) infestation

Aphid infestation was assessed by counting and recording the number of plants infested by green peach aphid *Myzus persicae* (Hemiptera: Aphididae) in each of the treatments. This was expressed as a percentage of the total number of plants (equation 1). This was done 30 days and 42 days after planting for both years

$$P = \frac{A}{T}\ x\ 100 \text{ .... eq. 1}$$

Where P – aphid infestation (%), A – total number of plants infested by aphids and T – total number of plants per plot.

2.3.3. Green peach aphid Myzus persicae (Hemiptera: Aphididae) population abundance

Aphid population abundance was determined in the field by scouting and the number of aphids on a plant was scored using the scale proposed by Lumbierres et al. (2010) (Table 2). The mean class of each treatment was recorded. This was done 30 days and 42 days after planting.

Table 2. Aphid abundance scale used in the evaluation of aphid population abundance

Class	Number of aphids on the plant
0	0
1	1 – 50
2	51 – 150
3	151 – 659
4	651 – 2550
5	>2550

Middle values of the intervals follow a geometric progression with common ratio = 4

2.3.4. Disease assessment

Disease incidence

Late blight incidence was collected by observing and counting the number of plants showing symptoms of the disease per treatment (Fig. 1a). The symptom of late blight is characterized by small, light green, circular or irregular shaped water-soaked spots on tips, margins or any other of the leaf, with dark brown lesions. Bacterial wilt incidence was collected by observing, counting and recording the number of plants showing symptoms of the disease in each treatment. Potato plants suffering from bacterial wilt are characterized by wilting, yellowing of leaves, necrosis and stunted growth (Fig. 1b). This was done 30 days after planting and 42 days after planting and expressed and the incidence of symptomatic plants (p) was expressed as a percentage using equation 2 (Rodrigues et al., 2019).

$$P = \frac{D}{T}\ x\ 100 \text{ .... eq. 2}$$

Where P is incidence of symptomatic plant (%), D is total number of diseased plants and T is total number of plants per plot.

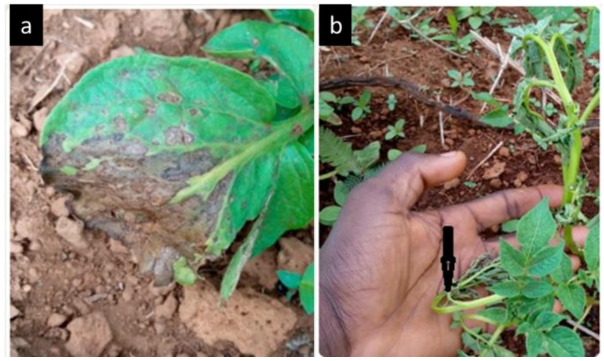

Figure 1. Potato plants with characteristics symptoms of late blight (a) and bacterial wilt (b)

Disease severity index estimation

The disease severity index (DSI) was calculated using equation 3 from disease ratings for each plant periodically according to the 6-point scale proposed by Messiha et al. (2007) and modified by Bensaci et al. (2021) describing the late blight symptoms and wilt symptoms in the plant foliage (Table 3). Five plants were randomly selected and tagged per plot for DSI assessment.

$$DSI = \frac{\sum X_i\ x\ n_i}{R\ x\ N_t}\ x\ 100 \text{ .... eq. 3}$$

Where *X*i is the disease severity scale score (0 – 5), ni is the number of plants with *i* disease severity, R is the highest disease severity score and Nt is the total number of plants examined

Table 3. Six-point symptomatic scale for disease severity index assessment

Scale score	Symptom on plants (%)	Description
0	0	No symptom
1	1 – 25%	Lowly symptomatic
2	26 – 50%	Moderately symptomatic
3	51 – 75%	High symptomatic
4	76 – 99%	Highly symptomatic
5	100%	Dead plant

2.4. Productivity

The total weight of tubers per treatment per plot was obtained on-farm. This was done by collecting, weighing (using a scale balance) and recording the weight of all the tubers in each treatment to give the yield. The values of the yield were converted to weight of tubers harvested per hectare and reported as productivity.

2.5. Statistical analysis

Homogeneity of variance and normality tests were conducted using Levene's test and Kolmogorov-Smirnov in SPSS (ver 23), respectively. The data were subjected to one-way Analysis of Variance (ANOVA) test. Where means were significantly different, they were separated using Tukey's Honestly Significant Difference (Tukey's HSD) *posthoc test* at alpha significance (α) level of 0.05 using SPSS (ver. 23). Where the blocking effect was not statistically significant, the ANOVA was redone with the blocking effect removed in order to increase the degree of freedom of the error term, thus increasing the reliability of the analysis (Achiri et al., 2021). Graphs were plotted using Microsoft Excel for Windows (ver. 2016).

3. Results

3.1. Plant emergence

In 2022, the number of potato plants that emerged (%) did not differ significantly (F = 0.889, df = 3, 8, *P* = 0.487) according to the seed size grade (Table 4). The emergence ranged from 96.67% from 30 mm seed size grade to 100% from 25 mm tuber seed size. The emergence was 98.33% for 20 mm and 35 mm seed size.

Also, the emergence was not significantly different (F = 0.250, df = 3, 8, *P* = 0.859) in 2023 from the different tuber seed size grades. The emergence was 91.67% for 20 mm seed size and 95.00% for 25 mm, 30 mm and 35 mm seed sizes, respectively (Table 4).

Table 4. Effect of different seed size grade of Cipira potato plant emergence

Seed size (diameter mm)	Plant emergence (%) 2022	Plant emergence (%) 2023
20 mm	98.33 ± 2.89a	91.67 ± 2.89a
25 mm	100.0 ± 0.0a	95.00 ± 8.66a
30 mm	96.67 ± 2.89a	95.00 ± 5.00a
35 mm	98.33 ± 2.88a	95.00 ± 5.00a

Means in the same column with the same letter are not significantly difference (Tukey HSD, *P* < 0.05).

3.2. Green peach aphid *Myzus persicae* (Hemiptera: Aphididae) infestation and population abundance

3.2.1. Green peach aphid Myzus persicae (Hemiptera: Aphididae) infestation

The percentage of potato plants infested by the green peach aphid is shown in figure 2. In 2022, the incidence of green peach aphid infestation at 30 DAP was significantly higher (F = 10.01, df = 3, 8, *P* = 0.033) from tuber seed size of 20 mm (45.71%), and was followed by 21.93% from tuber seed size of 25mm. The incidence was 17.41% and 16.37% from tuber seed sizes of 35mm and 30mm, respectively (fig. 2). At the same time in 2023, the incidence of green peach aphid varied significantly (F = 9.24, df = 3, 9, *P* = 0.04).

The incidence of green peach aphid ranged from 53.72% to 19.37%, from tuber seed size of 20mm and 30mm, respectively (fig. 2).

In 2023, the incidence of green peach aphid infestation at 40DAP was significantly (F = 14.33, df = 3, 8, *P* = 0.03) higher from tuber seed sizes of 20mm (53.15%), compared to 32.19%, 21.83% and 24.44% from 25mm, 30mm, and 35mm, respectively (fig. 2). At the same time in 2023, the trend was similar with values ranging from 60.15% to 27.82% from tuber seed sizes of 20mm and 30mm, respectively (F = 8.7, df = 3, 8, *P* = 0.041; fig. 2).

3.2.2. Green peach aphid Myzus persicae (Hemiptera: Aphididae) population abundance

The population abundance of the green peach aphid was significantly different (F = 12.34, df = 3, 8, *P* = 0.043) at 30DAP in 2022 (Table 5). The population abundance was 2.4, 2.2, 1.9, and 1.2 from 35mm, 30mm, 25mm and 20mm tuber seed sizes respectively (Table 5). At the same time in 2023, the highest population abundances were 2.6 and 2.5 from 35mm and 30mm tuber seed sizes, and they differed significantly from those of 25mm (1.4) and 20mm (1.7) tuber seed sizes.

At 45DAP, the aphid population abundance in 2022 did not differ significantly (F = 0.41, df = 3, 8, *P* > 0.05). The values ranged from 2.5 to 1.5 from 35mm and 20mm tuber seed sizes (Table 5). The pattern was similar at the same time in 2023 (F = 0.74, df = 3, 8, *P* > 0.05) with values from 2.6 to 2.1 from 30mm, 25mm, and 20mm tuber seed sizes (Table. 5).

3.3. Late blight disease incidence and severity index on Cipira potato variety

3.3.1. Late blight disease incidence (%)

Late blight is reported on 30DAP and 45DAP for both years in figure 3. In 2022, the incidence of late blight at 30DAP varied significantly (F = 9.12, df = 3, 8, *P* = 0.003) across different tuber seed sizes. The highest late blight incidence was 9.16% and 8.99, recorded from 30 mm and 20mm tuber seeds, respectively (fig. 3). The lowest late blight incidence was 1.67% from 35mm tuber seed size. At 30DAP in 2023, the late blight incidence also varied significant (F = 7.32, df = 3, 8, *P* = 0.041). The late blight incidences are 9.97%, 9.75%, 8.16% and 3.67% from 20 mm, 25 mm, 30 mm and 35 mm tuber seed sizes, respectively (fig. 3). At 45DAP in 2022, the late blight incidence was significantly different (F = 12.34, df = 3, 8, *P* = 0.031) with 20 mm (20.12 %) and 30 mm (18.22%) recording the highest incidences. The lowest late blight incidence was 10.37% from 35 mm tuber seed size (fig. 3). In 2023, late blight incidence varied significantly (F = 14.01, df = 3, 8, *P* = 0.014) (fig. 3). The highest late blight incidences were 18.93%, 17.2% and 16.23% from 25 mm, 20 mm and 30 mm tuber seed sizes, respectively. The late blight incidence for 35 mm tuber seed site was 12.37% (fig. 3).

3.3.2. Late blight disease severity index for Cipira potato variety

Late blight disease severity index for Cipira in 2022 and 2023 is reported in table 2. At 30DAP in 2022, late blight disease severity index was 22.67% and 24.0% from 20 mm and 25mm tuber seed size, respectively and these significantly varied (F = 14.13, df = 3, 8, *P* = 0.041) from 14.33% and 8.67% from 30 mm and 35 mm tuber seed sizes (Table 6). The pattern was similar for late blight disease severity index at 30DAP in 2023 with severity of 22.33%, 18.34%, 15.76% and 9.00% from 20 mm, 25 mm 30 mm and 35 mm tuber seed sizes, respectively (F = 9.43, df = 3, 8, *P* = 0.034) (Table. 6). Late blight disease severity index also varied at 45DAP in 2022 (F = 13.14, df = 3, 8, *P* = 0.039), 31.67% observed from 20mm tuber seed sites and 20.33% from 35 mm tuber seed sites (Table. 6). In 2023, the late blight disease severity index at 45DAP was highest from 25 mm (31.33%) and 20 mm (30.0 %), and they differed significantly (F = 15.47, df = 3, 8, *P* = 0.021) from 24.0% and 18.33% recorded from 30 mm and 35 mm tuber seed sizes (Table 6).

3.4. Bacterial wilt disease incidence and severity index on Cipira potato variety

3.4.1. Bacterial wilt disease incidence (%)

In 2022, the bacterial wilt incidence at 30DAP varied significantly (F = 8.47, df = 3, 8, *P* = 0.041) (fig. 4) with 20 mm and 30 mm tuber seed sizes recording 3.39% and 3.20%, respectively. At the same time in 2023, the highest bacterial wilt incidence was 6.12%, followed by 4.78%, 3.23% and 2.0%, from 20 mm, 30 mm, 25 mm and 35 mm tuber seed sizes, respectively (F = 9.43, df = 3, 8, *P* = 0.044; fig.4). At 45DAP in 2022, bacterial wilt incidence varied across tuber seed sizes (F= 12.33, df = 3, 8, *P* = 0.021) with the highest value 9.05% from 20 mm tuber seed size and lowest value 3.21% from 35 mm tuber seed size (fig. 4). At 45DAP in 2023, the bacterial with incidence was 10.12%, 6.32%, 5,8% and 3.0% from 20mm, 25 mm, 30 mm and 35 mm tuber seed sizes, respectively (F= 10.4, df = 3, 8, *P* = 0.041; fig. 4).

3.4.2. Bacterial wilt disease severity index on Cipira potato variety

The bacterial wilt disease severity index for 2022 and 2023 and presented in table 7. In 2022, the bacterial wilt disease severity index at 30DAP was 7.0% from 20 mm tuber seed sizes and it differed significantly (F = 11.12, df = 3, 8, P = 0.027) from 4.33% recorded from 30 mm tuber seed size. No bacterial wilt disease was observed from plants 25 mm and 35 mm tuber seed sizes. At 30DAP in 2023, the bacterial wilt disease severity index varied across tuber seeds sizes significantly (F = 13.12, df = 3, 8, *P* = 0.043) (Table 7). The bacterial wilt disease severity index was 12.33%, 12.30%, 11.67% and 7.67% from 20 mm, 25 mm, 30 mm and 35 mm tuber seed sizes, respectively (Table 7). In 2022 at 45DAP, the bacterial wilt disease severity index was 14.67% from 20 mm tuber seed site and it differed significantly (F = 9.47, df = 3.8, *P* = 0.037) from that of 25mm (5.10%) (Table 7). At the same time in 2023, the value was 22.67%, 24.0 % and 19.0% from 20 mm, 25 mm, 25 mm and 30 mm tuber seed sizes and the differed significantly (F= 10.94, df = 3, 8, *P* = 0.04) from 14.67 % recorded from 35 mm tuber seed size (Table 7).

3.4.3. Productivity of Cipira potato varity at different tuber seed sizes

The productivity (yield in t ha^{-1}) of Cipira potato variety at different tuber seed sizes is presented in figure 5. In 2022, the highest yield was 8.06 t ha^{-1}, reported from 35mm tuber seed size, which differed significantly (F = 11.04, df = 3, 8., *P* = 0.03) from the yield of 6.2 t ha^{-1}, 5.7 t ha^{-1} and 5.8 t ha^{-1} from 30mm, 25mm and 20mm tuber seed sizes, respectively (fig, 5). The yield also varied significantly (F = 13. 31, df = 3, 8, *P* = 0.023) in 2023. The yield was 8.9 t ha^{-1}, 7.8 t ha^{-1}, 7.1 t ha^{-1}, and 6.3 t ha^{-1}, from 35mm, 30mm, 25mm and 20mm, respectively (fig. 5).

4. Discussion

A number of issues can be attributed to different rates of potato seed emergence to eventual establishment of the plant, ranging from diseases, physiological conditions of seeds, soil conditions, seed age and seed sizes (Robinson and Banks, 2022). However, the current study did not reveal any variations in potato establishment due to tuber seed sizes. Nevertheless, tuber seed sizes are reported to significantly affect other parameters of emergence and plant establishment such as days to 50% emergence and days to maturity, with larger tuber seed sizes taking a shorter time to emerge and mature (Ebrahim et al., 2018).

The number of plants infested (incidence) with green pitch aphids was higher in plants from small seed sizes compared to plants with larger seed sizes. In fact, the values from 20mm tuber seed sizes sometimes doubled those from other tuber seed sizes investigated. This trend is similar for both years. This implies that the distribution of aphids on smaller tuber seed plants was more widespread and probably even compared to larger tuber seed sizes. This phenomenon of more smaller tuber seed plants being infested by aphids compared to larger tuber seed plants could be attributed to resource partitioning tendencies of aphids to maximize food resource. Wurr et al. (1993), Love and Thompson-John (1999), and Karbi et al (2004) argued that that large tuber seed sizes have a greater reserve material which translate in higher vegetative growth needed by aphids. As such, the aphid infestation is rather distributed to many plants from small tuber seed sizes and to fewer plants from larger seed sizes. This hypothesis is made clearer as the population abundance is higher in plants with larger tuber seed sizes than with plants with smaller tuber sizes. Our result suggests that plants from larger tuber seed sizes can tolerate larger aphid populations more than smaller plants from smaller tuber seed sizes. Even though leaf sizes were not measure, it can be inferred from the works of Karbi et al (2004) that large tuber seed sizes have a greater reserve material which translate in higher vegetative growth and therefore higher photosynthetic rates. Strauss and Agrawal, (1999) reported that plants tolerate hemipterans (especially aphids) by increasing photosynthetic rates after injury, increase relative growth rates and increasing branching.

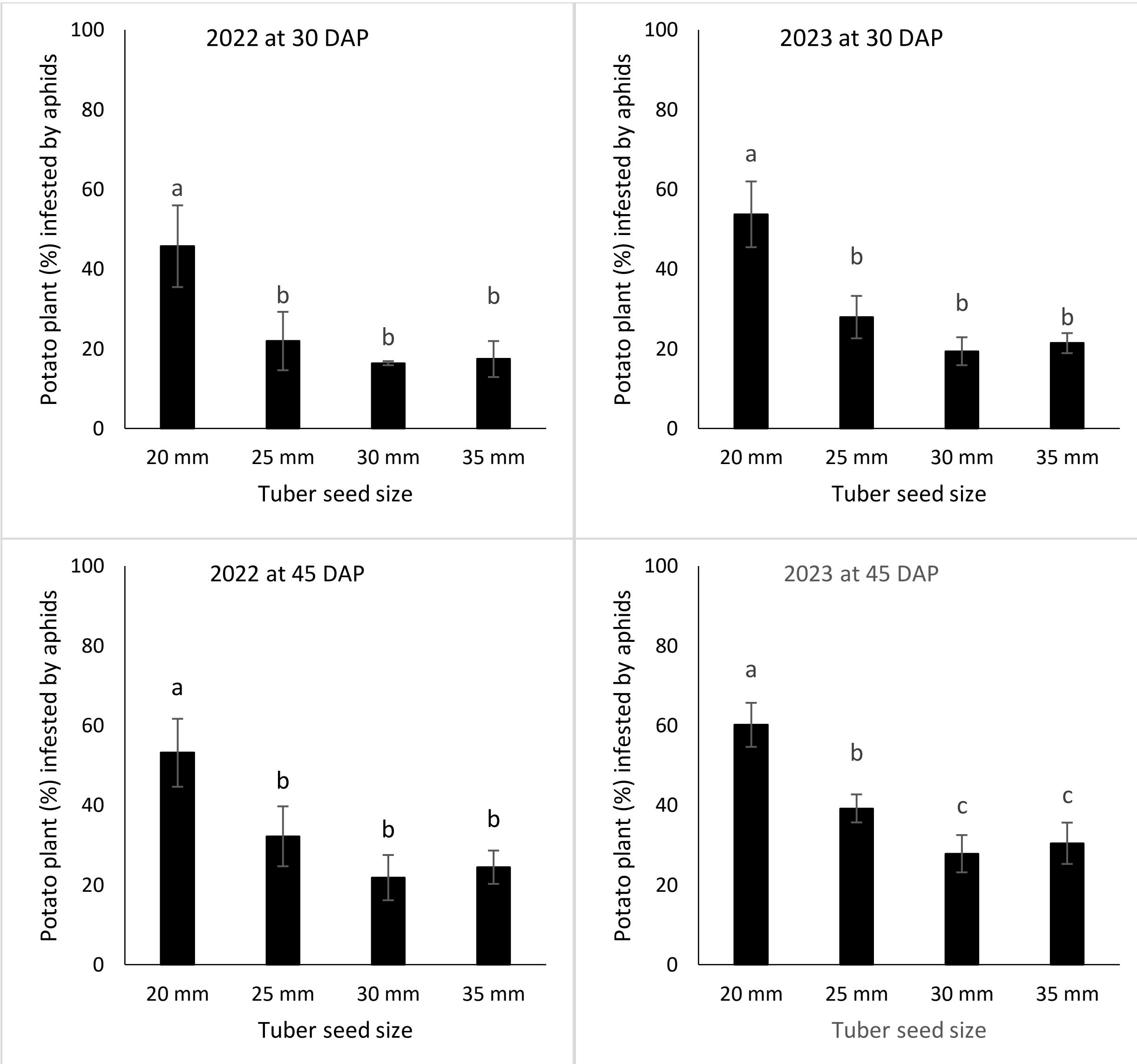

Figure 2. Incidence (%) of green peach aphid *Myzus persicae* infestation on Cipira. Mean bars with the same letter are not significantly different (Tukey's HSD, $P < 0.05$).

Table 5. Green peach aphid Myzus persicae population abundance

Tuber seed size	2022		2023	
	30DAP	45DAP	30DAP	45DAP
20mm	1.2 ± 0.8b	1.5 ± 1.3a	1.7 ± 0.9ab	2.1 ± 1.1a
25mm	1.9 ± 0.2ab	2.0 ± 0.4a	1.4 ± 0.4b	2.6 ± 1.3a
30mm	2.2 ± 0.7ab	2.2 ± 1.1a	2.6 ± 1.2a	2.6 ± 0.6a
35mm	2.4 ± 1.5a	2.5 ± 0.7a	2.5 ± 1.4a	2.4 ± 1.5a

Mean (± standard deviation) with a column with the same letter are not significantly different (Tukey's HSD, $P < 0.05$)

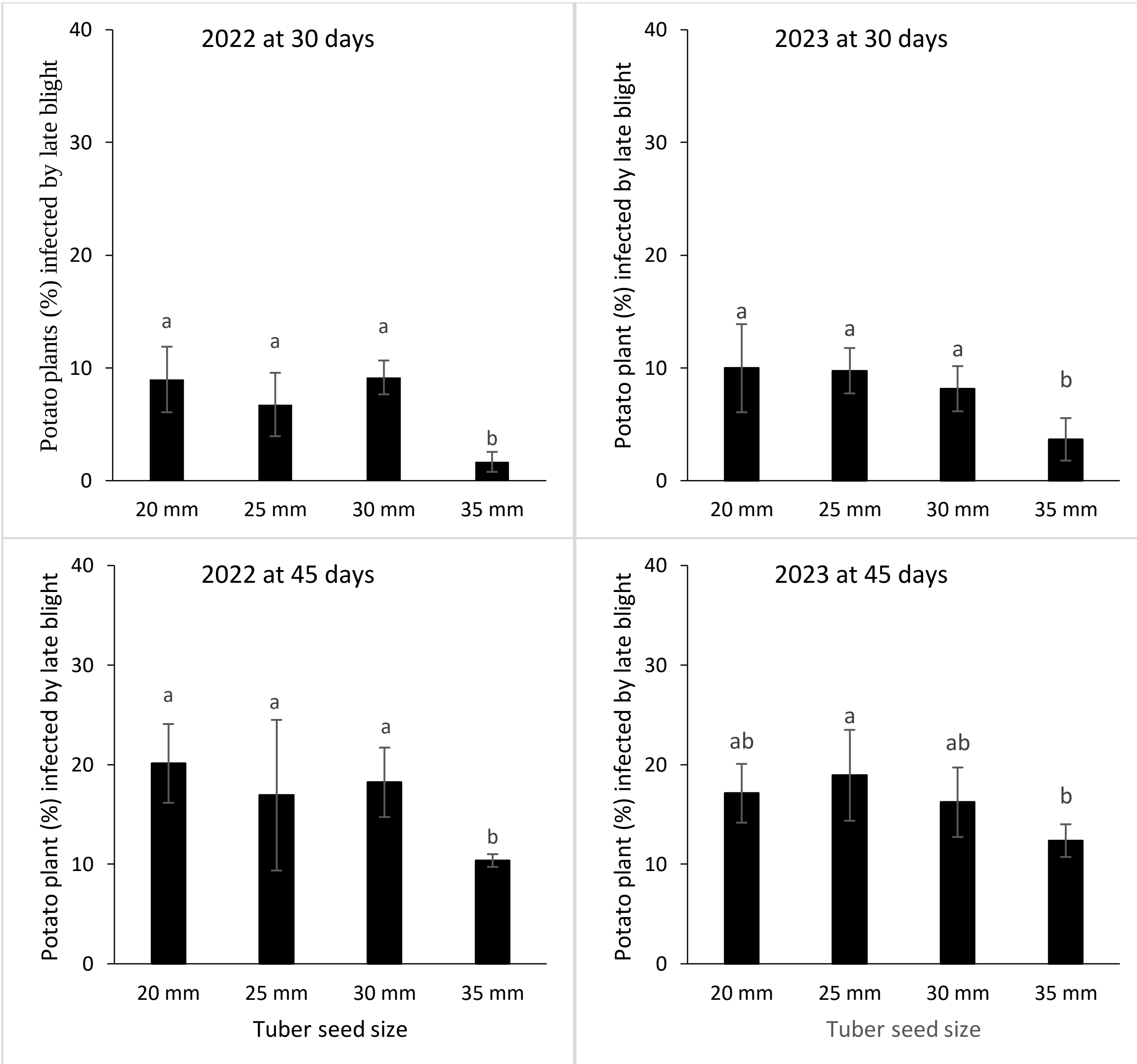

Figure 3. Incidence (%) of late blight on Cipira at different tuber seed sizes. Mean bars within a graph with the same letter are not significantly different (Tukey's HSD, *P* < 0.05).

Table 6. Late blight severity index on Cipira potato in 2022 and 2023

Tuber seed size	2022		2023	
	30DAP	45DAP	30DAP	45DAP
20 mm	22.67 ± 9.2b	31.67 ± 7.6b	22.33 ± 3.8c	30.00 ± 2.0c
25 mm	24.00 ± 4.0b	31. 34 ± 2.9b	18.34 ± 7.6bc	31.33 ± 2.3c
30 mm	14.33 ± 4.0a	25.67 ± 1.2a	15.76 ± 2.1b	24.00 ± 3.6b
35 mm	8.67 ± 1.5a	20.33 ± 3.5a	9.00 ± 2.6a	18.33 ± 1.5a

Mean (± standard deviation) with a column with the same letter are not significantly different (Tukey's HSD, *P* < 0.05).

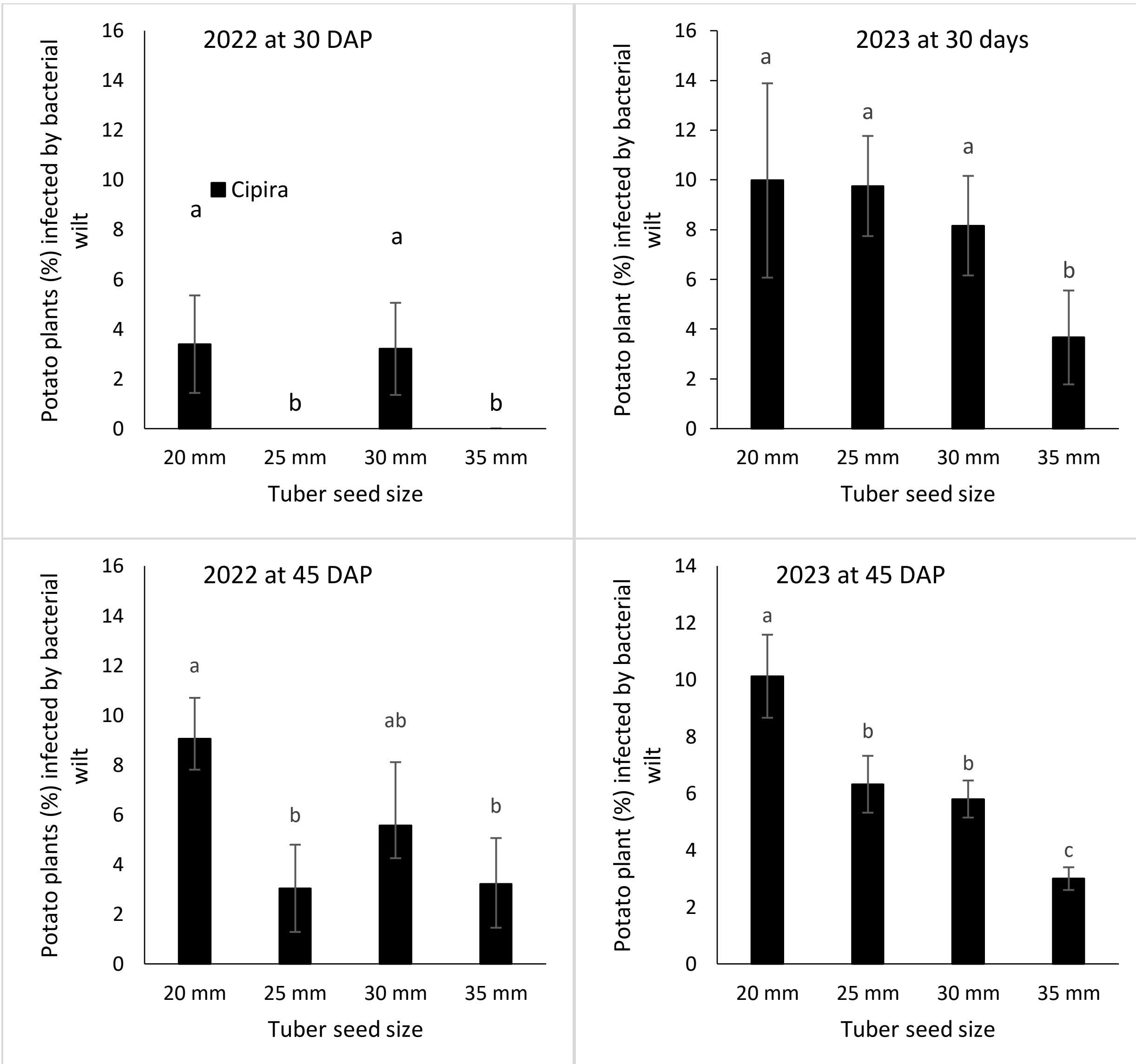

Figure 4. Incidence (%) of bacteria wilt infestation on Cipira potato variety plant at different seed sizes. DAP – days after planting. Mean bars with different letter(s) are significantly different (Tukey's HSD, $P < 0.05$)..

Table 7. Bacterial wilt severity index on Cipira potato in 2022 and 2023

Tuber seed size	2022		2023	
	30DAP	45DAP	30DAP	45DAP
20mm	7.0 ± 1.0a	14.67 ± 3.1a	12.33 ± 2.5a	22.67 ± 2.5a
25mm	0.00 ± 0.0b	10.8 ± 1.0b	12.30 ± 2.1ba	24.00 ± 3.1a
30mm	4.33 ± 1.5a	10.1 ± 2.1b	11.67 ± 2.1a	19.00 ± 2.0a
35mm	0.00 ± 0.0b	5.1 ± 1.2c	7.67 ± 1.5c	14.67 ± 2.1b

Mean (± standard deviation) with a column with the same letter are not significantly different (Tukey's HSD, $P < 0.05$)

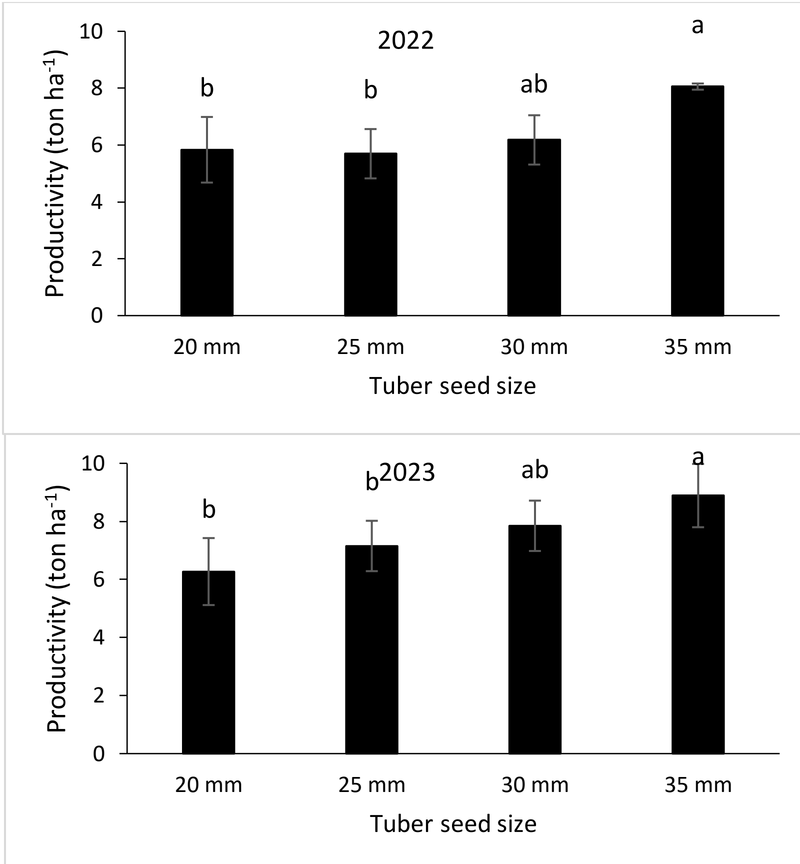

Figure 5. Productivity (t ha^{-1}) of Cipira potato variety at different tuber seed sizes. Mean bars in a graph with different letters are significantly different (Tukey HSD, $P < 0.05$).

The late blight incidence for both varieties and both records decreased with increased seed size. This observation is in line with the argument of Wurr et al (1993), Love and Thompson-John (1999), and Karbi et al (2004) that large tuber seed sizes have a greater reserve material. It can be argued that this reserved material is an initial capital to plants from larger tuber seeds sizes to withstand pathogens such as late blight causative agent, *Phytophthora infestans*. This could explain the observation in the current study.

In general, there are two mechanisms of plant defense against pathogens: resistance i.e., the host plant's ability to limit pathogen multiplication, and (ii) tolerance i.e the host plant's ability to reduce the effect of infection on its fitness irrespective of the degree of pathogen multiplication (Pagan and Garcia-Arenal., 2018). Our study suggests that plants from larger tuber seed sizes have the initial food capital to resist late blight as seen by the low disease severity index in plants from larger seed sizes and vice versa. Resisting disease is one of the attributes of Cipira potato variety (Deffo and Demo, 2003). Furthermore, it is known that pathogen and pest build-up is common in potato tubers and a primary cause of low productivity in developing countries (Fuglie, 2007; Gildemacher et al 2009; Cromme et al., 2010). Therefore, it is suggested that smaller seed sizes provide a high surface area to volume ratio for pathogen which eventually manifest in adult plants thus explaining the observation of the current study.

Incidence of bacteria wilt disease was generally very low 30DAP. However, the values increased 45DAP. It was observed again, just like late blight that bacterial wilt decreased with increased seed sizes. The arguments for late blight also hold here. The findings suggest that Cipira may be resistant to bacteria wilt and the low occurrence of bacteria wilt maybe attributed to environmental factors. In general, the Cipira variety was developed as improved variety to improve yields and resistance to pathogens (Deffo and Demo, 2003; Deffo et al., 2003; Bihnchang–Ngwa et al., 2017).

The potato tuber yield was also affected by the tuber seed sizes. Our findings revealed that tuber seeds sizes of 35mm produced the highest yield (greater than 7 t ha^{-1}). In Cameroon, yield of potatoes grown in monocropping commercial farms ranged from 7 to 20 t ha^{-1} (Njualem et al., 2001). Therefore, in 2022, only plants from tuber seed size of 35mm was within the range of a regular Cameroonian commercial farm. In 2023, plants from 25mm, 30mm and 35mm tuber seed sizes were within the range of a regular commercial farm in Cameroon, although 35mm tuber seed plants produced the highest yield. Our observation is in tandem with that of Georgakis et al. (1997) and Ebrahim et al. (2018). Georgakis et al.

(1997) examined the performance of four minitubers (<10, 10–15, 15–20, 20–25 mm) of potato as planting material. They observed that yield of potato increased with increased tuber seed sizes. It could be inferred that plants from larger tuber seed sizes had a higher tolerance to pest by increasing photosynthetic potential, and higher resistances to late blight and bacterial wilt through high up-regulation of detoxification mechanisms to counteract pathogen effect (Heng-Moss et al., 2003; Ramm et al., 2013).

5. Conclusion

The findings of this study revealed that seed size is an important factor that influences pest and disease incidence and severity of Cipira of potato. Yield was significantly influenced by seed size. Therefore, it is recommended that farmers should consider seed size as a critical factor on potato production. For optimal yields and low pest and disease prevalence, Cipira at seed size 35mm is recommended.

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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