Items falling in the first category included seed; gas, oil and grease; repair and maintenance; depreciation; interest on production capital; interest on capital investment; miscellaneous expenses; and hauling expenses. The second category included fertilizer; spray and dust; cultural labor; machine hire; picking; grading and packing; containers; and selling expenses. As noted above, machine hire costs in 1978 had decreased from their 1968 level. Only two items (land rent and licenses and insurance) fell in the third category.

To illustrate the estimated trend models, the equations for land rent, repair and maintenance, and fertilizer are shown in Figure 3. Note the plot of the estimated trend for repair and maintenance is a straight upward sloping line. The plot of the estimated trend for fertilizer projects that fertilizer costs were increasing at a decreasing rate and have begun to decline. The plot of the estimated trend for land rent shows this cost increasing at an increasing rate.

A word of caution is in order. The data used was expressed in current dollars and did not take into account adjustments for the quantities and qualities of inputs. It could also be argued that the cost of some items may have declined in terms of real dollars. Thus, differential inflation rates could have benefited the tomato producers—particularly if tomato prices have increased at a faster rate.

The latter, however, does not seem to be the case. During the study period, tomato prices showed an average rate of increase, compounded annually in current dollars, of 5.17 percent (2). That figure is far below the 12 percent rate of increase for total costs. Therefore, Florida producers should be particularly concerned with those items which have risen most rapidly and with those which displayed similar recent trends.

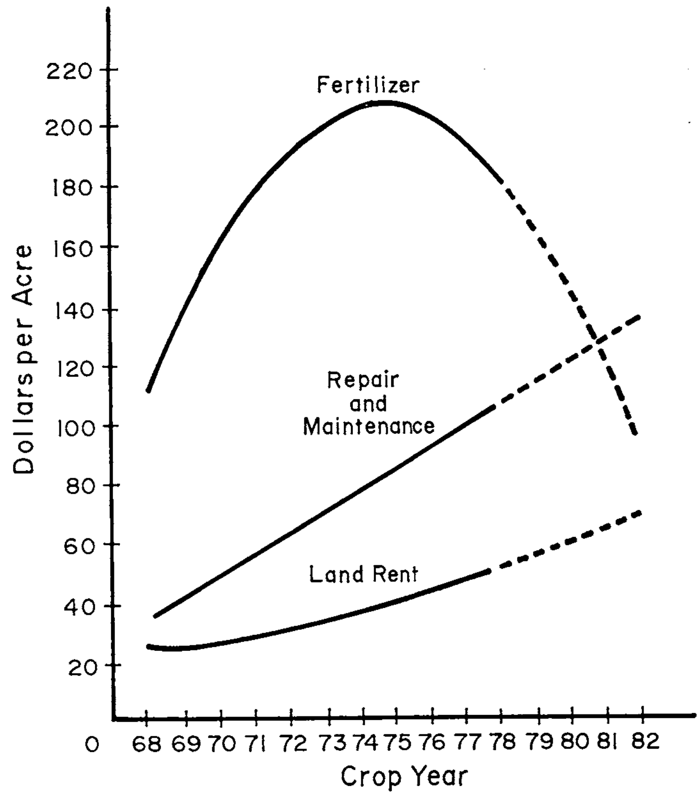

Fig. 3. Plots of three of the estimated trend models.

Literature Cited

1. Brooke, D. L. Annual Issues. Costs and returns from vegetable crops in Florida, with comparisons. Univ. of Fla. Ec. Info. Report.
2. Florida Crop and Livestock Reporting Service. Annual Issues. Florida agricultural statistics-vegetable summary. Orlando.
3. Zepp, G. A. and R. L. Simmons. 1979. Producing fresh winter vegetables in Florida and Mexico: costs and competition. ESCS-72, U.S. Dept. of Agr., Washington, D.C.

Proc. Fla. State Hort. Soc. 94:193-197. 1981.

A PRODUCTION AND MARKET FORECASTING MODEL FOR FLORIDA WATERMELONS BY REGION[1]

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Abstract. **A causal model as well as time series models are derived and employed to predict the planted acres and monthly prices for Florida watermelons. The different techniques are used to generate forecasts from each and a *composite* forecast, which may be more accurate. These forecasts can be derived before the production decisions are made by Florida producers and will thus provide Florida producers information they can use in their production decision process.**

A demonstration of the forecasting technique is given for the 1981 season and is compared with realized values. Finally, a forecast for the 1982 season is derived.

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The state of Florida is a major producer of spring and early summer watermelons. Florida produced 72.3% of the total U.S. spring watermelon production in 1980 (Table 1) and 34.8% of total U.S. production. The 1980 watermelon crop was valued at approximately 48.5 million dollars or 7.8% of the total value of fresh vegetables in Florida. Areas competing with Florida for the spring watermelon market include Georgia, Texas, Alabama, California, Arizona, and Mexico.

Table 1. Spring watermelon production by state.[z]

State	Percent of total
Florida	72.3
Georgia	4.8
Texas	11.0
Alabama	2.0
California	7.8
Arizona	2.0

[z]Source: Crop Reporting Board, *Vegetables 1980 Annual Summary.* ESS, USDA, December, 1980.

Florida watermelon planted acreage has shown considerable variation, ranging from 65,000 acres in 1976 to 45,000 acres in 1980. Accompanying this variation in production has been a contrasting variation in the annual average price received for Florida watermelons [4]. This variation indicates that higher acreages planted to watermelons tend to lower the price paid to the grower.

The price individual producers in Florida receive for their products depends on the time within the season the product is marketed. The production season for watermelons is defined as beginning with the first week of April of each year and ending one to two weeks after the July 4th holiday. Mexico typically dominates the U.S. market for watermelons during the early part of the season while Florida is normally the major supplier from the first week of May through mid-July.

Because of climatic conditions, individual Florida producers differ as to when they market their watermelons within a given season. This period depends on the area of the state in which watermelons are produced. The Florida Crop and Livestock Reporting Service divides the producing areas of Florida into four areas. Figure 1 shows these pro-

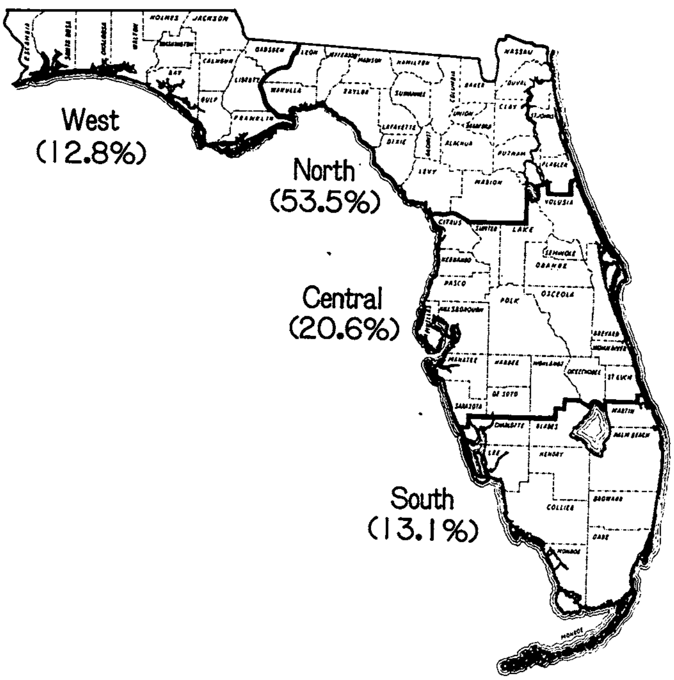

Fig. 1. Average percent of total harvested acres in Florida by area for years 1970-1980.

ducing areas along with the average percent of total harvested acreage in Florida for each region for the years 1970 to 1980. Table 2 shows the total harvested acreage for Florida and percent of total harvested acres by area for each year from 1970 to 1980. Examination of Table 2 shows that the north Florida area has increased its production share from 38.9% in 1970 to 62.4% in 1980 while all other areas have decreased. The north and central producing areas ship most of the watermelons they produce from mid-May to late June, a time when Florida supplies over 50% of the total U.S. market. The south production area competes with Mexico for the available early market. The west production area competes with other Southeastern U.S. producers for the available late season market.

Table 2. Total harvested acres in Florida and percent of total harvested acres by area.[z]

Year	Area				Florida harvested acres
	West	North	Central	South	
1970	15.1	38.9	26.1	19.8	47,500
1971	18.0	39.7	24.3	18.1	50,100
1972	17.1	46.7	21.4	14.8	56,100
1973	14.9	50.3	21.6	13.1	48,700
1974	16.1	52.8	18.0	13.0	44,500
1975	14.4	53.4	20.2	11.9	43,600
1976	13.5	56.4	21.8	8.4	55,000
1977	7.8	62.1	19.8	10.2	51,000
1978	10.0	62.0	18.6	9.4	50,000
1979	7.0	64.0	17.2	11.9	43,000
1980	6.5	62.4	17.9	13.2	42,500
Average	12.8	53.5	20.6	13.1	

[z]Source: Florida Crop and Livestock Reporting Service, *Vegetable* Summary. F.C.I.L.R.S., USDA, Issues from 1970 to 1980.

A study by Wall and Tilley [5] of Florida watermelon production analyzed the relationship between prices, planted acres, harvested acres, and shipments of watermelons from Florida and other states competing with Florida. This study determined that a 10% increase in the current years price will on the average, cause producers to increase production 6% the following year. In addition, the study determined that the price increase will influence planted acres in the two years following. Producers will tend to increase production 6% the second year and 3.5% the third year following the price increase.

The results of the Wall study indicate that producers are developing price expectations based on the prices received in the three most recent years. The dependence of production on these price expectations appear to contribute to the cyclical nature of watermelon production and prices received (e.g., the results indicate why total planted acres in Florida decreased from 65,000 in 1976 to 45,000 in 1980 and then increased to 54,000 in 1981 while price received increased from $2.61 in 1976 to $5.92 in 1980). Reliable forecasts would benefit producers by providing more accurate information which would assist them in making their production decisions. The purpose of this study is to develop a technique for forecasting both planted acres within each production area of Florida and monthly prices in advance of the season.

Methods

Watermelon producers must make production decisions

Table 3. Estimated and observed planted acreage for each producing area and total.

Year	West		North		Central		South		Total	
	Actual	Forecast	Actual	Forecast	Actual	Forecast	Actual	Forecast	Actual	Forecast
1978	9,500	7,920	34,000	29,448	10,700	8,343	4,800	5,830	59,000	51,541
1979	5,000	6,770	31,000	31,692	8,800	9,258	5,200	5,213	50,000	52,933
1980	4,000	6,411	27,500	30,454	7,800	9,469	5,700	5,634	45,000	51,968
1981	4,500	14,460	32,000	36,000	10,700	16,920	6,800	7,960	54,000	75,340
1982		14,370		28,170		11,460		6,730		60,730

in advance of the season. These decisions are based on expectations concerning future production and market conditions. This study derives and uses an econometric model to forecast planted acreage in each of the four watermelon production areas in Florida. In addition, monthly prices received for Florida watermelons are forecast a season in advance using three separate forecasting techniques and a composite forecast.

Forecasting Planted Acres

In this study, we are assuming that the producers in each producing area of Florida formulate their planting decisions in similar ways. In addition, because of the seasonality associated with prices received, the decision for each producing area is based on a different expectation of price. To account for this difference, the price received by producers in each area is specified to be the price for the month corresponding to the period in which most of the area's production is marketed. The south area markets the first watermelons of the season and is matched with the average value for watermelons marketed in April. When no watermelons are marketed in April, the May average value is used. The central area is matched with May prices, north area with June prices, and west area with July prices.

In addition, yields in the previous seasons are hypothesized to have an affect on planting decisions in the following year. Producers are more likely to plant more of a crop the following year if they perceive themselves to be a successful producer of that crop. Finally, shipments from competing states for each of the corresponding months in previous seasons are hypothesized to affect the planting decision of Florida producers. Producers expect shipments in previous years from other areas to be an indicator of competition in the forthcoming season. Higher shipments in prior years from competing states should cause lower planted acreage in the current year for Florida.

Forecasting Monthly Prices

The forecasting of the average monthly prices received for Florida watermelons was done using three separate forecasting techniques and a composite forecast. The three separate techniques used included an econometric model, an autoregressive integrated moving average (ARIMA) time series model, and an exponential smoothing model. The forecasts derived from each of these were then used to construct a composite forecast for Florida watermelons one season in advance. Each of the four forecasting methods are discussed below.

Econometric model. The econometric model used for forecasting monthly watermelon prices was a recursive model. First, a model was estimated for annual watermelon prices. The annual price was then used with seasonal adjustments to forecast monthly watermelon prices.

The model used for estimating annual prices was the reduced form of a conceived structural econometric model. Wall and Tilley constructed a structural econometric model for exploring the relationship between prices received, planted acreage, and shipments from Florida and other competing states. The reduced form of their econometric model for prices received included prices received in prior years, shipments from other states, yield, and a trend term to account for shifts in technology, U.S. disposable income, and U.S. population. Since we are attempting to forecast with this econometric model, we used expected values for shipments from other competing states, yield, U.S. disposable income, and U.S. population. Naive expectations were used which consisted of using the value of each variable observed in the prior year for each corresponding month.

The model for monthly watermelon prices hypothesized that prices were a function of the annual average price received in Florida, a trend variable, and monthly intercept shifters. In addition, both models used a dummy variable in the years 1977 and 1981 to allow for structural shock caused by the freeze observed in Florida in each of those years.

ARIMA Models. This forecasting technique is based upon the idea that a time series of observations constitutes a realization of an unknown stochastic process contained in the class of ARIMA models. The basic procedure used in implementing this technique involves identifying and estimating the parameters of a model in this class which has the highest probability of generating a given time series. While the 'true' process can never be discovered with certainty good empirical approximations can usually be obtained by following the procedures outlined by Box and Jenkins [2].

The ARIMA forecasting technique differs considerably from the structural econometric approach. The difference lies in the fact that ARIMA models forecast future prices solely on the basis of information contained in previous prices whereas econometric models utilize additional information in the form of explanatory variables. Thus in a sense, the relative performance of ARIMA models as compared to econometric models can be seen to rest in the amount of information contained in past prices.

Exponential Smoothing Models. Exponential smoothing models are largely *ad hoc* forecasting models which provide reasonably accurate forecasting at low cost in terms of both time and money. These models are also fully automatic in that there is no explicit reliance on estimated parameters as in the case of ARIMA models.

The underlying assumptions of exponential smoothing models state that any time series can be decomposed into a level component, trend component and an unexplained residual component. There are many specific exponential smoothing methods. The exponential smoothing model used in forecasting watermelon prices is a variant of the model developed by Winters [6] with the Trigg and Leach [3] method of adapting the forecast response rate incorporated.

Composite Forecast. A composite forecast for watermelon prices is formed by taking a weighted average of the one season ahead forecasts generated from the above models. Weights in the composite forecasts are functions of the forecast errors of the three individual forecasting techniques. Generally values of these weights are such that the most accurate forecast from the previous period is given the most weight in the subsequent forecast. As usual, these weights are constrained to sum to one.

The notion of using a composite forecasting technique for perishable products such as watermelons is appealing because of the large number of uncontrollable or unmeasurable factors which can influence perishable products. One cannot expect any single forecasting technique to capture all of these. However, different techniques may be able to capture some of the effects of these factors in a complementary fashion so that the composite forecast is considerably more accurate than any individual forecasting technique. Bates and Granger [1] have found that when the forecasting techniques utilized in forming the composite are based on considerably different information sets, the composite forecasts can be considerably superior to those obtained by the individual techniques.

The composite forecasting technique utilized here was developed by Bates and Granger. Forecast weights for computing the composite forecast for season t are given by

$$W_{j,t} = \frac{\sum_{i \neq j} e^2_{i,t-1}}{2\sum_{i} e^2_{i,t-1}}$$

where $W_{j,t}$ is the weight assigned to the jth forecasting technique, $e_{i,t-1}$ is the forecast error corresponding to the ith forecasting technique in season t-1 and $\Sigma W_{j,t} = 1$.

Results

Annual Watermelon Acreage

Watermelon acreage by area was forecasted using ordinary least squares regression analysis. The model derived for forecasting purposes was

$$1)\quad PA_{it} = \underset{(1.62)}{3.87} + \underset{(3.92)}{2.79}*(RPR_{it}) + \underset{(7.27)}{0.0278}*(MEY_{it}) + \underset{(14.26)}{0.1841}*(JEY_{it}) + \underset{(4.17)}{0.0833}*(LEY_{it}) - \underset{(-2.18)}{0.00084}*(ETS_{it}) - \underset{(-4.02)}{0.307}*(T_{it})$$

where

PA_{it} = acreage (1000's) planted to watermelons in production area i in year t.

RPR_{it} = expected real price in $/cwt. received for watermelons in year t in production area i (real price is the observed price divided by the U.S. Agricultural Prices Received index for the corresponding year).

MEY_{it} = expected yield/acre in the central area in year t when i equals the central area, 0 otherwise.

JEY_{it} = expected yield/acre in the north area in year t when i = north, 0 otherwise.

LEY_{it} = expected yield/acre in the west area in year t when i = west, 0 otherwise.

ETS_{it} = expected shipments (1000 cwt.) from competing states in year t for area i.

T_{it} = the year t minus 1963 (1964 is the first year of the sample period).

i = areas in Florida, i.e., west, north, central, and south.

t = year of observation (1964 through 1981).

R^2 = .915, F-ratio = 108.84, degrees of freedom = 61.

The expected value of a variable in year t equals the value of the variable in t—1 multiplied by .66 plus the value of the variables in t—2 multiplied by .34. The t values for the coefficients are in parentheses below each. Table 3 contains the observation for each production area for the years from 1978 to 1981 and the forecasted value for each. In addition, the forecasted values from the model for 1982 are given.

Monthly Watermelon Prices

The model for annual watermelon prices was estimated using ordinary least squares regression. The only variables used were those where the value was known prior to the season. The annual price was then used with seasonal adjustments to develop a model for forecasting monthly prices. The models estimated were

$$2)\quad AVY_t = \underset{(-5.97)}{-25.68} - \underset{(-2.67)}{0.000152}*(LOS_{t-1}) - \underset{(-2.07)}{1.270}*(FZ_t) + \underset{(6.52)}{0.1452}*(USPOP_{t-1})$$

R^2 = .798 F-ratio = 15.76 d.f. = 12

$$3)\quad AVM_{m,t} = \underset{(-2.28)}{-0.622} + \underset{(5.23)}{0.7012}*(AVY_t) + \underset{(3.09)}{0.096}*(T_t) + \underset{(10.98)}{2.408}*(DA_{m,t}) + \underset{(7.72)}{1.694}*(DM_{m,t}) + \underset{(1.22)}{0.267}*(DJ_{m,t}) - \underset{(-1.95)}{0.723}*(FZ_t)$$

R^2 = .866, F-ratio = 66.22, degrees of freedom = 61

where

AVY_t = average value ($/cwt.) for watermelons in year t.

LOS_{t-1} = total shipments from competing areas in year t—1 in 1000 cwt. units.

FZ_t = 1 if year equals 1977 or 1981 (severe freezes hit Florida in these years).

$USPOP_{t-1}$ = U.S. population in year t—1 in millions.

$AVM_{m,t}$ = average value ($/cwt.) for watermelons in month m and year t.

T_t = year t minus 1963.

$DA_{m,t}$ = 1 if observation is in April, 0 otherwise.

$DM_{m,t}$ = 1 if observation is in May, 0 otherwise.

$DJ_{m,t}$ = 1 if observation is in June, 0 otherwise.

m = month of observation (April, May, June, July).

t = year of observation (1964 through 1981).

The ARIMA model estimated the natural log of monthly prices for watermelons. The price series was regularly differenced and seasonally differenced to attain stationarity. The ARIMA model estimated a moving average process of order 1 and a season moving average process of order 1. The model estimated was

$$5)\quad (1-B)(1-B^4)\,\widetilde{AVM}_t = \underset{(.11290)}{(1-.50075B)}\underset{(.08082)}{(1-.99283B^4)}e_t$$

where

$\widetilde{AVM}_t = \ln\left(\frac{AVM_t}{\overline{AVM}}\right)$, e_t is a white noise process, B is the backshift operator (e.g., $B^iX_t = X_{t-i}$) and standard errors are in parentheses below the coefficients.

Finally, forecasts were generated for monthly watermelon prices from the exponential smoothing model and a composite forecast was then developed as previously described. Table 4 contains the observation for monthly prices and the forecasted values from each estimator, including the composite estimator, for the years 1978 to 1981. Table 5 contains the weights used in forming the composite forecasts for the same seasons. Examining Table 5 shows that in terms of mean absolute forecast error (MAE) the composite forecasting technique outperformed all of the individual forecasting techniques. The composite forecast had a MAE of 1.28 as opposed to 2.01, 1.45, and 1.95 respectively for the structural econometric, ARIMA, and exponential

Table 4. Forecasting monthly watermelon prices for 1982.

Period	Estimated value				
	Obs.	Causal	ARIMA	Exponential smoothing	Composite estimate
April, 1978	$6.00	$3.73	$6.19	$10.74	$6.17
May, 1978	6.00	3.06	5.10	2.80	4.02
June, 1978	3.00	1.80	3.00	3.08	2.55
July, 1978	2.50	1.40	2.32	2.00	1.96
April, 1979	7.20	4.67	5.79	8.93	6.59
May, 1979	7.20	4.04	4.54	4.09	4.25
June, 1979	4.20	2.85	2.96	4.71	3.54
July, 1979	3.40	2.87	2.56	2.75	2.49
April, 1980	7.20	5.46	6.38	9.37	7.08
May, 1980	7.20	5.19	5.00	4.60	4.93
June, 1980	5.50	3.82	3.27	5.35	4.10
July, 1980	5.80	3.74	2.83	3.74	3.46
April, 1981	8.00	5.50	7.06	12.54	7.87
May, 1981	8.00	4.97	5.55	4.27	5.02
June, 1981	6.00	4.80	3.63	5.10	4.13
July, 1981	5.00	4.50	3.15	4.50	3.98
April, 1982		7.33	9.68	17.63	10.82
May, 1982		6.62	8.18	10.93	8.30
June, 1982		5.19	5.28	7.15	5.71
July, 1982		4.92	4.52	5.42	4.77

Table 5. Estimated forecast weights and mean absolute forecast errors (MAE) for each forecasting technique in the 1978 through 1981 seasons.

	Structural		ARIMA		Exp. smoothing		Composite
	Weight	MAE	Weight	MAE	Weight	MAE	MAE
1978	0.3330	1.92	0.4914	0.32	0.1756	2.13	0.79
1979	0.276	2.13	0.3741	1.54	0.3513	1.50	1.28
1980	0.3512	1.92	0.3065	2.06	0.3423	1.75	1.53
1981	0.3618	2.01	0.3881	1.90	0.2501	2.42	1.50
Average mean absolute error		1.99		1.45		1.95	1.28

smoothing forecasting techniques. The table contains monthly composite forecasts for 1982 prices of 10.82, 8.30, 5.71, and 4.77 for April, May, June, and July respectively.

These forecasts point to one problem encountered in using strictly statistical methods in forecasting. Statistical methods of estimation do not allow the forecaster to incorporate factors, which may have been unobserved in the sample period into the forecasts. The 1981 watermelon season was unique for Florida. First, Florida experienced a freeze in the early part of the season which caused a need for replanting in the south area. In addition, the spring and early summer seasons were typified with hot and dry weather which caused the season in Florida to be exceptionally long. Florida shipped watermelons into the early part of August, a part of the season Florida rarely experiences. These factors, the freeze and hot and dry weather are termed shocks. This type of shock influences the forecasts for the subsequent season. The watermelon price situation suggests that the structural econometric model be weighted more heavily than the composite suggests. Since the shock in the 1981 season was temporary, a more reasonable forecast is derived by using the structural econometric model as the final forecast. This suggests that the final forecasts for the 1982 season are 7.33, 6.62, 5.19, and 4.92 for April, May, June, and July, respectively.

In addition, the longer shipping season and improved markets allowed west Florida to experience larger yields in the two most recent years, growing from 90 cwt. in 1979 to 147 cwt. and 177 cwt. in 1980 and 1981 respectively. These increased yields have led to exceptionally large forecasts for planted acres in west Florida in 1981 and 1982. Although one might expect a substantial increase in planted acreage for 1982, it is doubtful that 14,370 acres will be planted. The previous highest value for planted acres in the west area was 11,900 acres in 1972. Any acreage estimate above this value is suspect since it is outside the sample range. If planted acres for west Florida are forecast at 11,000 acres, the forecast for total planted acres in Florida would be 56,360, an increase of 2,360 acres over 1981. This would be a more reasonable forecast for 1982.

This paper presented forecasts for planted acres of watermelons by region in Florida and one season ahead forecasts of monthly watermelon prices. The 1982 forecasts for each are: 7.33, 6.62, 5.19, and 4.92 for watermelon prices in April, May, June, and July respectively, and; 6,730, 11,460, 28,170, and 11,000 for planted acres in south, central, north, and west Florida, respectively.

The composite forecasting technique was shown to outperform each individual technique by providing, on average, more reliable forecasts for monthly watermelon prices. The superior performance of the composite forecasting technique is, in a heuristic sense, traceable to the nature of perishable products. The production of perishable products is influenced by many factors (e.g., weather) which are difficult to forecast. Any single forecasting technique is limited in its forecasting ability. When a variety of forecasting techniques which have complementary qualities for dealing with such uncertainties can be combined, considerable improvement in forecasting performance can result. This is not to say that the composite forecast is best in all situations. In some instances, unforeseen shocks to the market create a situation wherein a single forecasting technique will provide more reasonable forecasts as is the case for the 1982 watermelon production season.

Literature Cited

1. Bates, J. M. and C. W. J. Granger. 1969. The combination of forecasts. Operations Research Quarterly 20:451-46.
2. Box, G. E. P. and C. M. Jenkins. 1970. Time Series Analysis, Forecasting and Control. San Francisco: Holden Day.
3. Trigg, D. W. and A. G. Leach. 1967. Exponential smoothing with an adaptive response rate. Operations Research Quarterly 18:53-59.
4. Van Sickle, John J. In press. Florida watermelon production and marketing outlook facts. University of Florida Agricultural Extension Circular FRE 37.
5. Wall, G. B. and D. S. Tilley. 1979. Production responses and price determination in the Florida watermelon industry. Southern Journal of Agricultural Economics No. 1:153-156.
6. Winters, P. R. 1960. Forecasting sales by exponentially weighted moving averages. Management Science 6:324-342.