COMPARATIVE PRODUCTIVITY & SEED QUALITY OF MUNGBEAN GROWN UNDER ORGANIC & CONVENTIONAL PRODUCTION SYSTEMS

ANNALISSA LAPPAY-AQUINO & PAMELA G FERNANDEZ

Different mungbean seedlots were evaluated for their productivity and seed quality under organic and conventional production systems. Seedlot 1 gave the highest seed yield particularly when fertilized with poultry manure and Gliricidia leaves. But when fertilized with complete fertilizer, seed yield was the same as when unfertilized. Seed yield of Seedlot 2 was lower than Seedlot 1 given the same fertilizer treatments. But percent germination and vigor of both Seedlots were comparable throughout the 6 months storage period. Without fertilizer treatment, both Seedlots had higher percent germination and vigor than Seedlot 3 and even higher when fertilized with Gliricidia leaves. Seed moisture content of Seedlots 1 and 2 was also maintained to an appropriate level either without fertilization or with Gliricidia leaves.

Seedlot 3 had the lowest seed yield but this was compensated by the greater amount of biomass it produced. Its percent germination and vigor was also beyond acceptable level after 2 months of storage in all of the fertilizer treatment except those without fertilizer treatment. Only seeds without fertilizer maintained an acceptable level of germination percentage, vigor and moisture content after the storage period.

In general, between organic and inorganic fertilization, seed yield and seed quality (in terms of germination, vigor and moisture content) were better under organic fertilization. Organic fertilizers such as poultry manure and Gliricidia leaves are effective fertilizer sources to obtain high mungbean seed yield and seed quality.

Keywords chemical fertilizer, germination, Gliricidia leaves as fertilizer, moisture content, mungbean, organic fertilizer, poultry manure, seed quality, seed vigor, seed yield, sustainable agriculture

INTRODUCTION

Modern agriculture is geared towards increasing agricultural production mainly through intensive cropping practices and use of chemical inputs such as synthetic fertilizers and pesticides. The continuous and indiscriminate use of these chemicals has resulted to serious ecological problems such as decline in soil quality and productivity, pollution of air and water, destruction of beneficial insects, increased resistance of weeds and insects against pesticides, hazard to human and animal health, and decline in quality of food (USDA, 1980). The increasing cost of chemical inputs as compared to the cheaper price of produce also caused serious economic problems among farmers. These have led farmers, consumers and researchers to seek alternative farming systems. One such alternative is organic farming. Organic agriculture is a production system that avoids or largely excludes the use of synthetically compounded fertilizers, growth regulators, pesticides, livestock feed additives, and genetically engineered organisms and products (USDA 1980).

In recent years, due to the growing interest in organic farming in many countries, the importance of organic matter in crop production has been emphasized (Hsieh and Hsieh 1990). A high level of organic matter is often correlated with a high level of soil fertility, productivity and tilth (USDA 1980). Organic matter is also known to improve the soil physical properties and provide a matrix for nutrient exchange and microbial growth (Sikora and others 1995). The high carbon content of organic matter promotes the growth of mycelia, promotes soil aggregation and improves fluid permeability of clayey soils (Hsieh and Hsieh, 1990). High levels of urease, phosphatase, and dehydrogenase activity under organically farmed soils have been observed (Reganold 1988). This indicates that microbial activity is greater under organic management systems. The use of organic manures allows the direct uptake by plants of specific chemicals, such as phenols, which are
needed for the development of the plant’s immune system. Furthermore in some soils, high levels of organic matter and biological activity are directly associated with low levels of disease incidence, even when a pathogen is introduced in the presence of a susceptible host (Lampkin 1992).

A review of studies comparing crop yields between organic agriculture and conventional agriculture found that differences are highly variable (Lotter 2003). According to the review, yield varies between crops and between places or countries. In the US, for example, organically grown California rice yielded 60-80% lower while Midwest oats yielded 50% higher than conventionally grown (Lotter 2003). Yield of soybean and oat over a five-year period showed a slightly higher average on organic farms compared to conventional farms (USDA, 1980). For vegetable soybean, pod yield differed greatly according to different organic manure compost and chemical fertilizer applied, with organic fertilizer giving much better yield than from chemical fertilizer (Lin 1997).

Yields of carrot and leek were not affected by the kind of fertilizer applied, but yield of cabbage using organic fertilizer significantly decreased during the first year but not in the second year (Nilsson 1979). Fresh yield of sweet corn applied with organic manures at a rate of 25 t ha-1 were equivalent to those applied with chemical fertilizer while the grain yield of rice applied with 6.6 t ha-1 compost was also equally good as with conventional farming (Lin 1997). These results indicate that with sufficient amount of available nutrients, organic farming can give yields as high as the conventional farming.

The review of Lotter (2003) on organic agriculture also reported that yield varies depending on the form of stress during production (i.e., drought, extreme cold or flooding). A study in the US corn belt showed that during drought conditions, crops under organic agriculture systems often outyielded conventional crops by 70-90% (Locke et al. 1981). On the other hand, an unusually cold summer nearly wiped out conventional rice crops in Japan while naturally or organically farmed rice yielded 60-80% of the annual average (Lotter 2003).

In the Philippines, a number of studies have been conducted but few focus on seed production. Many point to some advantages of organic to inorganic if not the same effect. Formal studies on organic production are mostly done for crop production and only meagre on seed production. Studies specifically on mungbean comparing conventional and non-chemical seed production systems are also scarce. In the few studies that focused on organic seed production, results showed that seed yield and quality under organic and inorganic fertilizer sources gave similar effects. Monocrop corn under low external input exceeded those of the high external input while seed yield of monocrop peanut under low external input was similar with that of high external. When tested for quality, peanut and corn seeds under low external input were also reported to be of better quality than under high external input (Cervantes 1997). In soybean the use of carabao manure, Gliricidia (Gliricidia sepium) leaves, and inorganic N sources gave similar effects on seed yield and seed quality (Pisithkul 1994). In another study, the seed yield per plant or per area basis of corn and mungbean grown with poultry manure were five to 16 times higher than inorganic fertilizer and no fertilizer treatments (Rattananupong 1996).

Mungbean, which is widely grown in the Philippines, is one of the cheapest and major sources of protein in the Filipino diet. It is an important intercrop, rotation and relay crop and grows well even under marginal condition. It requires less amount of nitrogen than other crops, grows fast, matures early and produces abundant succulent tops making it an excellent green manure crop. Mungbean seed is also processed into a variety of food products and a valuable substitute to soybean for protein source of vegetarian. However, the present production and average yield of 0.70 t ha-1 is still low such that there is always a scarcity in supply (PCARRD, 1991). Problems in productivity are often remedied by the application of chemical inputs. With the various problems brought about by the increased use of chemical inputs, however, high quality seed production, especially on a commercial scale, should be through an alternative system.

The study was conducted to assess the productivity and seed quality of different mungbean cultivars under organic, conventional and zero input production system. The study was also conducted to determine whether a formally-bred variety which was grown under contrasting production history (organic and conventional) respond similarly to organic fertilization and whether a formally-bred and a farmer maintained cultivar respond similarly to organic and conventional fertilization. The hypothesis of the study is that productivity and seed quality in organic production system is comparable to, if not better than, that of conventional (chemical) system even in the short run.

**Materials & Methods**

The field experiment was conducted at the Central Experiment Station, University of the Philippines Los Banos, Laguna, Philippines on February to April 1999. The condition that year deviated from the normal dry season, attributed to the La Niña phenomenon. The area has been used for experiments for conventional and chemical-based upland farming and planted mostly to corn. During the study adjacent areas were planted with
corn, cabbage, pepper and bean. The laboratory portion to conduct storage and seed quality testing, was done from June to December 1999 at the Seed Science and Technology Laboratory, Department of Agronomy, UPLB.

Three mungbean Seedlots and four nitrogen sources were evaluated. Seedlots 1 and 2 are both Pag-asa 7 variety, which is formal-bred but were grown under different production system. Seedlot 1 was obtained from the Institute of Plant Breeding in UP Los Baños and adapted to conventional crop production. Seedlot 2 was also obtained from Los Baños but had been organically grown for four cropping seasons. Seedlot 3 is farmer maintained seeds called ‘Red mungbean’ obtained from Davao, City and is adapted to organic crop production. The nitrogen treatments were (N1) control or without fertilizer, (N2) poultry manure, (N3) Gliricidia leaves, (N4) complete fertilizer (14-14-14).

Treatments were arranged in an incomplete factorial combination with four replications and the experimental design was split-plot in randomized complete block design (RCBD). Mainplot was mungbean Seedlots and subplot was fertilizer sources. Seedlots 1 and 3 were given all the four fertilizer sources selected in the study while Seedlot 2 was given only the control and Gliricidia, because of insufficient quantity of seed The amount of inorganic fertilizers applied was based on the recommended rate for mungbean which is 30-30-30 (PCARRD, 1991). The amount of organic fertilizer was computed based only on the estimated nitrogen rate and on the nutrient analysis of organic fertilizer (IIRR). Poultry manure used was 750 kg ha⁻¹ while Gliricidia leaves was 1034.5 kg ha⁻¹.

Plot dimensions were 16.0 m x 8.0 m (main) and 4.0 m x 8.0 m (subplot). There was 0.5 m distance between subplots and 1.0 m between mainplots. Border rows on the shorter and longer side of the plot was 1.0 m starting from the boundaries. Harvest area in each plot was 12 m². Distance between replications was 2.0 m. Distance was 50 cm between rows in a block and 20 cm between hills.

The field was plowed once and harrowed twice. Gliricidia and poultry manure were incorporated into the soil two weeks before planting. The field was then irrigated once to provide moisture for faster decomposition of the organic materials. Complete fertilizer was applied at the bottom of the furrows and covered with thin layer of soil on the day of planting. Seeds were sown by the hill method. Irrigation was then done the following day. Subsequent irrigation and weeding were done when needed. Harvesting was done when the pods were brown or black and the leaves started to turn yellow and defoliate which was within 62-75 days after sowing.

Seed quality parameters that were determined were moisture content, germination percentage, and vigor. These parameters were determined just before and at different times of storage. The moisture content (fresh weight basis) of the seeds from the harvest area in each plot was determined following the rules of ISTA (1983). Seed germination percentage at ambient temperature was determined following the top of paper method (ISTA, 1985) using slightly covered plastic boxes to maintain the moist condition of the set-up. Seed vigor was assessed through field emergence test (Copeland & McDonald, 1995). For the field emergence test, four replicates of 50 seeds each were sown in plots. The number of germinated seedlings was counted 14 days after sowing.

Seed yield was obtained from all plants from the plot within the harvest area. Pods were dried, and shelled. Seeds collected were further sundried for one week until moisture content was reduced to at least 10%, then cleaned and sorted into good and damaged ones. The good seeds were weighed and this represented seed yield expressed in kg ha⁻¹.

From the seeds collected in each plot, samples were placed in bottle containers with three replications per treatment and stored under ambient condition. Samples from each bottle were tested for germination, field emergence and moisture content every 2 months until 6 months of storage.

Data were analyzed using the analysis of variance (ANOVA) procedure with the aid of Statistical Analysis System Software (SAS Systems for Windows v6.12). Least significant difference (LSD) at 5% level was used to make general comparisons between and among selected treatment means.

**RESULTS**

**Seed yield and shoot biomass**

Significant differences in seed yield were observed among Seedlots and fertilizer sources as well as their interaction. Seedlot 1 which was formally bred and previously grown under conventional production system, consistently gave higher seed yield regardless of the fertilizer source (Table 1). Its yield, however, was highest under poultry manure (1532.6 kg ha⁻¹) followed by Gliricidia leaves (1407.3 kg ha⁻¹). But the difference between the two treatment combinations was only 8% compared to the 16% difference with that of complete fertilizer. Seedlot 2, which was also formally-bred but previously grown under organic production system, and had only Gliricidia and zero fertilizer treatment, ranked second to Seedlot 1 in seed yield. With Gliricidia leaves and without fertilizer treatment, respectively, its yield was 9% and 7.5% lower than Seedlot 1 of the same fertilizer treatment. Seedlot 3, which was farmer-maintained, had the lowest seed yield. The yield
difference between that of Seedlot 1 and 2 in any of the fertilizer treatment was greater than 50%. In general, the difference in yield between Seedlot 1 given poultry manure and all the other treatment combinations ranged from 8-61%. The mean difference among Seedlots ranged from 14-49% while the mean difference among fertilizer sources was 5-22%.

Differences in shoot biomass among Seedlots were not significant. Shoot biomass was also not affected by fertilizer sources or the interaction between Seedlots and fertilizer sources. However, mean values across fertilizer sources showed that shoot biomass of Seedlot 3 was higher than Seedlot 1 and 2 by 5% and 19%, respectively (Table 2).

**Seed quality**

The different seed quality tests that were done to evaluate the response of different Seedlots given organic and inorganic fertilization include germination, field emergence and moisture content. In general, there were significant differences in seed quality among Seedlots and fertilizer sources as well as their interaction at different storage period. Seedlot 1 did not undergo significant decline in germination after 6 months of storage under zero fertilizer and with Gliricidia leaves treatment (Figure 1). Instead, germination was maintained above 92% and 95%, respectively. But with poultry manure and inorganic fertilizer, a 24% decline in germination was observed after 2 months. Seedlot 2 also maintained a germination percentage that is greater than 95% after 6 months of storage in both zero fertilizer and Gliricidia leaves treatment. Seedlot 3 had the steepest decline in germination starting on the second month of storage for all fertilizer treatments, with complete fertilizer leading to the fastest deterioration. After 2 months, germination under complete fertilizer declined by as much as 83% while those of Gliricidia leaves and poultry manure declined by as much as 15% and 10%, respectively. After 4 months in storage, seeds grown with complete fertilizer were no longer viable. In contrast, germination of seeds without fertilizer treatment declined only by about 5% after 2 months. Seeds remained viable all throughout the storage period and had greater than 82% germination after 6 months.

Field emergence, which is a test to determine seed vigor, significantly varied among Seedlots and fertilizer sources and their interaction. On the second month of storage, steep decline in field emergence was observed for all Seedlots regardless of the fertilizer treatment (Figure 2). Despite this steep decline in vigor, Seedlots 1 and 2 without fertilizer treatment and those with Gliricidia leaves maintained their vigor level above 82% throughout the storage period. In Seedlot 3, only seeds without fertilizer treatment maintained a vigor level of 70% after 6 months. Seeds grown with poultry manure and Gliricidia leaves declined in vigor level of below 50% after 4 months in storage and were no longer viable after 6 months. Seeds grown with complete fertilizer declined below 20% after only 2 months and were no longer viable after 4 months.

Seed moisture was significantly affected by Seedlot and fertilizer sources but not by their interaction. Moisture content of Seedlot 1 generally did not differ among fertilizer treatments. After 6 months of storage seed moisture content under the different fertilizer treatment remained from 10-11%. Seed moisture content of Seedlot 2 with both fertilizer treatments was lowest among the Seedlots and was maintained below 10% throughout the storage period (Figure 3). Seedlot 3 showed highly varied moisture content with different fertilizer treatments on the second month of storage. It also showed higher moisture values than Seedlots 1 and 2. Seeds without fertilizer treatment had only a slight increase in moisture content for all Seedlots regardless of the fertilizer treatment.

### Table 1. Mean yields in kilogram per hectare of three mungbean seedlots given organic and inorganic fertilizer sources.

<table>
<thead>
<tr>
<th>SEEDLOT</th>
<th>NUTRIENT SOURCES</th>
<th>Zero fertilizer</th>
<th>Poultry manure</th>
<th>Gliricidia leaves</th>
<th>Complete fertilizer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seedlot 1</td>
<td>1107.1</td>
<td>1324.6</td>
<td>1407.3</td>
<td>1301.9</td>
<td></td>
</tr>
<tr>
<td>Seedlot 2</td>
<td>1023.0</td>
<td>___</td>
<td>1274.7</td>
<td>___</td>
<td></td>
</tr>
<tr>
<td>Seedlot 3</td>
<td>592.4</td>
<td>789.3</td>
<td>632.7</td>
<td>698.8</td>
<td></td>
</tr>
</tbody>
</table>

CV % (A) = 13.5
CV % (B) = 3.6

*Seedlot 1 produced from conventional nutrient management, Seedlot 2 produced from four seasons of organic nutrient management, Seedlot 3 = farmer-maintained seeds.*

### Table 2. Mean shoot biomass in kilogram per hectare of three mungbean seedlots given organic and inorganic fertilizer sources.

<table>
<thead>
<tr>
<th>SEEDLOT</th>
<th>NUTRIENT SOURCES</th>
<th>Zero fertilizer</th>
<th>Poultry manure</th>
<th>Gliricidia leaves</th>
<th>Complete fertilizer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seedlot 1</td>
<td>465 a</td>
<td>542 a</td>
<td>486 a</td>
<td>486 a</td>
<td></td>
</tr>
<tr>
<td>Seedlot 2</td>
<td>481 a</td>
<td>___</td>
<td>367 a</td>
<td>___</td>
<td></td>
</tr>
<tr>
<td>Seedlot 3</td>
<td>468 a</td>
<td>542 a</td>
<td>543 a</td>
<td>538 a</td>
<td></td>
</tr>
</tbody>
</table>

CV % (A) = 45
CV % (B) = 25

*Seedlot 1 produced from conventional nutrient management, Seedlot 2 produced from four seasons of organic nutrient management, Seedlot 3 = farmer-maintained seeds.*
throughout the storage period, while those with inorganic fertilizer increased beyond acceptable level on the second month of storage.

**DISCUSSION**

Seedlot 1 responded positively to any of the fertilizer treatment, more so with poultry manure and Gliricidia leaves, resulting in seed yield higher than Seedlots 2 and 3. Although Seedlot 1 was previously grown under conventional production system, its yield response to organic fertilization was even greater than under inorganic fertilization. Furthermore, the yield level obtained under organic fertilization was within the average yield obtained if grown by conventional method. This yield response could have been influenced by the characteristic of organic fertilizers that have lower solubility and release nutrients slowly (Patriquin, 1995). By slowly releasing nutrients, both Gliricidia and poultry manure may have provided plants with steady supply of nutrients especially during the critical stages of nutrient requirement. The presence of micronutrients in Gliricidia and poultry manure may have also contributed to the higher yield of Seedlot 1 under organic fertilization. Despite the higher equivalent amount of NPK applied under inorganic fertilization, seed yield was lower than that of organic fertilization. This suggests that higher yield in both organic fertilizer sources could not have been influenced by the amount of nitrogen applied but could have been influenced by the micronutrients present in them, which was lacking in inorganic fertilizer.

Seedlot 2 has been “detoxified” or has been grown under organic production system to allow the seeds to become adapted to such condition, until such time that its performance or yield becomes stable. The lower yield level obtained from the “detoxified” seeds compared to seeds previously produced from conventional method (Seedlot 1) could be an indication that this population was not yet fully adapted to organic production system having been “detoxified” for only four seasons. This result is the same as the results of other studies that under organic production system, there is a reduction in yield level during the first few years and starts to gradually increase as the crop adapts to the production system (USDA, 1980).

Seedlot 3 responded poorly either under organic or inorganic fertilization although yield level was slightly higher when fertilized with poultry manure or complete fertilizer. This Seedlot has been previously grown in a marginal soil that is highly acidic and eroded and so farmers may have focused on adaptation rather than on yield when it was selected. Los Baños condition also presents a very different growing environment and this may have contributed to its poor performance. Unlike Seedlots 1 and 2 which were formally-bred and therefore were already genetically improved especially in terms of seed yield and adaptability, Seedlot 3 may not even gone through selection much more crop improvement. This could be another reason for the big difference in seed yield and quality between the farmer-maintained and formally-bred Seedlots. The low seed yield, however, was compensated by the quantity of biomass produced. Having the highest biomass, this means that greater amount of nitrogen can be plowed back into the soil.

Although seed yield of Seedlot 1 was higher than Seedlot 2, their germination percentage, vigor, and moisture content were comparable without fertilizer treatment or when fertilized with Gliricidia leaves. In both fertilizer treatments, seed moisture content was maintained to an appropriate level for storage unlike seeds fertilized with complete fertilizer which increased beyond tolerable level. The lower moisture content of these seeds throughout the storage period may have partly contributed to the maintenance of viability and vigor. Seeds fertilized with poultry manure also had
lower moisture content, although a little higher than seeds fertilized with Gliricidia leaves, but vigor and viability was much lower.

Studies show that soils applied with organic fertilizer were observed to have lower and more stable moisture tension and this has favorable effects on the moisture status of plants (Koshino 1990). Moisture content of seeds grown with Gliricidia and poultry manure suggests that lower and more stable soil moisture tension in organically treated soils also favorably affects seeds, hence seed moisture content was maintained to an appropriate level. However, despite the lower moisture content of seeds fertilized with poultry manure, viability and vigor were not as high as seeds fertilized with Gliricidia or seeds without fertilizer. This superior seed quality with Gliricidia fertilization can be explained by previous study which reported that the use of green manure increase plant resistance which consequently produce vigorous seeds by suppressing disease organisms or by enhancing the growth of microorganism that are antagonistic to the pathogens (Linderman 1989). The use of Gliricidia leaves may have increased the resistance of the seeds to certain pathogens and diseases, hence the higher germination and vigor.

Seedlot 3 on the other hand had poor quality in all the fertilizer treatment except for seeds without fertilizer. The abrupt increase in moisture content from 11% before storage to 17% after 2 months in storage may have contributed to the significant decline in germination since at 14% moisture content storage fungi that contribute to faster seed deterioration start to become active. Evidence of fungal activity was confirmed when seeds were periodically tested for viability. Most of the seeds that germinated were infected with fungi while some seeds failed to germinate at all due to severe infection. In contrast, moisture content of seeds from the control treatment was maintained at 13%, and this probably explains why the seeds remained viable after 6 months of storage.

CONCLUSION

Fertilization with Gliricidia leaves gave seed yield slightly lower than with poultry manure but this is compensated by the better quality of seeds it produced since seeds could be stored longer. If seed germination and vigor is kept high, lesser amount of seeds will be needed for the succeeding cropping. Poultry manure was effective in increasing yield but had an unfavorable effect on seed quality.

In terms of seed yield Seedlot 1, which was produced from conventional method, responded better to organic and inorganic fertilization than Seedlot 2, which was detoxified or produced by organic method. But percent germination and vigor of both Seedlots were comparable with organic fertilization. The better quality of detoxified seed will be an advantage in community seed banking where there are no special provisions for maintaining viability and moisture content of seed.

Figure 2. Field emergence of mungbean

<table>
<thead>
<tr>
<th>Seedlot 1</th>
<th>Seedlot 2</th>
<th>Seedlot 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Field emergence (%)</td>
<td>Field emergence (%)</td>
<td>Field emergence (%)</td>
</tr>
<tr>
<td>100</td>
<td>80</td>
<td>60</td>
</tr>
<tr>
<td>zero fertilizer</td>
<td>zero fertilizer</td>
<td>zero fertilizer</td>
</tr>
<tr>
<td>&lt;br&gt; poultry manure</td>
<td>&lt;br&gt; poultry manure</td>
<td>&lt;br&gt; poultry manure</td>
</tr>
<tr>
<td>&lt;br&gt; gliricidia leaves</td>
<td>&lt;br&gt; gliricidia leaves</td>
<td>&lt;br&gt; gliricidia leaves</td>
</tr>
<tr>
<td>&lt;br&gt; complete fertilizer</td>
<td>&lt;br&gt; complete fertilizer</td>
<td>&lt;br&gt; complete fertilizer</td>
</tr>
</tbody>
</table>

Higher yield and seed quality and long term benefits to the soil and to the environment are the two main reasons why organic fertilizers are better than inorganic fertilizers.

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Figure 3. Moisture content of mungbean (LSD = 0.01)