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The effect of seed provenance and organic fertilizer types on growth and yield of G_2 potato (*Solanum tuberosum* L. cv. Medians) seeds in Jatinangor medium plains

Abstract. Potato growth is influenced by the seed provenance and fertilization, but the availability of high quality potato seeds is still limited. To overcome those challenges, solutions include using temperature-tolerant potato varieties from medium plains and applying organic fertilizers to improve potato growth and yield. The purpose of this research was to determine the effect of the interaction between seed provenance and application of organic fertilizers on the growth and yield of G_2 potato seeds of the Medians cultivar in the Jatinangor medium plains. The research was conducted from June to October 2023 at the Ciparanje Experimental Farm, Faculty of Agriculture, Universitas Padjadjaran, Jatinangor. The research design used was Factorial Randomized Group Design (RBD). The first factor is the provenance of the potato seeds from the medium and high plains. The second factor is the type of organic fertilizer, namely chicken manure, cow manure, and guano fertilizer. The results showed that there was no interaction between the seed provenance and types of organic fertilizer on the growth and yield of G_2 potato seeds of the Medians cultivar in Jatinangor medium plains. The use of seeds from medium plains had a significant effect on plant height, plant dry weight, and the percentage of stolons forming tubers. The application of cow manures with a dose of 225 g gave the best effect on leaf area, the number of tubers, and the weight of tubers per plant.

Keywords: Medium plains · Organic fertilizer · Potato seed · Seed provenance

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Introduction

Potato (*Solanum tuberosum* L.) is one of the vegetable crops commonly consumed and cultivated by the society giving it high commercial value. Potatoes can grow well in high plain areas with an altitude of 1,000-2,000 metres above sea level with humid and cold climatic conditions, soil that is crumbly, loose, and contains organic matter (Hamdani *et al*., 2020).

Potato seed is one of the most expensive components of potato production, which can cost up to 30-40% of the total cost of potato production (Fuglie *et al.,* 2006; de Putter *et al.,* 2014). Hamdani *et al*. (2020) stated that the availability of quality seed potatoes in Indonesia is still unable to meet the needs of farmers due to the limitations of land use in the high plain areas, one of which is due to land conversion. Efforts can be made to expand the area of potato cultivation to the medium plains, which are widely available in Indonesia.

Originally planted in the high plain areas, potato seeds that are later planted in the medium plains with hotter temperatures will experience obstacles in their growth and development because they require a longer adaptation period because the seed provenance affects its adaptability and can inhibit potato seedling initiation (Mubarok *et al*., 2022). A new potato cultivar such as the Medians cultivar that has more resilient to high temperatures must be developed so that the potato plants can grow well in the medium plains (Muthoni & Kabira, 2015).

Another factor that must be considered in potato cultivation is fertilization. The application of fertilizers containing essential nutrients, especially macro-nutrients such as high N, P and K can also help increase the yield and growth of potato plants (Muhibuddin *et al*, 2022). Organic fertilizers containing the sufficient macro and micronutrients will be able to increase the vigor, viability, and storage capacity of potato seeds. The application of organic fertilizers will also be able to improve the soil fertility, soil structure, and increasing water holding capacity that allow potatoes to grow optimally (Ahmed *et al*., 2019). The objective of this research was to determine the interaction between potato seed provenance and different types of organic fertilizers on the growth and yield of G_2 potato seed cultivar Medians in medium plains.

Materials and Methods

The research was conducted from June to October 2023 in a plastic house located at Ciparanje Experimental Farm, Faculty of Agriculture, Universitas Padjadjaran, Jatinangor, Sumedang Regency (6˚54’52.9"S, 107˚46’16.6"E) with an altitude of ± 752 metres above sea level (masl). The materials used in this study include G_1 potato seed cultivar Medians originating from the medium plains of Jatinangor and the highlands of Garut Regency, top soil of Inceptisol, polybags measuring 30 cm x 30 cm, chicken manure (already mature, odorless, crumbly structure, light brown to grey color), cow manure (already mature, odorless, dark brown color), guano fertilizer from Gunungkidul Regency (light brown color, odorless), bamboo stakes, plastic ropes, labels, silver black plastic mulch (MPHP), brown envelopes, fumigant Basamid 98 GR (Dazomet 98%), fungicide Antracol 70 WP (Propineb 70%), Urea (46% N), SP-36 (36% P_2O_5), KCl (60% K_2O), and insecticide Curacron (Profenofos 500 g/L). The tools used included hoes, plastic buckets, embraters, scissors, cutters, rulers, hole punches, digital and analytical scales, thermohygrometers, ovens, and some supporting equipment such as stationery and documentation equipment. The research design used was Factorial Randomised Group Design (RBD) consisting of two factors, namely 2 potato seed provenances (A) and 3 types of organic fertilizers (P).

a_1 : G_1 Potato Seeds cultivar Medians from Medium Plains
a_2 : G_1 Potato Seeds cultivar Medians from High Plains
p_1 : Chicken Manure
p_2 : Cow Manure
p_3 : Guano Fertilizer

There were 6 treatment combinations that were repeated 4 times, resulting in 24 experimental units. Each experimental unit consisted of 5 plants, resulting in a total of 120 plants. The planting media used were chicken manure, cow manure, guano fertilizer, and Inceptisol soil that had been sterilized by adding Basamid 98 GR fumigant as much as 500 g for 1 ton of soil and incubated for 1 week.

The preparation of planting media and application of organic fertilizers were carried out by mixing soil with organic fertilizers at a dose

of 0.225 kg for each type of organic fertilizer and 2.8 kg of soil in a polybag arranged with a spacing of 30 x 30 cm. Samples were taken by purposive sampling method, where samples were selected by their better attributes such as higher number of leafs and plant height. Each polybag has 3 kg maximum weight consists of a mixture of soil and organic fertilizer. Potato seeds were first soaked in Antracol 70 WP fungicide solution for 10 to 15 minutes. The planting of potato seeds in polybags was done in the morning, starting with watering the planting medium with water until it was moist, then each polybag was planted with 1 potato seed. Fertilizers used in this study include Urea (46% N), SP-36 (36% P_2O_5), and KCl (60% K_2O). The dosage of Urea fertilizer was 300 kg/ha which was divided into two applications of 150 kg/ha each, SP-36 as much as 150 kg/ha, and KCl as much as 100 kg/ha. Urea fertilizer was applied when the plants were aged 7 days after planting (DAP) and 30 DAP at 1.7 g/polybag each, while SP-36 fertilizer at 1.7 g/polybag and KCl at 1.1 g/polybag were applied when the plants were 7 DAP. Plant maintenance consists of watering, weeding, fertilizing, installing stakes, tying plants, pruning flowers, and controlling plant disturbing organisms (PDOs).

The observation parameters consisted of plant height (cm), plant dry weight (g), shoot root ratio (SRR), leaf area (cm^2), leaf area index, number of stolons and percentage of stolons forming tubers (%), number of tubers per plant, tuber weight per plant (g), and percentage of tubers per seed quality grade (%). Plant height was measured by ruler from the base of the stem to the highest growing point. Plant dry weight and shoot root ratio was measured by destructive method, where plant samples were washed, oven-dried, and then weighed. Leaf area was measured by Gravimetric method. Leaf area index was measured by calculating the average leaf area per clump divided by the area of the plant canopy.

The number of stolons was measured by adding up the primary and secondary stolons, while percentage of stolons forming tubers was measured by dividing the total number of tubers formed with the number of stolons and then multiplied by 100%. Both were measured by destructive method. The number of tubers per plant was calculated manually at harvest time. Tuber weight per plant was measured by weighing all of the tubers produced by each plant using a digital scale. Percentage of tubers per seed quality grade was measured by adding up all of the potato seeds from the same class category, divided by the total of seed yield, then multiplied by 100%. According to Direktorat Perbenihan Hortikultura (2014), G_1 potato seeds classification were divided into three class categories, namely Small (< 40 g), Medium (40 – 90 g), and Large (> 90 g – 120 g).

The influence of the treatments were tested with the F test at a significance level of 5%, while to test the difference in mean values between treatments was carried out with the Duncan Multiple Range Test at a significance level of 5%. Data analysis was conducted using SPSS software version 27.

Results and Discussion

Plant Height (cm) and Plant Dry Weight (g). Plant height observations were conducted when the plants were 2, 4, 6, and 8 weeks after planting (WAP), while observations of plant dry weight were conducted when plant destructive on 50 and 60 days after planting (DAP).

The results of the analysis showed that there was no interaction effect between seed provenances and application of organic fertilizer types on plant height and dry weight, but independently the treatment of seed provenances and application of organic fertilizer types had a significant effect on plant height and dry weight (Table 1). Plant height and dry weight is one indicator of plant growth because the better the plant growth, the height and dry weight of the plant will increase.

G_1 potato seeds from the medium plains were able to produce significantly higher plant height and dry weight than those from the high plains. This could allegedly occur because the G_1 potato seeds from the medium plains are the result of previous potato planting carried out in the same environment, so they have better adaptability. Plant height is known to be influenced by several factors, one of which is the adaptability of plants to the environment in which they grow. The adaptability of seeds is thought to have a relationship with gibberellin content, where seeds from the medium plains have a higher gibberellin content. According to Alexopoulos *et al.* (2017), gibberellin may induce faster potato seeds dormancy breakage and affecting the sprout growth. It has a function to

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stimulate potato germination, so the higher the gibberellin content, the faster the potato seeds will sprout.

Based on Table 1, the application of cow manure could produce the highest potato plant height compared to other treatments because cow manure generally contains higher nutrients and cellulose levels compared to other types of organic fertilizers, such as 3.00% N; 2.00% P_2O_5; and 1.00% K_2O (Gilroyed, et al., 2015). Chicken manure may contain N 1.00%, P_2O_5 0.80%, K_2O 0.04% (Dani *et al*., 2021). Pure guano fertilizer may contain higher nutrients, such as N 8.0-13%, P 5-12%, K 1.5-2.5%, Ca 7.5-11%, Mg 0.5-1%, and S 2-3.5% but nowadays it is usually already mixed with other ingredients, such as rice husks, so it could lower the nutrients (Karimou *et al*., 2020). Macro nutrients such as N, P, and K are needed by potato plants to encourage vegetative growth, such as the stem which will make potato plants grow taller. Cow manure also contains organic matter that can improve soil aeration and drainage and high water content so that nutrients can be absorbed by plants better.

Shoot Root Ratio, Leaf Area (cm^2), and Leaf Area Index. The results of the analysis showed that there was no significant effect of the use of seed provenances and the application of organic fertilizer types on the shoot root ratio, but the treatment of seed provenances and application of organic fertilizer types had a significant effect independently on the parameters of leaf area and leaf area index (Table 2).

Shoot root ratio is the ratio between the dry weight of the upper part of the plant (shoot) which functions as a place for photosynthesis and the dry weight of the roots which functions as a place for nutrient absorption. The treatment of seed provenances and organic fertilizer application did not show significant differences on shoot root ratio. This might occur because the macro nutrient content contained in organic fertilizers, such as N and P elements will increase the supply of nutrients to the shoot part of the plant which is higher due to the influence of high temperatures compared to the growth of the root part, thus increasing the value of the shoot root ratio. All shoot root ratio values produced are more than 1, meaning that plant growth tends towards shoot or upper part or the plant.

Leaf area is closely related to leaf area index, where the wider the plant leaves, the higher the leaf area index value. Based on the data in Table 2, it is known that the treatment of potato seed provenances from the high plains produced lower leaf area and leaf area index compared to those from the medium plains. The low value of leaf area and leaf area index is thought to be due to the response of plants to deal with environmental conditions that have high temperatures by reducing the transpiration rate in the leaves, resulting in small leaves. In agreement with Parker (2020), leaf area and leaf area index are influenced by weather, such as temperature.

The application of cow manure was able to produce the highest value of leaf area and leaf area index compared to other treatments because the essential macro and micronutrients contained in cow manure are higher than other types of organic fertilizers, so as to accelerate plant leaf growth due to an increase in the photosynthesis process. The Nitrogen plays a role in increasing chlorophyll production in leaves, thereby increasing the surface area of the leaves, while Phosphorus plays a role in increasing the number of leaves and increasing leaf area of potato (Sun *et al*., 2015). This is in line with the results of research conducted by Arzad *et al*. (2017) which showed that the application of cow manure can increase the number of leaves that can increase the total leaf area of plants because the availability of nutrients and the cation exchange capacity of the soil also increases so that the absorption of nutrients by plants is more optimal.

G_1 potato seeds from the high plains were able to produce a greater number of stolons, but produced a lower percentage of stolons forming tubers compared to seeds from the medium plains. High environmental temperatures can cause higher gibberellin synthesis on potato that can promote the vegetative growth, but reducing the tubers growth (Caliskan *et al*., 2021). Gibberellin, which acts as a trigger for cell division and elongation, will trigger the stolons to continue growing rather than the enlargement of the stolons into potato tubers, so that the formation of potato tubers will be inhibited.

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Table 1. Effects of seed provenances and organic fertilizer types on plant height (cm) and plant dry weight (g).

Treatments	Plant Height (cm)				Plant Dry Weight (g)	
	2 WAP	4 WAP	6 WAP	8 WAP	50 DAP	60 DAP
G_1 Potato Seed Provenances (A)						
a_1 : Seed from Medium Plains	8.88 b	16.90 b	23.47 b	32.19 b	5.01 b	10.00 b
a_2 : Seed from High Plains	4.25 a	14.20 a	20.51 a	25.78 a	4.02 a	9.11 a
Types of Organic Fertilizers (P)						
p_1 : Chicken Manure	4.83 a	13.37 a	20.04 a	27.49 a	3.41 a	8.59 a
p_2 : Cow Manure	8.51 b	18.20 b	24.44 b	31.73 b	5.68 c	10.90 b
p_3 : Guano Fertilizer	6.35 a	15.09 a	21.49 a	27.73 a	4.46 b	9.17 a

Description : Mean values followed by notations with the same letter are not significantly different based on Duncan's Multiple Range Test at the 5% significance level.

Table 2. Effects of seed provenances and organic fertilizer types on shoot root ratio, leaf area (cm^2), and leaf area index.

Treatments	Shoot Root Ratio		Leaf Area (cm^2)	Leaf Area Index
	50 DAP	60 DAP		
G_1 Potato Seed Provenances (A)				
a_1 : Seed from Medium Plains	3.77 a	4.53 a	586.28 b	0.65 b
a_2 : Seed from High Plains	3.56 a	4.05 a	293.01 a	0.33 a
Types of Organic Fertilizers (P)				
p_1 : Chicken Manure	3.20 a	3.98 a	231.57 a	0.26 a
p_2 : Cow Manure	4.56 a	4.72 a	690.25 b	0.77 b
p_3 : Guano Fertilizer	3.25 a	4.17 a	397.11 a	0.44 a

Description : Mean values followed by notations with the same letter are not significantly different based on Duncan's Multiple Range Test at the 5% significance level.

The data in Table 3 also showed that the application of organic fertilizer did not significantly different on the number of stolons and the percentage of stolons forming tubers. The application of organic fertilizers could improve soil structure, soil permeability, soil porosity, soil aggregation, water holding capacity, and regulates soil pH which can make the soil in an optimal condition for the growth and development of potato tubers that may stimulate the growth of stolons in large quantities (Bhujel *et al.*, 2021).

Number of Tubers and Tubers Weight per Plant. The analysis showed that there was no interaction effect between the use of potato seed provenances and the application of organic fertilizer types on the weight of potato tubers and the number of potato tubers per plant, but independently the treatment of potato seed provenances and the application of organic fertilizer types had a significant effect on the number of potato tubers and the weight of potato tubers per plant (Table 4).

G_1 potato seeds from the medium plains were able to produce a higher number of potato tubers and the weight of potato tubers per plant compared to those from the high plains because they have better adaptation to high temperature environments, so that the formation and development of potato tubers become more optimal. This is in accordance with the opinion expressed by Bischoff *et al.* (2008) which shows that seeds planted in their area of origin will provide better crop yields compared to seeds that are not from the same area due to genetic differences influenced by specific environmental conditions.

The application of cow manure was able to produce the highest weight and number of potato tubers per plant due to the high content of macro nutrients, such as N, P, and K.

The element of Nitrogen plays a role potato tubers growth and yield, Phosphorus plays a role in root growth and development, and Potassium for the potato tubers production and quality (Parganiha *et al.*, 2022). This is in line with the results of research conducted by Sufianto (2013) which showed that the application of cow manure at a dose of 20 tons/ha was able to produce the highest number

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of potato tubers per plant and the weight of potato tubers per plant compared to the application of chicken and goat manure, which were 10.96 knols and 400.04 g, respectively. According to Hamdani *et al*. (2020), the number of potato tubers is influenced by other factors such as the number of stolons formed, while the weight of potato tubers is influenced by the amount of photosynthetic products stored in the tubers in the form of food reserves.

Percentage of Tubers per Seed Quality Grade. The results of the analysis showed that there was no interaction effect between the use of potato seed provenances and the application of types of organic fertilizers on the percentage of potato tubers per seed quality grade (Table 5). Based on the results of the analysis, it is known that the treatment of potato seed provenances and the application of organic fertilizer types did not have a significant effect on the percentage of potato tubers per seed quality grade. The data in Table 5 shows that all potato tubers produced were S-sized or weighed < 40 g. This is thought to occur because at high temperatures, the flow of carbohydrates to the potato tubers will decrease because the energy released will be used for the formation of the upper part of the plant, resulting in small-sized potato tubers. This is in line with the results of research conducted by Muhibuddin *et al*. (2022) which showed that high temperatures can affect the yield of potato.

The competition between a large number of sweet potatoes in obtaining photosynthetic products is also thought to cause the development of potato tubers to be not optimal. Muhibuddin *et al*. (2022) stated that if the number of tubers formed is large, there will be competition between tubers in obtaining assimilates, so that many prospective tubers cannot develop because they experience a lack of assimilates which then produce small-sized tubers.

The G1 potato seeds from medium plains can be used in further research to be planted in highlands with the aim of studying in more depth the effect of seed adaptability on potato growth and yield.

Table 3. Effects of seed provenances and organic fertilizer types on number of stolons and Percentage of Stolons Forming Tubers (%).

Treatments	Number of Stolons		Percentage of Stolons Forming Tubers (%)	
	50 DAP	60 DAP	50 DAP	60 DAP
G_1 Potato Seed Provenances (A)				
a_1 : Seed from Medium Plains	10.92 a	11.92 a	37.35 b	43.05 b
a_2 : Seed from High Plains	12.75 b	13.50 b	26.43 a	35.64 a
Types of Organic Fertilizers (P)				
p_1 : Chicken Manure	11.38 a	12.38 a	28.85 a	37.51 a
p_2 : Cow Manure	12.38 a	13.13 a	36.41 a	41.86 a
p_3 : Guano Fertilizer	11.75 a	12.63 a	30.40 a	38.67 a

Description : Mean values followed by notations with the same letter are not significantly different based on Duncan's Multiple Range Test at the 5% significance level.

Table 4. Effects of seed provenances and organic fertilizer types on number of tubers and tubers weight per plant.

Treatments	Number of Tubers	Tubers Weight per Plant (g)
G1 Potato Seed Provenances (A)		
a_1 : Seed from Medium Plains	4.78 b	69.53 b
a_2 : Seed from High Plains	3.87 a	44.19 a
Types of Organic Fertilizers (P)		
p_1 : Chicken Manure	3.12 a	51.09 a
p_2 : Cow Manure	5.79 c	62.58 c
p_3 : Guano Fertilizer	4.06 b	56.91 b

Description : Mean values followed by notations with the same letter are not significantly different based on Duncan's Multiple Range Test at the 5% significance level.

Table 5. Effects of seed provenances and organic fertilizer types on percentage of tubers per seed quality grade.

Treatments	Percentage of Tubers per Seed Quality Grade		
	S (%)	M (%)	L (%)
G1 Potato Seed Provenances (A)			
a_1 : Seed from Medium Plains	100.00 a	0.00 a	0.00 a
a_2 : Seed from High Plains	100.00 a	0.00 a	0.00 a
Types of Organic Fertilizers (P)			
p_1 : Chicken Manure	100.00 a	0.00 a	0.00 a
p_2 : Cow Manure	100.00 a	0.00 a	0.00 a
p_3 : Guano Fertilizer	100.00 a	0.00 a	0.00 a

Description : Mean values followed by notations with the same letter are not significantly different based on Duncan's Multiple Range Test at the 5% significance level.

Conclusions

Based on the results of the research and discussion, it can be concluded that:

1. There was a non-significant interaction between the application of organic fertilizer types and seed provenance that could increase the growth and yield of G2 potato seed cultivar Medians in the Jatinangor medium plain.
2. The use of G1 potato seeds from the medium plains gave a better effect than potato seeds from the high plains on the parameters of plant height, dry weight, leaf area, leaf area index, percentage of stolons forming tubers, number of tubers per plant, and.
3. The application of cow manure gave the highest average value on plant height, dry weight, leaf area, leaf area index, number of tubers per plant, and tubers weight per plant.

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