

Short communication. Agronomic comparison between organic rice and biodynamic rice

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Abstract

Biodynamic agriculture is a type of organic agriculture which has been applied successfully to different crops, including rice. Due to the lack of published studies comparing biodynamic and organic rice, the objective of the present study was to compare the performance of rice (*Oryza sativa* L.) under these two agronomical methods. Two varieties were transplanted mechanically in Pego-Oliva Natural Park (Alicante, Spain) under continuous flooding, without fertilization or rotation. Grain yield was not significantly different between methods of culture (4,188 vs 4,237 kg ha⁻¹ under organic and biodynamic agriculture, respectively). In our study, grain yield was not significantly different between varieties either (4,228 vs 4,199 kg ha⁻¹ for 'Bomba' and 'Albufera', respectively), but whole grain milling yield was higher in 'Albufera' than in 'Bomba' (66% vs 55.4%). It is concluded that in these conditions and with these varieties, both methods yield equally.

Additional key words: ecological agriculture; mechanical transplanting; *Oryza sativa*.

Resumen

Comparación agronómica entre arroz ecológico y arroz biodinámico

La agricultura biodinámica es un tipo de agricultura ecológica que ha sido utilizada con éxito en varios cultivos, incluyendo arroz. Debido a la falta de estudios publicados que comparen el arroz ecológico con el arroz biodinámico, el objetivo del presente estudio fue comparar el comportamiento del arroz (*Oryza sativa* L.) bajo estos dos métodos de cultivo. Dos variedades fueron transplantadas mecánicamente en un parque natural de Pego (Alicante, España), bajo riego continuo por inundación, sin fertilizantes ni rotación. La productividad no fue significativamente distinta entre métodos de cultivo (4.188 frente a 4.237 kg ha⁻¹ en cultivo ecológico y biodinámico, respectivamente). En nuestro estudio, no hubo diferencias de productividad de grano entre variedades (4.228 frente a 4.199 kg ha⁻¹ en 'Bomba' y 'Albufera', respectivamente), pero el rendimiento de granos enteros en molino fue mayor en 'Albufera' que en 'Bomba' (66% frente a 55.4%). Se concluye que, en estas condiciones y con estas variedades, ambos métodos producen igual.

Palabras clave adicionales: agricultura ecológica; *Oryza sativa*; transplante mecánico.

The label «Organic Agriculture» protects those agricultural goods which are produced, elaborated and conserved without synthetic chemicals (Aguilar *et al.*, 1999). The use of manure as a general agricultural fertilizer goes back at least to the Roman empire (Maroto, 1998), but modern organic agriculture (also called ecological or biological agriculture, depending on the country) was born in 1924 for a range of crops. That year, two methods were independently developed, by two different authors. Sir Albert Howard travelled to

India to teach western agricultural techniques, but became more interested in traditional Indian agricultural practices. Between 1924 and 1931 he refined an Indian composting system, calling it Indore method (Howard, 1943). The second method was published by Rudolf Steiner (1924) as a course given to farmers in Poland, and was named biodynamic agriculture. This method differs from properly called organic agriculture in the use of special preparations—in addition to compost or manure—, consisting in mixed animal, plant and mineral products, that stimulate soil organisms. Biodynamic agriculture began to be applied to rice in Australia in 1980, in rotation with pastures (<http://>

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Received: 10-03-10; Accepted: 21-01-11.

www.bdgrowing.com/mediaLibrary/files/PDF/BiodynamicRice.pdf). In Egypt, Sekem cooperative also grows biodynamic rice (Abouleish, 2004). Reganold *et al.* (1993) found that biodynamic farms had better soil quality than the neighbouring conventional farms with several crops (vegetables, apples, pears and cereals) in New Zealand. No literature was found comparing both methods in rice.

The objective of the present study was to compare the performance of rice (*Oryza sativa* L.) under two agronomical methods, organic and biodynamic.

The trials were set up under continuous flooding in Pego-Oliva marshland (38° 52' 21" N 0° 3' 47" O), a Natural Park which is flooded in winter for duck hunting; this prevents crop rotation. Soil properties are (Dominguis *et al.*, 2007): loamy/clay-loamy texture; average oxidizable organic matter, 12.9%; mean N content 0.47%; 93.2 mg of available P kg⁻¹ (Olsen method) and an average of 461 mg K⁺ kg⁻¹. Since nutrient and organic matter contents were high, it was not considered necessary to apply any fertilisation in either culture. Rice was transplanted mechanically. The only difference between methods was that in the biodynamic plots, the following preparations were applied (Wistinghausen, 2000):

— Preparations «Maria Thun» (named by its author, prepared in 20 min and directly applied to the soil) and «500» (cow dung inside cow horn, prepared in 60 min). Applications were made before transplanting, on dry soil, with a spray of big drops.

— Preparation «501» (silica inside cow horn, prepared in 60 min). Applied just after transplanting, when the plant had expanded three leaves.

In 2005, a preliminary test was made with the variety 'Bomba' (traditionally used for *paella*, a typical Spanish rice dish), comparing the grain yield of two adjacent plots (one organic and one biodynamic). Both plots were sown with seed from the same lot, harvested in 2004.

From 2007 to 2009, a replicated trial was set up with two varieties: 'Bomba' and 'Albufera'. 'Albufera' is a recent variety obtained by the Rice Department (*Instituto Valenciano de Investigaciones Agrarias*, IVIA), with a culinary quality similar to 'Bomba', but shorter (it lodges less than 'Bomba'). There were 4 replicates per treatment combination (16 plots in total). Each individual plot had four plant rows 13.5 m long, with 15 cm spacing between plants and 30 cm between rows. In order to avoid contamination of organic with biodynamic treatments (due to water runoff), organic plots

were located closer to the entry of the irrigation channel (upstream) than biodynamic plots, with a separation of 3 m between treatments. The same field was used during the three years. In 2007, the seeds in the transplanted bed did not emerge properly and only 12 plots were transplanted. Grain yield (expressed at 14% relative humidity) and milling yield (both percentage in weight of whole grains —also called head rice— and of broken grains after milling) were determined.

In the 2005 trial, grain yield means of both methods were statistically compared by the Student-t test. Results of 2007-2009 trial were submitted to unbalanced analysis of variance, where cropping methods were treated as two localities (they occurred in the same marked places throughout the three years). SAS statistical package was used (SAS Institute, 2002-2003). The percentage of broken grains after milling and the total milling yield (whole grain yield + percentage broken grains) were transformed by the square root, in order to normalize their distribution.

The mean grain yield in the 2005 test was similar under organic and biodynamic culture (4,987 and 4,962 kg ha⁻¹, respectively).

The analysis of variance of the 2007-2009 trials are shown in Table 1. Grain yield and total milling yield were at par in both the methods and varieties. In accordance with this, Carpenter-Boggs *et al.* (2000) found no significant differences in yield of wheat (*Triticum aestivum* L.) and lentil (*Lens culinaris* L.) cultured under organic *versus* biodynamic agriculture, although the yield of lentil per unit of plant biomass was higher.

Whole grain yield and the percentage of broken grains varied significantly between varieties: 'Albufera' kernels broke less in the mill than 'Bomba' kernels, and showed higher head rice recovery.

Table 2 shows the means of the variables showing significant Culture × Variety × Year interaction. The only significant differences between cultures occurred in two cases in 2009, favouring the biodynamic method: 'Albufera' yielded significantly more under biodynamic culture than under organic culture, while 'Bomba' had greater total milling yield under biodynamic culture than under organic culture. In 2009, grain yield was about half the yield in the other years. There are several reasons for this: first, a bad condition of the plantlets grown in the transplanting trays; second, the soil was not levelled and some transplanted plants got drowned; finally, there were more weeds than in other years. This affected more 'Bomba' than 'Albufera', and affected more the organic than the biodynamic plots.

Table 1. Mean squares from the analysis of variance of grain yield and milling yield of two rice varieties under organic and biodynamic culture during 2007-2009

Source of variation	df ¹	Grain yield (kg ha ⁻¹)	WGY ² (%)	%Broken ³	TMY ⁴ (%)
Culture	1	71,737 ^{NS}	19.7 ^{NS}	0.1 ^{NS}	0.0005 ^{NS}
Error (Culture)	6	1,085,973	9.1	0.1	0.0009
Year	2	27,273,057 ^{***}	455.8 ^{***}	3.4 ^{**}	0.2 ^{***}
Culture × Year	2	1,880,208 ^{NS}	95.9 ^{NS}	1.5 ^{NS}	0.001 ^{NS}
Error (Year)	11	279,172	21.8	0.3	0.0004
Variety	1	455,091 ^{NS}	963.6 ^{***}	19.8 ^{***}	0.003 ^{NS}
Culture × Variety	1	853,276 ^{NS}	0.1 ^{NS}	0.2	0.00002 ^{NS}
Year × Variety	2	6,737,992 ^{NS}	145.0 ^{NS}	1.6 ^{NS}	0.007 ^{NS}
Error (Variety)	6	460,187	29.0	0.2	0.0007
Culture × Year × Variety	2	2,881,794 [*]	83.7 ^{NS}	1.1 ^{NS}	0.002 [*]
General error	9	519,067	20.0	0.3	0.0005 ^{NS}
R ²		0.96	0.95	0.94	0.99
CV (%)		17	7	18	25
Organic mean		4,188 ^a	59.68 ^a	12.18 ^a	71.86 ^a
Biodynamic mean		4,237 ^a	62.13 ^a	9.84 ^a	71.97 ^a
Bomba mean		4,228 ^a	55.4 ^b	16.3 ^a	71.7 ^a
Albufera mean		4,199 ^a	66.0 ^a	6.1 ^b	72.1 ^a

¹ df: degrees of freedom. ² WGY: whole grain yield. ³ %Broken: percentage of broken grains. ⁴ TMY: total milling yield. NS: non significant. *, **, ***: significant differences at $p(\alpha) \leq 0.05$, 0.01 and 0.001, respectively. Means followed by the same letter in each column do not differ significantly after Duncan test.

In two other studies of organic rice, the first made in the same marsh, also with mechanical transplanting (Dominguis *et al.*, 2007), the second made in the lake Albufera (Valencia) (Garcia *et al.*, 2010), ‘Albufera’ was on average more productive than ‘Bomba’, but the difference was again not statistically significant. In these two trials, ‘Albufera’ also showed on average a higher whole grain yield and a lesser percentage of broken grains than ‘Bomba’ (but it was not significant in the first trial). Under conventional culture, ‘Albufera’ grains also break less in the mill than Bomba’s, but

in addition of that, grain yield is higher (Ballesteros, 2005).

It is concluded that, under the conditions of these trials, organic and biodynamic culture showed similar grain yield and milling yield in both varieties.

Acknowledgements

This study was financed by the *Conselleria de Agricultura, Pesca y Alimentación (Generalitat Valenciana, Spain)*,

Table 2. Means of variables showing Culture × Variety × Year interaction

	Organic			Biodynamic		
	2007	2008	2009	2007	2008	2009
<i>Grain yield (kg ha⁻¹)</i>						
Bomba	6,410 ^a	5,167 ^a	2,047 ^c	6,105 ^a	5,240 ^a	1,881 ^c
Albufera	4,721 ^{ab}	4,949 ^{ab}	2,523 ^c	5,363 ^a	3,616 ^b	4,154 ^b
<i>Total milling yield (%)</i>						
Bomba	73.3 ^{ab}	73.0 ^b	69.4 ^d	72.8 ^b	72.8 ^b	70.1 ^c
Albufera	72.0 ^b	73.7 ^a	70.3 ^c	72.8 ^b	73.5 ^a	70.3 ^c

Means followed by the same letter in each column do not differ significantly at $p(\alpha) \leq 0.05$.

under development project ref. 2007TAHALI00006.
J. Sanchís made and applied biodynamic preparations.
V. Dominguis S. supplied technical help.

References

- ABOULEISH I., 2004. Die Sekem-vision. Mayer, Stuttgart, Germany. [In German].
- AGUILAR M., ESPINOSA M., CONTRERAS J.M., 1999. Producción integrada de arroz en Andalucía. *Agrícola Vergel* 209, 328-336. [In Spanish].
- BALLESTEROS R., 2005. Variedades de arroz del IVIA. *Agrícola Vergel* 281, 212-215. [In Spanish].
- CARPENTER-BOGGS L., REGANOLD J.P., KENNEDY A.C., 2000. Biodynamic preparations: short-term effects on crops, soils, and weed populations. *Am J Altern Agr* 15(3), 110-118.
- DOMINGUIS R.V., JUAN M., CARRERES R., GARCÍA A., BALLESTEROS R., DOMINGUIS S.V., 2007. Rendimiento de distintas variedades de arroz en cultivo ecológico en Alicante. *Agrícola Vergel* 305, 248-252. [In Spanish].
- GARCÍA A., CARRERES R., ZREIK C., RIBO M., GIMÉNEZ M., 2010. Comparación agronómica de variedades de arroz bajo cultivo ecológico en la Albufera de Valencia. *Agrícola Vergel* 335, 58-60. [In Spanish].
- HOWARD A., 1943. *An agricultural testament*. Oxford Univ Press, Oxford, UK.
- MAROTO J.V., 1998. *Historia de la agronomía*. Mundi-Prensa, Madrid. 371 pp. [In Spanish].
- REGANOLD J.P., PALMER A.S., LOCKART J.C., MACGREGOR A.N., 1993. Soil quality and financial performance of biodynamic and conventional farms in New Zealand. *Science* 260, 344-349.
- SAS INSTITUTE, 2002-2003. SAS 9.1. Cary, NC, USA.
- STEINER R., 1924. *Geisteswissenschaftliche grundlagen zum gedeihen der landwirtschaft*. Steiner Verlag, 1985 edition. Dornach, Switzerland. [In German].
- WISTINGHAUSEN C. Von, 2000. *Elaboración de los preparados biodinámicos*. Ed Rudolf Steiner, Madrid. [In Spanish].