

Full Length Research Paper

Growth response of fluted pumpkin (*Telfairia occidentalis* Hook. F) to combinations of irrigation intervals and spent mushroom substrate in the Niger Delta region of Nigeria

Fubara-Manuel, I.^{1*}, Nwonuala, A.² and Davis, D. D.¹

¹Department of Agricultural and Environmental Engineering, Rivers State University of Science and Technology, Nkpolu, P.M.B. 5080, Port Harcourt, Rivers State, Nigeria.

²Department of Crop/Soil Science, Rivers State University of Science and Technology, Nkpolu, P.M.B. 5080, Port Harcourt, Rivers State, Nigeria.

Accepted 6 October, 2011

An investigation of the growth response of fluted pumpkin to different combinations of irrigation intervals and spent mushroom substrate (SMS) was conducted during the dry season, with a view to determining the combination that would give the best performance of the crop. The experiment lasted for a period of thirteen weeks in a sandy loam soil. Three irrigation intervals of 4, 7 and 10 days, and three levels of SMS, 10, 20 and 30 t/ha were randomly combined, including a control with neither irrigation nor SMS. Results indicate that there were significant differences in growth parameters such as vine length, number of leaves, leaf area, number of branches, vine fresh weight and total shoot yield across the treatment variants. The combination of 7 days irrigation interval and 20 t/ha SMS gave the highest mean vine length of 1.99 cm, while the greatest mean leaf area (75.95 cm²) was obtained from the combination of 4 days irrigation interval and 20 t/ha SMS. However, the combination of 4 days irrigation interval and 30 t/ha SMS gave the highest mean number of leaves (54), number of branches (9.67), vine fresh weight (2.15 t/ha), percent emergence (92.88%), and total shoot yield (2.17 t/ha). The results of this study therefore suggested that the best growth performance of fluted pumpkin during the dry season is obtainable from a combination of 4 days irrigation interval and 30 t/ha SMS.

Key words: Growth response, fluted pumpkin, irrigation interval, spent mushroom substrate.

INTRODUCTION

Available literature indicates that fluted pumpkin (*Telfairia occidentalis* Hook. F) is a leaf and seed vegetable indigenous to Southeastern Nigeria but now cultivated in many parts of the country, with high nutritional, medicinal and industrial values (Akoroda, 1990; Akanbi et al., 2007; Odiaka et al., 2008). Its leaves locally referred to as Ogu in the riverine areas of the Niger Delta region of Nigeria, is an important dietary component. However, despite its nutritional value, the production of this crop in the Niger Delta is still at the subsistence level. Olaniyi and Akanbi (2007) posit that the agronomy of fluted pumpkin, like

most other tropical vegetable crops, has been neglected because it does not fall into the export category. Other factors affecting the productivity of fluted pumpkin in the region include the total dependence by farmers on rain-fed agriculture, and the low fertility of the soil.

The total dependence on rainfall for crop production in the Niger Delta region is an age-long practice borne out of the misconception that the region is blessed with abundant rainfall despite the fact that the area is also characterized by distinct wet and dry seasons. The other inhibiting factor is the soil. Fubara (1983) observed that the soils of the Niger Delta are such that the movement of gravitational water is usually very slow as a result of the poor permeability, leading to high surface runoff. Furthermore, there is high evaporation which is about one-half

Abbreviation: SMS, Spent mushroom substrate.

of the rainfall. These therefore imply that only a small fraction of the observed rainfall actually infiltrates and percolates into the root zone to sustain plant growth. Opuwaribo et al. (1990) also stated that the soils of the Niger Delta are generally strongly weathered, have low cation exchange capacity, low base saturation and low fertility level usually suffering from multiple nutrient deficiencies.

It is obvious from the foregoing that apart from irrigation, the enhancement of the soil quality is *sine qua non* for effective production of crops in the Niger Delta region of Nigeria. The enhancement of soil quality can be achieved by the use of inorganic (chemical) or organic fertilizers. However, Nottidge et al. (2005) asserted that the use of inorganic fertilizers has not been able to sustain high productivity due to increase in soil acidity, nutrient leaching and degradation of soil organic matter and physical conditions. Organic fertilizers therefore offer great prospects. The spent mushroom substrate (SMS), for example, has a potential application as a soil fertilizer. The advantages of SMS as a soil fertilizer over chemical fertilizers is that SMS provides slow-release nutrients that will not burn crop upon application. Furthermore, SMS contains a wealth of micronutrients that are usually not present in standard NPK fertilizers. In addition, when SMS is added to soil, it affects the levels of P, K and Mg but does not raise the level of $\text{NO}_3\text{-N}$ (Maher, 1994). The objective of this paper therefore was to determine the most suitable combination of irrigation interval and level of spent mushroom substrate that will produce the best growth performance in fluted pumpkin during the dry season.

MATERIALS AND METHODS

Description of the study area

The study was conducted at the Teaching and Research farm of the Rivers State University of Science and Technology, Port Harcourt, in the Niger Delta region of Nigeria during the dry season between the months of November, 2009 and February, 2010. Port Harcourt is characterized by a humid tropical climate, with an average rainfall of about 2100 mm, of which 70% occurs between May and August. The rest of the year is relatively dry, with mean air temperature varying from 25 to 30°C (Fubara-Manuel, 2005). The soil type is ultisol (USDA classification) and its texture is sandy loam (Ayotamuno et al., 2007).

Experimental layout

Treatments consisted of irrigation intervals (0, 4, 7 and 10 days) and spent mushroom substrate (0, 10, 20 and 30 t/ha) combined to give a total of 10 treatment variants. The zero irrigation interval and zero SMS combination served as the control as it represented the natural condition of the soil. The treatment combinations were laid out in a factorial experiment and fitted into a randomized complete block design with three replications, thus giving a total of thirty experimental plots. The net plot size was 5 x 5 m. Shallow drains were constructed between plots to prevent treatment from one plot flowing into the adjacent plot either by surface runoff or interflow.

Planting

Three seeds of fluted pumpkin were planted per stand, at a spacing of 1 x 1 m. The plants were later thinned to two plants per stand two weeks after planting.

Treatment applications

SMS was obtained from Dilomat Mushroom Development Centre, Rivers State University of Science and Technology, Port Harcourt, Nigeria. It was formulated with standard sawdust, austine white lime and rice bran in the ratio (by weight) of 1 : 0.04 : 0.08 and used to grow oyster mushroom (*Pleurotus* spp.). After three mushroom harvests, the fresh SMS was collected from the mushroom houses and kept outside in sack bags for four months for additional composting. This weathered SMS was then incorporated into the soil seven days before planting. Irrigation water, at a rate of 0.002 m^3/s was applied uniformly to each plot, using watering cans with roses similar to overhead irrigation method. Irrigation application commenced immediately after planting. The treatment combinations were control, with neither irrigation interval nor SMS, 4 days irrigation interval combined with 10, 20 and 30 t/ha SMS, 7 days irrigation interval combined with 10, 20 and 30 t/ha SMS, and 10 days irrigation interval combined with 10, 20 and 30 t/ha.

Cultural practices

There was no application of inorganic fertilizer. Weeding was done manually two weeks after planting and at subsequent intervals as the need arose.

Soil

Composite soil samples were collected prior to planting and at thirteen weeks after planting (13 WAP) with soil auger at a depth of 0 to 25 cm for analysis. Parameters determined include pH, electrical conductivity, organic matter, total nitrogen, available phosphorus and exchangeable cations (Ca, Mg, K and Na). The methods adopted were those described by Jackson (1964), Bremner and Mulvaney (1982) and Black et al (1965). Other parameters determined were the moisture content and, by extension, available water. The gravimetric method was used in determining the moisture content, after which the available water was obtained from the following equation (Fubara-Manuel, 2006):

$$AW = [(MC - 8.63)/12.20] \times 100$$

Where, AW is the available water (%) and MC is the moisture content (%) by volume

Plant

Four plants were selected by simple randomization of each plot, 13 WAP. The average values from the selected plants were then used to determine the vine length, number of leaves, leaf area, number of branches, vine fresh weight and total shoot yield. Percent emergence was also determined, but this was done two weeks after planting.

Leaf area

The leaf area was estimated using the following equation proposed by Akoroda (1993):

Table 1. Chemical properties of the spent mushroom substrate.

pH	Ec (ds/m)	%											
		Organic matter	Organic carbon	Total N	C/N ratio	Available P	Ca	Mg	K	Cu	Zn	Fe	Mn
6.8	0.40	54.2	32.03	1.25	25.62	0.15	0.10	0.06	0.14	0.003	0.13	0.10	0.004

Table 2. Physicochemical properties of the soil between 0 and 25 cm depth.

Period	Plot	pH	EC (ds/m)	Organic matter (%)	Total N (%)	Available P (mg/kg)	Exchangeable bases (cmol/kg)				Moisture content (by volume) (%)	Available water (%)
							Ca	Mg	Na	k		
Before experiment	General	5.18	0.52	2.48	0.07	9.00	6.83	2.00	0.08	0.15	15.54	56.64
After experiment	Control	4.93	0.19	1.75	0.07	8.94	5.15	1.73	0.07	0.16	12.28	29.92
	Treated	5.07	0.21	1.60	0.09	25.19	4.79	1.83	0.07	0.15	19.57	89.67

$$LA = 0.9467 + 0.2475LW + 0.9724LWN$$

Where, LA is the leaf lamina area; L is the length of central leaflet; W is the maximum width of the central leaflet and N is the number of leaflets in a leaf.

Statistical analysis

The values obtained for the various plant parameters were subjected to simple univariate summary statistics such as the mean and standard deviation. The analysis of variance (ANOVA) was then used to compare the variability in selected parameters due to the treatment applications, according to the procedure outline by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

The chemical properties of the spent mushroom substrate (SMS) used are shown in Table 1. Although, the range of values of the properties of SMS suitable for the growth of fluted pumpkin in the study area is yet to be investigated, a general guide for SMS selection for the production of turf, recommends, for example, that the pH should be between 6.0 and 8.0, organic matter should be greater than 40%, while carbon : nitrogen ratio should be below or equal to 30:1 (Landschoot and McNitt, 1995). Thus, the pH of 6.8, organic matter of 54.2% and C : N ratio of 25.6:1 of the SMS used for this study meet these recommendations.

Table 2 presents the physical and chemical properties of the soil between 0 and 25 cm depth before and after the experiment. The soil was acidic, with a pH of 5.18 before the experiment, but decreased to 4.93 and 5.07 after the experiment in the control and treated plots, respectively. Ouda and Mahadeen (2008) however, found that soil pH was not significantly affected by different

doses of organic and inorganic fertilizers in a plastic house experiment. The electrical conductivity also decreased from 0.52 ds/m before the experiment to 0.19 and 0.21 ds/m in the control and treated plots, respectively after the experiment. It is difficult to offer tangible explanation for the drop in EC in the control that had no treatment except to attribute it to plant uptake. In the treated plots, however, the drop is attributable mainly to the leaching effect of the irrigation water. This, in part, agrees with the findings of Maher (1994) who stated that the addition of fresh SMS at a rate of 25 metric tons per ha drastically increased EC but after a certain amount of harvest, EC would be reduced due to leaching and plant nutrient uptake. Table 2 further shows that available P increased from 8.94 mg/kg at the control, to 25.19 mg/kg in the treated plots. This, certainly, is due to the application of SMS. The result conforms with those of Wisniewska and Pankiewicz (1989) who observed that soil treatment with SMS increased the P, K, Ca and Mg contents in the soil. However, uptake by plants has the capacity to reduce these parameters. The last row of Table 2 showed a reduction of available water from 56.64% before the experiment to 29.92% in the control after the experiment, which is obviously due to moisture uptake by the crop. Although, the increase of available water to 89.67% in the treated plots can be attributable to irrigation, the contribution of SMS as much to this moisture increase cannot be underestimated. Harpster et al. (2000) observed increase in soil nutrient levels including water holding capacity in soils amended with SMS.

The effect of the different applications of irrigation intervals combined with different levels of SMS on the growth parameters of fluted pumpkin at the end of thirteen weeks after planting (13 WAP) is presented in Table 3.

Table 3. Growth parameters of fluted pumpkin.

Treatment		Growth parameter						
Irrigation interval (days)	Spent mushroom substrate (t/ha)	Vine length (m)	Number of leaves	Leaf area (cm ²)	Number of branches	Vine fresh weight t/ha	Percentage emergence	Total shoot yield (t/ha)
0	0	0.97±0.03	17.33±0.94	27.14±2.06	2.67±0.47	0.72±0.02	51.27 ± 0.75	0.42 ± 0.03
4	10	1.82±0.02	30.67±0.94	56.22±3.38	5.33±0.47	1.82±0.01	81.27±1.54	1.09±0.07
	20	1.83±0.04	48.33±1.25	75.95±2.66	8.00±0.00	1.89±0.09	87.11±0.91	1.70±0.05
	30	1.97±0.02	54.33±2.36	72.04±0.98	9.67±0.47	2.15±0.07	92.88±0.71	2.17±0.05
7	10	1.60±0.04	29.00±0.82	53.59±4.39	4.33±0.47	1.44±0.01	80.93±2.55	1.41±0.02
	20	1.99±0.02	27.33±0.94	56.95±3.26	6.67±0.47	1.38±0.06	80.22±1.07	1.22±0.01
	30	1.83±0.04	42.67±1.25	72.76±1.03	8.33±0.47	1.89±0.08	84.20±2.14	1.74±0.05
10	10	1.23±0.14	23.33±2.49	33.70±1.84	4.00±0.00	1.28±0.02	77.66±1.11	1.23±0.01
	20	1.17±0.03	21.00±0.82	36.27±1.44	5.67±0.45	1.30±0.02	78.59±4.19	1.25±0.02
	30	1.18±0.04	24.67±0.94	44.32±3.06	6.33±0.45	1.62±0.12	82.12±1.42	1.27±0.02

Values are mean ± standard deviation of three replicates.

The maximum vine length of 1.99 m was obtained from the combination of 7 days irrigation interval and 20 t/ha SMS. Apart from the control, the least vine length of 1.17 m occurred from the combination of 10 days irrigation interval and 20 t/ha SMS. Furthermore, the highest average number of leaves of 54.33 was obtained from the combination of 4 days irrigation interval and 30 t/ha SMS. This result agrees with that of Asoegwu (1988) who observed a decrease in the number of leaves with increase in irrigation interval, although, his research did not include SMS. Similar findings were made by Mateen ul Hassan et al. (2005) on the growth and yield of bell pepper. For leaf area, combining 4 days irrigation interval with 20 t/ha SMS gave the highest mean value of 75.95 cm², while the lowest value of 33.70 cm² was obtained from the combination of 10 days irrigation interval and 10 t/ha SMS.

The combination of 4 days irrigation interval and 30 t/ha SMS also showed the highest values for number of branches (9.67), vine fresh weight (2.15 t/ha), percent emergence (92.88%) and total shoot yield (2.17 t/ha). The lowest values from the treated plots were however obtained from the combination of 10 days irrigation interval and 10 t/ha SMS for number of branches (4), vine fresh weight (1.28 t/ha) and percentage emergence (77.66%), while the combination of 4 days irrigation interval and 10 t/ha SMS gave the least value of 1.09 t/ha for total shoot yield which is attributable to the small quantity of SMS.

Table 3 further indicates that there was increase in growth parameters with shorter irrigation intervals and higher amount of SMS, with optimum values obtained by combining 4 days irrigation interval with 30 t/ha SMS. For irrigation intervals, the 4 days interval must have caused

a greater water use efficiency, thus indicating that the moisture level was within the readily available moisture zone. On the other hand, the longest irrigation interval of 10 days must have made the moisture level to dwindle beyond the lower available limit and, hence, into the wilting range, thus causing the plant to undergo some moisture stress. Similar results were obtained by Channabasavanna and Setty (2000) for sweet pepper, and Olalla and Valero (1994) for bell pepper.

In the case of SMS, research findings showed an increase in growth and yield parameters with increasing organic and inorganic fertilizers up to a point, after which the parameters start decreasing. For example, Olaniyi and Akanbi (2007) showed that growth parameters of fluted pumpkin increased significantly with increasing organomineral fertilizer rate from 0 to 30 M/ha, then declined thereafter. Olaniyi and Odedere (2009) further observed that although the application of 6 t/ha compost gave the highest growth and yield parameters of fluted pumpkin, there was no significant difference between the values obtained at 4.5 and 6 t/ha. However, Polat et al. (2004) found that there were statistically significant differences among different levels of spent mushroom compost (SMC) applied, in terms of total yield of lettuce, as 2 and 4 t/ha SMS gave the best result. In the case of cucumber grown in green houses with drip irrigation, Polat et al. (2009) also observed that the highest total fruit yield was obtained through the application of 40 tonha⁻¹ SMC, followed by 80 and 20 tonha⁻¹ applications. This further confirms the fact that increase in application of SMC increases yield parameters up to a point, after which the parameters start declining.

Table 4 presents the summary of ANOVA used to compare the means of the selected growth parameters.

Table 4. Summary of the analysis of variance (ANOVA).

Parameter	Source of variation	Degree of freedom	Sum of squares	Mean square	F value
Vine length	Replication	2	0.01	0.005	110**
	Treatment	9	3.93	0.44	
	Error	18	0.08	0.004	
	Total	29	4.02		
Number of leaves	Replication	2	8.47	4.24	139.62**
	Treatment	9	4130.14	458.90	
	Error	18	50.86	3.30	
	Total	29	4189.47		
Leaf area	Replication	2	16.354	8.177	86.62**
	Treatment	9	8106.145	900.683	
	Error	18	191.599	10.644	
	Total	29	8314.098		
Number of branches	Replication	2	-82.500	-41.250	2.85*
	Treatment	9	125.367	13.930	
	Error	18	87.833	4.880	
	Total	29	130.700		
Vine fresh weight	Replication	2	-0.040	-0.020	129.75**
	Treatment	9	4.674	0.519	
	Error	18	0.068	0.004	
	Total	29	4.702		
Total shoot yield	Replication	2	0.002	0.001	214.67**
	Treatment	9	5.792	0.644	
	Error	18	0.045	0.003	
	Total	29	5.839		

** = Significant at 1% level; * = significant at 5% level.

The table shows that only the difference in treated means between the number of branches is significant at the 5% level, while the means of all the other parameters are significant at the 1% level.

Conclusions

All the combinations of irrigation interval and SMS resulted in higher growth parameters than the control, thus indicating that the application of irrigation and SMS greatly enhanced the growth of the crop. Furthermore, although the combination of 7 days irrigation interval and 20 t/ha SMS, and 4 days irrigation interval with 20 t/ha SMS resulted in the maximum vine length and leaf area, respectively, the application of 4 days irrigation interval combined with 30 t/ha SMS gave the best result in all the other parameters measured. The combination of 4 days irrigation interval and 30 t/ha SMS should therefore be used in the study area during the dry season for flute

pumpkin.

The results of this study further buttress the fact that effective crop growth in the Niger Delta region of Nigeria can only be achieved through supplemental irrigation and by improving the quality of the soil.

ACKNOWLEDGEMENT

We appreciate the invaluable contributions made by Chief M. M. Chinda, Director, Dilomat Mushroom Development Center, Rivers State University of Science and Technology, Port Harcourt.

REFERENCES

- Akanbi BW, Adebayo AT, Togun AO, Adeyeye SA, Olaniran AO (2007). The use of compost extract as foliar spray nutrient source and botanical insecticide in *Telfairia occidentalis*. World J. Agric. Sci. 3(5): 642-652.

- Akoroda MO (1990). Seed Production and Breeding Potential of the Fluted Pumpkin (*Telfairia occidentalis*). *Euphytica*, 49: 25-32.
- Akoroda MO (1993). Non-destructive estimation of area variation in shape of leaf lamina in the fluted pumpkin *Telfairia occidentalis*. *Sci. Horticult.* 53(3): 261-267.
- Asoegwu SN (1988). Effects of irrigation on the leaf and pod production of fluted pumpkin *Telfairia occidentalis* Hook. F.) in Southern Nigeria. *Sci. Horticult.* 34: 161-168.
- Ayotamuno MJ, Zuofa K, Ofori AS, Kogbara BR (2007). Response of maize and cucumber intercrop to soil moisture control through irrigation and mulching during the dry season in Nigeria. *Afr. J. Biotechnol.* 6(5): 509-515.
- Black CA, Evans DD, Whils JL, Ensminger LE, Clerk FE (1965). *Methods of soil analysis, Part 2.* Am. Soc. Agron. Inc. Madison, Wisconsin. pp. 1147-1573.
- Bremner JM, Mulvaney CS (1982). Soil total Nitrogen In: *Methods of soil analysis.* Part 2. Page et al (2nd ed.) Agron. Mono 9. Assa. Ssa WI. pp. 595-624.
- Channabasavanna AS, Setty RA (2000). Effect of different irrigation Intervals on sweet pepper. *South-Indian-Hort.* 39(5): 296-299.
- Fubara DMJ (1983). Physical conquest and development of the Niger Delta. Commemoration lecture, Rivers State University of Science and Technology, Port Harcourt.
- Fubara-Manuel I (2005). Scheduling irrigation in an area transiting from rainfed to irrigated agriculture using the water-balance approach. Proceedings of the 6th International conference of the Nigerian Institute of Agric. Eng. 27(1): 122-129.
- Fubara-Manuel I (2006). Mathematical model for determining the irrigation schedule for maize in the Niger Delta region of Nigeria. Ph.D thesis, Rivers State University of Science and Technology, Port Harcourt, Nigeria.
- Gomez AK, Gomez AA (1984). *Statistical procedures for agricultural research.* 2nd Edn John Wiley and Sons New York. p. 680.
- Harpster T, Sellmer J, Kulins L (2000). Evaluating the soil building characteristics and growth benefits of four composted organic waste products on field grown woody nursery stock. Proceedings, spent Mushroom substrate symposium: pp. 112-115.
- Jackson ML (1964). *Soil chemical analysis.* Prentice Hall Inc., Engle wood cliffs, N.J. p. 498.
- Landschoot P, McNitt A (1995). Using spent mushroom substrate (mushroom soil) as a soil amendment to improve turf. Staff paper, Pennsylvania State University U.S.A. (<http://spentmushrooms substrate.turfgrass.psu.edu/pubs/spentmushroom>.)
- Maheer MJ (1994). The use of Spent Mushroom Substrate (SMS) as an organic manure and plant substrate component. *Compost. Sci. Util.* 2(3): 37-44.
- Mateen ul Hassan K, Muhammad I, Tahir HC (2005). Effects of irrigation intervals on growth and yield of onion varieties Swat-1 and Phulkara. *J. Appl. Sci. Res.* 1(2): 112-116.
- Nottidge DO, Ojeniyi SO, Asawalom DO (2005). Comparative effect of plant residue and NPK fertilizers on nutrient status and yield of maize *Zea mays* L. in humid ultisol. *Soil Sci. Soc.* 15: 9 – 13.
- Odiaka NI, Akoroda MO, Odiaka EC (2008). Diversity and production methods of fluted pumpkin (*Telfairia occidentalis* Hook F.); Experience with vegetable farmers in Makurdi, Nigeria. *Afr. J. Biotechnol.* 7(8): 944-954.
- Olalla F, Valero JA (1994). Growth and production of bell pepper under different irrigation intervals. *RSAA. Expt. Station 466:* 92-95.
- Olaniyi JO, Akanbi WB (2007). Effect of Organo mineral and inorganic fertilizers on the yield quality of fluted pumpkin *Telfairia occidentalis* hook. F. *Afr. Crop Sci. Conference Proceed.* 8: 347-350.
- Olaniyi JO, Odedere MP (2009). The effects of mineral N and compost fertilizers on the growth, yield and nutritional values of fluted pumpkin (*Telfairia occidentalis*) in south western Nigeria. *J. Anim. Plant Sci.* 5(1): 443-449.
- Opuwaribo EE, Enwezor WO, Ohiri AC, Udo EJ (1990). A review of fertilizers. Federal Ministry of Agriculture, Water Resources and Rural Development FPDD. p. 53063.
- Ouda BA, Mahadeen AV (2008). Effect of fertilizers on growth, yield, yield components, quality and certain nutrient contents in broccoli *Brassica Oleracea*. *Int. J. Agric. Biol.* 10: 627-632.
- Polat E, Onus AN, Demir H (2004). The effects of spent mushroom compost on yield and quality in lettuce growing. *J. Fac. Agric. Akdeniz Univ.* 17(2): 149-154.
- Polat E, Uzun IH, Topcuoglu B, Onal K, Onus NA, Karaca M (2009). Effects of spent mushroom compost on quality and productivity of cucumber *Cucumis sativus* L. grown in green houses. *Afr. J. Biotechnol.* 8(2): 176-180.
- Wisniewska G, Pankiewicz, T (1989). Evaluation of the suitability of spent mushroom substrate for tulip cultivation. *Prace Inst. Sad. Kwi.* 14: 7-13.