The growth analysis of soybean cultivars on the application of banana pseudo-stem bokashi in Samas Coastal Land, Yogyakarta

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Article Info

Abstract

A coastal sandy land is a potential land used for soybean cultivation. The success in developing soybeans in coastal sandy land depends on the suitability of cultivars used and the cultivation technology applied. Therefore, this study aimed to analyze the growth of twelve soybean cultivars in coastal sandy land as affected by the application of banana pseudo-stem bokashi. The experiment was carried out in factorial randomized complete block design with three replications. The treatment factors consisted of rates of bokashi (0, 20, 40, and 60 ton.ha^{-1}) and 12 soybean cultivars (Anjasmoro, Argomulyo, Burangrang, Demas 1, Dena 1, Devon 1, Gamasugen 1, Gema, Gepak Ijo, Grobogan, Kaba, and Slamet). The net assimilation rate, relative growth rate, and root and shoot dry weight were affected by the bokashi rates, with varying responses according to the soybean cultivar. Demas 1 cultivar was the most adaptive cultivar in coastal sandy land based on its ability to accumulate dry matter of plants. The accumulation of dry matter of roots and shoots increased with bokashi application and the optimum rate were 42.83 ton.ha^{-1} and 45.56 ton.ha^{-1}, respectively.

INTRODUCTION

Soybean is an important source of food, protein, and oil. Hence, more research is essential to increase its yield under different conditions (Pagano and Miransari, 2016). The need of soybean in Indonesia continually increases every year, while national soybean production is so low that the import policy of soybeans must be stipulated (Adijaya et al., 2005). National soybean imports in the last 5 years reached more than 2 million ton (Badan Pusat Statistik, 2020). According to Sumarno and Adie (2011), the main problem in the national soybean production system is the unavailability of land, specifically allocated for soybean production.

A potential land used for the development of soybeans is coastal sandy land (Faozi et al., 2016). However, the development of soybeans on the land is constrained by the physical conditions of the land, which are not able to provide sufficient water and nutrients for plants (Cyio, 2006; Syukur and Harsono, 2008; Hoa et al., 2010;), as well as the ability to store nutrients, which is low (Hall and Bell, 2015; Faozi et al., 2019). The texture of the sandy soil has a rapid infiltration permeability (Patle et al., 2019) so that the water storage capacity is extremely low. To overcome these obstacles, one of them is by providing organic material (Rajiman et al., 2008).

One source of abundant organic material that has not been widely used is the banana pseudo-stem. Banana pseudo-stem is a potential ingredient as raw material for bokashi, because it contains N (2.8 %), P (0.4 %), and K (4.2 %) (Elnour et al., 2015). According to Kusumawati (2015), bokashi made from banana pseudo-stem aged 2 months containing organic C (29.7 %), C/N ratio (17.8), H_2O pH (5.64), total NPK (7.74 %) is already qualified as organic fertilizer. The main components of banana plant waste are banana pseudo-stem, which contains oligocellulose, including 39.12 % cellulose, 72.71 % hemicellulose, and 8.88 % lignin based on their dry weight (Li et al., 2010). These complex carbohydrates would be degraded during composting. Biologically, lignin can be decomposed by bacterial strains such as *Pseudomonas*, *Bacillus*, *Flavobacteria*, *Xanthomonas*, *Aeromonas* and *Cellulomonas*.

The selection of adaptive superior soybean cultivars in coastal sandy land is very important to do, considering the superior cultivars existing today are mainly assembled for fertile land (rice fields) (Adie et al., 2015). The high leaching of $N-NO_3^-$ in sandy land can be overcome through the use of cultivars that are capable of fixing N_2 and efficient in using nutrients N. Purwaningsih et al. (2012) reported that soybean cultivars varied in response to rhizobium inoculation, including in increasing seed yields, especially in novel growing environments such as coastal sandy land. Only small amount of N fertilizer is needed in soybean plants if biological N_2 fixation can take place (Salvagiotti et al., 2008; Francisco et al., 2014).

Accordingly, the success in developing soybeans in coastal sandy land depends on the suitability of cultivars used and the cultivation technology applied. The cheapest and easiest way is to provide soybean varieties that are suitable for the specific location of the coastal area, namely soybean varieties that can still grow and produce high dry matter in a suboptimum environment.

The accumulation of dry matter reflects the ability of plants to use sunlight energy through photo-synthesis and its interaction with the other environmental factors. Distribution of dry matter in plant organs such as roots, stems, leaves, and seeds can reflect plant productivity. Various measures can be used to analyze plant growth by comparing the dry matter weight and leaf area of plants over time (Pandey et al., 2017). Growth analysis is an approach to the analysis of factors that affect crop yields and analysis of plant development as a net accumulation of photosynthetic yield integrated with time. Calculation of plant growth analysis is based on two measurements, namely leaf area and dry weight, which is carried out at frequent time intervals (2–3 days or 1–2 weeks). Growth analysis can be done on a plant or plant community (Anten and Ackerly, 2001).

The aims of this experiment were to analyze the growth based on changes in dry matter accumulation of several soybean cultivars in coastal sandy land and to determine the effect of banana pseudo-stem bokashi rates on the growth soybean plants.

MATERIALS AND METHODS

The research was carried out at Samas Beach, Srigading Village, Sanden District, Bantul Regency, Special Region of Yogyakarta. The duration of this present experiment was 4 months, starting from January to April 2017.

The experiment was a pot experiment in the field, consisting of factorial treatments (4×12) arranged in a Complete Randomized Block Design with three replications. The first factor was the rates of bokashi (B), consisting of without bokashi and the application of bokashi at a rate of 20 ton.ha^{-1}, 40 ton.ha^{-1}, and 60 ton.ha^{-1}, and the second factor was soybean cultivars, namely Anjasmoro, Argomulyo, Burangrang, Demas 1, Dena 1, Devon 1, Gamasugen 1, Gema, Gepak Ijo, Grobogan, Kaba, and Slamet. Each experimental unit consisted of six pots, each with two plants per pot.

Based on the chemical analysis, bokashi made from banana pseudo-stem contained organic C of 16.79 %, total N of 1.26 %, C/N ratio of 13.28, organic matter of 28.95 %, moisture content of 40.85 %, pH H_2O of 9.22, total P_2O^- of 1.69 %, total K_2O of 2.15, total Ca of 5.94 %, and total Mg of 0.28 % (Faozi, 2018).

Sandy soil was sifted using a 2 mm sieve to separate litter and dirt. The sand media was weighed as much as 15 kg (including polybag). Bokashi at rates of 0 ton.ha^{-1}, 20 ton.ha^{-1}, 40 ton.ha^{-1}, and 60 ton.ha^{-1} (0 g per pot, 90 g per pot, 180 g per pot, and 240 g per pot) was given by mixing it into the surface of the sand media. The media was watered and maintained at field capacity conditions for two days before the soybean seeds were planted.

The seeds were inoculated with 5 g.kg^{-1} legume inoculants (legin) of soybean and planted at a depth of 2 cm to 4 cm depth, with 2–4 seeds per pot. At the age of 1 week after planting, two plants were left as sample plants, by removing the plants with poor growth.

Soil moisture was maintained at field capacity conditions, by adding water according to water loss through evapotranspiration. Plants were fertilized with NPK (16-16-16) at a dose of 100 kg.ha^{-1}. Pest control was carried out using insecticides, while disease control was performed using fungicides. Weeds were controlled manually.

Growth observation included leaf area and plant dry weight, and plant growth analysis included the calculation of Net Assimilation Rate (NAR) and Relative Growth Rate (RGR) based on leaf area data and plant dry weight at age 4, 6, and 8 weeks after planting (WAP). Soybean growth could be determined based on the plant dry weight at harvest, including root and shoot organs.

The Net Assimilation Rate (NAR) and Relative Growth Rate (RGR) was calculated by the formula:

$$NAR = \frac{W2 - W1}{T2 - T1} \times \frac{\ln La2 - \ln La1}{La2 - La1}$$

$$RGR = \frac{\ln W2 - \ln W1}{T2 - T1}$$

Note:
W1 : 1st observation of plant dry weight
W2 : 2nd observation of plant dry weight
T1 : 1st observation time
T2 : 2nd observation time
La1 : Total leaf area of the 1st observation plant
La2 : Total leaf area of the 2nd observation plant
NAR : Net Assimilation Rate (g.cm^{-2} per week)
RGR : Relative Growth Rate (g.g^{-1} per week)

Observational data were analyzed with analysis of variance (ANOVA), continued to Duncan's Multiple Range Test at a significance error of 5% to determine soybean cultivar responsiveness to the application of bokashi made from banana pseudo-stem.

RESULTS AND DISCUSSION

The results of the statistical analysis showed the interaction effects of soybean cultivar and rates of bokashi on the NAR, RGR, and accumulation of dry matter of root organs, canopy, and root/shoot ratio.

Net Assimilation Rate (NAR)

The formation and accumulation of dry matter per unit leaf area was faster in the period of 4–6 weeks, which was 1.119 g.dm^{-2} per week (Table 1) compared to those in the growing period of 6–8 weeks, which was only 0.300 g.dm^{-2} per week (Table 2). However, when viewed from the cultivars used and their responses to the application of bokashi, these cultivars had different pattern in terms of dry matter accumulation in both of these growing periods.

NAR in the growing period of 4–6 weeks was the highest in Slamet cultivar (1.347 g.dm^{-2} per week), and this cultivar was relatively unresponsive to application of bokashi. Other cultivars showing high NAR were Anjasmoro, Dena 1, Gamasugen 1, Grobogan, and Kaba (1.238 g.dm^{-2} per week; 1.314 g.dm^{-2} per week; 1.168 g.dm^{-2} per week; 1.130 g.dm^{-2} per week; and 1.147 g.dm^{-2} per week, respectively). In general, NAR of soybean increased with the increasing rates of bokashi applied up to 40 ton.ha^{-1}, and did not increase again even decreased at higher rates.

In the growing period of 6–8 weeks, the rate of plant growth declined, indicating that broader leaves might not be effective in photosynthesis so that the accumulation of dry matter was not as high as in the previous growing period (4–6 weeks). According to Table 2, the dry matter accumulation in Gamasugen 1 and Gema Cultivar in the growing period of 6–8 weeks greatly decreased, with NAR of 0.084 g.dm^{-2} per week and 0.100 g.dm^{-2} per week, respectively. Meanwhile, other cultivars still produced relatively high NAR. Both cultivars had early harvesting age, which was 66 days (Gamasugen 1) and 73 days (Echo). They were already in the phase of seed filling in the period of 6–8 weeks, while other cultivars with longer age were still in the flowering phase or pod formation.

NAR of Demas 1 cultivar was the highest at 6–8 weeks, reaching 0.547 g.dm^{-2} per week. Bokashi rate of 20 ton.ha^{-1} could increase NAR from 0.573 g.dm^{-2} per week to 0.670 g.dm^{-2} per week. The application of bokashi at rates of 40 ton.ha^{-1} and 60 ton.ha^{-1} actually lowered the NAR. According to Faozi (2018), the application of bokashi at high rates could increase the total leaf area of the plant. However, the accumulation of dry matter was not in line with the leaf area, thereby decreasing NAR .

Table 1. Net assimilation rate (g.dm^{-2} per week) of several soybean cultivars as affected by banana pseudo-stem bokashi at the age of 4–6 weeks

Cultivars	Bokashi rates (ton.ha^{-1})				
	0	20	40	60	Mean
Anjasmoro	1.237 c-f	1.255 b-e	1.227 c-g	1.231 c-f	1.238
Argomulyo	1.121 g-m	1.134 f-l	1.091 h-n	0.901 qr	1.062
Burangrang	0.896 q-r	0.847 r	0.866 r	0.993 n-q	0.901
Demas 1	0.878 r	0.950 p-r	1.105 h-m	1.035 l-p	0.992
Dena 1	1.251 b-e	1.350 ab	1.341 ab	1.313 a-c	1.314
Devon 1	0.961 -r	1.031 l-p	1.043 k-p	1.016 m-p	1.013
Gamasugen 1	1.146 e-k	1.171 e-i	1.160 e-j	1.196 d-h	1.168
Gema	0.986 n-q	1.054 j-p	1.156 e-j	1.034 l-p	1.058
Gepak Ijo	1.011 m-p	1.089 h-n	1.059 j-p	1.066 i-o	1.056
Grobogan	1.112 h-m	1.116 h-m	1.145 e-k	1.147 e-k	1.130
Kaba	1.111 h-m	1.179 d-h	1.178 d-h	1.118 g-m	1.147
Slamet	1.350 ab	1.377 a	1.381 a	1.281 a-d	1.347
Mean	1.088	1.130	1.146	1.111	1.119 (+)
CV= 5.01 %					

Remarks: Means followed by the same letters are not significantly different based on DMRT at α= 5%; (+)= interaction of treatment factors is significant.

Table 2. Net assimilation rate (g.dm^{-2} per week) of several soybean cultivars as affected by banana pseudo-stem bokashi application at the age of 6–8 weeks

Cultivars	Bokashi rates (ton.ha^{-1})				
	0	20	40	60	Mean
Anjasmoro	0.286 j-m	0.338 g-j	0.331 g-k	0.335 g-k	0.322
Argomulyo	0.357 f-i	0.367	0.382	0.364	0.367
Burangrang	0.410 ef	0.308 i-l	0.312 h-l	0.372 e-h	0.350
Demas 1	0.573 b	0.670 a	0.514 c	0.429 d-e	0.547
Dena 1	0.386 e-g	0.344 g-j	0.338 g-j	0.470 cd	0.384
Devon 1	0.427 de	0.425 de	0.286 j-m	0.264 l-o	0.351
Gamasugen 1	0.080 p	0.084 p	0.090 p	0.081 p	0.084
Gema	0.110 p	0.108 p	0.099 p	0.084 p	0.100
Gepak Ijo	0.214 o	0.226 n-o	0.274 kn	0.215 o	0.232
Grobogan	0.329 g-k	0.335 g-k	0.331 g-k	0.358 f-i	0.338
Kaba	0.224n-n	0.231 m-o	0.217 n-o	0.214 o	0.221
Slamet	0.327 g-k	0.265 l-o	0.311 h-l	0.318 h-l	0.305
Mean	0.310	0.308	0.290	0.292	0.300 (+)
CV= 10.46 %					

Remarks: Means followed by the same letters are not significantly different based on DMRT at α= 5%; (+)= interaction of treatment factors is significant.

NAR is the ability of plants to store photo-synthates in the form of dry matter. According to Gardner el al. (1991), NAR is the net result of assimilation of most photosynthetic results per unit of leaf area and time. NAR shows the rate of increase in plant dry weight per unit area of leaves. Photosynthetic rate per unit leaf area in a certain period of time would produce plant dry matter, with its efficiency reflected in the rate of net assimilation of plants.

Relative Growth Rate (RGR)

Data on the relative growth rate of soybean cultivars grown in coastal sandy land as affected by bokashi rates are presented in Table 3 (age 4–6 weeks) and Table 4 (age 6–8 weeks).

Anjasmoro, Burangrang and Slamet cultivars decreased their RGR as affected by bokashi rates. Meanwhile, Argomulyo, Demas 1, Dena 1, Gema, and Grobogan cultivars increased their RGR at a bokashi rate of 20 ton.ha^{-1} or 40 ton.ha^{-1} and decreased with the addition of bokashi rate to 60 ton.ha^{-1}. The soybean cultivars that continued to increase RGR when given with bokashi up to 60 ton.ha^{-1} were Gamasugen 1, Gepak Ijo and Kaba. Devon 1 cultivar was not responsive to the application

of bokashi because the RGR was relatively same at all rates of bokashi. Bokashi was given in order to increase soil organic matter so that it could increase the soil capacity to store nutrients and water. However, at a rate that was too high (60 ton.ha^{-1}), the growth of some cultivars decreased.

RGR of soybean cultivars in the growing period of 6–8 weeks showed that the responses of soybean cultivars varied to the application of bokashi. In general, RGR for all cultivars was still high, except for Gamasugen 1 and Gema cultivars, which no longer accumulated dry material because their generative growth was close to maximum. Gamasugen 1 and Gema cultivars were included early maturing culti-vars, so that when they were examined carefully, they had a maximum RGR at 4–6 weeks, while other cultivars with a longer age showed higher values of RGR. The relative growth rate of Demas 1 cultivar showed that it could last longer, which remained high until the growth period of 6–8 weeks.

RGR in conditions without bokashi and at bokashi rate of 20 ton.ha^{-1} tended to be higher, and decreased at higher rate of bokashi. Demas 1 cultivar still had the highest RGR in the period of 6–8 weeks, especially at a bokashi rate of 20 ton.ha^{-1} and without bokashi, showing values of 0.623 g.g^{-1} per

Table 3. Relative growth rate (g.g^{-1} per week) of several soybean cultivars as affected by banana pseudo-stem bokashi at the age of 4–6 weeks

Cultivars	Bokashi rates (ton.ha^{-1})				
	0	20	40	60	Mean
Anjasmoro	1.628 ab	1.466 d-j	1.443 d-k	1.412 f-l	1.487
Argomulyo	1.410 f-m	1.418 e-l	1.369 h-p	1.288 n-q	1.371
Burangrang	0.977 r-t	0.918 st	0.923st	0.896 t	0.929
Demas 1	1.281 o-q	1.317 l-g	1.365 i-p	1.355 j-p	1.330
Dena 1	1.472 d-i	1.607 a-c	1.424 e-l	1.407 f-m	1.477
Devon 1	1.067 r	0.929 st	1.030 r	1.012 rs	1.010
Gamasugen 1	1.371 h-p	1.350 k-p	1.327 l-p	1.468 d-i	1.379
Gema	1.279 o-q	1.300 m-q	1.395 g-n	1.328 l-p	1.325
Gepak Ijo	1.380 h-o	1.499 c-g	1.478 d-h	1.524 b-e	1.470
Grobogan	1.217 q	1.290 n-q	1.275 o-q	1.264 pq	1.262
Kaba	1.509 c-f	1.500 c-g	1.553 a-d	1.540 b-d	1.525
Slamet	1.652 a	1.593 st	1.623 ab	1.541 b-d	1.602
Mean	1.353	1.349	1.350	1.336	1.347 (+)
CV= 4.23 %					

Remarks: Means followed by the same letters are not significantly different based on DMRT at α= 5%; (+)= interaction of treatment factors is significant.

Table 4. Relative growth rate (g.g^{-1} per week) of several soybean cultivars as affected by banana pseudo-stem bokashi application at the age of 6–8 weeks

Cultivars	Bokashi rates (ton.ha^{-1})				
	0	20	40	60	Mean
Anjasmoro	0.316 e-i	0.326 d-h	0.332 d-h	0.335 d-g	0.327
Argomulyo	0.330 d-h	0.324 d-h	0.349 d-f	0.377 cd	0.345
Burangrang	0.288 g-k	0.240 k-n	0.236 k-n	0.261 i-m	0.256
Demas 1	0.622 a	0.623 a	0.480 b	0.492 b	0.554
Dena 1	0.366 c-e	0.310 e-i	0.275 h-m	0.358 c-f	0.327
Devon 1	0.408 c	0.315 e-i	0.245 k-n	0.275 h-m	0.311
Gamasugen 1	0.071 o	0.071 o	0.070 o	0.066 o	0.069
Gema	0.117 o	0.109 o	0.099 o	0.078 o	0.101
Gepak Ijo	0.240 k-n	0.282 g-l	0.326 f-j	0.262 i-m	0.277
Grobogan	0.249 j-n	0.217 mn	0.223 l-n	0.276 h-m	0.241
Kaba	0.263 i-m	0.225 l-n	0.221 mn	0.202 n	0.228
Slamet	0.305 f-j	0.275 h-m	0.307 f-j	0.306 f-j	0.299
Mean	0.298	0.276	0.263	0.274	0.278 (+)
CV= 10.76 %					

Remarks: Means followed by the same letters are not significantly different based on DMRT at α= 5%; (+)= interaction of treatment factors is significant.

week and 0.622 g.g^{-1} per week, respectively and decreased with the increasing rates of bokashi to 40 ton.ha^{-1} and 60 ton.ha^{-1}, which were 480 g.g^{-1} per week and 492 g.g^{-1} per week, respectively. In contrast, the RGR of Anjasmoro and Argomulyo cultivars were seen to still increase with the increasing bokashi rates up to 60 ton.ha^{-1}, which was equal to 3.16 g.g^{-1} per week (Anjasmoro) and 3.30 g.g^{-1} per week (Argomulyo), which increased to 3.35 g per week and 3.77 g per week. Demas 1 cultivar had the highest average of RGR (0.554 g.g^{-1} per week), which was the highest one compared to other soybean cultivars at 6–8 weeks due to the active growth, especially in forming generative organs.

Root dry weight

Roots are plant organs that play a role in the absorption of water and mineral nutrients from growing media for plant growth and development (Gardner et al., 1991). According to Sitompul and Guritno (1995), the role of roots in plant growth is as important as the role of shoot. Provision of bokashi to optimum rate increased root dry weight due to the availability of water, nutrients, and environmental conditions that supported root growth for plants, including the root formation. The

root dry weight (g per pot) observed at harvest time from various soybean cultivars as affected by bokashi rates is presented in Table 5.

The root dry weight of Demas 1 cultivar showed the largest, reaching 10.71 g per pot, and this cultivar was not responsive to the application of bokashi to a rate of 60 ton.ha^{-1}. Genetically, it could be said that Demas 1 cultivar had the best adaptation because its roots continued to grow well under conditions without or with bokashi. Other soybean cultivars that had high root dry weight were Anjasmoro, Agromulyo, Devon 1, and Slamet cultivars, with root dry weight of 6.97 g per pot, 7.62 g per pot, 7.57 g per pot, and 7.52 g per pot, respectively. The application of 20 ton.ha^{-1} and 40 ton.ha^{-1} of bokashi effectively increased root dry weight in most of the cultivars except Slamet cultivar, which increased at a dose of 60 ton.ha^{-1}.

Bokashi could increase the soil's ability to retain water and nutrients, and the granulation of grains of sand allows the roots to grow more evenly in the growing space. Granulation of sand by organic materials sourced from bokashi banana stalks will reduce the resistance to soil penetration by the roots. According to Ramos et al. (2010), soybean root growth decreased by 10 % and 50 % when the

Table 5. Root dry weight (g per pot) of several soybean cultivars grown in coastal sandy land as affected by pseudo-stem bokashi application

Cultivars	Bokashi dose (ton.ha^{-1})				
	0	20	40	60	Mean
Anjasmoro	6.32 g-k	8.54 cd	6.61 g-k	6.41 g-k	6.97
Argomulyo	7.64 d-g	9.64 bc	6.52 g-k	6.67 f-j	7.62
Burangrang	5.33 j-m	5.73 i-m	5.34 j-m	7.52 d-h	5.98
Demas 1	10.32 ab	10.85 ab	10.65 ab	11.05 a	10.71
Dena 1	5.74 i-m	5.90 i-l	5.96 i-l	6.10 h-k	5.92
Devon 1	6.08 h-k	8.03 d-f	8.07 d-f	8.10 d-e	7.57
Gamasugen 1	1.76 q	2.30 pq	2.28 pq	2.16 pq	2.13
Gema	3.06 o-q	3.43 n-p	3.10 o-q	3.13 o-q	3.18
Gepak Ijo	4.39 m-o	4.54 l-n	7.66 d-g	5.88 i-l	5.62
Grobogan	4.39 m-o	6.47 g-k	5.63 j-m	6.58 g-k	5.77
Kaba	6.22 g-k	6.32 g-k	5.12 k-m	5.74 i-m	5.85
Slamet	6.77 e-j	6.78 e-j	6.91 e-j	9.60 bc	7.52
Mean	5.67	6.54	6.14	6.59	6.24 (+)
CV= 11.94 %					

Remarks: Means followed by the same letters are not significantly different based on DMRT at α= 5%; (+)= interaction of treatment factors is significant.

Table 6. Shoot dry weight (g per pot) of several soybean cultivars grown in coastal sandy land as affected by banana pseudo-stem bokashi application

Cultivars	Bokashi rates (ton.ha^{-1})				
	0	20	40	60	Mean
Anjasmoro	27.61 i-o	33.70 f-h	32.75 f-j	30.03 g-n	31.02
Argomulyo	27.75 i-o	35.10 e-g	36.27 ef	30.96 f-k	32.52
Burangrang	21.78 p-t	25.20 m-r	25.93 l-r	27.00 k-q	24.98
Demas 1	45.38 c	63.00 a	58.52 ab	55.45 b	55.59
Dena 1	28.72 h-o	32.88 f-i	31.96 f-k	30.12 g-n	30.92
Devon 1	17.50 tu	17.62 tu	23.85 o-s	24.48 n-s	20.86
Gamasugen 1	9.08 v	9.52 v	8.86 v	8.84 v	9.07
Gema	12.44 uv	13.52 uv	12.50 uv	11.29 v	12.44
Gepak Ijo	21.38 q-t	24.52 n-s	31.17 f-l	30.83 f-m	26.97
Grobogan	19.16 st	27.10 j-p	27.71 i-o	33.08 f-i	26.76
Kaba	21.31 r-t	24.74 n-r	28.00 i-o	28.15 h-o	25.55
Slamet	23.51 o-s	24.94 n-r	43.55 cd	39.23 de	32.81
Mean	22.97	27.65	29.99	29.22	27.46 (+)
CV= 10.63 %					

Remarks: Means followed by the same letters are not significantly different based on DMRT at α= 5%; (+)= interaction of treatment factors is significant.

soil penetrometer resistances were 0.52 MPa (bulk density of 1.45 g.cm^{-3}) and 1.45 MPa (bulk density of 1.69 g.cm^{-3}), respectively.

Shoot dry weight

The shoot dry weight data of various soybean cultivars at various rates of bokashi are presented in Table 6. The highest shoot dry weight was observed in Demas 1 cultivar given with 20 ton.ha^{-1} and 40 ton.ha^{-1} of bokashi (63.00 g per pot and 58.52 g per pot), and the lowest one was in Gamasugen 1 cultivar. The application of bokashi starting from 20 ton.ha^{-1} could increase shoot dry weight in Anjasmoro, Argomulyo, Burangrang, Demas 1, Dena 1, Gepak Ijo, Grobogan, Kaba and Slamet cultivars. Devon 1 cultivar began to increase the shoot dry weight at bokashi rates of 40 ton.ha^{-1} to 60 ton.ha^{-1}. Gamasugen 1 and Gema cultivars showed the lowest shoot dry

weight, and they were relatively unchanged both in conditions of without and with bokashi (not responsive).

Demas 1 cultivar had the highest shoot dry weight when given with 20 ton.ha^{-1} bokashi, which was 63.00 g per pot, or increased by 38.83 % compared to without bokashi. The application of bokashi at higher rates of 40 ton.ha^{-1} and 60 ton.ha^{-1} no longer increased shoot dry weight, or conversely it was potentially to reduce the shoot dry weight compared to the application of 20 ton.ha^{-1} of bokashi. Based on these data, it could be seen that higher bokashi rates were ineffective in increasing shoot dry weight due to the overgrowth of plant, especially Demas 1 cultivar. Availability of incorrect nutrients might be in excess conditions, which could affect the availability of other nutrients as affected by bokashi rate of 60 ton.ha^{-1}. High rate of bokashi also increased the activity of decomposing micro-

Table 7. Correlation between growth rate with plant organ dry weight of several soybean cultivars grown in coastal sandy land as affected by banana pseudo-stem bokashi application

Component	NAR 1	NAR 2	RGR 1	RGR 2	RDW	SDW
NAR 1	1.000	-0.143^{ns}	0.720**	-0.139^{ns}	-0.076^{ns}	0.010^{ns}
NAR 2		1.000	-0.188^{ns}	0.927**	0.766**	0.752**
RGR 1			1.000	0.002^{ns}	-0.039ns	0.163^{ns}
RGR 2				1.000	0.806**	0.814**
RDW					1.000	0.833**
SDW						1.000

Remarks: NAR 1= net assimilation rate at 4-6 weeks; NAR 2= net assimilation rate at 6–8 weeks; RGR 1= relative growth rate at 4–6 weeks; RGR 2= relative growth rate at 6-8 weeks; RDW = root dry weight; SDW= shoot dry weight; R/S Ratio= root/shoot ratio; (**)= Significantly different at α= 1 %; (*) Significantly different at α= 5 %; and (ns)= not significantly different at α= 5 %.
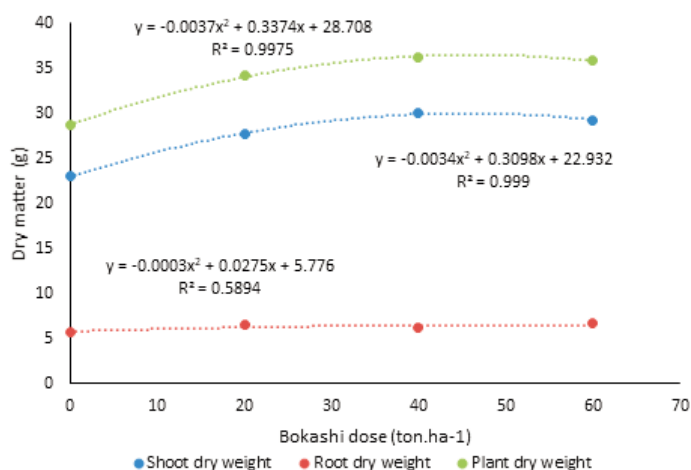
Figure 1. Dry matter of some soybean plant cultivars at the bokashi rates in coastal sand soils.

organisms, thereby causing the competition in taking nutrients and oxygen with plants.

Correlation between growth components

The correlation between the growth components of soybean plant and the application of bokashi is presented in Table 7. NAR of plants in each growth period was positively correlated with RGR (r= 0.720** at period of 4–6 weeks and r= 0.927 ** at period of 6–8 weeks). The positive correlation between NAR and LPR (r= 0.97) was also reported by Ratnasari et al. (2017) on the growth of oil palm plants that experienced aluminum poisoning stress. NAR that increases for a certain period of time will be followed by an increase in long-term plant LPR, followed by an increase in RGR. If NAR and RGR are high at the beginning of growth phase (period of 4–6 weeks), they will decrease in the next growth period because the correlation is negative.

Based on the plant dry matter (root and shoot dry weight), it could be seen that the effect of banana pseudo-stem bokashi rates on some soybean cultivars planted in the coastal sandy land was following quadratic equation (Figure 1). The optimum rate of bokashi was obtained for root growth (42.83 ton.ha^{-1}), shoot (45.56 ton.ha^{-1}), and the overall plant (45.59 ton.ha^{-1}). In general, the soybean plant growth increased with the application of bokashi up to the optimum rate and decreased when the rate increased. Although statistically not significantly different from other manure rates, according to Barus et al. (2013), the application of manure at a dose of 40 ton.ha^{-1} resulted in the highest seed yields in sesame plants grown on coastal lands. Yields of many crops are now larger on soils with extra organic matter both on the sandy loam at Woburn and the silty clay loam at Rothamsted. Some of the effect appears to be related to extra water holding capacity, some to availability of nitrogen in ways which cannot be mimicked by dressings of fertilizer N, and some to improved soil physical properties. Responses to N fertilizer have been larger on soils with more organic matter (Johnston, 2007).

CONCLUSIONS

The net assimilation rate, relative growth rate, and root and shoot dry weight were influenced by the application of bokashi, with varying responses according to the soybean cultivar used. Demas 1 cultivar was the most adaptive cultivar in coastal sandy land based on its ability to accumulate plant dry matter. In general, the accumulation of the root and shoot dry matter increased with the application of bokashi to the optimum rate, reaching 42.83 ton.ha^{-1} and 45.56 ton.ha^{-1}, respectively.

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