

Full Length Research Paper

A study of the application of HA in the presence of biofertilizer along with P to see if the P use efficiency can be improved

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Optimization of phosphorus (P) fertilizer for mungbean (*Vigna radiata*) was studied during kharif 2012 through integrated use of humic acid (HA), chemical fertilizers and biofertilizer viz., plant growth promoting rhizobacteria (PGPR) at NARC. The plots were arranged in split-split design under three factors (HA, P levels and PGPR inoculation). Results indicated that application of HA at 50 kg ha⁻¹ along with 45 kg ha⁻¹ P₂O₅ (75% P) in presence of PGPR inoculation recorded the highest grain yield (1.96 t ha⁻¹) that is 19% more than the treatment receiving 100% P application alone (no HA and PGPR). The highest concentration of P (0.3 %) and N (3.5%) in whole shoot mung bean were observed in the treatment where HA was applied at 50 kg ha⁻¹ along with 60 kg ha⁻¹ P₂O₅ (100% P) and PGPR inoculation. However mungbean yield and P concentration was statistically at par with the treatment where P was applied at 75% of recommended rate along with H.A and PGPR. Based on findings of this study it can be suggested that HA and PGPR inoculation have significant effect on grain yield and improved P use efficiency (PUE). It showed that HA and PGRP enhanced P availability through chelation and reduce soil P fixation.

Key words: Humic acid, bio fertilizer (PGPR), P use efficiency, and mung bean.

INTRODUCTION

The low soil fertility has raised the concerns about the sustainability of agricultural production. Strategies for increasing agricultural productivity focused on efficient utilization of available nutrient and effectively on sustainable basis for maintaining soil health. For sustainable agriculture, integrated management of the nutrients is needed for proper plant growth along with effective use of resources such as crop, water, soil and land management. Secondly owing to the ever increasing cost of inorganic chemical fertilizers, the integration of

inorganic fertilizers with organic manures and crop residues has become imperative for sustained crop production and maintenance of soil health (Babulkar, 2000). Phosphorus (P) is the most important nutrient required by the plants for growth and development. It is the second major essential macronutrient and plays an important role in metabolism of crop plants (Vikram and Hamzehzarghani, 2008). Most of the soils contain the substantial reserves of total P; large part of it relatively remains inert and only less than 10-15% of soil P enters the plant-animal cycle (Kucey et al., 1989). As a result of soil P fixation P in soil is not immediately available for plant. It fixed. The soil microorganisms solubilise this P and make it available to the plants (Pal, 1998; Hilda and

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Table 1. Physico chemical soil characteristic of soil.

Soil characters	Unit	Values
Textural Class		Clay loam
pH	-	7.70
EC (1:1)	(dS m ⁻¹)	0.35
Organic Matter	(%)	0.59
NO ₃ -N	(mg kg ⁻¹)	1.36
K	(mg kg ⁻¹)	134
P	(mg kg ⁻¹)	1.29

Fraga, 1999). The P-solubilising bacteria are relevant in this context and have the potential to be used as biofertilizer for the crops. The use of P-solubilizing bacteria as inoculants simultaneously increases P uptake by the plant and crop yield subsequently. Strains from the genera *Pseudomonas*, *Bacillus* and *Rhizobium* are among the most powerful phosphate solubilizers (Rodriguez and Fraga, 1999). Humic acid (HA) is an organically charged bio-stimulant that significantly affects plant growth and development and increases crop yield. HA improves physical, chemical and biological properties of soils (Keeling *et al.*, 2003; Nardi *et al.*, 2004 and Mikkelsen, 2005). The role of HA is well known in improving soil health and nutrient uptake by plants, mineral availability, fruit quality, etc (Mauromicale *et al.*, 2011). Humic acid based fertilizers increase crop yield (Mohamed *et al.*, 2009), enzymes/hormones and improve soil fertility in an ecologically and environmentally benign manner (Mart, 2007; Sarir *et al.*, 2005). Several research workers highlighted the positive benefits of HA on higher plants (Ashraf *et al.*, 2005; Susilawati *et al.*, 2009). Enhanced nutrient uptake by plants as a result of HA application is also well established (Mackowiak *et al.*, 2001). Likewise, the increased yield is also observed in many crops due to HA application, in vegetables such as potato (Vetayasuporn, 2006), pepper and Peas (Khan *et al.*, 2013 ab) tomato, onions, pear and other leafy vegetables (Erik *et al.*, 2000), (Albayrak, 2005).

Keeping the declining soil fertility, ever increasing fertilizer costs and continuous increasing demand for more food the current study was initiated. The current study aimed at applying HA in presence of biofertilizer along with P to see if the P use efficiency can be improved.

MATERIALS AND METHODS

Field trial

A field experiment was conducted at pulses programme, National Agricultural Research Institute (NARC), Islamabad, Pakistan. The latitude and longitude of Islamabad is 33° 42' N, 73° 10' E'. The plots were

assigned according to their respective treatments and arranged in split-split design under three factors (HA, P levels and PGPR inoculation). Humic substances have characteristics of pH 7.83, EC 0.94 and OM 68% N, P and K were 3.40, 0.15 and 3.42% respectively. The treatments were:

Factor 1: Fertilizer levels

P1: 75% Recommended Dose of P (45 kg ha⁻¹ P₂O₅)

P2: 100% Recommended Dose of P (60 kg ha⁻¹ P₂O₅)

Factor 2: Humic acid levels

HA1: Control (No humic acid)

HA2: Soil application of HA at 50 mg Kg⁻¹

HA3: Spray 1 g/L

Factor 3: PGPR inoculation

O: without PGPR inoculation

I: PGPR inoculation

Soil sampling

The composite soil samples were collected before experiment; air dried; sieved (2 mm). Plant samples were analyzed for the content of P and K adopting standard analytical methods. The data thus obtained were subjected for statistical analysis using Statistic 8.1 package. The basic physical and chemical characteristics of soil under investigation were analyzed using standard methods and presented in Table 1.

SOIL AND PLANT LABORATORY ANALYSIS

The composite soil samples were collected before experiment and were air dried and sieved through a 2 mm mesh screen. Standard analytical methods were followed in analyzing the soil samples and mung bean plant (whole root and shoot) for N, P and K contents at maturity. Soil texture class was determined according to hydrometer method as described by Bouyoucos, (1962). Soil pH and ECE (1:1 soil to water ratio) were measured using digital pH/EC meter. Total nitrogen in mung bean was determined by the Kjeldahl procedure as described by Bremner and Mulvaney (1982). Available P in the soil

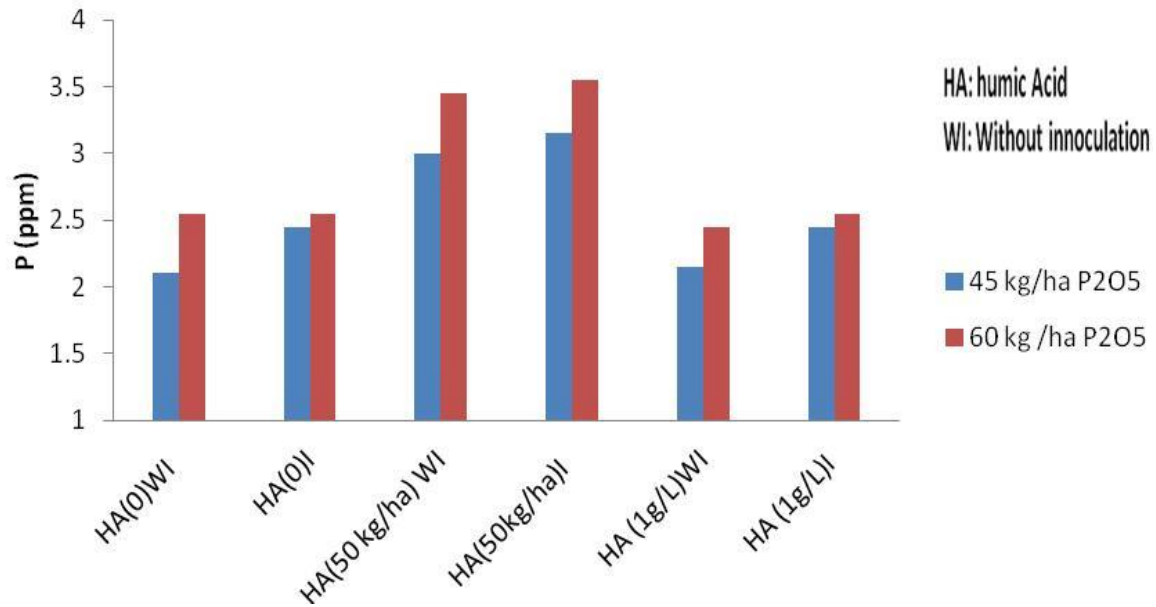


Figure 1. Combined effect of HA, PGPR and P fertilizer on P content of soil.

samples was determined by AB-DTPA method as described by Soltanpour and workman (1979). The data thus obtained were statistically analysed using MSTATC package.

RESULT AND DISCUSSION

Plant available soil P

Phosphorus content in the soil were positively affected with the interaction of HA, Inoculation and P application. The highest concentration of soil P (3.57 mg kg^{-1}) was recorded with the application of HA at 50 kg ha^{-1} along with $60 \text{ kg ha}^{-1} \text{ P}_2\text{O}_5$ (100% P) and PGPR inoculation which was 65% higher than 100% P application alone (Figure 1). However, it was statistically at par with the treatment where P was applied 75% of recommended rate along with HA and PGPR application. It shows that HA and PGPR application significantly reduce the phosphorus fixation and increase its availability through chelation effect. This is in consonance with the findings of David et al., (1994) who reported slow and continuous dissolution of phosphate minerals in soil by HA increased P availability. The soil phosphates activity improved by humic acid might have resulted in increased P availability as phosphatase hydrolyses the phosphate esters into inorganic phosphorus Malcolm and Vaughan (1979). Heng (1989) reported that HA reduces P soil fixation and hence increased P availability. Results of this study also showed that HA along with PGPR application reduced P soil fixation and rendered it available for plant to uptake.

Phosphorus content in mungbean whole shoot (%)

Treatments significantly improved the P content in whole shoot mungbean plant at flowering stage. Results show that the highest concentration of P in mungbean (0.33%) was observed in with HA application at 50 kg ha^{-1} along with $60 \text{ kg ha}^{-1} \text{ P}_2\text{O}_5$ (100% P) and PGPR inoculation (Figure 2). However it was statistically at par with the treatment where P was applied 75% of recommended rate along with HA and PGPR application. P (0.31%) were registered where HA was applied at 1 g L^{-1} in foliar spray along with $60 \text{ kg ha}^{-1} \text{ P}_2\text{O}_5$ (100% P) and PGPR inoculation which is significantly higher than the 100% dose of phosphorus alone. The increase in P uptake ascribed to low soil P fixation and or formation of humophospho complexes, which are easily assimilable by the plants (Raina and Goswami, 1988). The HA and PGPR application with P fertilizer significantly increased the amount of water-soluble phosphate and strongly retard the formation of occluded phosphate, and increased P uptake by plants Wang et al. (1995).

Potassium content (%) in mungbean

Potassium in mungbean plant was positively affected by HA and PGPR. Data showed that mungbean plant K content was increased both with HA application and PGPR inoculation (Figure 3). The highest K concentration (3.75%) was observed with the HA application at 50 kg ha^{-1} along with P at $60 \text{ kg ha}^{-1} \text{ P}_2\text{O}_5$ (100% P) and PGPR inoculation. which was 23% more than the 100% dose of phosphorus alone. However statistically it is at par with treatment where

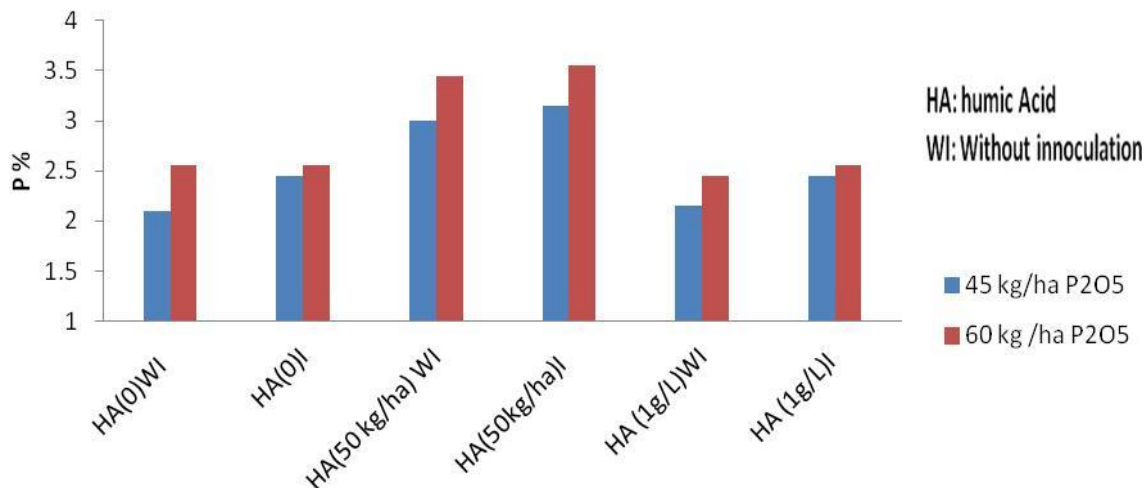


Figure 2. Combined effect of HA, PGPR and P fertilizer on mung bean P concentration (%).

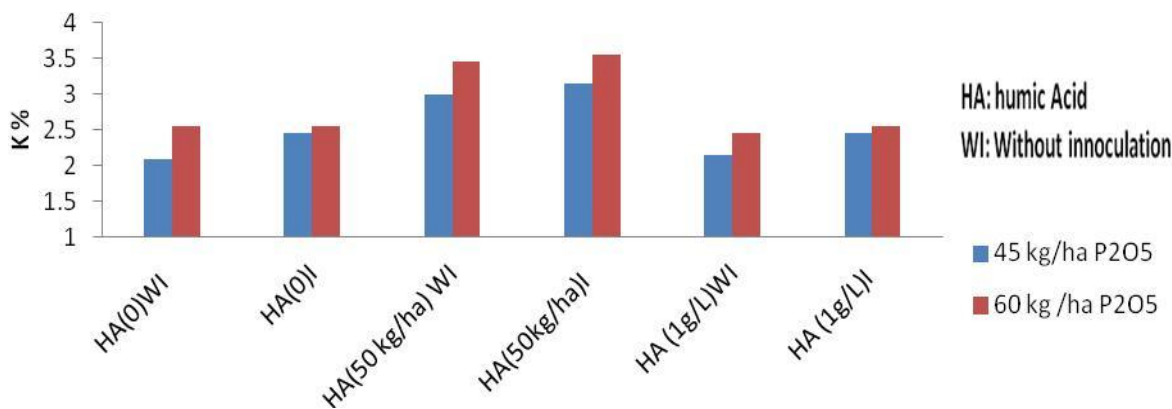


Figure 3. Combined effect of HA, PGPR and P fertilizer on mung bean K concentration (%).

HA and P (75%) was applied with inoculation. So HA has profound effect on plant K uptake, Similar findings have been reported Samson and Visser (1989) that humic acid increased in permeability of biomembranes for electrolytes accounted for increased uptake of K.

Available NO₃ (mg kg⁻¹) in soil

Nitrate content in the soil were affected with the interaction of HA, Inoculation and P application. The highest concentration (4.95 mg kg⁻¹) was found with the application of HA at 50 kg ha⁻¹ along with 60 kg ha⁻¹ P₂O₅ (100% P) and PGPR inoculation. An increase of 85% higher than In comparison to 100% P application alone (Figure 4). It was followed by the treatment at HA at 50 Kg ha⁻¹ along with 45 kg ha⁻¹ P₂O₅ (75% P) and PGPR inoculation. It shows that

HA and PGPR application significantly reduces the uncase activity led to reduce the losses of N volatilization as described by Vaughan and Ord (1991).

Nitrogen content (%)

Results showed that N contents of mungbean increased with the application of HA, P and PGPR inoculation (Figure 5). The highest value of N in mungbean (3.55%) was observed in the treatment where HA was applied at 50 kg ha⁻¹ along with 60 kg ha⁻¹ P₂O₅ (100% P) and PGPR inoculation. It was 39% higher than the 100% dose P application. The increased N uptake was supposed to be due to the better use efficiency of applied N fertilizers in the presence of humic acid coupled with retarded nitrification process enabling the slow availability

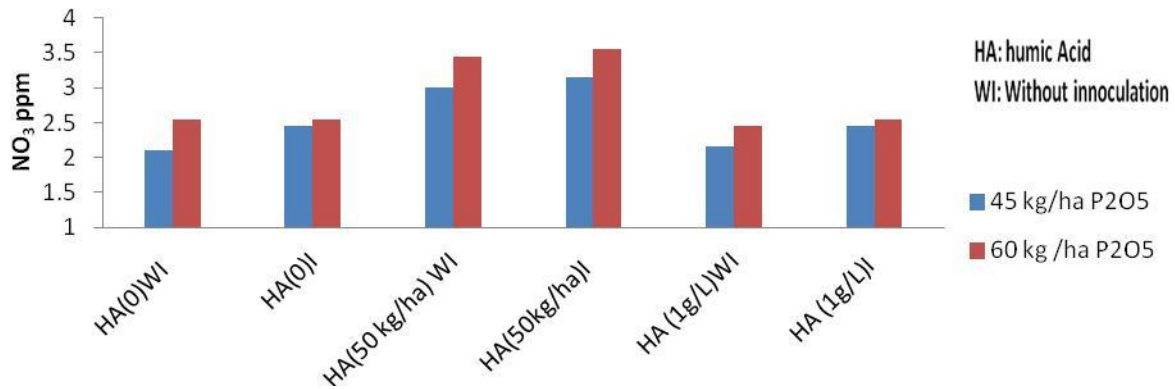


Figure 4. Combined effect of HA, PGPR and P fertilizer on NO₃ content of soil.

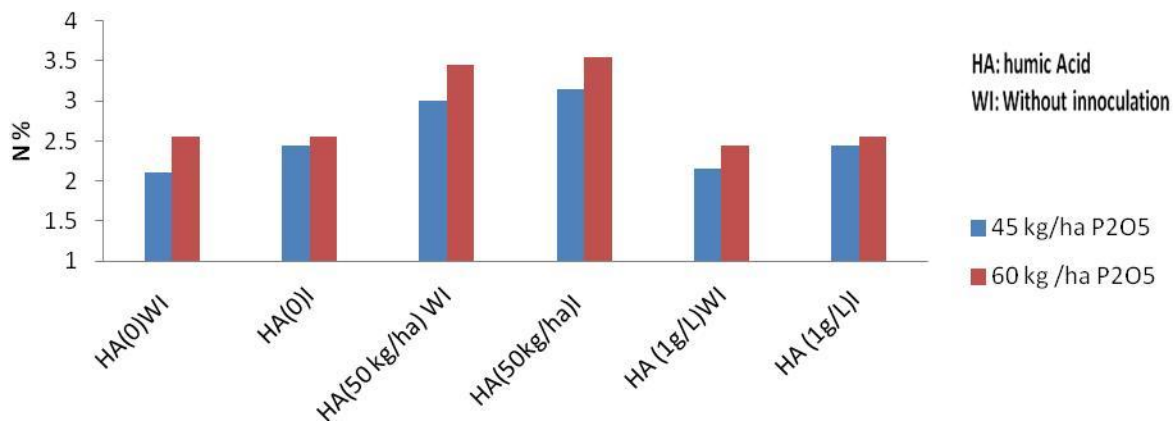


Figure 5. Combined effect of HA, PGPR and P fertilizer on mung bean N concentration (%).

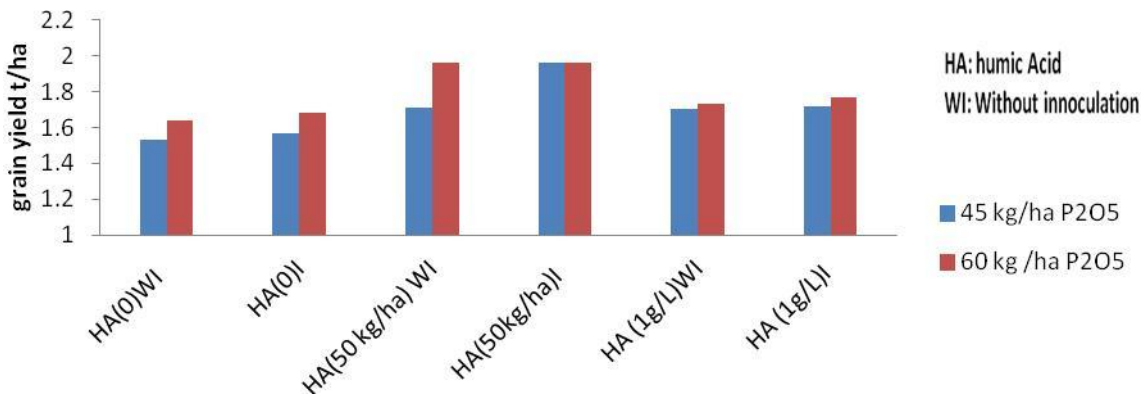


Figure 6. Combined effect of HA, PGPR and P fertilizer on mung bean yield (t/ha).

of applied N (Guminiski, 1968).

Grain yield

Data about interactive effect of humic acid, biofertilizer

inoculation and P fertilizer on grain yield (Figure 6) showed that soil application of humic acid at 50 kg ha⁻¹ along with 45 kg ha⁻¹ P₂O₅ (75% P) and PGPR inoculation recorded the highest grain yield 1.965 t ha⁻¹ that is 19% more than the treatment receiving 100% phosphorus application alone. It is concluded that HA and

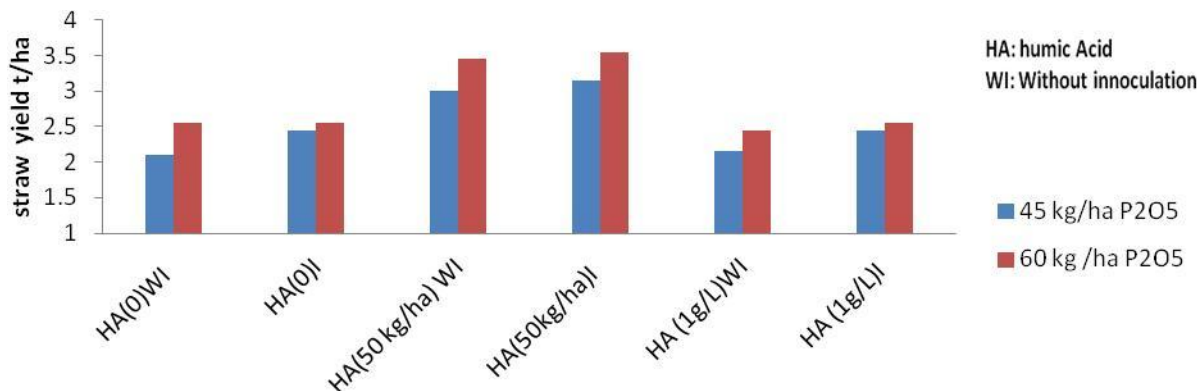


Figure 7. Combined effect of HA, PGPR and P fertilizer on mung bean straw yield (t/ha).

PGPR - inoculation have significant effect on P use efficiency and grain yield on mungbean by enhancing P availability and reducing the P fixation and increases its availability through chelation effect (any reference). Therefore, increased availability of P and its uptake confirmed the soil fertility improvement by humic acid addition at 60 kg ha⁻¹ along with 45 kg ha⁻¹ P₂O₅ (75% P) and PGPR inoculation which helped to enhance mungbean yield.

Straw yield

The maximum straw yield 4.8 t ha⁻¹ was recorded in the treatment where humic acid was applied at 50 kg ha⁻¹ along with 60 kg ha⁻¹ P₂O₅ (100% P) and PGPR inoculation (Figure 7) followed by 4.65 kg ha⁻¹ in the treatment receiving humic acid at 50 kg ha⁻¹ along with 45 kg ha⁻¹ P₂O₅ (75% P) and PGPR inoculation.

CONCLUSION

The combined effect of HA at 50 Kg ha⁻¹ along with 60 Kg ha⁻¹ P₂O₅ (100% P) and PGPR Inoculation has registered not only the maximum P availability in soil and its uptake by mungbean but also attained the maximum yield (1.965 t ha⁻¹). However it was statistically at par with soil application of HA at 50 Kg ha⁻¹ along with 45 Kg ha⁻¹ P₂O₅ (75% P) and PGPR. It may be concluded that humic acid couple with PGPR inoculation can help to improve phosphorus use efficiency and therefore reduce phosphorus fertilizer cost by 25% in mungbean production.

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