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Technology Assessment of Growing Superior Mungbean (*Vigna radiata* L.) Varieties on a Dryland in North Lombok

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ABSTRACT

This study was aimed at finding the highest yielding variety and its best growing technology among selected superior mungbean (*Vigna radiata* L.) varieties grown on a dryland. The assessment was done based on four field experiments conducted at Gumantar village, sub-district of Kayangan, and North Lombok. The soil was categorised as poor (low fertility) with 0.46% organic matter, 0.05% total nitrogen (N) (Kejdhal), 11.25 ppm available phosphate (P) (Olsen) and exchangeable potassium (K) 0.77 me%. Mungbean varieties of Kenari and Betet coupled with fertiliser rate, population density and time of weeding were the objects of assessment. The experiments focused on variety and fertiliser rate, population density and fertiliser rate, variety and population density, and time of weeding to study their effects on yield of mungbean. The results show the highest yielding variety was Kenari with yield ranging from 876 to 1,215 g/5 m^2 (1.75 to 2.43-ton ha^{-1}), followed by Betet, from 880 to 949 g/5 m^2 (1.76 to 1.90 ton/ha). The optimum population density was at 500,000 plants ha^{-1} with fertiliser (NPK Phonska, 15-15-15) rate of 200 kg ha^{-1}. It was found the weeding time improved yield and the best time for weeding was 49 Days After Sowing (DAS). It appears that Kenari is the most suitable variety to be grown in North Lombok at population density of 500,000 plants ha^{-1} fertilised with Phonska at rate of 200 kg ha^{-1} and weeding at 49 DAS.

Keywords: Fertiliser, low soil fertility, population density, weeding, yield

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INTRODUCTION

Change in land use is occurring worldwide at an alarming rate. In just five years, between 2000 and 2005, the annual conversion of forestland into non-forest uses was 6.3 million hectares (Food and Agriculture Organization & Joint Research Centre, 2012). As a result, greenhouse gasses have also increased significantly. Conversion of the forest into cropland for instance, resulted in a release of greenhouse gasses as many as 6.5±0.2 Gt CO_2 per year (Kim & Kirscbaum, 2015). With that huge release of greenhouse gasses, global warming that leads to climate change is becoming a problem. Another form of land-use change is usage of cropland for non-agricultural purposes, such as housing, offices and shopping centres. These types of conversions usually occur in urban areas resulting in an increased pressure on the country's natural resources (Jiang et al., 2013), such as drylands.

In Indonesia, the pressure to utilise dryland areas for growing food crops is mounting due to population increase in urban areas. Data shows temporarily unused land in Indonesia, dominated by dryland, declined as much as 4.48% from 2009 to 2013 (Ministry of Agriculture, 2014). The same trend is occurring in dryland areas in West Nusa Tenggara. More food crops are grown on drylands, especially during rainy seasons. In the past, the lands were mainly left alone and overgrown with natural vegetation but now, food crops such as maize, mungbean and groundnut are planted there during the rainy season.

Recent erratic rainfall pattern as a result of climate change has affected food crop productivity in dryland areas. Jaya et al. (2012) reported that excessive rainfall in Lombok in January and February 2012 had caused significant loss in maize and mungbean production in dryland of East Lombok. The El-Nino effects (dry rainy season) during the 2015/2016 rainy season, had also caused significant loss for farmers in North and East Lombok (Jaya, data not published). Unfortunately, most dryland farmers do not have sufficient technology and money to cope with detrimental effects of the changing climate while their livelihood and agricultural practices are dependent on weather. For these reasons, growing crops technology, such as the choice of crop species, time of planting and crops management, is becoming very important, especially for dryland farmers. Short growing period and multipurpose legume crops with a high economic value, such as mungbean, can be considered.

Mungbean is a drought-tolerant crop that rich in mineral and its sprouts contain high amounts of vitamin C and iron (Keatinge et al., 2011). This crop has been grown in Indonesia for long time by smallholder farmers and is now the third important legume after soybean and groundnut. Productivity of this crop varies greatly. In Yogyakarta province, for example, it was only 0.58-ton ha^{-1} in 2015, while in West Sulawesi, it was 1.36-ton ha^{-1} (Central Bureau of Statistics [CBS], 2016). According to the same source, mungbean productivity in West Nusa Tenggara, which is mainly grown in dryland areas, was only 1.61-ton ha^{-1}. Some superior mungbean varieties, such as Kenari, Betet, Vima-1, Vima-2, Vima-3 had potential yield of more than 2.0-ton ha^{-1} (BALITKABI various sources). Based on the above, it is possible that inappropriate growing technologies, such as lack of population density, low rate of fertiliser application and variety selection have contributed to the low mungbean productivity in dryland of West Nusa Tenggara. Thus, it is critical to asses growing technology of mungbean on a dryland in order to improve crop productivity.

MATERIALS AND METHODS

Four field experiments, consisting of various growing technologies of cultivating mungbean, were conducted at the same time between September and November 2015 on a piece of dryland in Gumantar village, North Lombok. Climate type in the experimental area based on Oldeman classification is D type. Four experiments were conducted an Entisol soil with loam structure and was considered poor soil with 0.46% organic matter, total 0.05% nitrogen (N) (Kejdhal), available 11.25 ppm phosphate (P) (Olsen) and exchangeable potassium (K) 0.77 me%, pH 7.0 and field capacity 29% (%/V). Due to low soil fertility, all treatments were given a basal Urea fertiliser with a rate of 100 kg ha^{-1}. Since the experiments were conducted during a dry season, a deep-well pump was operated as the source of irrigation water. The irrigation was done by flooding the plots.

The first experiment tested the effect of Phonska (N-P-K, 15-15-15) fertiliser dosage and planting space/population density on yield of mungbean var. Kenari. The fertiliser dosage treatment consisted of four levels, namely at: 50, 100, 200 and 400 kg ha^{-1}. Planting space/population density treatment consisted of two levels, namely: 20 x 20 cm and 40 x 20 cm. The population density in 20 x 20 cm and in 40 x 20 cm treatments was 500,000 and 250,000 plants ha^{-1}, respectively since there were two seeds per hill.

In the second experiment, two mungbean varieties and four fertiliser dosages were tested for their effects on yield. The varieties were Kenari and Betet while the fertiliser (N-P-K, 15-15-15) dosages were: 0, 100, 200 and 300 kg ha^{-1}. The third experiment tested the effect of mungbean variety and planting space/population density on yield. The varieties were Kenari and Betet while the three spacing were 40 x 10, 40 x 20 and 40 x 30 cm or equals to 500,000, 250,000 and 166,666 plants ha^{-1} since there were two seeds sown per hill. All three experiments were designed with a Randomized Block Design Factorial with three replications.

The fourth experiment was not a factorial experiment. There were six weeding treatments tested, namely: no weeding, weeding 3, 4, 5, 6 and 7 weeks after sowing (WAS). All the treatments were arranged in a Randomized Block Design with three replications. The variety tested in this experiment was Kenari with planting density of 250,000 plants ha^{-1} (spacing of 20 x 40 cm). The crops were fertilised with 300 kg ha^{-1} of NPK Phonska fertiliser.

The plot size in all experiments was 2 x 2.5 m and there were five (5) clumps of mungbean crop sampled in each plot for individual measurements. Except for the weeding time experiment, the rest of the crops were mechanically weeded once at 4 WAS. Pesticide (Lamda Sihalotrin 106 g l^{-1}, Tiametoksam 141 g l^{-1}) was applied when the crops were attacked by aphids and leaf hopper. Irrigation water was applied once a week by flooding method due to the porosity of soil.

Variables measured for yield and yield components were number of pods, number of seeds per pod, seeds weight per plant, seeds weight per plot and weight of 1000 seeds. Number of pods was calculated at harvest and the rest of the variables were measured after harvest. Data collected was analysed using Analysis of Variance (ANOVA) at 5% level using statistical package Minitab 15.

RESULTS AND DISCUSSION

Results

No rain was recorded during the experiment period. The highest maximum temperature and the lowest minimum temperature were 39^{o}C and 21^{o}C, respectively with an average relative humidity of 80%. The first harvest was done at 56 DAS for both Kenari and Betet. All crops in the treatment plots were harvested three times at a three-day interval. After three harvests, yield data collections ended.

Experiment 1. Fertiliser dosage and spacing (population density) experiment. No interaction was found between NPK fertiliser dosage and spacing in affecting yield and yield components of mungbean. Mungbean yield (seeds weight per plot) was not affected by fertiliser dosage but its yield components, such as pod number per plant and weight of 1000 seeds, were significantly affected, as seen in Table 1. There was no clear pattern of the effect of increasing fertiliser rate both on yield and yield components.

Mungbean at population density of 500,000 plants ha^{-1}, which was achieved in planting density of 20 x 20 cm, produced significantly higher yield than that at 250,000 plants ha^{-1} (20 x 40 cm). The yield components were significantly higher in a lower population density as presented in Table 1.

Table 1
Mean of yield and yield components of mungbean as affected by NPK fertiliser dosage and spacing

Treatment	Pod number per plant	Seed number per pod	Seed weight per plant (g)	Seed weight per plot (g)	Seed weight per ha (ton)	1000 seeds weight (g)
Dosage						
50 kg ha^{-1}	17.3^{b}*	11.2	15.6	1,049.7	2.1	77.4^{b}
100 kg ha^{-1}	18.0^{b}	11.3	16.2	1,030.5	2.1	78.8^{ab}
200 kg ha^{-1}	19.1^{a}	11.4	17.2	1,136.3	2.3	80.7^{a}
400 kg ha^{-1}	18.0^{b}	11.9	16.2	1,001.0	2.0	80.8^{a}
HSD 5%	1.07	-	-	-	-	2.20
Spacing						
20 x 20 cm	15.2^{b}	10.3^{b}	13.7^{b}	1,144.3^{a}	2.3^{a}	78.1^{b}
20 x 40 cm	21.0^{a}	12.6^{a}	18.9^{a}	964.4^{b}	1.9^{b}	80.8^{a}
HSD 5%	0.56	0.41	3.59	100,35	0.10	1.98

Note. *Data in column (with the same treatment) marked with different superscript letters are significantly different by HSD (P<0.05).

Experiment 2. Fertiliser dosage and variety experiment. Fertiliser dosage treatment did not interact with variety treatment in affecting yield and yield components of mungbean grown on a dryland. As in the previous presented experiment results, increasing the rate of NPK fertiliser application did not increase mungbean yield and its components significantly, except in number of pods and seeds weight per plant (Table 2). Applying 200 kg ha^{-1} or more of NPK fertiliser produced more pods and seed weight per plant compared with those plants without NPK fertiliser treatments.

Kenari variety out yielded Betet variety not only in seeds weight per plot but also in almost all yield components. The only yield component that was not affected was in seed number per pod (Table 2).

Table 2
Mean of yield and yield components of mungbean as affected by NPK fertiliser dosage and variety

Treatment	Pod number per plant	Seed number per pod	Seed weight per plant (g)	Seed weight per plot (g)	Seed weight per ha (ton)	1000 seeds weight (g)
Dosage						
0 kg ha^{-1}	19.7^{b}*	7.7	12.3^{b}	942.9	1.9	70.7
100 kg ha^{-1}	21.4^{ab}	7.9	13.6^{ab}	1003.4	2.0	70.9
200 kg ha^{-1}	23.8^{ab}	7.4	15.8^{a}	1020.2	2.0	70.5
300 kg ha^{-1}	24.8^{a}	7.5	16.1^{a}	1037.5	2.1	73.9
HSD 5%	2.80	-	3.21	-	-	-
Variety						
Kenari	23.2^{a}	7.8	16.2^{a}	1,089.1^{a}	2.2^{a}	78.7^{a}
Betet	21.7^{b}	7.5	12.6^{b}	912.9^{b}	1.8^{b}	64.3^{b}
HSD 5%	1.46	-	1.67	168.94	0.17	2.85

Note. *Data in column (with the same treatment) marked with different superscript letters are significantly different by HSD (P<0.05).

Experiment 3. Spacing (population density) and variety experiment. Spacing or population density did not affect yield and yield components of mungbean. The spacing itself, however, significantly affected yield and some of the yield components (Table 3). Yield components that were not affected by spacing or population density were seed number per pod and weight of 1,000 seeds. Seed weight per plant decreased with the increase of population density while seed weight per plot increased with the increase of population density.

Unlike fertiliser rate and variety experiment, there was no significant different between Kenari and Betet yield in spacing and variety treatments. However, most yield components, such as pod number per plant, seed weight per plant and weight of 1,000 seeds, were affected by variety (Table 3). The Kenari variety produced significantly higher yield components than Betet.

Table 3
Mean of yield and yield components of mungbean as affected by spacing and variety

Treatment	Pod number per plant	Seed number per pod	Seed weight per plant (g)	Seed weight per plot (g)	Seed weight per ha (ton)	1000 seeds weight (g)
Spacing						
40 x 10 cm	18.0^{c}*	11.2	10.8^{b}	1,215.4^{a}	2.4^{a}	69.3
40 x 20 cm	21.5^{b}	11.3	15.2^{ab}	993.5^{ab}	2.0^{ab}	70.3
40 x 30 cm	23.5^{a}	11.4	18.3^{a}	781.0^{b}	1.6^{b}	71.3
HSD 5%	1.07	-	6.01	271.56	0.27	-
Variety						
Kenari	25.6^{a}	11.8	16.3^{a}	1,085.6	2.2	79.1^{a}
Betet	16.4^{b}	11.5	11.9^{b}	907.7	1.8	61.8^{b}
HSD 5%	5.49	-	2.72	-		3.28

*Data in column (with the same treatment) marked with different superscript letters are significantly different by HSD ($P<0.05$).

Experiment 4. Weeding treatment experiment. Weeding did not affect yield and yield components of mungbean. Even though the values of seed weight per plot in weeded plots appeared higher than that of the unweeded plot, those values actually did not significantly differ at 5% level. There was no clear pattern of the effect of weeding time on yield and yield components in all treatments as shown in Table 4 but weeding at 7 WAS appeared to be effective to improve yield of the mungbean.

The most dominant weed species found during the experiment was *Cyperus rotundus*. This weed, however, was only present during the early stage of the vegetative growth of the mungbean. When the mungbean canopy had formed a complete cover, other weed species, such as *Eleusine indica*, *Cynodon dactylon* and *Euphorbia prumifolia*, were recorded at the experimental site.

Table 4
Mean of yield and yield components of mungbean as affected by time of weeding

Weeding Treatment	Pod number per plat	Seed number per pod	Seed weight per plant (g)	Seed weight per plot (g)	Seed weight per ha (ton)	1000 seeds weight (g)
No weeding	21.8	8.9	15.2	658.3	1.3	82.9
3 WAS	27.9	8.7	19.0	836.9	1.7	82.1
4 WAS	26.3	9.0	18.5	876.3	1.8	80.5
5 WAS	28.5	8.2	19.0	801.2	1.6	81.9
6 WAS	15.8	8.7	12.3	719.5	1.4	81.8
7 WAS	21.7	8.3	20.6	943.6	1.9	81.7

DISCUSSION

The effect of increasing NPK fertilizer rate from 50 kg ha^{-1} up to 400 kg ha^{-1} (in experiment one) or from 0 kg ha^{-1} to 300 kg ha^{-1} (in experiments two) surprisingly did not improve yield of mungbean on dryland (Tables 1 and 2). There are two possible reasons for this. First, all treatments in experiment one and two had received 100 kg ha^{-1} Urea as a basal fertiliser. The reason for applying 100 kg ha^{-1} Urea was that the soil was very low in soil organic matter and very low in total N. The application of Urea that contained 46% N and 50 kg ha^{-1} of NPK fertiliser in experiment one provided basic nutrient requirement of the mungbean.

Anjumet al. (2006) had reported that N fertiliser improved yield and yield components of mungbean. Adding fertiliser that contains K benefits mungbean vegetative growth when the availability of water is limited (Sangakkara et al., 2001). In these experiments, the mungbean crops were well watered throughout the growing period. For this reason, increasing NPK rate from 50 up to 400 kg ha^{-1} did not give further benefit to the mungbean crops. In experiment two, crops that did not receive additional NPK fertilizer (0 kg ha^{-1}) produced approximately 10% less seed weight than other treatments (100-300 kg ha^{-1}) as seen in Table 2, even though statistically, the seed weight was not significantly different. The second possible reason may be related to the flooding irrigation method that was used in this experiment. It was possible that the water mixed all the unused fertiliser in all plots during the irrigation.

Yield and yield components of mungbean grown on dryland North Lombok responded to population density. Improving population density up to 500,000 plants ha^{-1} by sowing two seeds per hole at planting density of 40 x 10 cm or 20 x 20 cm produced 1,215 g/5 m^2 (2,4-ton ha^{-1}) and 1,144 g/5 m^2 (2.3-ton ha^{-1}), respectively. These findings confirmed that of Haqqani and Pandey (1994) which showed that mungbean yield increased with the improvement of ground cover and leaf area index. The yield components, such as pod number, seed weight per plant and weight of 1000 seeds were higher in a lower density since there was less intraspecific competition in the less dense population.

The superior variety of Kenari yielded better than the superior variety of Betet. Both varieties produced a constant yield by fertiliser and spacing treatments (Table 2 and 3). The average yield of Kenari and Betet was 1,087.4 g/5 m^2 (2.2-ton ha^{-1}) and 909.8 g/5 m^2 (1.8-ton ha^{-1}), respectively. Both varieties were produced by *Balai Penelitian Kacang-kacangan dan Umbi-umbian* (Indonesian Legumes and Tuber Crops Research Institute). Suhartina (2005) from the Institute described that the average yield of Betet is 1.5-ton ha^{-1} while Kenari is 1.38-ton ha^{-1}. She added that Kenari variety can produce yield as high as 2.45-ton ha^{-1}. It suggests that Kenari is a better option to be grown on dryland North Lombok.

It appeared that weed was not a great problem in mungbean growing areas in dryland of North Lombok. Seed weight per plot and other yield components were not significantly affected by weeding and time of weeding (Table 4). Earlier, Chatta et al. (2007) reported that weeds could cause 50% reduction in mungbean yield. Jaya and Nurrachman (2015) also reported that weeds could reduce the effectivity of fertiliser that was applied to mungbean crops. Weed species that are present during crop growth and developmental stages may determine the yield lost severity caused by weeds.

CONCLUSION

The mungbean superior variety of Kenari seems to be the best option to be grown on drylands of North Lombok. In order to improve productivity of this variety, a growing population of 500,000 plants ha^{-1}, which can be achieved by plant spacing of 20 x 20 cm or 40 x 10 cm with two seeds per hole, is recommended. Applications of basal fertiliser of Urea at 100 kg ha^{-1} plus at least 50 kg ha^{-1} NPK Phonska are suggested in this study. Weeding at 7 WAS further improved productivity of mungbean grown on dryland.

Since there are so many superior varieties of mungbean produced by Indonesian Legumes and Tuber Crops Research Institute with great genetical variabilities, similar research with different varieties is needed in the near future. This kind of research is important to improve the livelihoods of dryland farmers who have to cope with some impacts of climate change.

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