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THE EFFECT OF BONE MEAL ON THE YIELD OF JICAMA, *PACHYRHIZUS EROSUS,* IN OAHU HAWAII

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Abstract. **Jicama is increasing in popularity in the United States as a specialty crop used in salad bars or in ethnic dishes from Asia and Latin America. For environmental reasons an increased demand also exists to grow crops using locally available nutrient resources instead of using imported fertilizers. With this in mind, two experiments were conducted in separate locations to evaluate the effect of bone meal (BM) applications on the yield of jicama in Waimanalo, Hawaii. In one experiment treatments included a control, synthetic fertilizer, bone meal at a 1× (1 ton/acre) application rate, bone meal at a 4× rate, and bone meal at a 1× rate in combination with chicken manure. Each treatment was established in a 40 ft long double-row bed, replicated four times, with the plots arranged in a RCB design. The second experiment was conducted as part of a long-term organic farming study. Treatments included controls, low and high rates of compost alone, BM plus low or high rates of composts, and synthetic fertilizer alone. Data collected included soil nutrient levels, stand establishment, top growth fresh weight, and root length, width, and fresh weight. High BM application rates, and high compost/BM treatments affected stand establishment and depressed yields by 35%. Chicken manure and BM combinations resulted in the greatest yields and in the largest root sizes. Yields from the low BM applications treatments were similar to those obtained with synthetic fertilizers, which were in turn, similar or numerically greater than those observed in the controls.**

Jicama, *Pachyrhizus erosus,* is a vining legume root crop growing in popularity as a specialty vegetable crop in the United States. It also is popular in countries of Asia and in Mexico. Little research has been conducted with regards to the response of jicama to fertilizer application rates. In addition, interest exists for the production of jicama and other specialties under organic farming conditions, which preclude the application of synthetic fertilizers. However, little research has been conducted to evaluate the growth and yield response of specialty crops such as jicama, to organic amendment application rates. Bone meal (BM), a byproduct from the livestock and poultry industries, rich in calcium phosphate (Baker et al., 1989), is commonly used as an organic amendment by gardeners and organic farmers. It is considered a potential source of P in areas of the tropics characterized by P depleted soils (Bekele and Hofner, 1993). In the U.S. recommendations for its use are often found in Cooperative Extension crop production guidelines, and in the popular literature (Davis, 1993; Kindersley, 2000). As an organic amendment it has relatively high levels (8-10%) of NPK. Jicama may benefit from BM applications due to its responsiveness to P and Ca applications (Lynd and Purcino, 1987). In addition bone meal applications have shown potential for the reduction of soil pathogens on vegetables (Blank, 1997).

The first experiment in this study was thus conducted to evaluate the growth and yield response of jicama to two rates (1× vs. 4×) of bone meal (BM) applications and to combinations of BM with chicken manure, as compared to yields obtained with the application of standard synthetic fertilizer applications. The second experiment was conducted to evaluate the response of low rates of BM applications (1×) on experimental plots that had been maintained for 6 years for the production of a variety of vegetables under organic farming conditions. The second experiment was thus part of a long-term experiment to evaluate the effect of compost and organic amendment applications on the yield of vegetables compared to the yields obtained with synthetic fertilizer applications.

Materials and Methods

Both experiments were conducted at the University of Hawaii Waimanalo Experiment station, located in the island of Oahu, Hawaii (22°N, 168°W). The station is located at 60 feet elevation, the mean annual temperature is 75.5 F with a mean monthly range of 70-80 F, and has a mean annual rainfall of 55 inches. The soil is a vertic haplustoll derived from lava and coral.

Experiment 1. The first experiment was conducted to evaluate the growth and yield effects of a low rate of bone meal (1× rate) combined with chicken manure, and a high rate of bone meal (4×) compared to the use of standard synthetic fertilizer recommendations. The low rate of BM used in this experiment, is approximately, the rate recommended for vegetable production in the popular literature (Johnson, 1998). The experiment was conducted in plots were vegetables are grown on an ongoing basis following standard commercial production practices. Soil analysis from the plots have shown a pH of 7.2, EC = 0.29 mmhos, P = 55 ppm, K = 234 ppm, Ca = 4904, Mg = 952 ppm, and organic matter content of 1.35%. The 'UH-yam bean' variety used, was planted in the fall, because of its short day-length response (Paull et al., 1988). The crop was direct seeded on 24 September 1999 in double rows at a planting distance of 8 inches between plants in the row and 2 ft between rows. Two drip-irrigation lines were placed on each bed. Each plot (treatment) was 40 ft long, for a total of 80 linear feet of crop per plot, and 4 replications (plots) per treatment were established. The distance between plots was 6 ft. A 5 ft alley was also established between plots along the length of the rows. The experiment had a completely randomized block design, blocked according to an irrigation supply gradient. The treatments for this experiment included: 1) bone meal at an application rate of 1 MT/acre (BM1×); 2) a combination of bone meal and chicken manure at a rate of 1 MT/acre each (BM & CM); 3) bone meal applied at a rate of 4 MT/acre (BM4×); 4) a complete synthetic fertilizer (10N-20P_2O_5-20K_2O) to supply a rate of 120 kg N/acre; and 5) controls receiving no fertilizer or amendment applications. Nutrient analysis from 9 different batches of bone meal showed an average pH of 6.1, N = 10%, and P = 965 ppm, K = 3542 ppm, Ca = 187 ppm, and Mg = 186 ppm. The crop was drip irrigated as needed and no pest control measures were used for this experiment. All of the organic amendments were applied 1 week prior to planting, and disked incorporated at a 15 cm soil depth. The synthetic fertilizer was split in two side-dress applications conducted at planting and again 1 month after planting. The crop was harvested 3 times on 14 and 28 Feb. and on 20 March. For the first two dates 5 roots were harvested per replication on each date, and 10 roots were harvested on the last harvest date. Data collected included soil nutrient analysis 2 weeks after bone meal application and again after experiment completion, plant stand 1 month after planting, and at harvest total plant weight, root fresh weight, root length and diameter, stem diameter at the soil level, and vine length.

Experiment 2. The second experiment was part of a long-term experiment established to evaluate the long-term effect of composts and organic amendment applications on the yield of vegetables as compared to the yield obtained with synthetic fertilizer applications. Prior to experiment initiation, soil analysis of control plots with no history of amendment applications had a pH of 7.0, P = 382 ppm, K = 548 ppm, Ca = 6834 ppm, Mg = 1484 ppm, and an organic matter content of 1.71%. Organic matter levels of plots that received annual compost applications over the previous 5 years ranged from 2.1 to 2.4% OM, and similar nutrient fertility levels as the controls. The planting schedule was as described for experiment one. However only one harvest was conducted for this experiment, on 27 March 2000, where up to 10 roots were harvested for each replication. The experiment had a Completely Randomized Block design blocked according to a fertilizer gradient across the field. The treatments in this experiment were: 1) bone meal at an application rate of 1 MT/acre (1×) in plots with a 5 year history of annual low compost application rates of 20-25 MT/acre (Low Compost +BM); 2) no treatment application in plots with a 5 year history of annual low compost application rates of 20-25 MT/acre (Low compost alone; it was expected that the jicama crop would use residual nutrients released from compost applications applied in previous experiments); 3) bone meal at an application rate of 1 MT/acre (1×) in plots with a 5 year history of annual high compost application rates of 25-80 MT/acre (High Compost +BM); 4) no treatment application in plots with a 5 year history of annual high compost application rates of 25-80 MT/acre (High compost alone); 5) application of a complete fertilizer (10N-20P_2O_5-20K_2O) to supply a rate of 120 lb of N/acre in plots with a 5 year history of annual synthetic N applications; and 6) a control with a history of no fertilizer or amendment applications. As with experiment No. 1, the jicama crop was established in double row beds. Plot length was 20 ft for plots receiving organic amendments, and 40 ft long for controls and for plants receiving synthetic fertilizers. Each treatment was replicated four times.

The data from both experiments was analyzed with a SAS GLM procedure, and mean separations conducted with Duncan's new multiple range test.

Results and Discussion

Crop yields. In Experiment 1 root yield data was collected at both 5 and 6 months after planting (Tables 1-3). At the earlier harvest date roots may be smaller and more uniform which are in demand by some ethnic markets. However, the larger roots, collected in the last harvest, are more desirable for restaurants and other food service buyers. For the first harvest, at 5 months after planting, average root size and yields per 100 ft length of row were greatest for the combined chicken manure and bone meal (CM & BM) treatment. Mean root weight for the CM & BM treatment was 45% greater than the pooled average of the other treatments harvested 5 months after planting. Mean root weights for the '1× Bone meal' (1× BM) treatment were numerically 17 and 11% greater than the control, and synthetic fertilizer treatments, respectively, but these differences were found not to be statistically significant. The lowest numerically mean root weight and yields per 100 ft row were obtained with the 4× BM treatment, which was attributed to the low plant stand obtained with this treatment. The synthetic fertilizer treatment had a greater top: root ratio (by weight), than the other treatments (Table 1), which indicates, as research has shown elsewhere with other crops, that synthetic N sources may promote top growth at the expense of root growth. The yield data from the third harvest conducted at 6 months after planting (Table 2) was first analyzed separately to determine yield and growth trends by delaying the harvest date by one month. By the third harvest date mean root weight and marketable yield per 100 ft of row were numerically greatest for the synthetic fertilizer treatment by 10 and 17%, respectively, compared to the yield obtained by the other treatments, excluding the 4× BM treatment (Table 2). However, no statistical significance was found between treatments with respect to mean root weight,

Table 1. Effect of chicken manure (CM) and bone meal (BM) organic amendments on the root yield of jicama (yam bean root), for the first two harvests about 5 months after planting, Waimanalo, Hawaii.

Treatment[z]	Total weight[y] (grams)	Root weight (grams)	Root diameter (cm)	Root length (cm)	Stem diameter (cm)	Vine length (cm)	Root yield[x] (lbs/100 ft)	Mean root weight (lbs/root)	Top: root ratio (%)
Control	1154 bc	916 b	12.5 bc	8.9 a	0.52 ab	76.1 b	1151	2.0 b	33 ab
Fert 10-20-20	1227 bc	967 b	12.4 bc	8.7 a	0.50 b	93.4 a	1127	2.1 b	37 a
Bone meal	1313 b	1072 b	13.2 b	8.6 a	0.53 ab	99.6 a	1213	2.3 b	25 b
CM & BM	1692 a	1383 a	15.1 a	9.2 a	0.56 ab	93.3 a	1257	3.0 a	25 b
BM × 4	1089 c	909 b	11.7 c	7.7 b	0.60 a	69.5 b	300	2.0 b	23 b

[z]Treatment Descriptions: CM & BM = chicken manure and bone meal at 1 ton/acre each; Bone Meal = 1 ton/acre rate; Fert = 10N-20P_2O_5-20K_2O synthetic fertilizer; Control = no fertilizer applications; BM4× = bone meal at 4 tons/acre. The synthetic fertilizer rate (10N-20P_2O_5-20K_2O) was 2.5 lbs per 40 ft of bed (60 lbs of N/acre), applied at planting and again about 1 month after planting for a total amount of 120 lbs N/acre. The low rate of bone meal was 20 lbs per 100 ft and the high rate was 80 lbs per 100 ft of bed. The chicken manure was applied at 20 lbs/100 ft of bed. These organic amendment rates are equivalent to 1 ton/acre for the chicken manure and bone meal and 4 tons/acre for the 4x Bone meal treatment.

[y]Data analysis: Numbers followed by the same letter within each column are not statistically different according to Duncan's New multiple range test at a 95% confidence level ($P < 0.05$).

[x]Yield calculation: Yield per 100 ft row based on 8-inch spacing between plants in-the-row, with double-row beds for a total of 300 plants per 100 ft long bed.

Table 2. Effect of chicken manure (CM) and bone meal (BM) organic amendments on the root yield of jicama (yam bean root), for the last harvest at 6 months after planting, Waimanalo, Hawaii.

Treatment[z]	Total weight[y] (grams)	Root weight (grams)	Root diameter (cm)	Root length (cm)	Stem diameter (cm)	Vine length (cm)	Root yield[x] (lbs/100 ft)	Mean root weight (lbs/root)	Top: root ratio (%)	Top weight (gr)
Control	1688 a	1546 a	16.1 a	9.7 a	0.50 ab	72.7 a	2914	3.4 a	10 a	141.7 a
Fert 10-20-20	1787 a	1643 a	16.2 a	7.3 c	0.51 ab	78.8 a	2932	3.6 a	11 a	144.7 a
Bone meal	1570 a	1435 a	15.8 a	8.9 b	0.51 ab	82.2 a	2477	3.2 a	10 a	135.4 a
CM & BM	1682 a	1535 a	16.2 a	8.9 b	0.55 a	80.9 a	2132	3.4 a	10 a	146.2 a
BM × 4	1019 b	933 b	12.7 b	7.4 c	0.47 b	68.6 a	463	2.1 b	10 a	85.3 b

[z]For treatment descriptions see Table 1.
[y]Numbers followed by the same letter within each column are not statistically different according to Duncan's New multiple range test at a 95% confidence level ($P < 0.05$). Significant treatment x block interactions found for the following variables: Total plant weight, root weight, root diameter, root length, stem diameter, top weight, and top: root ratio.
[x]Yield calculation: Yield per 100 ft row based on 8-inch spacing between plants in-the-row, with double-row beds for a total of 300 plants per 100 ft long bed.

excluding the 4× BM treatment. Sen and Mukhopadhyay (1989), in India, also found that an input of 120 lb of N/acre resulted in maximum jicama yields.

Overall, with all treatments pooled together, the mean root weight increased by 37% and the marketable yield per 100 ft row increased by 116% by the second harvest at 6 months after planting, compared to similar data collected at 5 months after planting. Also, by the third harvest, the plant foliage contained only an average of 10% of the total plant biomass, compared to a pooled average for all treatments of 29% a month earlier, which indicates that the plants continued to some extent to fix atmospheric carbon through photosynthetic activity, and to partition the available carbohydrate resources toward root growth, and thus doubling the overall marketable yields by delaying the harvest period by one month. Thus both the controls and the synthetic fertilizer plots showed increased relative yields by the last harvest, by having a significantly higher top: root ratio in the early growth stages, compared to the other treatments. When data from all harvests was pooled together (Table 3), the greatest mean root weight was obtained by the CM & BM and synthetic fertilizer treatments, compared to the other treatments. However, due to differences in final plant stand, total marketable yields per 100 ft row were numerically greater in the synthetic fertilizer and control plots than for the other treatments.

In Experiment 2, the greatest mean root weight and marketable yields per 100 ft row were obtained with the low compost +BM treatment (Table 4). Mean root weight for the low compost +BM treatment was 106% greater than the low compost -BM, 78% greater than the high compost +BM treatment, and 155% greater than for all the other treatments pooled together. Differences in total marketable yields per 100 ft row between the low compost +BM treatment and the other treatments were not as drastic due to low plant stands in treatments receiving high organic amendment inputs. Yields obtained between plots that have historically received low rates of composts (25 MT/Ha) were numerically and statistically similar to those obtained in plots that have historically received high compost application rates (25-80 MT/Ac). It is plausible that yield depressions occurred in the latter plots due to an excessive accumulation of soluble salts in the rhizosphere, decreasing plant stands and overall plant growth rates.

Root uniformity. For the commercial production of jicama, root uniformity and shape may be as important as potential final yields. In Experiment 1, coefficient of variation determinations (Table 3) indicate that the fertilizer and control plots had a greater variability in root weight and in other root dimensions, compared to the other treatments. Similarly, in Experiment 2, plots with a higher input of nutrients, including the synthetic fertilizer, plants that received BM in plots with a history of compost applications, and the 'high' compost plots had a greater coefficient of variation than the low 'compost - BM' plots (Table 4). These data indicates that increased root uniformity may be obtained when the adequate amount of nutrients needed to reach maximum yields are released in a pattern that better matches crop growth rates, and that excessive or uneven nutrient availability may result in possible

Table 3. Effect of chicken manure (CM) and bone meal (BM) organic amendments on several growth parameters, their coefficients of variation, and on the root yield of jicama, after all harvests, at 6 months after planting, on Oahu, Hawaii.

Treatment[z]	Total weight[y] (grams)	Root weight (grams)	Root diameter (cm)	Root length (cm)	Top: root ratio (%)	Vine length (cm)	Root yield[x] (lbs/100 ft)	Mean root weight (lbs/root)	Top weight (gr)
Control	1421.1 b	1231.4 (48.6) b	14.3 (22.8) b	9.3 (17.1) a	21 (105.4) a	74.4 b	2321	2.7 b	189.7 (62.5) ab
Fert 10-20-20	1510.9 ab	1309.3 (53.0) ab	14.3 (24.6) b	8.0 (40.2) b	24 (115.6) a	86.0 a	2338	2.9 b	201.7 (68.8) a
Bone meal	1441.5 b	1253.6 (43.9) b	14.5 (17.1) b	8.8 (17.6) a	17 (97.7) a	90.6 a	2164	2.8 b	187.8 (88.8) ab
CM & BM	1686.8 a	1459.4 (42.5) a	15.6 (17.1) a	9.1 (16.7) a	18 (80.1) a	87.1 a	2027	3.2 a	227.4 (65.3) a
BM × 4	1057.8 c	909.7 (49.9) c	12.0 (23.5) c	7.5 (26.1) b	19 (99.9)a	68.5 b	451	2.0 b	148.7 (85.6) b

[z]For treatment descriptions see Table 1.
[y]Numbers followed by the same letter within each column are not statistically different according to Duncan's New multiple range test at a 95% confidence level ($P < 0.05$). Significant treatment × block interactions found for the following variables: total plant weight, root diameter, root length, stem diameter, and top (foliage) weight. Stem diameter values (no significance found, perhaps due to treatment x blk interaction) were 0.51 for fert, 0.51 for control, 0.52 for bone meal, 0.56 for CM & BM, and 0.51 for BM4X).
[x]Yield calculation: Yield per 100 ft row based on 8-inch spacing between plants in-the-row, with double-row beds for a total of 300 plants per 100 ft long bed.

Table 4. Effect of several compost and bone meal treatment combinations on the mean root yield, final plant stand, and marketable yield per 100 ft row of jicama grown at the UH Waimanalo Experiment Station, Hawaii.

Treatment[z]	Mean root weight[y] (grams)	Final stand (%)	Yield[x] (lb/100 ft)
Control	842.1 (46.3) b	95	264.5
Fertilizer 10-20-20	830.3 (43.7) b	95	260.8
Low compost (-BM)	1,028.4 (37.4) b	90	306.1
Low compost (+BM)	2,123.3 (100.7) a	55	386.2
High compost (-BM)	818.4 (50.7) b	85	230.0
High compost (+BM)	1189.8 (61.4) b	40	157.4

[z]Treatment descriptions: Control = no fertilizer or amendment applications; Fertilizer- synthetic fertilizer applied annually for the previous 6 years; Low Compost (-BM): these beds received annual low rates (ca. 25 tons/acre) of compost applications; High compost (-BM): over the previous 2 years these beds received annually 20-80 tons/acre of composts; Low compost (+BM) = Bone meal at 1 ton/acre on the low-rate compost treatments; High Compost (+BM) = bone meal at 1 ton/acre on the high rate compost treatments.
[y]Numbers followed by the same letter within each column are not statistically different according to Duncan's New multiple range test at a 95% confidence level ($P < 0.05$). Coefficients of variation are listed in parentheses.
[x]Yield calculation: Yield per 100 ft row based on 8-inch spacing between plants in-the-row, with double-row beds for a total of 300 plants per 100 ft long bed.

growth 'spurts' and in an overall lower root uniformity. The data also indicates that uneven growth (resulting in lower root uniformity) from untimely or excessive nutrient release rates may occur when the nutrient source is either an organic amendment or a synthetic fertilizer.

Plant stands. Stand establishment evaluations were conducted in both experiments at about 2 weeks after planting. Overall plant stands were uniform and nearly 100% in the controls. In Experiment 1, plant stands were reduced by 73% in the '4× BM' treatment, and by 26% in the 'CM & BM' treatment as compared to the controls (Table 5). In Experiment 2 plant stands in the 'High compost +BM' plots were reduced by 69%, and in the 'Low compost plots +BM', by 44%, compared to the controls. Overall, compared to the controls, BM resulted in 40% and 65% stand reductions when applied to the low and high compost plots, respectively. These data indicate the potential deleterious effects from the high soluble salt levels from excessive organic amendment applications, as shown in Table 7, and from the potential high fluoride levels present in bone meal, a variable that was not evaluated in these experiments. Measures that growers can take to minimize stand reductions from organic amendment applications include better soil incorporation, increasing the amount of time between application and crop planting, and better matching the amendment application rates to the fertility of the soil and nutritional requirements of the crop based on calibrated soil and tissue analyses determinations.

Table 5. Effect of chicken manure and bone meal amendments on the germination of jicama, at 2 weeks after planting, Waimanalo, Hawaii.

Treatment[z]	No. germinated plants	Percent germination[y]
Control	228	95%
Fert	218	90%
Bone meal	209	87%
CM & BM	169	70%
BMx4	62	25%

[z]For treatment descriptions see: Table 4.
[y]Percent germination calculated based on total estimated possible of 240 seedlings per treatment (60 plants per treatment times 4 replications per treatment = 240 plants total).

Table 6. Effect of several compost and bone meal organic amendments on the germination of jicama, about 2 weeks after seeding on Waimanalo, Hawaii.

Treatment[z]	No. germinated plants	*Percent germination*[y]
Control	83	92%
Fertilizer 10-20-20	83	92%
Low compost (-BM)	80	88%
Low compost (+BM)	48	53%
High compost (-BM)	74	82%
High compost (+BM)	26	29%

[z]For Treatment descriptions see Table 4.
[y]Percent germination calculated based on total estimated possible of 240 seedlings per treatment (60 plants per treatment times 4 replications per treatment = 240 plants total).

Soil fertility. In Experiment 1, by one month after planting, the bone meal applications tended to increase the soil pH, the electrical conductivity, and the levels of P, K, and Ca compared to the controls (Table 7). The greatest increases in EC, P, K, Ca, and Mg were obtained from the 'CM & BM' plots. Except for K, the '1× BM' treatment increased soil nutrient levels compared to the synthetic fertilizer plots. A similar trend was observed with the soil analyses obtained after experiment completion, with the exception that soil fertility from the '1× BM' treatment this time was similar to the control plots. EC for the '4× BM' plots was 30, 59, 59, and 72% greater than the '1× BM', 'BM & CM', 'Fert', and control plots, respectively, which would help to explain in part for the lower plant stands observed in the '4× BM' plots. Also, the 'Fert' and '4× BM' treatments had lower pH levels than the controls (Table 8). A similar trend in terms of increased soil nutrient levels and EC with fertilizer or amendment applications was observed in Expt. 2. Data from both experiments indicate that soil EC and plant germination were related. Overall, treatments from both trials which had an EC of 0.33 or higher (Tables 7 and 8) had an average 61% plant stand ($N = 6$) compared to an 88% stand (Tables 5 and 6) for those treatments with an EC below 0.33 ($N = 5$). Data from experiment 2 also showed increased OM levels in the organic amendment plots, compared to the controls. OM levels were about 38 and 13% greater in the 'High compost' and 'Low compost +BM' plots, respectively, than in the controls. The soil fertility analyses thus indicate that it is possible to modify the soil short- and

Table 7. Soil fertility about 1 month after bone meal and chicken manure amendment applications on jicama, Waimanalo, Hawaii.

Treatment	pH[y]	EC	P	K	Ca	Mg
Control (no fert)	5.6	1.19	164	406	3858	1254
Chemical fert	5.0	1.58	265	610	3682	1198
Bone meal 4×	6.2	3.00	591	546	3974	1234
Bone meal 1×	5.3	2.38	328	520	4156	1298
Bone meal & CM	5.6	3.10	468	646	4416	1354

[z]For treatment descriptions see Table 1.
[y]Soil analysis conducted by the UH Agricultural Diagnostic Laboratory.
Chemical fertilizer = $10N\text{-}20P_2O_5\text{-}20K_2O$; CM= chicken manure at 1 ton/acre.

Table 8. Soil fertility conducted after experiment completion with bone meal and chicken manure amendment applications on jicama at the Waimanalo Experiment Station, Hawaii.

Treatment[z]	pH[y]	EC	P	K	Ca	Mg
Control	5.7	0.25	126	404	3954	1304
Chemical fert	4.8	0.27	261	700	3576	1130
Bone meal 1×	5.6	0.33	167	356	3968	1256
BM & CM	6.1	0.27	180	482	4264	1250
Bone meal 4×	5.4	0.43	463	366	4196	1208

[z]For treatment descriptions see Table 1.
[y]Soil analysis conducted by the UH Agricultural Diagnostic Laboratory. Chemical fertilizer = 10N-20P_2O_5-20K_2O; CM = chicken manure at 1 ton/acre.

Table 9. Soil fertility conducted after experiment completion at the Waimanalo Station organic-farming plots, Hawaii, with a combination of bone meal and high or low rates of compost applications.

Treatment[z]	pH[y]	EC	P	K	Ca	Mg	OM
Control	7.2	0.25	55	194	6416	1454	1.78
Synthetic fert	7.3	0.32	86	88	7628	1102	1.90
Low compost (-BM)	7.6	0.33	80	206	6398	1432	1.78
Low compost (+BM)	6.8	0.38	1029	378	5884	1272	2.02
High compost (-BM)	7.6	0.35	146	624	6470	1458	2.45
High compost (+BM)	7.4	0.39	143	448	7146	1346	2.35

[z]For treatment descriptions see Table 4.
[y]Soil analysis conducted by the UH Agricultural Diagnostic Laboratory.

long-term fertility through the application of organic amendments but that it is important to monitor important variables such as the soil pH, EC, and the OM levels, to tailor fertility programs that will maintain high crop yields and quality and that will minimize nutrient imbalances or crop injury.

The results from these experiments indicate that it is possible to obtain jicama marketable yields that are equivalent or greater than those obtained with standard synthetic fertilizer applications. The results also indicate that problems that may occur with the application of synthetic fertilizers, such as nutrient imbalances from excessive applications, may also be encountered with the application of organic amendments. Thus, growers that rely on organic amendments as an important component of their fertilizer programs should also understand and periodically monitor the soil and crop nutrient status on their farms, and make organic amendment applications that will complement the existing soil fertility, and which will meet the nutrient requirements of their crops.

Literature Cited

Baker, A. M., J. R. Trimm and F. J. Sikora. 1989. Availability of phosphorus in bone meal. J. Assoc. Off. Anal. Chem. 72(5):867-869.

Bekele, T. and W. Hofner. 1993. Effects of different phosphate fertilizers on yield of barley and rape seed on reddish brown soils of the Ethiopian highlands. Fert. Res. 34:243-250.

Blank, C. 1993. Deadline pressure. The Grower magazine. Vol. 20, no. 11, pp. 20-21.

Davis, J. M. 1993. Chives. North Carolina Coop. Ext. Serv. Leaflet No. 124.

Kindersley, D. 2000. Tubers, corms, and bulbs. Microsoft Encarta Encyclopedia. CD-Rom edition.

Johnson, P. H. 1998. Building soil with bone meal. Organic Gardening Mag. 35(1):30-32,34 (January).

Lynd, J. Q. and A. A. C. Purcino. 1987. Effects of soil fertility on growth, tuber yield, nodulation and nitrogen fixation of yam bean grown on a typic eutrustox. J. Plant Nutrition 10:485-500.

Paull, R. E., N. J. Chen and S. K. Fukuda. 1988. Planting dates related to tuberous root yield, vine length, and quality attributes of yam bean. HortScience 23:326-329.

Sen, H. and S. K. Mukhopadhyay. 1989. Effect of nitrogen and potassium on tuber yield and quality of yam bean. J. Root Crops 15:33-37.

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PERFORMANCE OF BELL PEPPER VARIETIES OVER TWO SEASONS IN SOUTHEAST FLORIDA, 1998-2000

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Additional index words. Capsicum annuum, variety trial, bacterial spot resistance.

Abstract. **Two demonstration trials were conducted to evaluate promising bell pepper varieties on sandland in Delray Beach, FL. Peppers were grown from transplants under commercial full bed plastic mulch culture using subsurface (seepage) irrigation. Fifty-four different varieties were evaluated at least once and twenty-one varieties were evaluated twice. Green fruits were evaluated from four blocks and an additional block was reserved for the evaluation of colored fruits (mature pepper). Peppers were evaluated for yield and average fruit size. Randomly selected fruits from the first pick were evaluated for length and width, lobe number, and bluntness at the blossom end. Mature (colored) fruits were counted, weighed and evaluated for deformities including softness, misshapen, rot, sunburn, and stip.**