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EFFECTS OF NITROGEN AND PHOSPHORUS FERTILIZER ON GROWTH AND YIELD OF DRAGON FRUIT (*Hylocereus polyrhizus*)

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Abstract. *Nitrogen and Phosphorus fertilizers are required to enhance the plant growth and yield. The appropriate nitrogen and phosphorus doses on the growth and yield of dragon fruit (Hylocereus polyrhizus) are not well known. A study to evaluate the effect of nitrogen and phosphorus fertilizers on the growth and yield of dragon fruit (Hylocereus polyrhizus) was arranged in a completely randomized block design with two factors and three replications. The treatments consisted of four nitrogen doses (0, 50, 75 and 100 g^{-1}pillar) and four phosphorus doses (0, 50, 75 and 100 g^{-1}pillar). Growth and yield were significantly ($p < 0.01$) affected by increasing nitrogen and phosphorus doses and showed interaction on the number of shoots, number of flowers, and fruit sets. The number of shoots increased from around 102.98 to 162.10 % at nitrogen dose 100 g and phosphorus doses 50, 75 and 100 g compared with no treatment. Nitrogen dose at 100 g and phosphorus dose at 100 g produced 152.64 % more number of flowers compared to 0 g phosphorus. The fruit set increased by 58.32% at dose of 50 g nitrogen and 50 g phosphorus. Nitrogen applied at 100 g compared with 0 g nitrogen and phosphorus at different phosphorus doses increased in the number of fruits were 139.35 % and 13.56 - 58.15 %. Individual fruit weight among nitrogen doses and TSS among nitrogen and phosphorus doses showed no significant difference. Application of nitrogen fertilizer at 50 g^{-1}pillar and phosphorus at 75 g^{-1}pillar produced maximum yield, respectively, and thus, it should be recommended as optimum doses.*

Keywords*: dragon fruit (Hylocereus polyrhizus); growth; nitrogen; phosphorous; yield*

1. Introduction

Dragon fruit (*Hylocereus sp.*) is an exotic fruit market, which contains antiproliferative activity and high antiradical for consumer's healthy (Luo *et al*., 2014). This fruit is widely spread and becoming a favorite because of its nutritional values, colors, and some other features (value added in food crops) and also known as a healthy food (Rebecca *et al*., 2010). In the past decade, the needs and demands for this fruit significantly increased due to consumer's concerns about the food's healthy, nutrients, and various food products (Altendorf, 2019).

Nitrogen (N) and Phosphorus (P) fertilizers are required to enhance plant growth, yield and the effects of these nutrients were observed in some commodities and showed significant effects on the growth, yield and quality (Turuko & Mohammed, 2014; Hazary *et al*., 2015; Razaq *et al*., 2017). These fertilizers were applied to improve the composition of soil bacterial and soil quality (Chen *et al*., 2018), increased plant biomass and soil accumulation of carbon (Li *et al*., 2014), improved soil fertility and nutrients availability leading to increase plant growth, crop productivity, fruit setting, crop yield, and improved nutrients depletion (Liu *et al*.,2010; Nasreen *et al*., 2013).

Fertilizer is becoming an important factor for the plant production and cultivation including dragon fruit (Pegoraro *et al*., 2014). Then (2014a) stated that application of compost and fertilizer

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of N:P:K: Mg mixture at 1.2 and 1.8 kg $pillar^{-1}year^{-1}$ increased total fruit number, fruit weight and total yields around 24.5 and 24.2 kg^{-1}pillar of red pitaya. Application of foliar fertilizers (3.5% N, 5% P_2O_5, and 16% K_2O) through spraying on the roots aerial zone and shoot increased fruit weight and both application of foliar fertilizer and potassium nitrate (13% N and 14% K_2O) increased fruit quality and produced around 22.1% and 16.2% grade A fruit compared to without foliar application on the red pitaya (Then, 2013). Biochar fertilizer applied at 10 tons ha^{-1} and 1 L in 10 L water of liquid organic fertilizer increased the chemical properties of the soil of dragon fruit (Zaitun *et al.*, 2014). Application biogas residue of organic fertilizers increased 12.84% of $yield^{-1}$ha, 60.55% of sugar-acid ratio, vario-cost ratio (VCR) value by around 4.95 compared with the traditional fertilization and also increased yield by 9.82% and sugar-acid ratio approximately 5.58% compared with application of cattle manure on dragon fruit (Huang *et al*., 2019).

Karunakaran *et al.* (2014) recommended that NPK (19-19-19) fertilizer dose at 100 g combined with organic manure applied in each three to four months on dragon fruit. Application NPK fertilizer at N 540 g, P_2O_5 310 g, and K_2O 250 g^{-1}plant resulted in a greater number of fruits, fruit length, fruit breadth, individual fruit weight and fruit yield (Chakma *et al.*, 2014). Other research showed that application of N 450 g, P_2O_5 350 g and K_2O 300 g^{-1}pillar produced maximum individual fruit weight, number of fruits and yield were 222.03 g, 68 and 24.15 t^{-1} ha was reported by Parween and Hasan (2019). In Taiwan, applications of NPK fertilizers were 540 g N, 720 g P and 300 g $K^{-1}plant^{-1}$year combined with 20 kg organic manure and 100 g^{-1}plant of NPK (13-13-13) mixture with 4 kg organic manure every four months while in India applied 500 g urea, 500 g P and 300 g K per year in the first two years old plant and 800 g N, 900 g P and 550 g K after two years old plant (Nangare *et al.*, 2020).

Although N and P fertilizers have been extensively observed in different crops, limited knowledge is available to investigate dealing with the beneficial role of soil application of N and P fertilizers on dragon fruit. Evaluating the comparative efficacy of these two fertilizers with or without combining other nutrients has been tried before. An accurate and appropriate dose of N and P fertilizers has never been attempted before at least in dragon fruit.

2. Methods

2.1. Experimental Design

The research was conducted at Indonesian Tropical Fruit Research Institute ($0^0$44'03".S.$100^0$37'15" E and 455 m above sea levels), Solok West Sumatera which used *Hylocereus polyrhizus* variety one year age with planting distance 3 X 3 m and line spacing 2.5 m. The plants were propagated by cuttings and then planting directly in the field. The plants were supported by cement pillars about 10 x 10 x 220 cm with four plants planted per pillar.

The average monthly temperature during the research was 26.03^0C, with 30.18^0C maximum and 21.88^0C minimum, the annual average rainfall was 144,21 mm per month and the average relative humidity was 81.99 % whereas 88.88 % as the maximum and 72.72 % as the minimum relative humidity per month. The soil used in the study contains N 0.06%, P_2O_5 3.12 ppm, pH 4.68, C-organic 2.03%, Fe 26,02 ppm, Mn 9.67 ppm, Zn 0.31 ppm, cation exchange capacity 14.98, Ca-dd 2.45 $cmol^{-1}kg$, K-dd 0.82 $cmol^{-1}kg$, Mg-dd 0.82 $cmol^{-1}kg$, Al-dd 0.21 $cmol^{-1}kg$ and H-dd 0.06 $cmol^{-1}kg$.

The treatments were arranged in a completely randomized block design with two factors, three replications, and each treatment consisted of 3 plants. The treatments consisted of four N doses (0, 50, 75, and 100 g^{-1}pillar) and four P doses (0, 50, 75, and 100 g^{-1}pillar). Urea and Triple Super Phosphate were used as sources of N and P fertilizers and applicated every four months. Potassium fertilizer as base fertilizer in the form of potassium chloride was applied every four months at around 100 g^{-1}pillar, whereas cow manure as a base fertilizer was applicated 10 kg^{-1}pillar twice of year. All these fertilizers were applied to the ground by putting the fertilizers surrounding the plants and plant distancing around 40 to 50 cm from the plants.

Variables of growth, yield and fruit quality data were collected. The growth parameter included the number of shoots collected during the research from January to December 2020. The number of flowers, fruit set (%) and the number of fruits were also collected, whereas data on individual fruit weight (g), total soluble solid (^{0}Brix) content, yield (kg) and fruit quality were measured in the laboratory after fruit harvested.

2.2. Data Analysis

The data were analyzed by analysis of variance (ANOVA) test and the difference between the treatments then were compared by employing the least significant difference (LSD) test at $p < 0.05$ and software Statistic 8 was used to analyze the data. Linear regression and Pearson correlation analysis were used to reveal the relationships between parameters, whereas step-wise multiple linear regression analysis was used to observe parameters, which affected the yield of dragon fruit by using SPSS 16 and Statistic 8.

3. Results and Discussion

3.1. Effect of nitrogen and phosphorus fertilizer on growth, number of flowers, and fruit set

The study showed that the number of shoots ($p < 0.01$) and number of flowers ($p < 0.01$) were affected by the main effects of N and P doses, whereas the fruit set ($p < 0.01$) was affected by the main effects of N dose and all these parameters were significantly affected by the interaction between N dose and P dose ($p < 0.01$) (Table 1). The two-way interaction between N dose and P dose for the number of shoots was highly significant ($p < 0.01$) (Table 1). Significant difference in the number of shoots among N doses across P doses was observed. The control (0 g N) had

20.02 % less number of shoots at P 50 g, while the same control had 22.23 % and 24.87 % less number of shoots at 75 and 100 g P. The treatment 50 g N and 0 g P resulted in a decreased number of shoots around 54.68 %, 59.63 % and 6.06 % at 50, 75 and 100 g P, respectively. The increasing the number of shoot with increasing N dose at 75 gr N resulted in 105.59%, 139.13% and 140.22 % more number of shoot at 50, 75 and 100 g P compared with 0 g P. A similar trend of the increasing number of shoot with increasing N dose at 100 g N was observed resulting in 102.98%, 126.81% and 162.10% more number of shoots than 0 g P at 50, 75 and 100 g P (Table 2). Increasing number of shoot with increasing P dose was observed regardless of N doses and 100 g N resulted in 39.80 %, 126.95 % and 146.29 % more number of shoot than 0 g N at 0, 50 and 75 g P, whereas the number of shoot increased with increasing P dose and 100 g N resulted in 165.32 % more number of shoot than 0 g N at 100 g P, respectively (Table 2).

The number of shoots is an important parameter for fruit production of dragon fruit which was a primary source to induce primordial flowers (Mizrahi, 2015). The study showed a positive response as a result N and P fertilizer applied lead to induce shoot growth and this result in line with Moreira *et al.* (2016) revealed that the number of shoots significantly increased compared with without fertilizer application. Almeida *et al.* (2014) stated that there was the interaction N and P in the root and shoot parameters and enhanced the early growth of dragon fruit (*Hylocereus undatus*). In addition, the number of branchs and shoot heights increased as a result application of NPK fertilizer compare to the control (Kumar *et al.*, 2018).

A highly significant ($p < 0.01$) two-way interaction between N dose and P dose was evident for the number of flower parameters (Table 1). At 0 and 50 g N, the number of flowers was the highest at 100 g P and 75 g P which was reduced by 54.90 % and 55.93 % at dose 0 g P. A progressive increase in the number of flowers with increasing N dose at 75 g was observed at 75 g P resulting in 151.70 % more number of flowers, while increasing N dose up to 100 g was observed at 100 g P result in 152.64 % more number of flowers compared to 0 g P. There was a significant difference in the number of flowers and increasing this parameter followed by increasing P dose was recorded regardless of N doses and 100 g N resulted in 33.17 %, 88.84 %, 52.75 % and 51.70 % more number of flower than 0 g N at 0-100 g P, respectively (Table 2).

Before the blooming stage, the plant required low N fertilizer, high P and K fertilizers application besides photoperiod and water irrigation to maintain nutrients competition, to assist the existing leaves to mature and induced the initiation of the flower. A long in a flowering stage, the plant required enough nutrients to meet its growth and development. At the stage of development flower bud, the amount of flower were affected by some factors such as plant growth regulator, temperature, light, and nutrients or fertilizer application (Zeng *et al.*, 2013). Thus, along this stage, fewer amounts of these fertilizers application produced early premature fruit dropped and lead to reduce the frut set. The result of the study showed that N and P applied a significant increase number of flowers on dragon fruit and the result in accordance with Then (2014a; 2014b) found that there was an improvement in flower induction of red pitaya and a significant increase in number of flower as a result of foliar spray fertilizer and application compost combined with fertilizer compared to without no foliar application.

The fruit set was highly significant ($p < 0.01$) affected by the two-way interaction between N dose and P dose (Table 1), which remained a statistically significant difference across N dose (0 and 50 g N). At 0 and 50 g N, the fruit set was the highest at 75 g P and 50 g P. Increasing N dose at 75 and 100 g N revealed similar effects on the fruit set (Table 2). The fruit set revealed a statistically significant difference between 0, 50 and 75 g P across N dose was observed. The highest fruit set was at 50 g N approximately 58.32 % and resulted in 15.30 %, 31.32 % and 33.97 % morefruit set at 0, 75 and 100 g P, whereas increasing P dose up to 100 g resulted in no significant difference across N dose, respectively (Table 2).

Table 1. Number of shoots, number of flower and fruit set as a function of soil application of N and P doses fertilizer.

Treatments	Number of shoots	Number of flowers	Fruitset (%)
N (g $^{-1}$plant)			
0	18.38±0.73 c	24.13±2.92 c	45.38±2.95 b
50	38.55±3.51 b	51.66±3.92 b	51.61±2.14 a
75	39.66±3.50 b	55.96±4.72 a	45.04±1.41 b
100	41.29±3.70 a	57.19±5.17 a	46.25±1.28 b
P (g $^{-1}$plant)			
0	18.82±0.77 d	35.71±0.86 d	45.73±2.37 a
50	36.23±3.05 c	45.71±3.72 c	49.41±2.64 a
75	40.60±3.70 b	50.94±2.62 b	46.66±1.09 a
100	42.22±3.94 a	56.58±2.60 a	46.49±1.11 a
Significance			
N	**	**	**
P	**	**	ns
N X P	**	**	**

Notes: N, nitrogen fertilizer; P, phosphate fertilizer; LSD 0.05, least significant difference at $p < 0.05$, means followed by the same letter within a column are not significantly different by least significant difference at $p < 0.05$; ns, not significant; * $p < 0.05$; ** $p < 0.01$; data are means ± standard errors of three replications.

During the fruit setting stage, the plant required amounts of N, P_2O_5, K_2O fertilizers and GA_3 to improve flowering and fruit set (Demirci & Canli, 2015: Pradeepkumar *et al.*, 2020). Less or no fertilizer applied leads to yellowish and the flower falls, whereas greenish flowers and increase in flower volume as a signal fruit set formed (Perween, 2017). Our study revealed that application N and P fertilizer significant increase fruit set parameters and similar results were observed by Nasreen *et al.* (2013), Demirci and Canli (2015) and Pradeepkumar *et al.* (2020) showed that fertilizer application increased flowering, fruit set and crop yield. In addition, Silva *et al.* (2011), Araújo *et al.* (2015) and Souza *et al.* (2018) showed that N and P fertilizers were applied to improve flowering, fruiting and fruit quality i.e. fruit size, fruit weight, fruit shape and coloration parameter.

Table 2. Interactive effects of N and P doses fertilizer on number of shoots, number of fruits, and fruit set.

P (g plant^{-1})	N (g plant^{-1})			
	0	50	75	100
	Number of shoots			
0	15.10±1.28 bB	18.88±0.94 cA	20.21±0.29 cA	21.11±0.11 dA
50	18.88±0.58 abB	41.66±1.83 bA	41.55±0.48 bA	42.85±0.78 cA
75	19.44±0.67 aB	46.77±0.86 aA	48.33±0.76 aA	47.88±0.40 bA
100	20.10±1.36 aC	20.10±0.77 cC	48.55±1.05 aB	53.33±0.40 aA
Significance N		**		
P		**		
N X P		**		
LSD (0.05)		2.77		
	Number of flowers			
0	20.44±1.60 cB	24.77±1.12 cAB	24.10±0.86 bAB	27.22±0.48 bA
50	34.77±0.22 bC	45.77±1.55 bB	60.44±2.16 aA	65.66±1.38 aA
75	42.33±0.76 aC	56.21±2.23 aB	60.66±1.38 aAB	64.66±1.34 aA
100	45.33±0.50 aC	56.10±1.55 aB	58.55±1.41 aB	68.77±2.32 aA
Significance N		**		
P		**		
N X P		**		
LSD (0.05)		4.27		
	Fruit set (%)			
0	34.63±0.99 cB	57.58±6.64 abA	44.41±2.41 aAB	46.29±2.75 aAB
50	50.58±2.38 abAB	58.32±3.80 aA	44.41±3.34 aB	43.53±1.73 aB
75	51.85±412 aA	44.55±1.63 bB	43.82±1.70 aB	46.42±1.24 aAB
100	44.47±2.76 bA	45.99±3.45 bA	46.74±2.00 aA	48.75±2.86 aA
Significance N		**		
P		ns		
N X P		**		
LSD (0.05)		8.67		

Notes: N, nitrogen fertilizer; P, phosphate fertilizer; LSD 0.05, least significant difference at p < 0.05, means followed by the same small letter within a column and the same capital letter within a row are not significantly different by least significant difference at p < 0.05 ; ns, not significant; * p < 0.05; ** p < 0.01; data are means ± standard errors of three replications.

3.2. Effect of nitrogen and phosphorus fertilizer on yield and fruit quality

The research revealed that the main effect of N and P fertilizer was significant on the number of fruits ($p < 0.01$) and yield ($p < 0.01$), whereas individual fruit weight ($p < 0.05$) was affected by the main effect of P fertilizer and total soluble solids (TSS) parameter showed no affected either by the main effect of N or the main effect of P (Table 3). The maximum number of fruits was observed at 100 g of N, which was statistically at par with 50 and 75 g N, but 139.35 % higher than without N application (Table 3). A progressive decrease in the number of fruits with decreasing in P and P at dose 100 g resulted in 58.15 %, 19.02 % and 13.56 % higher number of fruits compared with 0, 50 and 75 g P, respectively.

The number of fruits parameter is an important parameter to produce a high yield. The lower number of fruits produced lower yielding in this study as the result of the fewer number of flowers compared to N and P fertilizer applied. A lower number of fruits is indicated not only due to less produced number of flowers but also lower application of fertilizer (Goenaga *et al.*, 2020). A similar trend of the increasing number of fruits with increasing fertilizer rates to a certain application of fertilizer were reported by Sarker and Rahim (2012), Oloyede *et al.* (2013), Chakma *et al.* (2014), and Gonzaga *et al.* (2017).

Among all N doses applied, individual fruit weight revealed no significant difference. Individual fruit weight at dose 75 g P resulted in 11.12 % higher than 0 g P and showed no significant difference with other treatments. Individual fruit weight in the study was affected by the main effect of P fertilizer with the average individual fruit weight around 476.89-529.92 g and showed no affected by the main effect of N approximately 484.66-515.10 g. The result in line with Nasreen *et al.* (2013) and Chakma *et al.* (2014) revealed that there was significantly reduced individual fruit weight compared to the treatments applied. Individual fruit weight produced fruit thinning to one or two per stem leading to an increase in fruit size and weight (Goenaga *et al.*, 2020). Then (2014a) showed that fruit quality improved by producing heavier fruit weight as a result of a mixture fertilizer (N:P:K and Mg) at 1.2 $kg^{-1}pillar^{-1}year$.

Then (2013) classified fruit grades of dragon fruit into three grades i.e. grade A (>450 g), grade B (300-450 g) and grade C (<300 g). Based on this fruit grade criteria, the study resulted in individual fruit weights around 476.89-515.10 g and included in grade A. Although this research revealed that application without N and P fertilizers produced grade A, our finding showed that application without N and P fertilizers produced both lower and significant differences with the application of N and P fertilizers in the number of shoots, number of flowers, number of fruits, and yield (Table 1 and Table 3).

The content of TSS indicated that more fruit sweetness produced a higher ^{0}Brix and a progressive increase in N and P doses applied in this study showed no significant difference in TSS parameter was observed (Table 3). Alves *et al.* (2021) showed that soluble solid parameter revealed no effect as a result of N fertilizer application on *Hylocereus polyrhizus, Hylocereus undatus, and Selenicereus megalanthus* variety from the first to the third production cycle. A similar trend was reported by Gonzaga *et al.* (2017) showed that there was a negative effect on TSS parameters as a result of nitrogen application and NPK application led to the production of sucrose or soluble solid content reduced due to high nitrogen fertilizer applied. The average TSS parameter affected by the main effect of N fertilizer and the main effect of P fertilizer were 13.61-14.14 ^{0} Brix and 13.71-14.30 ^{0} Brix. Based on the results of the study showed that the value of TSS produced it ^{0} Brix higher than reported by Esquivel and Quesada (2012) and Balois-Morales *et al.* (2013) found that TSS parameters ranged from 7 to 11 ^{0} Brix and 9 to 11 ^{0} Brix.

Table 3. Number of fruits, individual fruit weight, TSS, and yield as a function of soil application of N and P doses fertilizer.

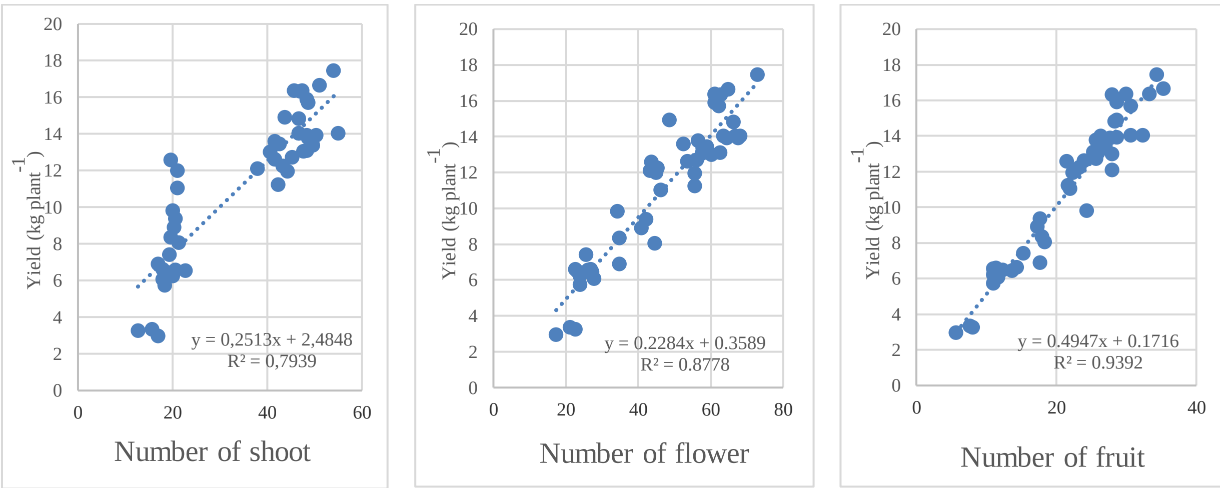
Treatments	Number of fruits	Individual fruit weight (g)	TSS (^{0} Brix)	Yield (kg)
N (g $^{-1}$plant)				
0	11.08±0.81 b	507.35±16.64 a	13.61±0.15 a	5.63±0.44 b
50	25.88±1.31 a	484.66±15.15 a	14.13±0.27 a	12.66±0.86 a
75	25.24±1.37 a	515.10±12.02 a	14.14±0.21 a	12.92±0.63 a
100	26.52±1.49 a	504.24±9.64 a	13.71±0.17 a	13.36±0.75 a
P (g $^{-1}$plant)				
0	16.73±1.80 c	476.89±17.89 b	14.30±0.24 a	8.04±0.96 c
50	22.23±1.82 b	506.98±10.74	13.84±0.22 a	11.19±0.87 b
75	23.30±1.93 b	ab	13.73±0.14 a	12.35±1.07 a
100	26.46±2.59 a	529.92±9.22 a	13.71±0.21 a	12.98±1.20 a
Significance		497.56±11.73		
N	**	ab	ns	**
P	**		ns	**
N X P	ns	ns	ns	Ns
		*		
		ns		

Notes: N, nitrogen fertilizer; P, phosphate fertilizer; LSD 0.05, least significant difference at $p < 0.05$, means followed by the same letter within a column are not significantly different by least significant difference at $p < 0.05$; ns, not significant; * $p < 0.05$; ** $p < 0.01$; data are means ± standard errors of three replications.

The yield was similar among 50, 75 and 100 g N, which was significantly higher 57.85 % than without N applied (Table 3). Among three P doses, the yield was significantly higher at 100 g P (12.98 kg) than 0 g P (8.04 kg) and 50 g P (11.19 kg) but showed no significant difference with 75 g P. N and P doses fertilizer markedly improved fruit yield compare to without nutrients application in this study were observed. Similar results showed that nitrogen fertilizer was applied to increase plant growth, fruit yield and quality of dragon fruit (Muchjajib & Muchjajib, 2012; Chakma *et al*., 2014). Fruit yield significantly increased as a result application of NPK fertilizer compared to without NPK fertilizer (Nasreen *et al.*, 2013; Chakma *et al.*, 2014). Boyd *et al.* (2013), Donno *et al.* (2013) and Kozera *et al.* (2013) revealed that fruit yield and quality increased as affected by N and P fertilizers applied. N fertilizer application improved yield and fruit quality on three species of dragon fruit (*Hylocereus polyrhizus, Hylocereus undatus* and *Selenicereus megalanthus*) was reported by Alves *et al.* (2021).

It can be found that the relationships between yield with the number of shoots, number of flowers, and number of fruits showed significant differences with the values of R^2 were 0.7939, 0.8778 and 0.9392, respectively (Figure 1). This result showed that the yield increased with an increasing number of shoots, number of flowers, and number of fruits, whichshowed relationships between yield with number of shoot ($y = 0.2513 x + 2.4848$, $R^2 = 0.7939$), the number of flowers (y = 0.2284 x + 0.3589, R^2 =0.8778) and number of fruits (y = 0.4947 x + 0.1716, R^2 = 0.9392). The results indicated that the number of shoots, number of fruit and number of flowers were important parameters for yield, whereas the relationships between yield with fruit set, individual fruit weight and TSS revealed relationships with the values of R^2 were 0.1866 ($y = -0.0175\ x^2 + 1.8854\ x - 37.87$), 0.1239 ($y = -0.004\ x^2 + 0.4018\ x - 91.534$) and 0.0011 ($y = -0.123\ x^2 + 3.3096\ x - 11.017$), respectively, and these parameters did not highly affect the yield.

There were significant positive correlations with all parameter traits used in the study (Table 4). This analysis showed correlations between yield and other parameters. Table 4 below revealed positive correlations between yield with number of shoots (r= 0.891), number of flowers (r=0.934) and number of fruits (r=0.969). This result indicated that increasing the yield is followed by the increasing number of shoots, number of flower and number of fruits.



a b C

Figure 1. Relationship between the yield with the number of shoots (a), number of flowers (b), and number of fruits (c).

3.3. The main parameter traits affected yield of dragon fruit

Based on the step-wise multiple linear regression analysis, there were three dominant parameters that affected the yield with a total affected around 99.25 %, respectively. The three dominant parameters that affected the yield from the higher to the lower were the number of fruits, individual fruit weight and fruit set (Table 5).

As one of the management practices to improve plant production and productivity, N and P fertilizers' effects on the number of fruits, individual fruit weight and yield were observed in this study. Increasing application of N and P followed by the increasing number of fruits, and individual fruit weight lead to yield increase (Table 3). This result indicated that the positive effects of N and P on the number of fruits, individual fruit weight and yield. The strong relationship between yield and number of fruits with R^2 0.9392 and positive correlations between yield with number of fruits in this study was recorded (Figure 1 and Table 4). The results in line with Chakma *et al.* (2014) and Then (2014a) which revealed that the application of NPK fertilizer and NPK added Mg fertilizers combined with composts increased the number of fruits, individual fruit weight and fruit yield of dragon fruit. The number of fruits, fruit weight and yield increased as a result of fertilizer application were observed by Muchjajib and Muchjajib (2012) and Then (2014b).

Table 4. Correlation between variable traits used in the study (n=144).

	NB	NF	NFR	YI	FS	IFW	TSS
NB	1						
NF	0.919**	1					
NFR	0.873**	0.934**	1				
YI	0.891**	0.937**	0.969**	1			
FS	-0.016	-0.042	0.296*	0.207	1		
IFW	0.153	0.071	-0.027	0.201	-0.238	1	
TSS	-0.141	-0.008	0.017	-0.026	0.065	-0.190	1

Notes: NB = number of shoots; NF = number of flowers; NFR= number of fruits; YI = yield; FS=fruit set; IFW= individual fruit weight; and TSS = total soluble solids; * = correlation is significant at the 0.05 level;** = correlation is significant at the 0.01 levels.

Table 5. T- student values as the main parameter traits affected the yield of dragon fruit.

Parameter	T- student values in equation					
	1	2	3	4	5	6
Number of shoots	-0.50	-0.56	-0.52	-	-	-
Number of flowers	0.32	0.33	-	-	-	-
Fruitset	-0.51	-0.52	-1.91	-1.96	-	-
Number of fruits	8.39	8.53	27.82	71.85	72.39	26.60
TSS	0.08	-	-	-	-	-
Individual fruit weight	15.47	15.71	15.95	16.61	17.07	-
R^2	0.9926	0.9926	0.9925	0.9925	0.9918	0.9390

Along the fruit development stage, the percentage of fruit set could be reduced. This study revealed that the fruit set was around 34.63 to 58.32 % and the average was approximately 47,08%. Based on our findings, the percentage of fruit set was lower than that reported by Jiang *et al.* (2011) and Osuna-Enciso *et al.* (2016) was approximately 70 – 80 %. Reducing the well-developed number of flowers, incompatibility, competition of photosynthate related to the ratio of flower and fruit, overlap in the flowers and fruit growth, rains lead to flower abscission and disease (Jiang *et al.*, 2011; Ortiz and Carillo, 2012) are factors could be reduced the percentage of flower transform to fruit (fruit set) that effects on yield reduced.

4. Conclusions

The Growth and yield of dragon fruit (*Hylocereus polyrhizus*) were affected by N and P fertilizers, and showed interaction on the number of shoots, number of flowers, and fruit set. At 100 g N, the number of shoots increased by 102.98 - 162.10 % at 50, 75, and 100 g P. Increasing N dose up to

100 g resulted in 152.64 % more number of flowers at 100 g P compared to 0 g P. The Fruit set at dose 50 g N increased by 58.32 % at 50 g P and increasing N dose up to 100 g N revealed no significant difference. The number of fruits increased by 139.35 % at 100 g N compared to 0 g N and 13.56 - 58.15 % at 100 g P at different P doses. There was no significant difference in individual fruit weight among N doses and TSS among N and P doses. N applied at 50 g^{-1}pillar produced maximized yield at 75 g^{-1}pillar P, respectively, and hence it could be recommended as the optimum dose.

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