Research Note

"AJÍ DULCE" (CAPSICUM CHINENSE) *YIELD AS AFFECTED BY CROTALARIA* (CROTALARIA JUNCEA) *AND A COMMERCIAL ORGANIC FERTILIZER*[1,2]

Ana Negrete[3] *and Elide Valencia-Chin*[4]*

J. Agric. Univ. P.R. 102 (1-2):83-88 (2018)

The challenge of producing a greater amount of food combined with concerns over the long-term sustainability of conventional production methods has increased interest in the potential for organic farming. Organic farming is just emerging in Puerto Rico, and many factors need to be explored. For one, organic farms are known to be susceptible to nitrogen (N) limitations because they rely on organic sources of N or those derived from natural processes. Such sources include fixed N from cover crops and green manure, compost produced from on-farm or off-farm materials, processed or composted manures from on-farm or off-farm sources and organic fertilizers purchased. All of these sources differ in cost, nutrient content, mineralization rate and environmental impact.

An ongoing challenge for organic farmers regarding N availability for subsequent crops is the lack of synchrony between N released by the cover crop and N demand of the subsequent crop. This can happen for two main reasons: (1) Residue materials decompose slowly and, therefore, N supply may come too late for crop demand or, (2) Residue materials decompose rapidly and N supply comes too early for crop demand and is lost to the environment (Baijukya et al., 2006).

Extensive research has been conducted with the tropical legume crotalaria (*Crotalaria juncea*) to improve soil fertility and it is the most widely used cover crop species in this genus. In the United States, this species is grown as a summer crop in Hawaii, Texas, Florida and Arkansas. The use of this cover crop is highly recommended not only because of its nitrogen contribution to the soil, but also because it suppresses weeds and nematodes, improves soil tilth and water holding capacity and reduces erosion (Giller, 2001). Studies in southeastern United States have suggested that crotalaria is well suited for use as a cover crop and green manure, as it has been proven to contribute up to half of the N needed by the subsequent crop (Balkcom and Reeves, 2005; Mansoer et al., 1997; Schomberg et al., 2007).

The use of composted manure in organic farms is highly recommended but can result in a significant reduction in N availability in the short term (Watson et al., 2002). However, composted manure can play a more long-term role in building soil fertility (Watson

[1]Manuscript re-submitted to the Editorial Board 5 March 2018.

[2]This work was supported by the Department of Agriculture of Puerto Rico and the Agricultural Experiment Station of the University of Puerto Rico, Project FIDA-012.

[3]Former Graduate Student, Department of Agroenvironmental Sciences. University of Puerto Rico, Mayagüez Campus.

[4]Professor, Department of Agroenvironmental Sciences. University of Puerto Rico, Mayagüez Campus. Tel.: 787-265-3852. *Corresponding author: *E-mail address*: elide.valencia@upr.edu

et al., 2002). An alternative to composted manure made from on-farm materials, may originate from commercial sources. The value of commercially available manures lies in the relatively rapid availability of nutrients they contain.

Whether a cover crop will increase or decrease N supply for a subsequent crop is a result of complex interactions that must be closely analyzed to avoid making erroneous assumptions (Thorup-Kristensen et al., 2003). When applying compost, the issue of timing N release to crop demand may arise as it does in using cover crops (Briggs, 2008).

Information is needed on management strategies that provide the necessary fertilization levels in order to maintain optimum yield in organic production systems in Puerto Rico. Therefore, the objective of this study was to determine the effect of the cover crop crotalaria and four rates of Bioflora Dry Crumbles™[5] (6-6-5), which is made from poultry manure, on the yield of ají dulce (*Capsicum chinense*).

Field studies were conducted at the University of Puerto Rico, Agricultural Experiment Substation in Lajas (latitude: 18° 01’ 55” N, longitude: 67° 04’ 18” W, elevation: 26 meters above sea level). The experimental site was certified organic in 2010 and covers an area of 4 hectares with a Vertisol clay soil type of the Fraternidad series (Fine, smectitic, isohyperthermic Typic Haplusterts) (Muñoz et al., 2018). This study consisted of two experiments: Experiment 1 began in December 2011, while Experiment 2 began in April 2012. The two experiments were established on different plots within the 4 ha of certified organic land.

Field methods

In Experiment 1, treatments were arranged in a split-plot experimental design with four replicates. Each replicate was divided: one half was sown with crotalaria as a cover crop (CC) using a mechanical planter (rows spaced 0.76 m apart) and a target seed density of 7 kg/ha; the other half remained fallow (NCC). Crotalaria was incorporated with a rototiller 40 days after sowing (DAS). Each plot (CC and NCC) was split into four subplots (3 m x 4 m), and Bioflora was randomly applied (0, 0.9, 1.9 and 2.8 t/ha) equivalent to 0, 56, 112 and 168 kg/ha of N and P_2O_5; and 0, 47, 93 and 140 kg/ha K_2O. Seven days later, seedbeds were raised, and ají dulce seedlings were transplanted (0.60 m between plants and 0.76 m between rows). Seedbeds were covered with a layer of hay mulch to suppress weed growth. Insect and pest populations were monitored and managed uniformly as needed.

In Experiment 2, the cover crop was planted in the assigned plots at a seeding rate equal to Experiment 1. Crotalaria was incorporated at 56 DAS, and BioFlora organic fertilizer rate was applied to every subplot similarly to Experiment 1. Seedbeds were raised and nine days later ají dulce seedlings were transplanted as described in Experiment 1. Seedbeds were also covered with a layer of hay mulch to suppress weed growth. Insect and pest populations were also monitored and managed uniformly as needed.

Ají dulce yields estimation

Ají dulce plants were harvested once the fruit had started to ripen or when they were fully ripe (i.e., the fruit had turned red). In Experiment 1, ají dulce was harvested once a week for eight consecutive weeks. In Experiment 2, ají dulce was harvested once a week for twelve consecutive weeks. The number and weight of the total and marketable fruit harvested per sub-plot sample were recorded each time.

[5]Company or trade names in this publication are used only to provide specific information. Mention of a company or trade name does not constitute an endorsement by the Agricultural Experiment Station of the University of Puerto Rico, nor is this mention a statement of preference over other equipment or materials.

Crotalaria biomass and N content estimation

Crotalaria's aboveground biomass was sampled right before incorporation by clipping one linear meter in each rep near the soil surface. Samples were air-dried, and after biomass was calculated, the samples were ground and sent to a private laboratory (Dairy One - Forage Testing Laboratory in Ithaca, New York) for N determination.

Data analysis

Data collected for Experiments 1 and 2 were analyzed separately due to differences in time of incorporation of the cover crop, number of harvests and overall weather conditions. Analyses of variance and linear regressions were performed using Infostat to show the effect of cover crop and BioFlora rate on ají dulce yield.

Ají dulce yields for Experiment 1

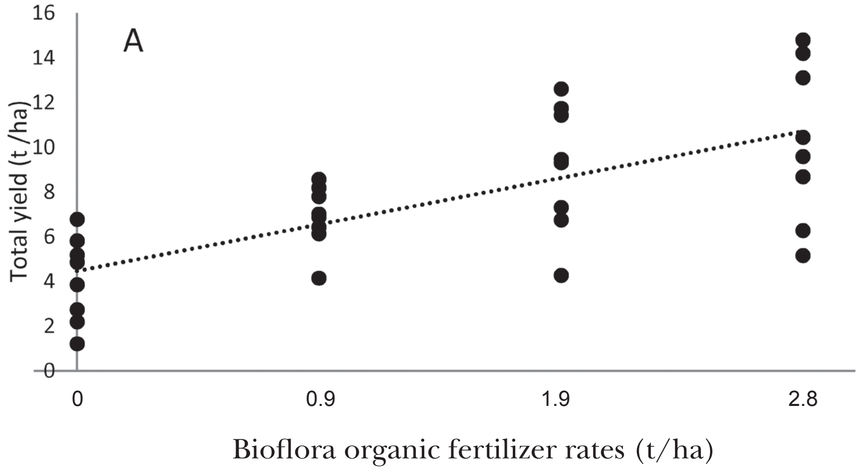
There was no significant interaction between cover crop treatments and BioFlora rate in relation to either marketable number of fruits and weight, or total number of fruits and weight (Table 1). Therefore, the effect of cover crop treatments and BioFlora rates were examined separately. There was no effect of cover crop on any of the ají dulce yield components (total and marketable number of fruits and weight). However, there was a trend (p= 0.0586-0.0906) toward lower yields when the cover crop was used. To evaluate yield response to BioFlora fertilization rate linear regression models were used. Models explained 48% of variation in total yields and 47% in marketable yields; and 51% and 50% of the variation in total and marketable number of fruits, respectively (Figure 1). Moreover, the model indicates an approximate 0.37 t/ha total yield increase for every 167 kg/ha BioFlora increment in fertilization. The highest mean total yield was 10.3 t/ha and was obtained with the 2.8 ton/ha BioFlora fertilization rate.

Ají dulce yield for Experiment 2

As in Experiment 1, there was no interaction between cover crop and BioFlora fertilization rates in relation to either marketable number of fruits and weight or total number of fruits and weight (Table 1). Therefore, cover crop treatments and BioFlora fertilization rates were examined separately. The cover crop had no effect on any of the ají dulce yield components (total and marketable number of fruits and weight). The linear regression models explained only 14% and 13% of the variation in total and marketable yields, respectively; and 16% of the variation in both total and marketable number of fruits. The highest mean total yield was 26.8 t/ha.

TABLE 1.—*Summary of analyses of variance showing the sources of variation in ají dulce yields for Experiments 1 and 2.*

		Fruit weight (t/ha)		Number of fruits	
		Total	Marketable	Total	Marketable
Exp.	Sources of variation	P>F			
1	Cover crop	0.0586	0.0553	0.0906	0.0892
	Fertilizer rate	<0.0001	<0.0001	<0.0001	<0.0001
	Cover crop x Fertilizer rate	0.4992	0.5352	0.5179	0.6117
2	Cover crop	0.5934	0.3648	0.5800	0.6292
	Fertilizer rate	0.0574	0.0322	0.0310	0.0325
	Cover crop x Fertilizer rate	0.2925	0.3517	0.3300	0.2956



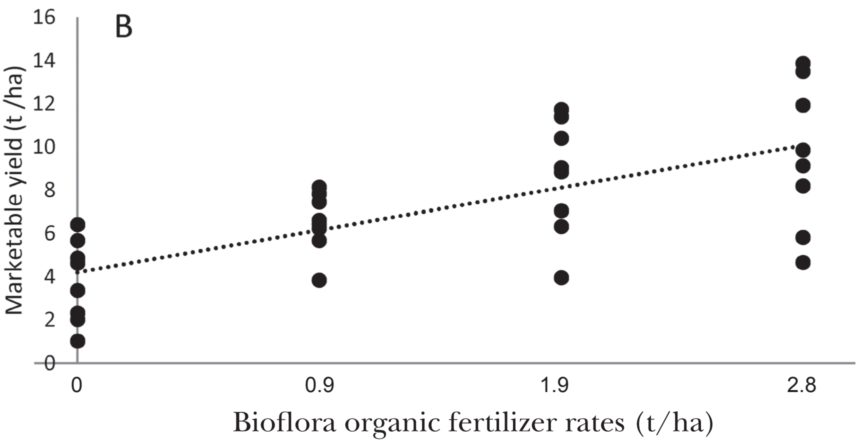


Figure 1. Relationship of total (A) and marketable (B) ají dulce yield and BioFlora fertilization.

Crotalaria biomass and N concentration

For Experiment 1, crotalaria was in flowering stage at the time of incorporation (40 DAP) and the mean biomass was 1,173 kg/ha DM. In Experiment 2, crotalaria had not yet reached the flowering stage at the time of incorporation (56 DAP), but more biomass was produced (1,913 kg/ha DM). Regarding N concentration of the cover crop, mean N concentration was 45 g/kg in Experiment 1 and 33 g/kg in Experiment 2. Total N incorporated based on dry biomass was 52.8 kg/ha for Experiment 1 and 63.1 kg/ha for Experiment 2.

Even though studies have shown crotalaria to increase subsequent crop yields (Jeranyama, 2000; Wang et al., 2003; Balkcom and Reeves, 2005), it had no significant effect on ají dulce yields in these experiments. According to Wang et al. (2004), crotalaria residues decompose rapidly, and the peak mineralization rate would also occur around the time period observed in ají dulce. However, meeting ají dulce nutrient demand with crotalaria would then depend on mineralization rates by soil microorganisms.

Tillage, which also affects decomposition rates, was done to incorporate crotalaria into the soil. Previous studies have reported 65 to 70% of the residues can decompose within approximately two weeks (Wang et al., 2004). Reeves et al. (1996) indicated that crotalaria residues left on the soil surface as organic mulch would decompose at a much slower rate over a longer period of time and can contribute to higher soil organic matter (SOM) accumulation compared to tilled counterparts. Additionally, a strip-till cover crop system, where the remaining crotalaria is cut and left on the soil surface, allows partial residues to be incorporated into the soil and to release N promptly, while the mulch portion will release nutrients over a longer period.

Chemical characteristics of cover crop residues, especially C:N ratio, also play an important role in residue decomposition and, consequently, in the supply of nutrients to subsequent crops. Decades of research have shown that when organic amendments with C:N ratios below 20:1 are added to soils, N is readily mineralized (Sylvia et al., 2005). Crotalaria residues have been reported to have a C:N ratio of 18.9:1 (Marshall, 2002), and most likely N was mineralized before the ají dulce had a high demand for it. Ají dulce nutrient needs increase during flowering, which, in both experiments, took place approximately eight weeks after transplanting and nine weeks after crotalaria incorporation.

Although there was no significant difference among cover crop treatments, Experiment 1 indicated a trend toward lower yields when crotalaria was used as a cover crop compared to the commercial organic fertilizer (p=0.0586-0.0906), which could have been caused by crotalaria's allelopathic properties. Previous work on crotalaria demonstrated allelopathic properties of ground-dried residues and aqueous leaf extracts on certain weeds and on vegetable crops inhibiting germination and seedling growth (Adler and Chase, 2007; Skinner et al., 2012). Allelopathic effects on bell pepper germination have been conflicting, with crotalaria leaf extract strongly inhibiting germination in one study (Skinner et al., 2012) and having no effect on another (Adler and Chase, 2007).

Experiment 1 showed a much greater yield response to BioFlora. However, the yield was less than half of what was obtained in Experiment 2. A greater response to BioFlora fertilization in Experiment 1 could be due to the initial fertility of the plots. The plot from Experiment 1 has been under organic management for less time and organic matter content was only 1.7%. Consequently, less fertile soils would be more responsive to BioFlora organic fertilization.

It is difficult to explain the lower yields during the 2011 Experiment as they could have been affected by a combination of factors such as weather conditions and insect pest infestation levels. Regarding pest infestation, fewer applications of products for insect control were used during the 2012 Experiment, which can be attributed to lower pest incidence. However, this variable was not measured and its effect on fruit yields for both experiments is not clear.

LITERATURE CITED

Adler, M. J. and C. A. Chase, 2007. Comparison of the allelopathic potential of leguminous summer cover crops: Cowpea, Sunn hemp and Velvetbean. *HortScience* 42: 289-293.

Baijukya, F. P., N. de Ridder and K. E. Giller, 2006. Nitrogen release from decomposing residues of leguminous cover crops and their effect on maize yield on depleted soils of Bukoba District, Tanzania. *Plant and Soil* 279: 77-93.

Balkcom, K. S. and D. W. Reeves, 2005. Sunn hemp utilized as a legume cover crop for corn production. *Agronomy Journal* 97: 26-31.

Briggs, S., 2008. Nitrogen Supply and Management in Organic Farming. Report, Institute of Organic Training and Advice (IOTA), Craven Arms.

Giller, K., 2001. Nitrogen fixation in tropical cropping systems. Second Edition. CABI Publishing, New York.

Jeranyama, P., 2000. Relay-intercropping of sunnhemp and cowpea into a smallholder maize system in Zimbabwe. *Agronomy Journal* 92: 239-244.

Mansoer, Z., D. W. Reeves and C. W. Wood, 1997. Suitability of Sunn hemp as an alternative late-summer legume cover crop. *Soil Science Society of America Journal* 61: 246-253.

Marshall, A. J., 2002. Sunn hemp (*Crotolaria juncea*) as an organic amendment in crop production. M.S. Thesis. University of Florida. Gainesville, FL.

Muñoz, M. A., W. I. Lugo, C. Santiago, M. Matos, S. Ríos and J. Lugo, 2018. Taxonomic Classification of the Soils of Puerto Rico, 2017. University of Puerto Rico, Mayagüez Campus. College of Agricultural Sciences, Agricultural Experiment Station. San Juan, Puerto Rico. Bulletin 313. 73 pp.

Reeves, D. W., Z. Mansoer and C. W. Wood, 1996. Suitability of Sunn hemp as an alternative legume cover crop. Proceedings of the New Technology and Conservation Tillage 96: 125-130.

Schomberg, H. H., N. L. Martini, J. C. Diaz-Perez, S. C. Phatak, K. S. Balkcom and H. L. Bhardwaj, 2007. Potential for using Sunn hemp as a source of biomass and nitrogen for the Piedmont and Coastal Plain regions of the southeastern USA. *Agronomy Journal* 99: 1448-1457.

Skinner, E. M., J. C. Díaz-Pérez, S. C. Phatak, H. H. Schomberg and W. Vencill, 2012. Allelopathic effects of sunnhemp (*Crotalaria juncea* L.) on germination of vegetables and weeds. *HortScience* 47: 138-142.

Sylvia, D. M., J. J. Fuhrmann, P. G. Hartel and D. A. Zuberer, 2005. Principle and applications of soil microbiology. 2nd ed. Pearson Education Inc., New Jersey.

Thorup-Kristensen, K., J. Magid and L. Jensen, 2003. Catch crops and green manures as biological tools in nitrogen management in temperate zones. *Advances in Agronomy* 79: 227-302.

Wang, Q., W. Klassen, H. H. Bryan and Y. Li, 2003. Influence of summer cover crops on growth and yield of a subsequent tomato crop in south Florida. *Proceedings of the Florida State Horticultural Society* 116: 140-143.

Wang, K. H., R. McSorley, A. J. Marshall and R. N. Gallaher, 2004. Nematode community changes following decomposition of *Crotalaria juncea* amendment in litterbags. *Applied Soil Ecology* 27: 31-45.

Watson, C. A., D. Atkinson, P. Gosling, L. R. Jackson and F. W. Rayns, 2002. Managing soil fertility in organic farming systems. *Soil Use and Management* 18: 239-247.