The Determination of Nitrogen Concentration in the G2 Potato Seed Production on Fertigation System

Meksy Dianawati[1*], *Hermawati* Cahyaningrum[1], and *Bayu* Suwitono[2]

[1]Research Center for Horticultural and Estate Crops, Cibinong, West Java 16911, Indonesia

[2]Research Center for Food Crops, Cibinong, West Java 16911, Indonesia

Abstract. The nitrogen concentration of AB mix fertilizer in the G2 fertigation system in the field would be influenced by various factors. This research aimed to increase the production of the G2 potato seed by using different concentrations of nitrogen in AB mix fertilizer in the fertigation system. The study was carried out in the G2 seed production area, Lembang, West Java, Indonesia from January to April 2019. The study used a randomized group design with four nitrogen concentrations in AB mix hydroponic fertilizer, namely 200, 215, 230, 245 ppm, and common AB mix (control) with five replications. The results showed that the number of big tubers of all nutrition formulas was higher than the control. The nitrogen concentration treatment increased the number of large tubers, small tubers, and total number of tubers, and decreased the weight per tuber compared to control. The best concentration to get the total number of tubers, small and large tuber, and weight per tuber was 217 ppm. The total number of tubers was affected by 93% by the number of small tubers. Meanwhile, the number of large tubers affected 78% of the tuber weight per plant.

1 Introduction

Potato agribusiness promises a high profit. Domestic demand for processed potato products such as chips, potato starch, and fried potatoes reaches 8.9 million tons per year, but national potato production is still in the range of 1.5 million tons per year with an area of 80,000 ha of potato plantations. The average national potato production in 2021 was 1.36 million tons, an increase of 6.10% from the previous year. The average productivity of potatoes is 15 tons per ha [1], under the potential production which is 25 tons per ha [2].

One of the causes of low potato production is the low use of quality seeds [3]. Seed support is crucial to developing and increasing potato production in Indonesia. Preferably, farmers should use quality seeds with labels, but it often cannot be fulfilled due to the price that is higher than average seeds [4]. [3] stated that the availability of quality and affordable potato seeds is significant and beneficial for farmers to produce long-term sustainable potatoes [4]. Potato seeds in Indonesia start from G0 to G2 seeds. Potato seeds propagation

* Corresponding author: herm024@brin.go.id

strategy using hydroponic and aeroponics systems has been carried out in Indonesia [5, 6]. This system can increase production and quality as well as provide various sizes of tubers harvested [5, 7].

Nitrogen (N) is required for plant growth and potato tuber development. Potato plants are very responsive to fertilization due to their shallow root system, but the absorption efficiency of N fertilizer is around 50 – 60% [8]. AB mix fertilizer is used to provide the macro and micro nutritional needs of plants in hydroponic cultivation systems, especially for the production of G0 potato seeds. Various AB mix fertilizers have been traded in the market, but the nutrient content is unknown. The nutrient concentration of N in AB mix fertilizer is 70 – 250 ppm [7, 10].

The nutrient requirement of the hydroponic substrate can be adjusted based on the needs of the plant. While in the field, the nutrient requirement is adjusted based on soil conditions. Fertilization is a vital step to maintain soil fertility and increase the yield of potato tubers. The amount of fertilizer applied should be equal to the amount absorbed by the potatoes due to the environmental impact of over-fertilizing. Rational irrigation and fertilization are two of the main ways to increase potato yield. With the widespread application of drip irrigation systems in potato production, fertigation is considered an efficient water and fertilizer management technology [11]. [12] confirmed that fertigation is a promising way to maintain the desired N concentration in the soil during the growth period. This method can provide efficient use of N by up to 20 – 35% and increase potato consumption production by 28%. A fertigation system with 72% of recommended fertilizer dose is effective in maintaining potato production in sandy soil [13].

AB mix fertilizer can be used in open fertilization with a fertigation system in the field. The best N concentration of AB mix fertilizer in the G0 seed production of the substrate hydroponic system was found at 220 ppm, but it is not significantly different from the control (AB mix well-known formula in the market) [14]. Further research reported that the changed treatment of nitrate and ammonium on G0 production could replace the control. The optimum rate of NO_3: NH_4 with 4: 1 was 222 ppm, while in 9: 1 was 215 – 257 ppm [15]. Thus, the range of N nutrients on AB mix fertilizer for hydroponic system on G0 production was 220 – 250 ppm. This formula can be tested under field conditions to produce G2. The N concentration of AB mix fertilizer in the G2 potato seed production with fertigation system in the field is influenced by various factors. This study aims to determine the appropriate N concentration for G2 potato seed production in the fertigation system.

2 Material and Methods

The study was carried out in the G2 potato seed production area in Lembang, West Java, Indonesia from January to April 2019. The study applied a randomized block design consisting of four N concentrations in AB mix fertilizer (180, 200, 220, and 240 ppm) and control. Each treatment was repeated five times. There were 25 experimental units. Each unit consisted of one-bed size 1 x 5 m double rows with spacing of 50 x 40 cm, so there were 26 plants per bed.

The G0 variety used was median. The AB mix fertilizer used in this study was self-formulated, consisting of stock A and stock B. Stock A consisted of 5Ca $(NO_3)2NH_4NO_3.10H_2O$, KNO_3, dan BMX library. On the other hand, stock B consisted of KH_2PO_4, $(NH_4)2SO_4$, K_2SO_4, and $MgSO_4H_2O.7H_2O$. The concentration of N used was according to the treatment with the ratio between nutrients N- NO_3-NH_4 (4:1), P and N-total 0.25; K and N total 1.3; Ca and N-0.8 total; Mg and N-total 0.3, and S and N-total 0.74. As for control, AB mix commercial was used in this study. Electrolyte conductivity (EC) and acidity (pH) of AB mix fertilizer were maintained at 1.5-2 mS/m and 5.8-6, respectively. AB mix fertilizer was applied in the morning for 5 weeks with a volume of 10 l per bed with different concentrations based on each treatment. Fertilizer flowed through a pipe connected from the container to the planting hole with a gravity drip system.

The parameters observed were the number of tubers per plant, the number of tubers based on weight per tuber (small tuber < 5 g, medium tuber 5-10 g, and large tuber >10 g), tuber weight per plant (total tubers), and weight per plant. Tuber weight per plant was the weight of total tubers produced per plant, while the average of each tuber weight was divided by the number of tubers produced. The observational data was analyzed with the F test and continued with the orthogonal contrast, polynomial orthogonal, and correlation test with a 95% confidence level.

3 Results and Discussion

The results showed that the N concentration treatment increased the number of large tubers, number of small tubers, and total number of tubers, and decreased the weight per tuber compared to control (Table 1). This indicated that there was the best N concentration to replace the AB mix on the market because it produced a higher total number of tubers and the number of big and small tubers compared to the control. The greater number of small tubers is important in the G2 seed business as farmers generally prefer small-sized seeds as a source of seeds so as not to burden the cost of farming. Small-sized seeds increase the canopy area and produce large potato tubers that are suitable for consumption. On the other hand, large-sized seeds will produce small tubers in large quantities [16]. The recommendation of AB Mix fertilizer application is more suitable for the production of potato consumption due to the higher weight per tuber production, while the number of tubers is lower than the N concentration treatment.

Table 1. Harvest observation of G2 seed on N concentration.

N concentration (ppm)	**Number of tuber-sized**				**Tuber weight per plant (g)**	**Weight per tuber (g)**
	Large	**Medium**	**Small**	**Total**		
AB mix control	1,4 b	3,1 ab	5,7 bc	10,2 bc	1427,8 ab	150,32 b
200	2,8 a	3,7 a	7,7 ab	14,2 ab	1545,2 ab	117,05 bc
215	2,5 a	2,45 b	9,0 ab	14,5 ab	1578,8 ab	124,48 bc
230	1,35 b	3,0 ab	12,0 a	15,8 a	1356,0 b	109,01 c
245	2,9 a	3,1 ab	2,8 c	8,7 c	1681,9 a	206,84 a
CV (%)	35,7	33,9	31,23	27,08	19,12	29,5
Treatment vs control	2,1 vs 1,4*	2,9 vs 3,1	7,5 vs 5,7*	12 vs 10*	1468 vs 1427	129 vs 150*

Note: The same letter in the column indicates that it is not significantly different from the DMRT test at the 95% confidence level
*showed significantly different from the orthogonal contrast test at a 95% confidence level

The 230 ppm N concentration produces the highest total number of tubers and number of small tubers compared to the control (Table 1). Meanwhile, 200 ppm produces the highest medium-sized tubers among all treatments. Most small-sized tubers are obtained from 230 ppm N concentration. The tubers from 200, 215, and 230 ppm N concentration are dominated by small-sized tuber, while the 245 ppm are medium-sized tubers. The highest tuber weight per plant is produced at 245 ppm N concentration. Increasing the N level generally would increase plant vegetative growth and potato tuber yield [17]. However, the nutritional needs of potato plants are mainly determined by the biological characteristics of the plant itself [13].

Four variables have a quadratic response with differences in the N concentration. The total number of large-sized tuber and weight tubers follow an inverse quadratic graph (Table 2 and Figure 1). The best concentration to obtain the total number of tubers, the number of small tubers, and the weight per tuber is 217 ppm. However, to get more large tubers, it needed more N concentration, i.e., 233 ppm (Table 2). This shows that to get the optimum total number of tubers, the number of small-sized tubers, and weight per tuber are different from the number of large-sized tubers (Table 2 and Figure 1a, 1b, 1d). This best concentration is still in the range of the N concentration recommendation, which is 70 – 220 ppm [7]. A similar result from a previous study for G0 potato production by using burnt husk and biogas waste media is 220 ppm N concentration [15]. If the dose of N is too high, it can suppress tuber growth resulting in low tuber weight and small-sized tuber [18]. Potato plants have different optimum doses of N fertilization [19]. The high tuber weight at the optimum doses is a response to N supply because of the increase in leaf area growth which increased the photosynthesis as well [20].

Table 2. Quadratic equation of N concentration on G2 potato yields variables.

No	Information	Number of Tubers			Weight per tuber (g)
		Total	Small-sized	Large-sized	
1	Maximum concentration (ppm)	216,79	217,18	-	-
2	Minimum concentration (ppm)	-	-	233,6	216,88
3	Maximum yield	14,9	9,87	-	-
4	Minimum yield	-	-	3,6	107,7
5	R2	98	93	82	87
6	Equation	−1,3875x2 + 4,9725x + 10,488	– 1,75x2 + 7,63x + 1,55	0,2x2 - 1,44x + 4,2	19,009x2 – 71,651x + 175,2

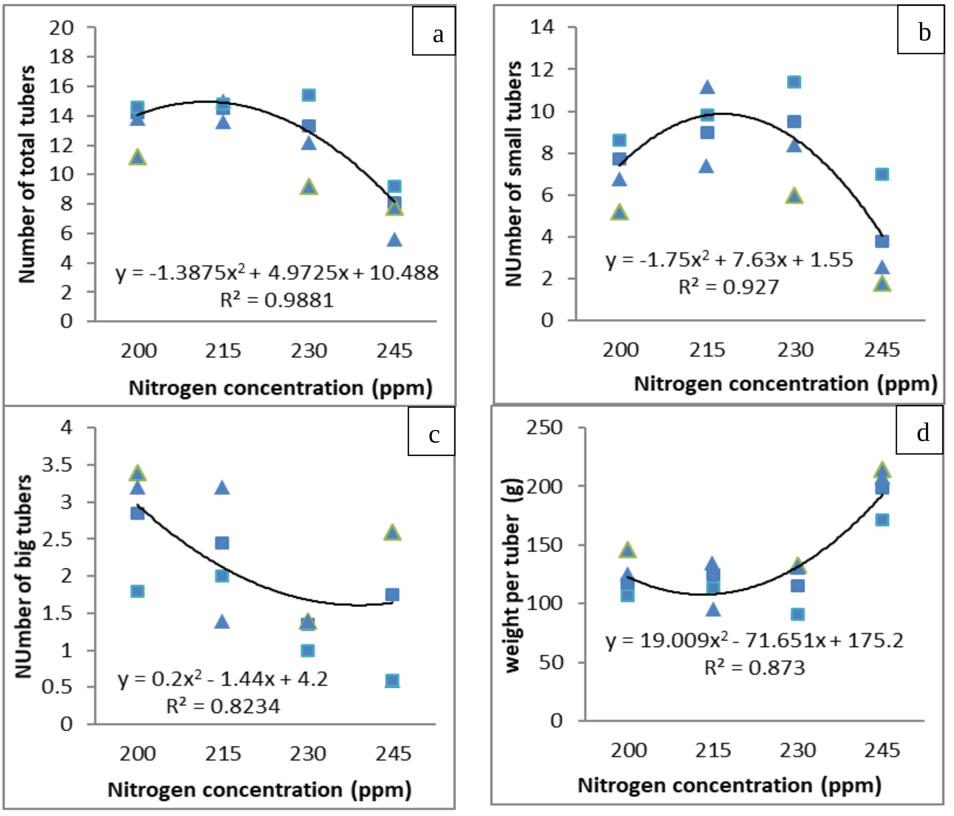

Fig. 1. Quadratic curve of the difference in the N concentration to the total number of tubers (a), number of small-sized tubers (b), number of large-sized tubers (c), and weight per tubers (d).

The total number of tubers is 93% affected by the number of small-sized tubers and 75% by weight per tuber (Table 3). If the number of small tubers and weight per tuber increases, the number of total tubers increases as well. The close relationship between the number of total tubers and the number of small tubers can be seen in the dominance of the small-sized tubers on the number of total tubers.

Table 3. The correlation on G2 potato yields variables.

Variable	JUS	JUK	JU	BU	BUP
JUB	10	-22	7	78*	31*
JUS		-16	9	24	-10
JUK			93*	-7	-75*
JU				19	-71*
BU					20

Notes: * significantly different from the correlation test at the 95% confidence level

JU = total number of tubers per plant, JUB = number of large tubers, JUS = number of medium tubers, JUK = number of small tubers, BU = weight of tuber per plant, BUP = weight per tuber

The quadratic graph of the total number of tubers and the number of small-sized tubers also have the same trend (Figure 2). Meanwhile, the number of large-sized tubers is 78% affected by tubers' weight per plant (Table 3). The higher number of large-sized tuber will increase the weight of tubers per plant, but not the weight per tubers. This result shows the small number of large-sized tubers or low dominance of large-sized tubers per plant. The application of N on potatoes generally affected tuber size, dry weight, sugar content, number of tubers per plant, and average tuber weight [21]. Plants that grew under N-deficient conditions would produce many small-sized tubers [22].

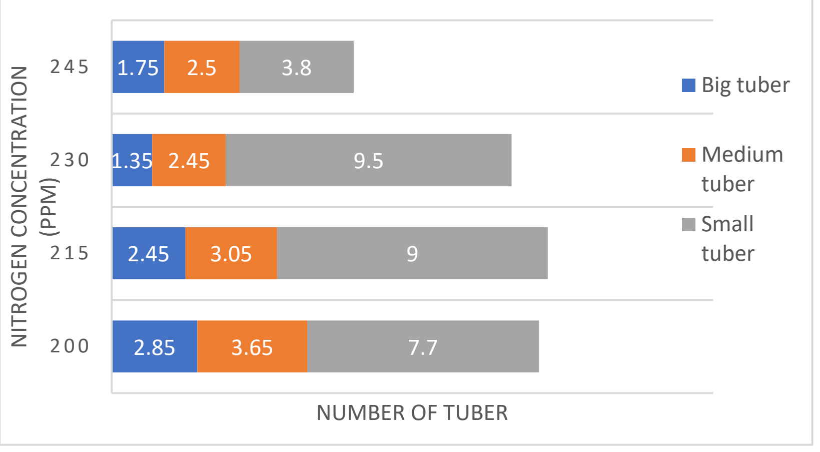

Fig. 2. The composition of total large-sized tubers, medium-sized tubers, and small-sized tubers.

[21] concluded that environmental factors that support cell division and expansion such as minerals and water supply can increase tubers' size. The application of N can prolong the growing period of tubers. Variations in the size of seed tubers will produce a variety of tubers. The application of N and K affects the number of medium and large-sized tubers, the variation of tubers yield due to the N treatment is related to the increasing of tuber weight. Average tuber weight contributed to the total tuber yields.

4 Conclusion

The N concentration treatment increases the number of large and small-sized of tubers and, the total number of tubers, and decreases the weight per tubers. Nutrient ingredients with a 217 ppm of N concentration can be used to replace common nutrients in the market. The total number of tubers is affected by 93% by the number of small-sized tubers. Meanwhile, the number of large-sized tubers is 78% affected by the tuber weight per plant. Further research needed to be done to determine the concentration of other nutrients, such as phosphate and potassium in the G2 potato seeds production on the fertigation system.

References

1. C.B.D Kuncoro, T. Sutandi, C. Adristi, and Y. Kuan. Sustainability, 1 – 18 (2021).
2. M. Dianawati. “Aeroponic seed production of potato mini tubers (*Solanum tuberosum* L.) through tuber induction”, Ph.D. thesis, IPB University, (2013).

3. M. Dianawati, S. Ilyas, G.A. Wattimena, and A.D. Susila. J.Hort, **23 (1)**, 47 – 55 (2013).
4. A. Sembiring, R. R. Murtiningsih, Kusmana. AGRARIS, **7 (1)**, 79 – 90 (2021).
5. M. Dianawati, H. Farida, and S. Muhartini. J. Hort, **29 (1)**, 53 – 60 (2019)
6. M.H. Tunio, J. Gao. S.A. Shaikh, I.A. Lakhiar, W.A. Quresh, K.A. Solangi, F.A. Chandio Chilean Journal of Agricultural Research, **80 (1)**, 118 – 132 (2020).
7. Sugiyono, L. Prayoga, E. Proklamasiningsih, K. Faozi, and R. Prasetyo, Biosaintifika, **13 (1)**, 77 – 83 (2021).
8. M. Bucher and J. Kossmann. “Molecular physiology of mineral nutrition of potato” in Potato Biology and Technology: Advances and Perspectives, edited by D. Vreugdenhil et al., Elsevier, Netherlands, pp 331 – 330 (2007)
9. Sutiyoso. Meramu Pupuk Hidroponik, Penebar Swadaya, Jakarta, (2003)
10. J. B. Jones. Hydroponic: A Practical Guide for the Soilless Grower, CRC Press, Boca Roton London New York Washington, 402 p (1995)
11. X. Wang, T. Guo, Y. Wang, Y. Xing, Y. Wang, and X. He. Agricultural Water Management 237, p.106180 (2020).
12. L. Jia, Y. Qin, Y. Chen, and M. Fan. Journal of Crop Improvement, 2 – 9, (2018).
13. Z. Feng, S. Wan, Y. Kang, and S. Liu. Emirates Journal of Food and Agriculture **29 (6)**, 476 – 484 (2017).
14. M. Dianawati. Production of Potato Seed on Many Nitrogen Concentration on Hydroponic Fertilizer in National Conference of PERHORTI, IPB Press, Bogor, pp 103 – 106 (2017)
15. M. Dianawati. Production of Potato Sed on Many Nitrogen Rates and Its Changes on Comparison NO3 and NH4 of AB Mix Fertilizer in The International Seminar on Tropical Horticulture, Conference Proceedings, edited by Awang Maharijaya (Center for Tropical Horticultural Studies, Bogor, pp. 184 – 189 (2018)
16. M. T. Masarirambi, F. C. Mandisodza, A. B. Mashingaidze, and E. Bhebhe. Intl. J. Agric. Biol **14**, 545 – 549 (2012).
17. A. A. Farag, M. Abulsoud and M. A. A. Abdrabbo, J. Agric. Sci **22 (1)**, 29 – 41 (2014).
18. G. Belanger, J.R. Walsh, J. E. Richards, P.H. Milburn, N. Ziadi. Am J Pot Res **79**, 269 – 279 (2002).
19. J. P. Goffart, M. Olivier, and M. Frankinet. Potato Research **51**, 355 – 383 (2008).
20. A. Zelalem, T. Tekalign, and D. Nigussie. Afr. J. Pl. Sci 3 (2), 16 – 24, (2009).
21. H. D. Muleta and M. C. Aga. Journal of Plant Sciences **7 (2)**, 36 – 42 (2019).
22. H. A. Oraby, Y. Lachance, and Desjardina. Am J. Pot. Res 92 (3), 387 – 397, (2015).