Black Sea Journal of Agriculture
Open Access Journal
e-ISSN: 2618 – 6578

BSJournals

Research Article
Volume 3 - Issue 4: 260-266 / October 2020

COMBINING MUDPRESS AND INORGANIC FERTILIZER TO INCREASE THE GROWTH, YIELD AND PROFITABILITY OF MUNGBEAN (VIGNA RADIATA L. VAR. PAGASA19) VARIETY

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Received: *April 10, 2020;* ***Accepted:*** *August 21, 2020;* ***Published:*** *October 01, 2020*

Abstract

Mudpress is considered as rejected waste material of sugarcane industries that cause problem of storage and pollution to surrounding of sugar mills on its accumulation are available in sugarcane milling plant hence, it can be utilized as source of organic fertilizer combined with inorganic fertilizer to agronomic crops. This study aimed to evaluate the effects, determine the optimum rates and assess the profitability of combined application of mudpress and inorganic fertilizer in mungbean production. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three (3) replications. T_1–no fertilizer (control); T_2–30-30-30 kg ha_{-1} N, P_2O_5, K_2O; T_3–10 t ha^{-1} mudpress; T_4–7.5 t ha^{-1} mudpress + 7.5 kg ha^{-1} N, P_2O_5, K_2O; T_5–5.0 t ha^{-1} mudpress + 15.0 kg ha^{-1} N, P_2O_5, K_2O; T_6–2.5 t ha^{-1} mudpress + 22.5 kg ha^{-1} N, P_2O_5, K_2O. Results revealed that plants applied with recommended inorganic fertilizer at 30-30-30 kg ha^{-1} N, P_2O_5, K_2O (T_2) and applied with 50-75 % inorganic fertilizer (T_5 and T_6) and without fertilizer application matured early compared to plants applied with pure organic mudpress at 10 (t ha^{-1}) and 7.5 (t ha^{-1}). Likewise, plants applied with 75-100% mudpress as fertilizer had the lowest fresh herbage yield comparable to the plants not applied with any fertilizer. On the other hand, highest number of seeds per pod (19-21 seeds/pod) was observed in plants applied with 50-100% inorganic fertilizer as compared to plants not applied and applied with 75-100 % mudpress. Pests response of mungbean Pagasa 19 variety had high to moderate resistant to insect pests and diseases. Highest net income ha^{-1} of Philippine Peso (PhP) 73392.00 was achieved with plants applied with (100%) inorganic fertilizer at the rate of 30-30-30 kg ha^{-1} N, P_20_5, K_20. Among the combined treatments, application of 5.0 t ha^{-1} + 15 kg and 2.5 t ha^{-1} + 22.5 and kg N, P_20_5, K_20 ha^{-1} (25-50% organic + 50-75% inorganic fertilizer) gave higher net income of PhP 63812.00 and PhP 52624.00, respectively.

Keywords: Combined application, Inorganic fertilizer, Mudpress, Yield performance, Income

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Cite as: Placido JAT, Cagasan U. 2020. Combining mudpress and inorganic fertilizer to increase the growth, yield and profitability of mungbean (*Vigna radiata* L. var. Pagasa19) variety. BSJ Agri, 3(4): 260-266.

1. Introduction

Mungbean (*Vigna radiata* L.) popularly known as "mungo" is one of the identified important grain legumes grown in the Philippines. It is cultivated for its edible seeds and sprouts across Asia. It is one of the cheapest sources of plant protein and also a good source of mineral, such as calcium and sodium, (Shukla, et al. 2016). In the Philippines, Bureau of Agricultural Statistics reported that the highest volume of production for the past five years was obtained in 2017, with 45283 metric tons from the total production area of 44324 hectares. In 2018, however production area declined to 32,364 hectares with total production of 32,364 metric tons, (PSA, 2018). However, national average yield per hectare remains low (0.73 metric tons). Hence, management techniques to increase production is necessary as well as to reduce input cost in order to increase income by the farmers, (Tang et al. 2014).

Organic waste, such as mudpress or filter cake, is generated as a by-product of sugarcane industries and characterized as a soft, spongy, amorphous, and dark brown to brownish material, (Ghulam et al. 2012). It is generated during the purification of sugar by carbonation or sulphitation process. Both the processes separated clear juice on top and mud at the bottom. In general, when 100 tons of sugarcane is crushed, about 3 tons of mudpress are produced as a by-product (Gupta et al. 2011). It is considered as rejected waste material of sugarcane industries that cause problem of storage and pollution to surrounding of sugar mills on its accumulation (Bhosale et al. 2012).

Organic sources have traditionally played an important role in maintaining soil productivity. Among the organic sources, crop residues are most easily available for recycling of the macro- and micro-nutrients (Dotaniya and Kushwah, 2013). Incorporation of these materials in soil could be a good source of nutrients and would influence agricultural sustainability by improving physical, chemical, and biological properties of soil (Mitani and Ma, 2005). The addition of organic acids to soils increases the plant uptake of phosphorus from water-soluble phosphorus fertilizers (Shukla et al. 2013).

Moreover, research on the rates of application of mudpress supplemented with organic fertilizers for optimum yield of mungbean is very limited. Furthermore, results indicated that combined use of organic and chemical fertilizers can be more productive, sustainable and can be recommended to improve the productivity of mungbean production. However, limited studies were done on the effect of mudpress combined with inorganic fertilizer on mungbean production. Hence, this study was conducted to evaluate the effects, determine the appropriate combination rates and evaluate the profitability of combined application of mudpress and inorganic fertilizer in mungbean production.

2. Material and Methods

An area of 324 m^2 Umingan clay loam soil, (FAO, 2013) located at the Agronomy Experimental Area College of Agriculture and Food Science, Visayas State University, Baybay City, Leyte, Philippines (Figure 1).

Figure 1. A map of Leyte showing the location of the research site at Visayas State University.

The experimental area has a GPS coordinates of 10°44' 59.8668" N, 124°47' 38.1264" E. This was plowed and harrowed twice at weekly interval by the use of tractor drawn implement to remove the weeds, pulverize and level the soil. Furrows were made immediately after the last harrowing at a distance of 0.5 m. Ten (10) soil samples were collected randomly from the experimental area before plowing. These were composited, air-dried, pulverized, sieved (2 mm wire mesh) and submitted to the Central Analytical Service Laboratory (CASL), PhilRootcrops, Visayas State University, Visca, Baybay City, Leyte to determine the soil pH Potentiometric method (1:2.5 soil water ratio), % organic matter Modified Walkley-Black method, total N by micro Kjeldal method, extractable P and exchangeable K 1 N ammonium acetate extraction method. For the final soil analysis, three samples were collected from each treatment plot after harvest of peanut. Collected soil samples were air dried, composited and processed to determine the same soil parameters mentioned above. The experimental area was laid out in a RCBD (Randomized Complete Block Design) with three replications. Each replication was divided into six treatment plots, measuring 3 m × 4 m with 1 m alleyways between replications and 0.50 m between treatment plots to facilitate farm operations and data gathering. These were processed and analyzed for the same soil parameters mentioned above. Likewise, samples of mudpress were also taken, processed and submitted to the laboratory for the analyses of pH, total nitrogen, phosphorus and organic matter contents. The treatments were designated as follows: T_1 – no fertilizer (control), T_2 – 30-30-30 kg ha^{-1} N, P_2O_5, K_2O, T_3 – 10 t ha^{-1} mudpress alone, T_4 – 7.5 t ha^{-1} mudpress + 7.5 kg ha^{-1} N, P_2O_5, K_2O, T_5 – 5.0 t ha^{-1} mudpress + 15.0 kg ha^{-1} N, P_2O_5, K_2O, T_6 – 2.5 t ha^{-1} mudpress + 22.5 kg ha^{-1} N, P_2O_5, K_2O. The experiment was conducted during dry season cropping in 2017, laid out in a Randomized Complete Block Design (RCBD) with six treatments and replicated three times. Each treatment plot had an area of 20 m^2 (5 m x 4 m) with eight (8) rows of mungbean per plot. Mungbean seeds (Pagasa 19) were sown evenly in the furrows by drill method. The seeds were covered with thin layer of soil to protect them from birds and other organisms. Thinning was done one (1) week after planting (WAP) leaving fifteen (15) healthy plants per linear meter to attain the approximate plant population of 300000 plants hectare^{-1}. Air-dried mudpress was applied as specified in the treatment two weeks before planting. It was uniformly spread in the furrows and then incorporated into the soil at a depth of 3-6 cm.

Complete fertilizer was applied to satisfy the rates specified in the treatments. This was applied along the furrows one week after planting and covered with thin layer of soil. Hand-weeding operation and shallow cultivation were performed at the base of the plants and between rows two (2) weeks after planting. Another hand-weeding was performed two (2) weeks later to remove the weeds from the experimental plants. Manual hilling up was employed to put the soil towards the plant for better anchorage and stability. Insect pests and diseases were monitored throughout the duration of the study. Incidence of harmful insects were minimal hence, no spraying was done. Priming started sixty-one (61) days after sowing. Handpicking of mature pods was done in the morning and late afternoon to minimize shattering. Priming was done three (3) times depending on the maturity of the pods (black pods). Freshly harvested pods were placed in a fine mesh net bag and sundried. Pods were threshed by beating and trampling the dried pods and then seeds were cleaned.

The data gathered on agronomic characteristics where based from the NCT Manual for Legumes. Revised (2017): number of days from seeding to flowering, number of days from seeding to maturity, plant height (cm), Leaf Area Index (LAI), and fresh herbage yield (t ha^{-1}). Likewise, for yield and yield components: number of pods plant^{-1}, number of seeds pod^{-1}, weight (g) of 1000 seeds and grain yield (t ha^{-1}).

Other parameters gathered such as; pest and disease resistance, Harvest index (HI), soil properties, cost and return analysis and meteorological data. All of the recommended cultural management practices for mungbean production were strictly followed. As shown in Table 1, the climatic conditions at the time of the study were favorable to the mungbean plants (PCARRD Handbook, 2002).

2.1. Mudpress and Soil Chemical Analyses

Result of initial and final soil analyses of the experimental area are presented in Table 2. Initial analysis indicated that the soil had a pH of 6.350, 1.053% organic matter, 0.218% total Nitrogen, 63.680 mg kg^{-1} available Phosphorus and 1.116 me 100 g^{-1} exchangeable Potassium.

These indicated that the experimental area was slightly acidic and with very low organic matter. The total nitrogen was medium with very high available P and exchangeable potassium (Landon, 1991). Final soil analysis showed a slight decrease in soil pH, total N, available P and exchangeable K while % organic matter was maintained. The decrease in nutrients could be due to the nutrient uptake by plants. Some nutrients were lost through mineralization and evapotranspiration.

The chemical analysis of organic fertilizer used in the experiment revealed that mudpress had a pH of 4.09, 14.430% organic matter, 2.991% total N and 2.414% total P. Data were analyzed using Statistical Analysis System (SAS version 6.12). Mean comparison was done using the Honestly Significant Difference (HSD) test at 5% level of significance.

Table 1. Total monthly rainfall (mm), average daily minimum and maximum temperatures (°C) and average daily relative humidity (%) throughout the duration of the experiment

Months	Total Rainfall (mm)	Temperature (°C)		Relative Humidity (%)
		Minimum	Maximum	
January	258	23.75	31.90	79.50
February	94	23.78	31.76	83.56
March	89	24.40	30.45	81.76
Total	441	71.93	94.11	244.82
Mean	147	23.97	31.37	81.60

Table 2. Results of soil analyses before and after planting of mungbean as affected by the application of mudpress and inorganic fertilizer

Treatment	Soil pH (1:2.5)	% OM	Total N (%)	Available P (mg kg^{-1})	Exchange-able K (me $100g^{-1}$)
Mudpress Analysis	4.09	14.43	2.99	2.45	-
Initial soil Analysis	6.350	1.053	0.218	63.680	1.116
Final soil Analysis					
T_1 – No fertilizer (control)	5.570	1.170	0.158	6.555	1.061
T_2 – 30-30-30 kg ha^{-1} N, P_2O_5, K_2O	5.930	1.092	0.194	12.204	1.014
T_3 – 10 t ha^{-1} mudpress alone	6.160	1.287	0.186	15.945	0.842
T_4 – 7.5 t ha^{-1} mudpress + 7.5 kg ha^{-1} N, P_2O_5, K_2O	6.250	1.131	0.180	13.552	1.031
T_5 – 5.0 t ha^{-1} mudpress + 15.0 kg ha^{-1} N, P_2O_5, K_2O	6.270	0.858	0.160	8.836	0.813
T_6 – 2.5 t ha^{-1} mudpress + 22.5 kg ha^{-1} N, P_2O_5, K_2O	6.180	0.780	0.163	7.236	0.952
Mean	6.060	1.053	0.174	10.721	0.952

3. Results and Discussion

3.1. Agronomic Characteristics

Agronomic characteristics of mungbean as affected by the application of mudpress and inorganic fertilizer is presented in Table 3. The number of days from seeding to maturity and the fresh herbage yield of mungbean significantly affected by the combined application of mudpress and inorganic fertilizer. Plants applied with organic mudpress 100% and 75% from the recommended amount plants matured later as compared to plants applied with inorganic and little amount of organic fertilizer. This result can be attributed to the slow release of nutrients from the organic fertilizer, (Sigh, 2017). In sweetpotato, Laude (2008) noted in her study that there was a significant effect of mudpress on the crop's agronomic parameters, particularly in the maturity and the leaf are index. Moreover, with mudpress application, immobilization of nutrients by soil microorganisms probably occurred which temporarily limited the release of nutrients for possible utilization of the plant resulted in the delayed development of the mungbean plants for its vegetative and reproductive production, resulted in the delayed maturity.

Table 3. Agronomic characteristics of mungbean as affected by the application of mudpress and inorganic fertilizer

Treatments	No. of days from seeding to		Plant height (cm)	Leaf Area Index (LAI)	Fresh herbage yield (t ha^{-1})
	Flowering	Maturity			
T_1 – No fertilizer (control)	42.67	63.33^a	83.03	2.14	8.16^b
T_2 – 30-30-30 kg ha^{-1} N, P_2O_5, K_2O	41.67	62.00^a	78.27	2.32	11.21^a
T_3 – 10 t ha^{-1} mudpress alone	42.33	72.33^b	78.93	2.15	10.29^{ab}
T_4 – 7.5 t ha^{-1} mudpress + 7.5 kg ha^{-1} N, P_2O_5, K_2O	42.00	71.67^b	80.80	2.33	9.82^b
T_5 – 5.0 t ha^{-1} mudpress + 15.0 kg ha^{-1} N, P_2O_5, K_2O	41.67	61.67^a	82.37	2.07	12.74^a
T_6 – 2.5 t ha^{-1} mudpress + 22.5 kg ha^{-1} N, P_2O_5, K_2O	41.67	62.00^a	75.17	2.03	11.95^a
CV%	2.92	11.93	9.79	19.73	20.21

Means with the same and without letters in a column are not significantly different at 5% level of HSD test.

On the other hand, mungbean plants not applied with any fertilizer as control treatment, also matured earlier than plants applied with pure (100%) and (75%) organic fertilizer. In as much as mungbean is a legume crop it can fix atmospheric nitrogen, which can add up more nitrogen into the soil. The inherent phosphorus content in the soil is also high which made mungbean responsive thus enhanced good nodulation, promoted vigorous root growth and development and maturity of the crop (Aleras, 2004).

Moreover, the high availability of exchangeable potassium gave adequate supply during its growth period that improved water relations of plants and photosynthesis. The early maturity of the plants applied with inorganic fertilizer can be attributed to the presence of enough macro and micro nutrients needed by the plants for its normal growth development. According to Dotaniya (2014) stated that inorganic fertilizer can improve the growth and yield of the plants because of macro and micro nutrient contents.

Likewise, plants applied with high amount of inorganic fertilizer produces more herbage yield as compared to the control plants and 75-100% organic fertilizer. This result can be attributed to the effect of inorganic fertilizer with enough amount of nutrients needed by the plants for its vegetative production.

3.2. Grain Yield, Yield Components and Harvest Index

Table 4 shows the grain yield, yield components and harvest index of mungbean plants applied with mudpress and inorganic fertilizer. Plants applied with ½ of the recommended rate of organic fertilizer (RROF) 5.0 t ha^{-1} mudpress + ½ of the recommended rate of inorganic fertilizer (RRIF) 15 kg ha^{-1} N, P_2O_5, K_2O (T_5) and plants applied with (1/4 RROF) 2.5 t ha^{-1} mudpress + (3/4 RRIF) 22.5 kg ha^{-1} N, P_2O_5, K_2O (T_6) is comparable to the plants applied with the recommended inorganic fertilizer at the rate of 30-30-30 kg ha^{-1} N, P_2O_5, K_2O (T_2). These treatment plants significantly produced higher number of seeds per pod and consequently resulted to produce higher grain yield (t ha^{-1}).

Table 4. Yield, yield components and harvest index of mungbean as affected by the application of mudpress and inorganic fertilizer

Treatment	Number of		Weight (g) of 1000 seeds	Grain Yield (t ha^{-1})	Harvest Index (HI)
	pods $plant^{-1}$	seeds pod^{-1}			
T_1 – No fertilizer (control)	19.80	12.50^{b}	61.21	0.60^{bc}	0.41
T_2 – 30-30-30 kg ha^{-1} N, P_2O_5, K_2O	20.27	20.99^{a}	60.64	1.47^{a}	0.51
T_3 – 10 t ha^{-1} mudpress alone	21.00	11.43^{b}	60.35	0.86^{b}	0.44
T_4 – 7.5 t ha^{-1} mudpress + 7.5 kg ha^{-1} N, P_2O_5, K_2O	18.67	11.50^{b}	59.69	0.73^{b}	0.44
T_5 – 5.0 t ha^{-1} mudpress + 15.0 kg ha^{-1} N, P_2O_5, K_2O	18.20	21.14^{a}	60.74	1.41^{a}	0.50
T_6 – 2.5 t ha^{-1} mudpress + 22.5 kg ha^{-1} N, P_2O_5, K_2O	17.93	18.58^{ab}	61.73	1.21^{ab}	0.48
CV%	11.61	14.60	12.33	8.81	12.74

Means with the same and without letters in a column are not significantly different at 5% level of HSD test.

This result implies that application of fertilizers with 25-50% organic and 50-75% inorganic resulted to a comparable result with the recommended rate of inorganic fertilizer of 30-30-30 kg ha^{-1} N, P_2O_5, K_2O and proper management of the crop is necessary to increase the yield of mungbean. Moreover, Shukla et al. (2013) reported that significant effects on grain yield of chickpea was due to the application of inorganic fertilizer. This fertilizer provides readily available nutrients needed by plants for the formation and development of mungbean pods resulting in increased yield. In this study, balanced application of inorganic fertilizer and mudpress increased the grain yield of mungbean compared to the untreated control plants (T_1) and other treatment plants applied with 75-100% organic mudpress (T_3, and T_4). According to Patil et al. (2013) in their study the use of bio-fertilizers in combination with sugar press mud (SPM) enhanced the macro and micronutrient status in soil that favors the vegetative and reproductive production of the crop, hence increases the total grain yield (t ha^{-1}).

3.3. Response of Insect Pest and Diseases

Response of different mungbean genotypes to insect pests and diseases is presented in Table 5. Insect pests and diseases damage did not show great differences among treatment plants. This result can be attributed to the genotypic characteristics wherein NSIC recommended varieties are selected and recommended as NSIC variety based on their performance not only yield but also the resistance to pest and diseases (NCT Manual for Legumes, 2017) (Table 6). All treatments plants showed highly resistant to the insect damage and resistant to diseases. Hence, they produce a reasonable high yield.

Moreover, based on the reaction of mungbean plants to insect pest and diseases damage, the farmers can minimize the cost of pesticide due to its high to moderate resistant rating of this mungbean variety (Pagasa19) to pests.

3.4. Cost and Return Analysis

Cost and return analysis of mungbean production as affected by the application of mudpress and inorganic fertilizer is presented in Table 7. Mungbean applied with pure inorganic fertilizer (T_2) obtained the highest net income of PhP of 73392.00 ha^{-1} followed by mungbean applied with 5.0 t ha^{-1} mudpress + 15.0 kg ha^{-1} N, P_2O_5, K_2O (T_5) with PhP 63, 812.00, and plants applied with 2.5 t ha^{-1} mudpress + 22.5 kg ha^{-1} N, P_2O_5, K_2O (T_6) with PhP 52624.00. The higher net income obtained from mungbean applied with inorganic fertilizer (T_2) was due to higher grain yield produced with lesser production cost.

Table 5. Incidence of insect pests and diseases of mungbean as affected by the application of mudpress and inorganic fertilizer

Treatment	Insect Pests Damage	Reaction	Disease (CLS)	Reaction
T_1 – No fertilizer (control)	1.25	Highly resistant	2.05	Moderately resistant
T_2 – 30-30-30 kg ha^{-1} N, P_2O_5, K_2O	2.30	Moderately resistant	1.98	Moderately resistant
T_3 – 10 t ha^{-1} mudpress alone	1.87	Highly resistant	1.75	Moderately resistant
T_4 – 7.5 t ha^{-1} mudpress + 7.5 kg ha^{-1} N, P_2O_5, K_2O	2.32	Moderately resistant	2.47	Moderately resistant
T_5 – 5.0 t ha^{-1} mudpress + 15.0 kg ha^{-1} N, P_2O_5, K_2O	1.49	Highly resistant	2.56	Moderately resistant
T_6 – 2.5 t ha^{-1} mudpress + 22.5 kg ha^{-1} N, P_2O_5, K_2O	1.67	Highly resistant	2.48	Moderately resistant

Table 6. Rating Scale for insect Pest and diseases (NCT Manual for Legumes, 2017)

Damage Index	Insects Leaf Damage (%)	Reaction	Damage Index	Range of Average Scale for Diseases	Descriptio
1	1-20	Highly resistant	1	1.00	Highly resistant
2	21-40	Moderately resistant	2	1.01-2.49	Moderately resistant
3	1-60	Moderately susceptible	3	2.50-3.49	Intermediate resistant
4	61-80	Susceptible	4	3.50-4.49	Moderately susceptible
5	80-100	Highly susceptible	5	4.50-5.00	Highly susceptible

Table 7. Cost and return analysis of mungbean production ha-1 as affected by the application of mudpress and inorganic fertilizer

Treatments	Grain Yield (t ha^{-1})	Gross Income (PhP ha^{-1})	Production Cost (PhP ha^{-1})	Net Income (PhP ha^{-1})
T_1 – No fertilizer (control)	0.60^{c}	42000	23880.00	18120.00
T_2 – 30-30-30 kg ha^{-1} N, P_2O_5, K_2O	1.47^{a}	102900	29508.00	73392.00
T_3 – 10 t ha^{-1} mudpress alone	0.86^{b}	60200	40280.00	19920.00
T_4 – 7.5 t ha^{-1} mudpress + 7.5 kg ha^{-1} N, P_2O_5, K_2O	0.73^{b}	51100	37584.00	13516.00
T_5 – 5.0 t ha^{-1} mudpress + 15.0 kg ha^{-1} N, P_2O_5, K_2O	1.41^{a}	98700	34888.00	63812.00
T_6 – 2.5 t ha^{-1} mudpress + 22.5 kg ha^{-1} N, P_2O_5, K_2O	1.21^{ab}	84700	32076.00	52624.00

Based on the current market price of PhP 70.00 kg^{-1}

4. Conclusion

Based on the results of the study, the following conclusions can be drawn:

1. Application of combined mudpress and inorganic fertilizers significantly affected the number of days from seeding to maturity and fresh herbage yield (t ha^{-1}). Likewise, number of seeds per plant and total grain yield (t ha^{-1}) significantly affected the yield of mungbean.
2. Plants applied with of 25-50% (2.5-5 tha-1RROF mudpress) + (50-75% RRIF 15-22.5 kg ha^{-1} N, P_2O_5, K_2O) (T_5 and T_6) produced higher yield of (1.41 t ha^{-1} and 1.21 t ha^{-1}) comparable to RRIF 30-30-30 kg ha^{-1} N, P205, K20 (T_2) of (1.47 t ha^{-1}) than that of other treatments.
3. Application of pure inorganic at the rate of 30-30-30 kg ha^{-1} N, P_2O_5, K_2O got the highest net income ha^{-1} of PhP 73, 392.00. Among the combined treatments, application of 5.0 t ha^{-1} + 15 kg and 2.5 t ha^{-1} + 22.5 and kg N, P_2O_5, K_2O ha^{-1} (50-100% inorganic fertilizer) gave higher net income of PhP 63812.00 and PhP 52624.00, respectively.

5. Recommendation

1. A follow-up experiment shall be conducted using other legumes in areas of different agro-climatic

conditions.

2. It is recommended to evaluate the effects of combined mudpress and inorganic fertilizer on the nodulation of mungbean.
3. Mungbean seeds should be sown in ridges to prevent from waterlogging especially during wet season cropping.

Conflict of interest

The authors declared that there is no conflict of interest.

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