Application of Petrobio Fertiliser in Addition

by Sudika I Wayan

Application of Petrobio Fertiliser in Addition to Inorganic Fertiliser Improved the Growth of Maize Plants

I Komang Damar Jaya[1*], Sudirman[1] and I Wayan Sudika[1]

[1]*Faculty of Agriculture, University of Mataram, Jalan Majapahit 62, Mataram, West Nusa Tenggara 83125, Indonesia*

This study aimed at improving the growth in maize plants by supplementing the standard fertilisation regime with Petrobio fertiliser. The experiment was conducted in Amor-amor hamlet, Gumantar village, Kayangan sub-district, North Lombok district (Indonesia), testing two levels of standard fertilisation doses (100% and 75% of maize fertilisation doses of 380 kg ha^{-1} Phonska + 500 kg ha^{-1} urea) and four doses of Petrobio (0, 20, 40 and 80 kg ha^{-1}). The experiment was designed with a factorial randomised block design with three replications. The variables observed were plant height, number of leaves, fresh and dry biomass weight, canopy interception of sunlight, and tissue concentrations of N, P and K. Data were subjected to analyses of variance and regression between particular variables. The results showed that, compared to without Petrobio fertiliser, the application of 80 kg ha^{-1} Petrobio fertiliser almost doubled the dry weight of maize plants, increased light interception by around 5%, and increased the total concentrations of N, P and K in tissues at least by 40%. There were strong relationships between Petrobio doses and dry weight of maize plants, and the concentration of N, P, and K in the maize plant tissues.

Keywords: canopy; light interception; microbes; plant tissue; vegetative

I. INTRODUCTION

Since it was launched as one of special programmes in 2008, maize production in West Nusa Tenggara (WNT), Indonesia has continued to increase. The increase occurred as a result of not only the expansion of maize planting area but also the improved cultivation technology. The use of superior hybrid varieties, provision of fertilisers in the right amount and time, and regulation of plant populations are among the technologies widely applied. All these efforts have contributed to the increase in production and productivity of maize plants in WNT. In 2013, the total production of maize in WNT was 633,733 tons of dry grains with productivity around 5.6 t ha^{-1}. Meanwhile, in 2017 WNT maize production was more than double the production in 2013, at 1,511,426 tons with productivity around 6.0 t ha^{-1} (unpublished data from Department of Agriculture and Estate, West Nusa Tenggara). The increased productivity and prices for dry grains exceeding IDR 3,000 kg^{-1} motivated the maize farmers to continue to increase the planting area and productivity of their crops.

Considering the productivity that has been achieved, the productivity of maize in WNT has been relatively high in general, even though it is still lower than that in other provinces such as Banten which recorded a productivity of 8.0 t ha^{-1}. In terms of the technology applied, almost all maize farmers in WNT have grown hybrid varieties with adequate quantities and types of fertilisers. This indicates the presence of some limitations to achieving optimal productivity of maize plants in WNT since the yield potential of maize hybrid varieties is between 8 and 10 t ha^{-1}. As is known, a large portion of maize in WNT is produced from dry land, especially in districts including North Lombok, East Lombok, Sumbawa and Dompu. The dry land in WNT, especially in the North Lombok district region, is mostly very poor in soil organic matter. It was reported that organic matter content in the Amor-amor hamlet, Gumantar

*Corresponding author's e-mail: ikdjaya@unram.ac.id

village, Kayangan sub-district, North Lombok was 1.24% (Jaya *et al*., 2014), and most maize plants are produced in Kayangan sub-district only during the rainy season.

The low content of organic matter in the soil results in the low or lack of biota in the soil, because organic matter is the main food source for soil biota (Doran & Zeiss, 2000). This condition is exacerbated by the condition of the sandy soil which has a high potential for nutrient leaching (Yang *et al.*, 2007). Therefore, fertilisers applied to the soil for maize crops in sandy dry land such as in Kayangan sub-district may not have been very effective in increasing the productivity of maize plants.

One way to increase the effectiveness of fertiliser to increase the production of crops such as maize is by increasing nutrients availability from the applied fertiliser. The availability of inorganic fertilisers applied to the soil can be increased by increasing the application dosage so that it is easily taken up by plants. In addition to increasing the doses, the availability of compound inorganic fertilisers such as N-P-K Phonska (15-15-15) produced by PT. Petrokimia Gresik and single fertilisers such as urea, can also be improved by applying biological fertilisers (Purba, 2015). One of the glazed examples of biological fertilisers is Petrobio fertiliser produced by PT. Petrokimia Gresik. Petrobio fertiliser is claimed by the producer as an ingredient that can increase the effectiveness of nitrogen (N) and phosphorus (P) fertilisers by increasing the availability of N and P elements in the soil, due to the role of several microorganisms contained in Petrobio, such as *Azospirillum* sp., *Azotobacter* sp., *Pseudomonas* sp., *Aspergillus* sp., and *Penicillium* sp. (Anonymous, 2013).

The objective of this paper was to study the improvement in growth and concentration of nitrogen (N), phosphorus (P) and potassium (K) in the shoots of maize plants with the application of different doses of Petrobio fertiliser as a supplement to the basic inorganic fertiliser. An increase in various growth parameters along with the nutrient concentrations in plant tissues was taken to reflect an increase in nutrient uptake that improved plant growth as a result of the application of Petrobio fertiliser.

II. MATERIALS AND METHODS

Field experiments were carried out in Gumantar village, Kayangan sub-district, North Lombok (8.253654 S, 116.285695 E). Climate type in the experimental site according to Oldeman classification is type D3, with only three wet and nine dry months (As-syakur *et al.*, 2011). Soil properties at the beginning of the experiment were as follows: pH 6.6; C-organic, 0.6%; total N, 0.06%; available P, 8.4 ppm; exchangeable K, 0.49 meq%. The soil type is Entisol with loamy texture.

The experiment was designed using a randomised block design with three blocks. Two treatments were tested, namely basic fertilisation and application of Petrobio fertiliser. The basic fertilisation treatment consisted of two levels, first the standard maize fertilisation and second, 75% of standard fertilisation dosage. Standard fertilisation involved the application of 380 kg ha^{-1} NPK fertiliser and 500 kg ha^{-1} urea by maize farmers in the experimental area. The Petrobio doses applied were 0, 20, 40 and 80 kg ha^{-1}. All treatments were arranged factorially.

Maize plants were grown in a double row pattern (35 × 20 cm in double rows and 70 cm between double rows). The plot size for each treatment was 455 cm × 200 cm which contained three double rows of maize in the middle and a single row on the left and right in an East-West row orientation. The variety of maize planted was NK212 (product of Syngenta).

Petrobio fertiliser in accordance with the treatment (0, 20, 40 and 80 kg ha^{-1}) was mixed and given together with basic fertilisers in the form of N-P-K (15-15-15) Phonska and urea. At planting, for a dose of 100%, Phonska was given at a dose of 190 kg ha^{-1} and urea at a dose of 150 kg ha^{-1}. Thus for 75% doses, Phonska and urea were applied each with a dose of 142.5 kg ha^{-1} and 112.5 kg ha^{-1} at the time of planting. The second fertilisation was carried out when the plants were at the age of 35 d after planting (DAP) with the same Phonska dose as the first fertilisation along with 200 and 150 kg ha^{-1} of urea for 100% and 75% treatments, respectively. The third fertilisation was carried out at 56 DAP with urea only as much as 150 kg ha^{-1} (100%) or 112.5 kg ha^{-1} (75%).

Irrigation was carried out with a flooding system using water originating from a deep-pump well around the experimental site. At the end of the vegetative growth phase

(60 DAP), plant height, number of leaves, and percentage of light interception were measured. Light interception was measured with *Accu*PAR (PAR/LAI Ceptometer Model LP-80, Decagon Devices) during a bright day at 60 DAP, full sunlight from 12:00 to 13:00, by measuring the photosynthetically active radiation above and below the canopy in each treatment. Fresh weight and dry weight of the maize biomass were also determined at the same date as the light interception measurement. Furthermore, the concentrations of nitrogen, phosphorus and potassium in the plant tissues (a mixture of leaves and stalks) at 60 DAP were analysed using semi-micro Kjeldahl, UV-Vis spectrophotometry and atomic absorption spectrophotometry, respectively. All collected data were analysed by analysis of variance using Minitab® 15 statistical package. Since there were strong indications of relationship between the increase in Petrobio dose and the observed variables, the data were subjected to regression analysis.

III. RESULTS

The results showed that there was no interaction between fertilisation with basic inorganic fertilisers and Petrobio fertiliser in affecting all variables. Standard fertiliser application at different doses affected plant dry weight, total N and total K in the plant tissues but showed no significant effect on other variables. On the other hand, Petrobio fertiliser doses affected all measured variables significantly. The effects of Petrobio fertiliser on the growth of maize plants measured as plant dry weight, plant fresh weight, plant height and the number of leaves of maize plants are presented in Table 1. Increasing the dose of Petrobio fertiliser caused an increase in dry weight, wet weight, plant height and number of leaves, indicating Petrobio fertiliser has a positive effect on the growth of maize plants. The lowest fresh and dry weight were observed in treatment without the addition of Petrobio fertiliser, and the highest weight was obtained in treatment with Petrobio fertiliser at a dose of 80 kg ha^{-1}. The addition of Petrobio at a dose of 80 kg ha^{-1} increased the plant dry weight to about twice of that not treated with Petrobio fertiliser. Plants that are taller and have more leaves from the treatment with higher Petrobio doses also showed a higher percentage of light interception, which was more than 95% in 80 kg ha^{-1} Petrobio fertiliser treatment compared to about 90% in the treatment without Petrobio.

Table 1 also showed that a 4.9% improvement of sunlight interception was achieved by adding 80 kg ha^{-1} of Petrobio fertiliser as compared to treatment without Petrobio. The sunlight interception improvement with the application of 80 kg ha^{-1} Petrobio was higher than that with 20 kg ha^{-1} Petrobio application, but not significantly different from that with 40 kg ha^{-1} of Petrobio fertiliser application.

Petrobio fertiliser application was highly correlated with plant dry weight as shown in Figure 1. Application of Petrobio fertiliser produced higher plant dry matter in plants treated with 100% of standard fertiliser than those with 75% basic fertilisation (p = 0.018). The difference in dry weight of plants treated with 100% and 75% basic fertilisation as seen in Table 1 was significant, but there was no interaction between standard fertilisation and application of Petrobio fertiliser in affecting the plant dry weight. This was shown by the seemingly parallel regression lines in Figure 1 with slopes that were not significantly different from each other (p = 0.168).

Table 1. The growth and light interception of maize plants treated with various combinations of standard inorganic and Petrobio fertilisers doses

Treatments	Dry weight (g)	Fresh weight (g)	Plant height (cm)	Number of leaves	Light interception (%)
Standard fertilisation					
100%	164.26 a	464.39	193.35	17.62	93.12
75%	151.87 b	460.78	190.37	17.50	93.36
Petrobio					
0 kg ha^{-1}	112.71 c	348.44 c	179.93 c	16.33 c	90.74 c
20 kg ha^{-1}	135.52 bc	427.39 bc	190.40 b	17.33 bc	91.84 bc
40 kg ha^{-1}	169.41 b	475.33 b	196.00 ab	17.90 ab	94.24 ab
80 kg ha^{-1}	214.63 a	599.17 a	201.10 a	18.67 a	95.63 a

Numbers followed by different letters in the same column and treatment are significantly different according to Duncan Multiple Range Test at 95% confidence level.

The growth of maize plants at vegetative phase was related to the concentrations of nitrogen (N), phosphorus (P) and potassium (K) in plants. There were strong and significant correlations (with $r^2 > 0.97$, $p \leq 0.05$) between plant dry weight and concentrations of N, P and K in the plant tissues. Table 2 showed that the higher the dose of fertiliser, the higher the concentrations of total N, total P and total K in the plant tissues, but the difference in total P concentration was not significant. A 25% reduction in standard fertilisation caused 12% and 18% reduction in the concentration of total N and total K in the plant tissues, respectively.

Petrobio fertiliser application dose significantly affected concentration of total N, total P and total K in the plant tissues as shown in Table 2. Except for total K, the application of 20 kg ha^{-1} of Petrobio fertiliser did not significantly improve the total N and total P in the plant tissues. The highest improvement was achieved when a dosage of 80 kg ha^{-1} of Petrobio fertiliser was applied. There was a strong correlation between Petrobio dosages and concentrations of total N ($r^2 = 0.99$, $p = 0.003$), total P ($r^2 = 0.98$, $p = 0.007$) and total K ($r^2 = 0.98$, $p = 0.008$) in the plant tissues.

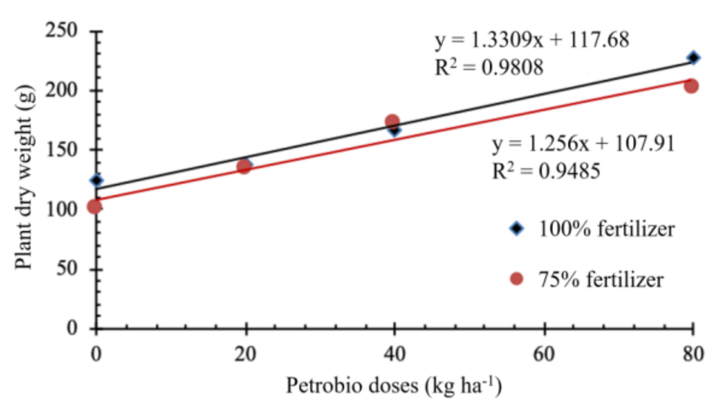

Figure 1. The relationship between Petrobio doses and dry weight of maize plants at 100% and 75% of standard fertiliser applications

Table 2. Concentrations of total N, total P and total K in tissues of maize plants treated with various standard fertilisation and Petrobio fertiliser doses

Treatments	Total N (%)	Total P (%)	Total K (%)
Standard fertilisation			
100%	0.96 a	0.18	2.92 a
75%	0.84 b	0.17	2.74 b
Petrobio			
0 kg ha⁻¹	0.65 c	0.15 b	2.38 c
20 kg ha⁻¹	0.78 bc	0.16 b	2.72 b
40 kg ha⁻¹	0.94 ab	0.18 ab	2.92 b
80 kg ha⁻¹	1.22 a	0.22 a	3.32 a

Numbers followed by different letters in the same column and treatment are significantly different according to Duncan Multiple Range Test at 95% confidence level.

IV. DISCUSSION

Application of Petrobio fertiliser improved the vegetative growth of maize. This can be seen in Table 1, where plant fresh and dry matter, plant height, and leaf number of the maize plants were all increased with the increased Petrobio fertiliser doses. The taller and bigger plants with more leaves caused a higher percentage of light interception. Puntel (2012) suggested that a good maize plant canopy should achieve at least 95% light interception at the end of the vegetative phase.

In this study, this level of light interception (95%) was achieved at the treatment with the addition of 80 kg ha^{-1} Petrobio fertiliser. High sunlight interception at the end of the vegetative phase can increase plant photosynthetic capacity as a way that increases plant dry weight (Andrade *et al*., 2002). The result of this study was in accordance with Andrade *et al.* (2002), as higher plant dry weights were observed in treatments with the addition of Petrobio fertiliser. There was a strong relationship between increasing doses of Petrobio and plant growth represented by plant dry weight as seen in Figure 1.

Table 2 showed that the higher the doses of Petrobio fertiliser added to the soil, the higher the total N, total P and total K concentrations in the plant tissues. This implied that Petrobio fertiliser made nutrients from N-P-K Phonska and urea fertilisers added to the soil more available and can be easily taken up by maize plants. The presence of beneficial microbes in Petrobio fertiliser such as *Azospirillum* and *Pseudomonas* might help maize plants to improve their root growth. These genera have been well documented as plant growth promoting microbes that can promote root growth of plants (Berg, 2009). Sufficient root surface area enables the plants to take up more nutrients from the soil (Baligar *et al*., 2001). It has been reported that Petrobio fertiliser is useful to enhance the effectiveness of inorganic fertilisers, especially those containing N, P and K, such as Phonska fertiliser (Anonymous, 2013). The ability of Petrobio fertiliser to increase the effectiveness of inorganic fertilisers containing N and P is attributed to several important microbes in this fertiliser, including those that have a role as N fixers from the air and producers of growth regulators, such as *Azospirillum* sp., *Azotobacter* sp. and *Pseudomonas* sp. Other microbes such as *Aspergillus* sp. and *Penicillium* sp. act as phosphate solubilizer, while *Streptomyces* sp. acts as a decomposer of organic matter. It is assumed that with such microbial consortium, Petrobio fertiliser can increase the availability of nutrients which can be easily taken up by plants so that the plants would grow well. These results agreed with an earlier review by Adesemoye and Kloepper (2009) that found microbes in the soil can improve fertiliser-use efficiency. Good plant growth is expressed in plant height and number of leaves. Taller plants with larger number of leaves have increased ability to intercept sunlight that subsequently results in an increased photosynthetic ability and thus plant dry weight.

The results of this study clearly showed that the application of Petrobio fertiliser at a dose of 80 kg ha^{-1} could increase the concentrations of total N, total P and total K in the plant tissues by 40 to 50%, compared to treatment without the addition of Petrobio fertiliser. In this case, it can be said that there was a complimentary effect of Petrobio fertiliser on the application of inorganic fertiliser (N-P-K Phonska + urea), and the effect was constant at all levels of the treatments as shown in Figure 1. If the increase in the concentration of total N, total P and total K present in maize plant tissues can be interpreted as an indication of the role of Petrobio fertiliser in increasing the availability of inorganic fertilisers added to the soil to increase fertilisation efficiency in the loamy texture fields as in this research location, then the addition of Petrobio fertiliser will be very meaningful and needs to be recommended even though economic analysis should not be ignored.

V. CONCLUSION

The application of Petrobio fertiliser in addition to standard fertilisation improved vegetative growth and concentrations of total N, total P and total K in the maize plants tissues. Compared to without Petrobio fertiliser, the addition of 80 kg ha^{-1} Petrobio fertiliser doubled the dry weight of maize plants, increased light interception by 5%, and increased the tissue concentration of nitrogen, phosphorus and potassium at least by 40%. A 25% reduction in standard fertiliser application in the dry land area of Gumantar village, North Lombok district caused a reduction in plant dry weight but had no effect on other variables. The strong relationship between increased dose of Petrobio fertiliser and dry weight of maize plants suggested that the application of Petrobio fertiliser as a supplement to basic fertilisation may lead to a better yield.

VI. ACKNOWLEDGEMENT

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VII. REFERENCES

Adesemoye, AO & Kloepper, JW 2009, 'Plant-microbes interactions in enhanced fertilizer use effeiciency', Applied Microbiology and Biotechnology, vol. 85, no. 1, pp. 1–12.

Andrade, FH, Calviño, P, Cirilo, A & Barbieri, P 2002, 'Yield responses to narrow rows depend on increased radiation interception', Agronomy Journal, vol. 94, no. 5, pp. 975–980.

Anonymous 2013, Petrobio, PT. Petro Kimia Gresik, viewed 8 March 2018, <http://www.petrokimia-gresik.com/PrintPage/Petrobio.Petrobio>.

As-syakur, AR, Nuarsa, IW & Sunarta, IN 2011, 'Updating agroclimate map based on Oldeman classification at Lombok island using geographic information system', in Proceedings of the National Scientific Seminar of the Indonesian Sanitary and Environmental Engineering Experts Association, Denpasar-Bali, 2010, pp. 79–87.

Baligar, VC, Fageria, NK & He, ZL 2001, 'Nutrient use efficiency in plants', Communications in Soil Science and Plant Analysis, vol. 32, no. 7-8, pp. 921–950.

Berg, G 2009, 'Plant-microbe interactions promoting plant growth and health: persepectives for controlled use of microorganism in agriculture', Applied Microbiology and Biotechnology, vol. 84, no. 1, pp. 11–18.

Doran, JW & Zeiss, MR 2000, 'Soil health and sustainability: managing the biotic component of soil quality', Applied Soil Ecology, vol. 15, no. 1, pp. 3–11.

Jaya, IKD, Nurrachman & Jayaputra 2014, 'The potential of intercropping food crops and energy crop to improve land productivity of a degraded agriculture land in arid tropics', Journal of Degraded and Mining Lands Management, vol. 1, no. 3, pp. 111–116.

Puntel, LA 2012, 'Field characterization of maize photosynthesis response to light and leaf area index under different nitrogen level: a modelling approach', PhD thesis, Iowa State University, Amesh, IA.

Purba, R 2015, 'Study of biological fertilizer application on wet rice crops in Banten', in Prosiding Seminar Nasional Masyarakat Biodiversitas Indonesia, vol. 1, no. 6, pp. 1254–1257.

Yang, J, He, Z, Yang, Y, Stoffela, P, Yang, A, Bank, D & Mishra, S 2007, 'Use of amendments to reduce leaching loss of phosphorus and other nutrients from a sandy soil in Florida', Environment Science Pollution Research, vol. 14, no. 4, pp. 266–269.

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