THE EFFECT OF FERTIGATION WITH SWINE WASTEWATER ON YIELD AND SEED QUALITY OF DRY BEANS

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1 INTRODUCTION

The technological improvement of pork meat production reflects on the production increase of liquid waste (swine wastewater - SWW), which may cause environmental problems if it is not applied a correct management (Fernandes & Oliveira, 2006; Cruz et al. 2008). This is due to the high content of organic matter, solids, nutrients, heavy metals and pathogens. However, the wastewater use, mainly for annual crops irrigation, is an available alternative to this problem since it shows a high content of nutrients (Cruz, 2008; Gomes Filho et al., 2001).

The wastewater application on crops using fertirrigation has shown satisfactory results regarding the utilization of nutrients. Freitas et al. (2005) have worked with swine wastewater in corn silage and found out an increase on dry matter yield of the plants in relation to irrigation water, as well as an increase in all yield components evaluated for the SWW treatment, even in higher doses than the recommended ones.

There are several studies in the literature showing the benefits of swine wastewater application for irrigation associated to the development of different crops (Baumgartner et al., 2007, Gomes Filho et al. 2001). But, there are a few studies concerning the bean crop and the relationship between the wastewater application as well as the quality of produced grain.

The vegetal protein sources have been widely used for human consumption, due to its low cost and low fat content when compared to foods based on animal. Furthermore, it is considered a traditional Brazilian food, consumed almost everywhere in the country. It is also cropped during all months of the year, in a wide range of ecosystems and besides its protein, it is an important source of carbohydrates, minerals and fiber (Faria et al., 2003) in beans, justifying the effort throughout the production chain to ensure its domestic supply. This has a great relevance not only for production, but also for the quality of this product.

The produced grain quality can be influenced by the management systems. According to Kigel (1999), the application of nitrogen and sulfur in beans, especially in poor soils, increases protein and sulfur amino acids such as methionine and cysteine. According to Andrade et al. (2002), fertilization levels that promote high bean yield can lead to an increased protein content of grain.

Technological and nutritional quality of beans is as important as productivity, which will reach the final consumer. The beans quality can be determined primarily by the consumers' acceptability, given by the technological characteristics of cooking time, water absorption, color of the product, as well as its nutritional characteristics. However, technological and even nutritional quality changes during the storage of the product (Bragantini et al., 2005).

Therefore this study evaluated some changes in nutritional and technological quality during storage of beans, grown with swine wastewater, also comparing with the conventional sprinkler irrigation system and a non-irrigation control.

2 MATERIALS AND METHODS

2.1 Material

The experiment was carried out at the Experimental Center of Agricultural Engineering – UNIOESTE, in Cascavel - PR, (latitude 24°57'21" S; longitude 53°27'19" W and altitude 781 m). The experiment was set in a 1728 m^2 area. The common bean sowing, IAPAR 81 cultivar, was manual in a consortium between jatropha and hybrid maize, without chemical fertilization. The distance among bean plants was 8 cm and 60 cm between rows from the maize and 60 cm from the jatropha. The experiment was divided in three blocks and each one was divided into three plots, with one different treatment per block, which were: swine wastewater irrigation (T1), conventional irrigation (T2) and non-irrigation system (T3). Application of T1 and T2 began at 30 days of sowing of beans, with four applications of these treatments at each 15 days. The wastewater was supplied by swine farm located in Toledo, Pr after integrated bio-system (on-site bioreactor). The wastewater treatment (T1) and conventional irrigation (T2) were carried out with irrigation rates of 65 m^3 ha^{-1} for each aplication. The crop practices aimed the maximum control of insects and weeds.

TABLE 1 **Physicochemical analysis of the SW treatment applied to the T1**

NUTRIENT	**$mg.kg^{-1}$**
Nitrogen	37.56
Phosphors	5.71
Potassium	6.0
Calcium	3.05
Magnesium	1.1
Sulphur	0.6
Carbon	19.20
Organic Matter	33.02

Source: Laboratory of Water Analysis – SOLANÁLISES® (2008).

2.2 Components of production and productivity of bean crop

At harvest, the beans for each plot were randomly collected from ten plants, which were used for the analysis of agronomic parameters. Based on these samples, water content by standard method of oven (RAAS) was determined and by direct measurement, the analyses of pods number per plant, number of grains per pod, number of grains per plant, average height of each plant and insertion of the first pod were performed (Bassan et al, 2001).

The yield of each treatment was estimated by weighing the mass of dry grains of each replication, dividing by the practical area of two rows of beans (28.8 m^2 of each plot) and multiplied by 10,000 to change to $Kg.ha^{-1}$, expressed with a 13% moisture content.

2.3 Cooking Quality

Determination of cooking time by the adapted Mattson cooker: the analysis was according to the adapted method, proposed by Proctor and Watts (1987): approximately 30 g seed were soaked overnight in deionized water and a Mattson bean cooker was used to test 25 seeds at a time. Cooking time was the mean time over four replications, when 50% of the beans were cooked, as indicated by plunger dropping, penetrating each bean.

2.4 Experimental design and statistical analysis

The experiment was carried out in a complete randomized block design (CRB) in factorial scheme with three kinds of irrigation as plots with three replications. For data analysis, it was applied a Sisvar software, while data were submitted to analysis of variance (ANOVA) and Tukey mean comparison (Tukey test) with a significant level ≤ 5%.

3 RESULTS AND DISCUSSION

It can be seen in Table 1 that there were no significant differences among treatments for any of the measured yield components, except for the number of grains per pod, which was higher in treatment using fertirrigation with swine wastewater.

TABLE 1 **Components of the common bean production in treated swine wastewater (T1), conventional irrigation (T2) and non-irrigated treatment (T3).**

	Yield ($Kg\ ha^{-1}$)	NPP	NGP	*NGPl*	*MHP*	FPI	Cooking time (min)
T_1	1233.8 a	20.1 a	6.1 a	124.2 a	100.3 a	15.8a	25.41a
T_2	1137.7 a	21.0 a	5.6b	129.8 a	97.1 a	15.9 a	22.41a
T_3	1341.4 a	20.6 a	5.4 b	111.5 a	102.3 a	14.1 a	18.50 a
$F_{calculado}$	0.575 ns	0.036n	14.773*	0.386ns	0.239ns	1.287ns	0.23 ns
CV	18.81	19.49	2.74	18.46	9.32	10.24	11.16 %

Means followed by the same letter in column do not differ by Tukey test at 5% significance level.
NPP: number of pods per plant; NGP: number of grains per pod; NGPl: number of grains per plant; MHP: mean height of plant and FPI: first pod insertion; ns: non-significant; * significant for 95%; CV: variation coefficient.

During the experimental period, there was no water deficit for the crop. So, this may explains why there was no difference in productivity of irrigation treatments (T1 and T2) when compared to beans grown in non-irrigation system. Andrade Júnior et al. (2002) evaluated yield components, grain productivity and technological characteristics of common bean cultivars and observed that the grain yield ranged from 2.251 kg ha^{-1} to 3.587 kg ha^{-1}, highlighting a superior average of productivity, ie, 3.046 kg ha^{-1}. Although, in this experiment, productivity did not exceed 1,350 kg ha^{-1}, it was superior to the average productivity of Paraná state.

There was no significant difference in the number of pods per plant, number of grains per plant, average plant height and first pod insertion. The number of grains per pod was the only one higher in beans irrigated with SWW. Lemos et al. (2004) pointed out that the number of pods per plant, number of grains per plant and grain weight are correlated with grain yield, which also did not differ among the treatments.

Andrade et al (2004) evaluated yield components in common beans and observed an increase in the number of pods per plant according to the increased levels of nitrogen applied, although the values found in the studied cultivars were lower than the ones from trial. Gonçalves and Maciel (2008) studied the use of swine biosolids on bean production and found out that the application of 6,000 $Kg.ha^{-1}$ stimulated a higher yield, but higher amounts showed inhibitory effect, probably due to the excess of some nutrients.

In this study, there were no significant differences in plant heights and first pod insertion, but there was a greater plant height in common beans cropped in a non-irrigated system, which was shorter regarding insertion of first pod. Rubin et al. (2002) studied the growth of bean plants, irrigated and cropped in a no-tillage and conventional system and observed that for plant height, there was no significant difference between the systems of soil management (no-tillage and conventional system), but for the water irrigation management, the plant height was 6.03% higher.

The cooking time did not show significant differences among treatments, but the grains grown with SWW showed an extra cooking time of seven minutes than the non-irrigated system. Thus, more studies are needed to prove that the SWW application does not change cooking quality of the product, especially during the storage of these grains.

4 CONCLUSIONS

It can be concluded that SWW application in Parana, Brazil did not affect the productivity or the components of bean production nor the technological quality.

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