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YIELD AND SEED QUALITY OF MODERN AND TRADITIONAL SOYBEAN [*Glycine max* (L.) MERR.] UNDER ORGANIC, BIODYNAMIC AND CHEMICAL PRODUCTION PRACTICES IN THE MEKONG DELTA OF VIETNAM.

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ABSTRACT

Soybean seed is highly in demand in Vietnam but seed production is a challenge especially during the wet season. Organic production could add value to the enterprise but has not been established as a viable option. The experiments was laid out in a split plot design with three replications at the CLRRI farm during the 2005 wet season. Main plots consisted of four production practices i.e. "organic" (cow manure at 40-105-10 NPK and botanicals); "biodynamic" (biodynamic preparations); "chemical" (synthetic fertilizers at 40-60-30 NPK and insecticides) and control (no inputs). Subplots consisted of two soybean varieties. The results of study showed that "Nam vang" which had smaller seeds had higher seed yield, better seed quality (germination and vigor at harvest and storability), and generally higher protein content than "OMDN111" especially under "organic". Variety differences were consistent for most measurements across the different production practices."Biodynamic" was not significant in general performance relative to "organic" and "chemical" (control was generally lowest) in number of filled pods, leaf area index (highest) and root nodule fresh weight.

The circular paper chromatography pattern of the seed, which may indicate biological complexity and enzyme activity, revealed differences between varieties and among production practices. "Organic" and "biodynamic" especially of "Nam vang" which was more storable than "OMDN111", tended to have stronger and more complex chromatographic pattern than the rest of the treatments. The study established that organic is more effective than chemical approach in soybean seed production but the trend for biodynamic (in many cases the source of significant interaction between production practice and variety) merits follow-up studies.

INTRODUCTION

Soybean (*Glycine max* L.) is the most valuable grain legume and the third crop in importance after rice (*Oryza sativa*) and corn (*Zea mays* L.) in Vietnam. It is a rich source of oil and protein. It is also processed into popular products in Vietnam such as soya-cheese, soya-cake, soya-milk, and cooking oil. In Vietnam, soybean is grown in about 130,000 ha, of which 42,000 ha (33%) is grown in the south of the country, consisting of the Eastern region and the Mekong Delta (Yen Thao Tran 2004).

The demand in the production, consumption and processing of soybean in Vietnam is increasing. In order to increase soybean production to meet this demand, Vietnamese farmers are using high amount of chemical fertilizers and pesticides and intensive cropping practices. However, high-input practices such as heavy use of chemicals have created a variety of economic, environmental, ecological and social problems. Furthermore, the increasing costs of chemical inputs have left farmers helpless, resulting to decreasing seed quality of certain crops and resulting in the fall of commodity prices and consequently reducing farm incomes. In addition, in Vietnam, organic/sustainable agriculture is mistakenly equated with primitive, traditional, or subsistence agriculture and their low yields. Therefore, most Vietnamese farmers resist adopting sustainable agriculture for their crop production.

With the various problems brought about by the increased use of chemical inputs, high quality seed production, especially on a commercial scale, should be through an alternative system, such as organic and biodynamic farming. This means reduced or zero use of chemical fertilizers and pesticides, use of alternative nutrient sources like green manure crops, animal manure, compost, and the likes and more natural ways of pest and disease control, and an overall ecological approach to farming.

The beneficial effect of organic farming systems for crop production relative to the conventional system is already well established. However, in the Mekong Delta, Vietnam this has not been verified, most especially during the wet season when seed supply is low and seed demand is very high.

The general objective of the study is to assess soybean seed production in terms of productivity, quality and economics using traditional and non-traditional (or modern) varieties under chemical (synthetic/conventional) and non-chemical (organic and biodynamic) production system in the Mekong Delta.

MATERIALS AND METHODS

The experiment was conducted at the Cuu Long Delta Rice Research Institute (CLRRI) designated experimental field for soybean located in the Mekong Delta from May to November of 2005. The cropping dates fell under the normal wet season in Southern Vietnam. The laboratory part of the experiment, particularly the storage and seed quality testing, was conducted at the Seed Technology Department Laboratory, CLRRI, Vietnam.

The experiments was laid out in a split plot design with three replications at the CLRRI farm during the 2005 wet season. Main plots consisted of four production practices i.e. “organic” (cow manure at 40-105-10 NPK and botanicals); “biodynamic” (biodynamic preparations); “chemical” (synthetic fertilizers at 40-60-30 NPK and insecticides) and control (no inputs). Subplots consisted of two soybean varieties.

The rate of fertilizer (40-60-30) was recommended for soybean production in Mekong Delta. The amount of cow manure used was only based on the recommended rate of N. Hence, the total amounts of P and K applied per hectare (40-105-10) were not necessarily according to recommendation. The analysis for N, P, K, Ca, and Mg and C:N ratio of cow manure was made at the Soil Science Department, CLRRI, Vietnam (see Table). The cow manure was obtained from organically fed cows at Seed Technology Department, CLRRI. The biodynamic treatment and the control did not receive any fertilizers and pesticides.

The main plot size was 6 m x 11 m, the distance between main plots was 1 m; and the subplot size was 5.5 m x 6 m. All plots were separated with a 30 cm width x 20 cm depth furrow drain in order to prevent flooding which is a common phenomenon during the wet season. The harvest area in each subplot was 33 m^2. The distance between replication (block) was also 1 m and the same dimension of furrow drain as the treatment plots. The plant spacing was 40 cm between rows and 20 cm between plants.

Table 1: Amount of fertilizers applied and their corresponding nutrient equivalents.

Treatment	Amount Applied	Equivalent Amount				
		N	P	K	Ca	Mg
1. Chemical fertilizers	kg ha^{-1}					
Urea (46%N)	75.8	34.9	-	-	-	-
Super phosphate (16.5%P_2O_5)	378.8	-	62.5	-	-	-
Potassium chloride (60%K_2O)	50.5	-	-	30.3	-	-
Calcium nitrate (15.5% N, 19.5% Ca)	50.5	7.9			9.9	
Total amount		42.7	62.5	30.3	9.9	-
2. Organic fertilizer	kg ha^{-1}					
Cow manure (15% MC)	3030.3	39.6	104.9	9.4	3.1	0.3
3. Biodynamic preparations	g (or mL) ha^{-1}					
BD500	10	-	-	-	-	-
BD501	10	-	-	-	-	-
BD502	100	-	-	-	-	-
BD503	100	-	-	-	-	-
BD504	100	-	-	-	-	-

Data Collection: Agronomic traits taken were as follows:

a. *Leaf area index (LAI);* b. *Shoot and root biomass and nodule fresh weight;* c. *Crop growth rate (CGR).*
d. *Stover biomass at harvest, yield and yield components.*

From 12 sample plants used to determine stover biomass, plant height (cm), number of internodes and branches per plant were noted. The number of filled and unfilled pods and number of seed per pod were counted. Good seeds were collected from dried and shelled pods and weighed to represent seed yield. The 1,000-grain weight (g) was determined from the same samples. Seed moisture content was determined (fresh weight basis) right after weighing to be able to adjust seed yield and 1000-seed weight to 13% MC. Seed yield to stover biomass ratio was determined by the ratio of seed yield to stover biomass.

$$\text{Seed yield} = \frac{10{,}000\ \text{m}^2}{\text{harvest area in m}^2} \times \frac{Y_i}{1{,}000} \times \frac{100 - \text{MC}}{100 - 13\%}$$

Where: MC = moisture content of seed weighing.
Y_i = seed in kg per sample harvest area.

Seed quality analysis

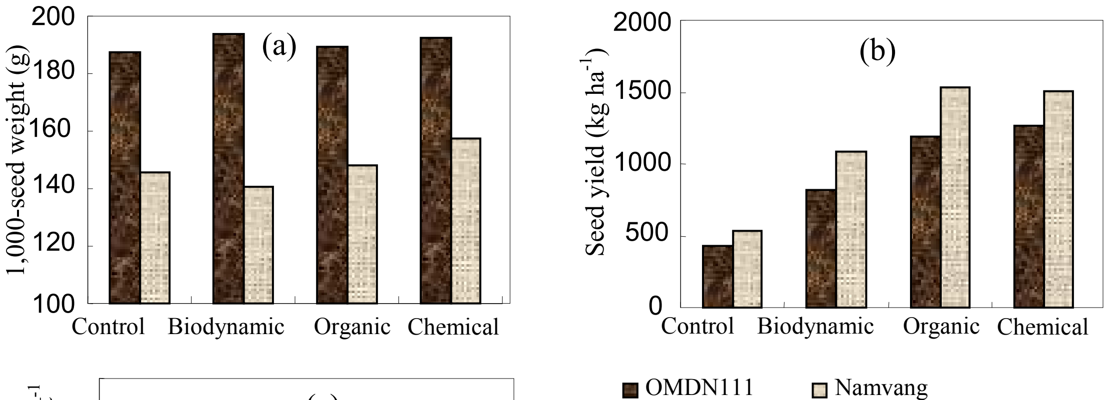
Seed quality parameters determined were: moisture content (MC), seed germination and vigor at harvest and seed storability under ambient condition expressed as germination and vigor (ISTA 1995), lipid and protein content and circular chromatographic pattern which is expresses biological and complexity, enzyme or biological activity of the seed (Pfeiffer 1999).

Statistical analysis of the data

Data was analyzed using the analysis of variance (ANOVA) procedure with the aid of IRRISTAT 5.0. Group comparison were made using orthogonal contracts, mainly to test significant different between control and other treatments, between biodynamic with organic and chemical, and between organic and chemical. General interaction between varieties and production practices was assessed using general ANOVA. Statistical analysis for parameters germination, field emergence and seed moisture content over time, a multiple analysis of variance was made where time was contributed as sub plot. Matrix correlation analysis among parameters was also made using the IRRISTAT 5.0 program. Graphs were created using the Microsoft Excel.

RESULTS AND DISCUSSIONS

The experiment revealed that seed yield from biodynamic, organic or chemical production practically the same and significantly higher by 50-66% than that of the control (Fig. 1b). Considering all parameters, the organic system was most favorable and yield wise it is comparable to the chemical system. The variety that is more suitable for seed production is Nam vang grown organically; it had the highest seed yield across production practices. The organic practice involved lower nitrogen fertilizer rate similar to the chemical (approximately 40 kg ha^{-1}) but this is an advantage giving a steady supply of nutrients over the different stages of growth, a phenomenon that is helpful especially during the wet season when leaching is severe. A contributory factor to the seed yield advantage of the organic system may be the amount of phosphorus applied. In the organic system, the equivalent amount of phosphorus applied was 105 kg ha^{-1} and it was only 62 kg ha^{-1} in the chemical system.



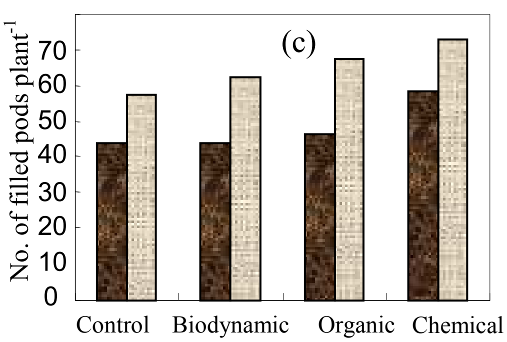


Figure 1. 1,000-grain weight, seed yield and number of pods $plant^{-1}$ at harvest of soybean varieties (V) under four production practices (T) in the Mekong Delta during 2005 wet season.

The lower yield of the modern soybean cultivar, OMDN111 relative to Nam vang is a function of the lower number of filled pods and lower leaf area index at pod filling stage (10WAP) (Fig. 1c and 2b). It shows that OMDN111 has lower adaptability to wet condition or marginal environment of Mekong Delta; the area has low soil pH (less than four). On the other hand, Nam vang variety showed high adaptability since it had been grown for hundreds years under the local condition. For sustainability, it is important that crops or varieties are specifically or adapted to the site where it is grown, otherwise, its potential will not be fully expressed (Lappay 2000).

The farmer-maintained variety, Nam vang, was not significantly different from OMDN111 in agronomic traits (shoot biomass, stover biomass, leaf area index, plant height, and crop growth rate), yield components (number of nodes per plant, number of pods per plant, number of branches per plant, 1000-seed weight) and nodule fresh weight (Fig. 2-4). Its higher seed density (1,000-grain weight) relative to Nam vang did not translate to higher yield.

Although seed yield given by biodynamic system was not significantly lower than that given by the organic and chemical systems, shoot biomass at pod filling stage of biodynamics was higher by 24-28% and crop growth rate as well for the two varieties (Fig. 4b and Fig. 5). This is not totally unexpected because in the biodynamic treatment, planting was done during a leaf day, which is known in biodynamic calendar (Don Bosco biodynamic calendar 2005) enhance leafiness, shoot or biomass.

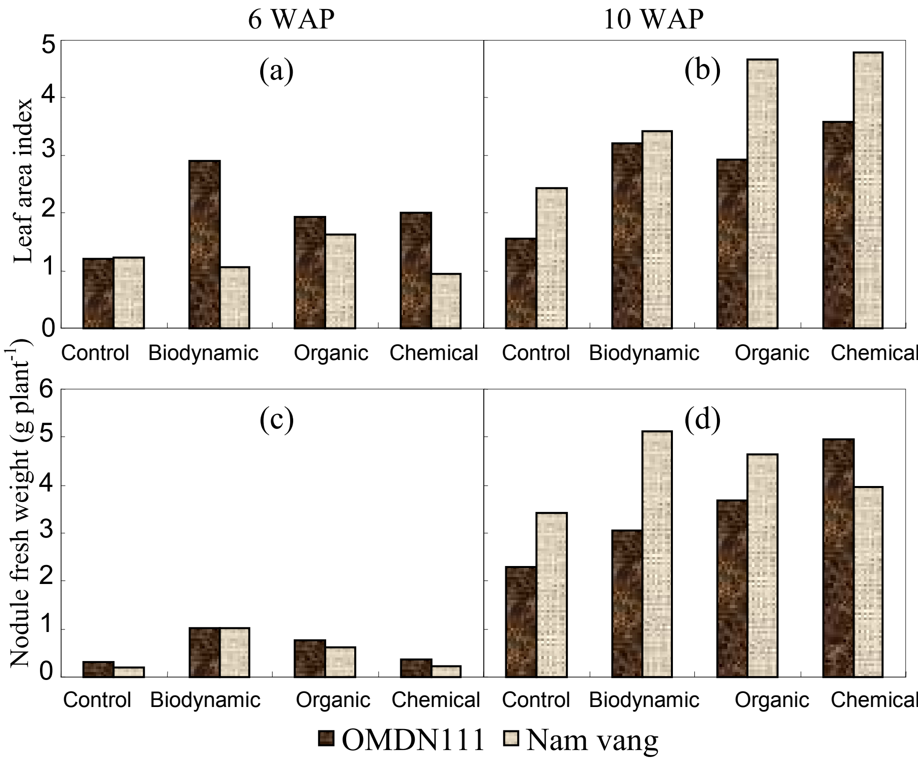
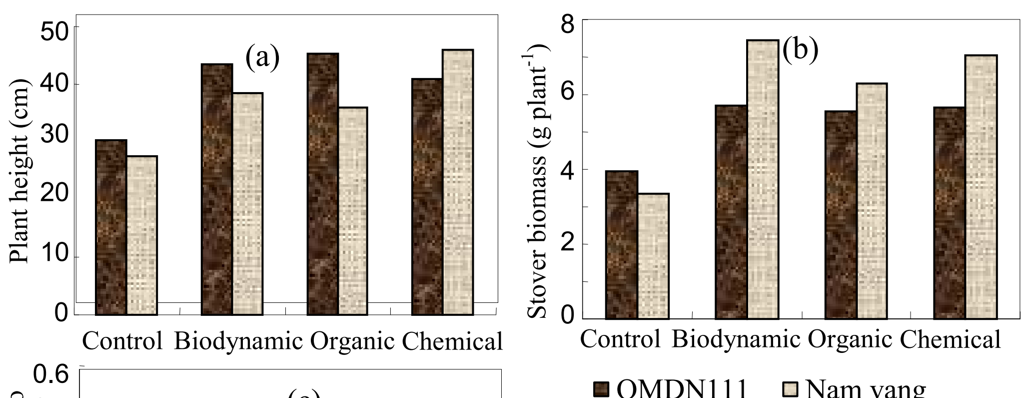


Figure 2. Leaf area index and nodule fresh weight at two stages (6WAP and 10WAP) of soybean varieties (V) under four production practices (T) in the Mekong Delta during 2005 wet season



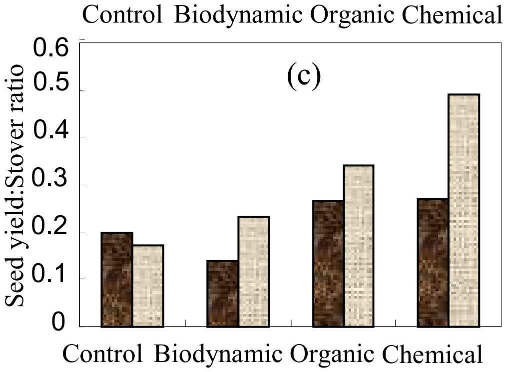


Figure 3. Plant height, stover biomass and seed yield: stover biomass ratio of soybean varieties (V) under four production practices (T) in the Mekong Delta during 2005 wet season

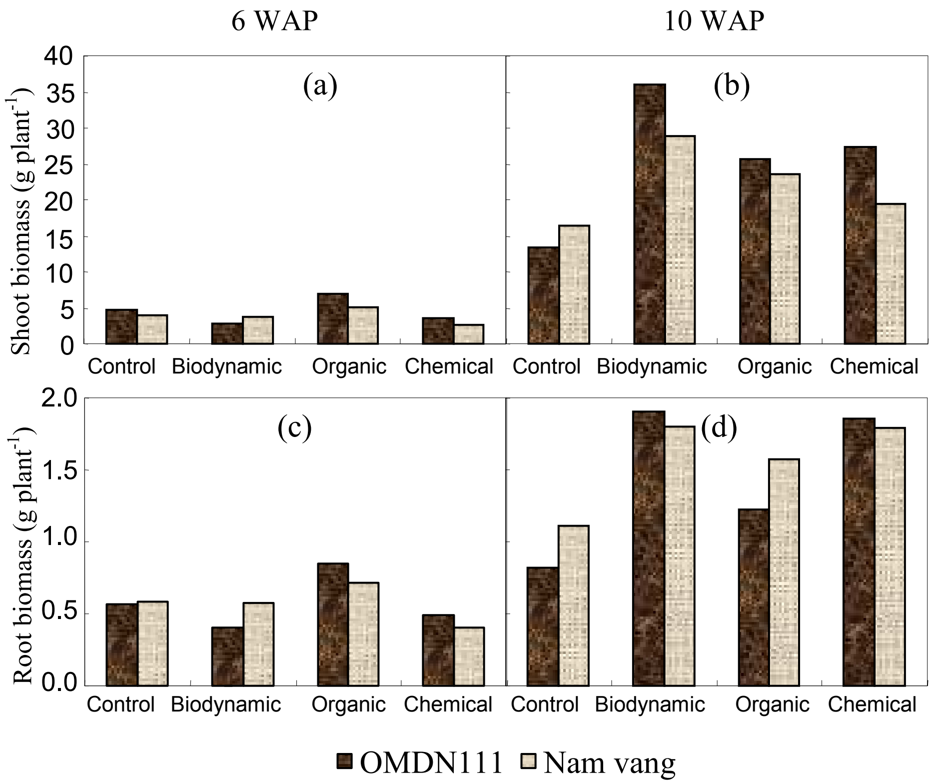


Figure 4. Shoot biomass and root biomass at two stages (6WAP and 10WAP) of soybean varieties (V) under four production practices (T) in the Mekong Delta during 2005 wet season

In terms of seed quality, the organic treatment also proved most effective among the production practices in enhancing storability expressed as germination and vigor (field emergence) (Fig. 6). Overall, however, seeds quality did not keep very long and by the 6th week germination level was already within 50% (Fig. 6). This is partly due to the relatively high initial moisture content (10-12%) (Fig. 7) and the high relative humidity during the air during storage period, coupled with the type of storage (airtight plastic jars). However, it may also be due to the timing of harvest. In this experiment, soybean seeds were harvested over the period of September 1st and 6th, 2005. In the biodynamic calendar, these are leaf and root day, respectively. In biodynamic, seeds are best harvested on a fruit/seed day to be most storable.

The control aside from having lowest yield also had the least germination and vigor after 6 weeks of storage when compared to the other production practices. This implies that there is a challenge to do seed production during the wet season, if none of the management practices were applied. With organic fertilizer application, protein content which was also highest in organic production practices may not be involved as a contributory factor to longevity because biodynamic which has high relatively high protein seed had also high moisture content, although no difference in lipid content (Fig. 8). The review of Fernandez (2002) detailed different seed storability between organic and chemical produced seed, and among organic, biodynamic and chemical produced seed. All point to the advantage of organic and especially biodynamic in keeping seeds longer.

The chromatograms, which indicate degree of biological or complexity or of the biological organization of a substance, proved more challenging to interpret. No published literature could be found detailing a similar study especially on soybean seed and experts on the subject affirmed this. Thus far, it may be considered a first attempt at least on soybean seed and in Vietnam. Despite the seemingly similar patterns of chromatograms at first glance, a closer examination indicated differences between varieties and among production practices (Fig. 9). Chromatograms of seeds grown from chemical production system gave weaker patterns than those from organic; this be inferred to be having lower protein organization and enzyme activity and thus contributory or translated to poorer storability of seeds that went under the same treatment. This is true for both varieties but seeds of OMDN111 which had been bred and maintained in chemical environment have weaker biological activity under organic than that in chemical production practices. Chromatogram pattern of seed under biodynamic system was consistently the best among the treatments. This confirms reports that quality of product given biodynamics is superior and with very high life forces (Podolinsky 1990). Considered a manifestation of this life force is photon emission of products. Lampkin (1995) showed in his review that vegetables grown chemically had lower photon emission than those in given organic treatment.

Although it was the first time to be applied in Mekong Delta and not all practices were according to recommendation (*e.g.* planting and harvesting were not on a fruit or seed day), the biodynamic production practice came close to organic in general performance. It gave improved soil properties especially in soil organic matter content and earthworm population (data not show); its seed yield was not significantly different from organic and chemical; it also gave good seed qualities such as high storability and high protein. The life form force and biological activity indicated by the chromatograms also affirm these. This production system maybe considered above other alternative farming practice in a way that it provides not only the food but the medicine within the food, including the necessary energy or "life force" that is needed for the development of the full human being potential (Perlas undated). Longer-term studies and techniques that are more refined could be the future agenda, *vis-à-vis* deepening in the study of scientific basis. Biodynamic farming's scientific basis already rides into quantum science, an area that is slowly gaining acceptance in institutions that are still highly framed within material science. When sufficiently understood, it would not be surprising to realize that many indigenous practices are according to quantum laws. They are currently greatly misunderstood although many of the practices are now explainable through the science that encompasses biodynamic farming, and such are associated in metaphysics, or quantum mechanics, rather than the conventional scientific body of knowledge.

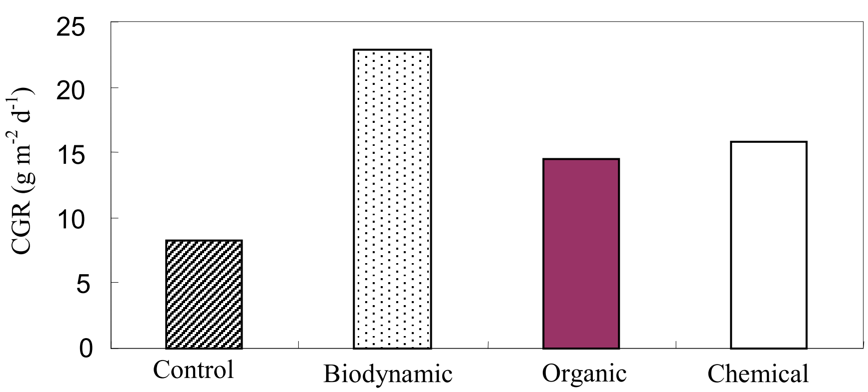


Figure 5. Crop growth rate from 6-10WAP of soybean varieties (V) under four production practices (T) in the Mekong Delta during 2005 wet season

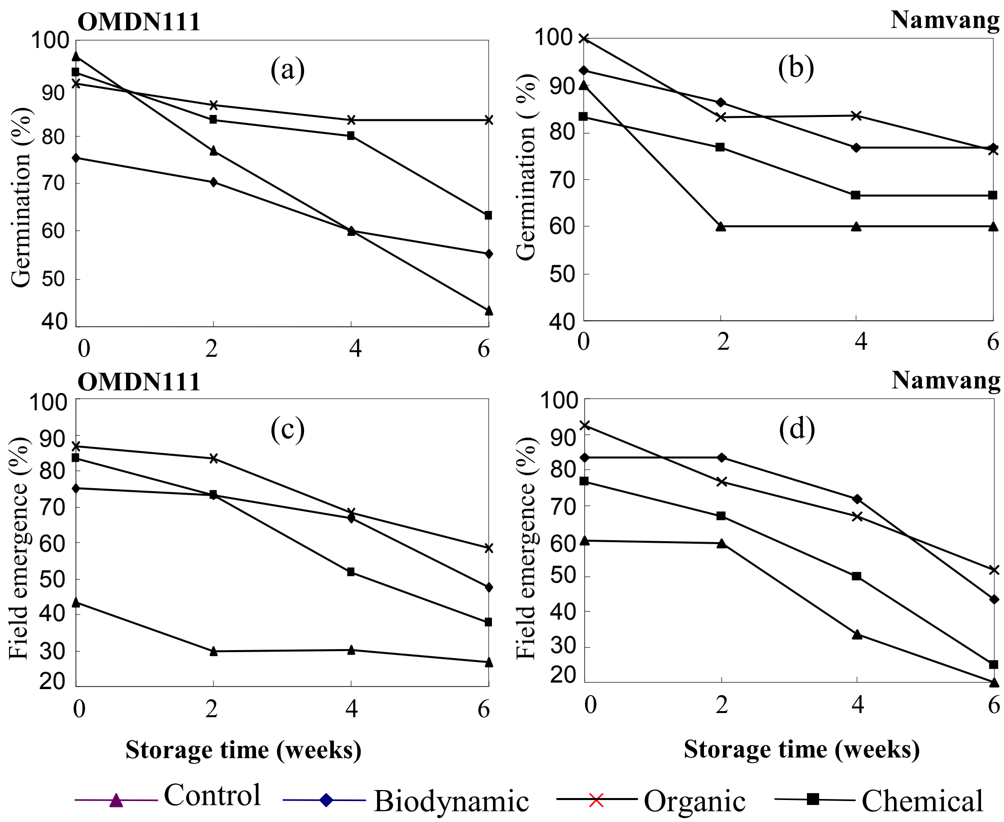


Figure 6. Soybean seed germination (%), field emergence (%) of varieties (V) for different production practices (T) stored in plastic bottles at ambient condition.

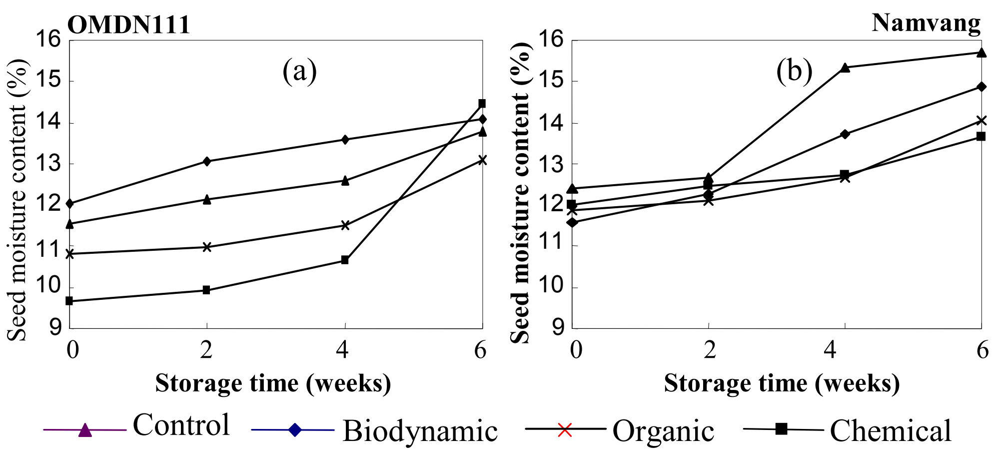


Figure 7. Seed moisture content of two soybean varieties (V) under four seed production practices (T) and stored in plastic bottles at ambient condition.

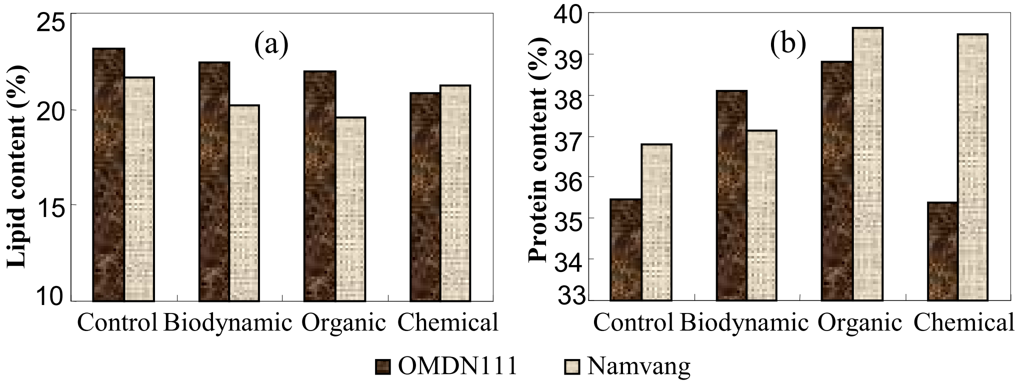


Figure 8. Lipid and protein content of seeds of soybean varieties (V) under four production practices (T) in the Mekong Delta during the wet season 2005.

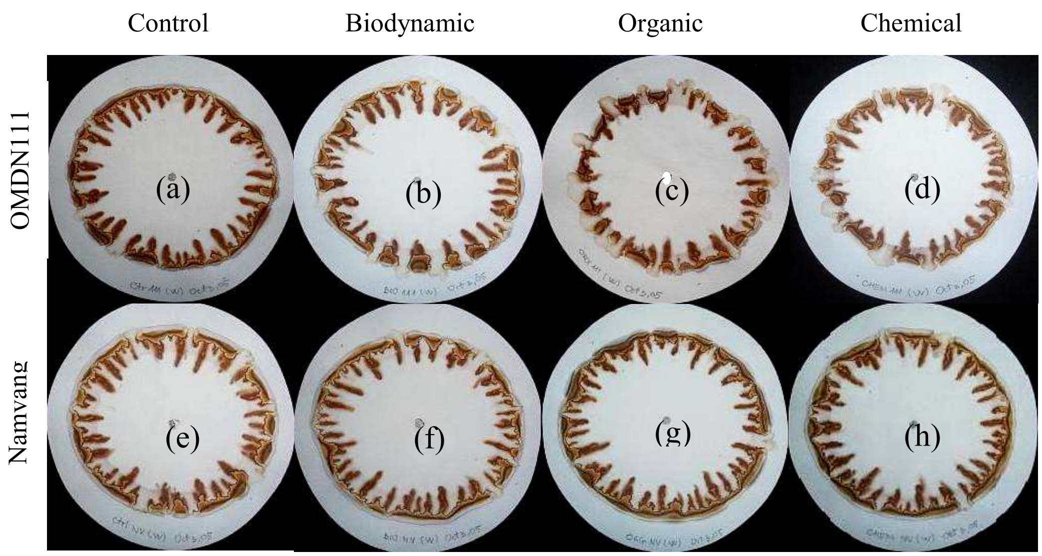


Figure 9. Seed chromatograms of soybean varieties given four different production practices in CLRRI during wet season 2005.

DISCUSSION AND CONCLUSIONS

Based on the results, it can be concluded that organic soybean crop or seed production using cow manure and botanicals (garlic, chili and lemon grass) is feasible but need to be validated if indeed differences from biodynamic approach. Despite the many parameters that point to organic being most advantageous over other practices, its seed yield, storability and biomass were also not significant to that of biodynamic over all. It was the fist time to investigate the effect of biodynamic production practices in the Mekong Delta but the effect of biodynamic seems to point towards greater benefits considering no fertilizer and pesticide application. Verifying its effect whether similar or better than organic in soil health and plant resistance is an encouraging study agenda for the future. Parameters such as seed yields, plant biomass production effect and the seed performance (like storability) maybe studied while chromatography analysis maybe further explored.

Further research should be conducted over extended periods and verified on another wet season as well as during the dry season. This way different status or levels of soil health and fertility could be included. Other environmental context such as various locations may also be used to establish interaction with the environment. Chemical agriculture should not predominate in soybean production or in any other endeavor as the short and long term effects are already well documented. The methodology in assessing chromatograph analysis could be improved. Research should also be extended to more than one season to determine the residual effects of different production practices. Long-term effects on the externalities such as soil erosion and degradation, nutrient leaching and pollution of water, air and human health related to fertilizer sources and pesticides should be looked into.

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So sánh năng suất và chất lượng hạt giống của hai giống đậu tương (*Glycine max* (L.) Merr.) mới và địa phương dưới tác động của biện pháp kỹ thuật canh tác, động sinh học, hữu cơ và hóa học tại Đồng bằng sông Cửu Long

Thí nghiệm được thực hiện tại Viện Lúa ĐBSCL, vụ Hè Thu năm 2005 nhằm so sánh năng suất và chất lượng hạt giống đậu tương (*Glycine max* (L.) Merr.) giữa giống mới được lai tạo ("OMDN111") và giống địa phương ("Nam Vang") dưới tác động của bốn kỹ thuật canh tác: "hữu cơ" (phân bò ủ hoai 40-105-10 NPK và thuốc trừ sâu bệnh chiết xuất từ thực vật); "động sinh học" (sản phẩm "động sinh học"); "hóa học" (40-60-30 NPK và thuốc trừ sâu bệnh hóa học) và đối chứng (không phân thuốc). Các nghiệm thức được bố trí theo phương pháp lô phụ 4 x 2 (với phương pháp canh tác là lô chính và giống là lô phụ), theo khối hoàn toàn ngẫu nhiên, ba lần lặp lại.

Kết quả cho thấy giống đậu tương Nam Vang có kích thước hạt nhỏ nhưng cho năng suất cao hơn, và chất lượng hạt giống cũng tốt hơn về tỉ lệ nảy mầm và sức sống của hạt giống ở giai đoạn ngay sau khi thu hoạch và trong 6 tuần bảo quản. Nam Vang cũng cho hàm lượng protein tổng cao hơn OMDN111 đặc biệt trong nghiệm thức "hữu cơ". Sự khác biệt về các chỉ tiêu về thành phần năng suất giữa hai giống biến thiên ổn định trong tất cả các nghiệm thức. Nghiệm thức "động sinh học" cho kết quả khác biệt không có ý nghĩa so với các nghiệm thức "hữu cơ" và "hóa học" ở các chỉ tiêu số trái có hạt, chỉ số diện tích lá và trọng lượng nốt sần (tươi). Kết quả phân tích hạt trên giấy sắc ký, các hoa văn chỉ thị cho sự phức hợp sinh học và sự hoạt động của các enzyme cho thấy có sự khác nhau giữa hai giống và giữa các kỹ thuật canh tác. Hoa văn trên giấy sắc ký ở kỹ thuật canh tác "hữu cơ" và "động sinh học", đặc biệt đối với giống địa phương Nam Vang có xu hướng phức tạp hơn hai nghiệm thức còn lại.