Southwest Florida Water Management District

AGMOD

Agricultural Water Use Model Version 2.0

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SOUTHWEST FLORIDA WATER MANAGEMENT DISTRICT

AGRICULTURAL WATER USE MODEL

VERSION 2.0

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PREFACE

This two **part** paper discusses the procedures and rational for determining agricultural water use requirements in the Southwest Florida Water Management District% **(SWFWMD)** permitting **process.** Part I explains equations and assumptions used in permitting agricultural water use. Part II is a detailed description of the District's agricultural **water** use model **AGMOD.** Additional permitting information is in the District's Water Use Permitting Information **Manual.** A copy can be obtained from your local District office.

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PART I

AGRICULTURAL WATER USES

INTRODUCTION

The distribution and amounts of Florida's rainfall are not always adequate to meet crop water use demands. Usually supplemental irrigation is required to meet those demands and to produce favorable yields. Also, growers irrigate for field preparation, crop establishment, crop and field (frost-freeze, erosion) protection, salt leaching, chemigation, and system maintenance. This part of the paper explains irrigation *water* use calculations in the District's permitting process.

Under ideal conditions, water required for favorable crop production is **equal** to the water lost or used during plant growth. This water goes to soil evaporation and plant transpiration. Typically both processes are combined and called evapotranspiration **(ET)**.

A crop's ET varies throughout: a growing season. After planting, evaporation is larger than transpiration. As foliage increases, transpiration will too, and eventually becomes larger than evaporation. Usually a crop's ET peaks during fruit production.

There are many methods and **techniques** for estimating ET. These methods are either physical or empirical based. Most methods use some climatic data as an index for estimating potential ET. This potential is multiplied by a crop's *water* use coefficient to find ET. The net irrigation requirement is the difference between ET and effective rainfall.

BLANEY-CRIDDLE

The Blaney-Criddle equation is an empirical method developed from work in New Mexico, Utah and California. It was developed to estimate seasonal crop water use in arid regions of the western United States. The original equation estimated'evapotranspiration by correlating average monthly temperatures and percentage of daylight, to a **crop's** ET.

$$U = KF$$

where: U = **crop's** potential ET (inches)
K = empirical seasonal crop water use coefficient
F = ET *Factor*
$= \frac{tp}{100}$
t = average temperature °F
p = percentage of daylight hours.

The Blaney-Criddle method is used around the world. It is a popular method because it predicts ET, using only long term daylight and temperature **data.** While other ET methods require more climatic data, that is not always available.

The original Blaney-Criddle method has gone through many changes. J. T. Phelan noticed that although the temperatures, where the same, the computed water use coefficients (K) were different in the spring and fall. In 1954, he developed a relationship between the K value and temperature by separating the crop and climatic factors of ET. Phelan developed crop growth stage coefficients (Kc) by relating a **crop's** ET, to a reference ET. Then he developed a linear relationship for the crop's water use coefficient (K), growth stage coefficient (Kc), and temperature.

$$K = K_c K_t$$

where: K = empirical seasonal crop water use coefficient
Kc = crop growth stage coefficient (crop ET/reference ET)
Kt = climate factor = 0.0173(t) - 0.314
t = mean temperature °F.

The Blaney-Criddle model, and its crop coefficients, need to be verified and calibrated for regions other than the arid western United States. In some regions Blaney-Criddle over and under estimates requirements during the year. For example, in humid areas such as Florida, the modified Blaney-Criddle seems to over estimate crop ET in the summer months.

The Soil Conservation Service (SCS) uses Blaney-Criddle (TR-21) to estimate consumptive use. TR-21 shows different arid and humid climate annual crop coefficients. S-CONUSE, (April 1987) the **SCS's** computerized version of TR-21, reduces the calculated humid area ET by twenty percent. This reduction comes from non-research field experience.

Dr. Shih (1981) from the University of Florida conducted research to determine the **Blaney-Criddle** method's accuracy in Florida. His work showed that by replacing percentage daylight with percentage incoming solar radiation, and by reducing crop coefficients, the Blaney-Criddle method gave accurate results for Florida. The incoming solar radiation adjusts the ET distribution, so, the peak moved to the correct month for Florida's humid climate. Reducing the crop coefficients adjusts the magnitude of ET.

Crop coefficients for **Shih's** method need to be locally established because climatic factors that are not explicitly included in the model are "lumped" into these coefficients. In his work Dr. Shih accounted for humidity and **cloud** cover by reducing the original crop coefficients by about 85%. Doorenbos and Pruitt (1977) recommend, and gave instructions, on adjusting the original crop coefficients for prevailing wind and humidity.

$$U(m) = Kc[0.0173\,t(m) - .314]*t(m)*R(m)/100$$

where: U(m) = crop's **monthly** potential ET
Kc = adjusted crop growth stage coefficient

$t(m)$ = mean month temperature ° F
$R(m)$ = monthly percentage of annual incoming solar radiation.

Both Shih's solar radiation modification and Doorenbos and Pruitt's crop coefficient changes where used in developing the District's procedures for estimating supplemental irrigation requirements. Estimated ET values where computed and factors where adjusted to field and published data.

Comparing AGMOD estimated irrigation requirements to field and other data sources, shows reasonable consistency between them. For example the difference between estimated citrus ET in Polk and Highlands County to adjusted pan evaporation ($Kp = .75$) was less than an inch for each county,

Comparing projected water use to field data showed that in most cases AGMOD's projections where somewhat higher than real use. The comparisons showed that the monthly trends where the same. There are several reasons why the model was higher. The model uses long term drought conditions, specific efficiencies, and assumes optimum yields. Whereas field data is very site specific, with many unknown production variables.

EFFECTIVE RAINFALL

Rainfall is a main source of water for crop development. However, the crop does not use all the rainfall directly. Some water is lost to evaporation, runoff, or deep percolation.

In Florida, most of the rainfall occurs during June through September. These rains are typically short-term high intensity thunderstorms, with significant amounts of water either running off or replenishing depleted aquifers and lakes.

Effective rainfall is the part of rain that is available to the plant. The amount depends on the quantity and distribution of rainfall, soil infiltration rate and water holding capacity, root depth, water use demand, farming practices, and other factors. The SCS developed an empirical equation for one dimensional irrigation, to predict effective rainfall. That equation considers monthly rainfall, crop water demand, and the crop rooting zone's soil water holding capacity. This capacity is the amount of water that remains in the soil between field capacity (gravitational water removed) and wilting point. It is the water that can easily be used by the crop.

$$re = (0.70917 * rt^{0.82416} - 0.11556) * (10)^{0.024264 * U} * (f)$$

where: $f = (0.531747 + 0.295164*D - 0.057697*D^2 + 0.003804*D^3)$
re = effective rainfall depth in inches
rt = monthly rainfall
U = crop ET predicted by the Blaney-Criddle method
D = available storage capacity in the crop's root zone, in inches.

In the above equation "D" is the net depth of irrigation. It is a function of soil, root zone, and water table depth. The "D" value is equal to a crop's root depth multiplied by the soil's water holding capacity, times the allowable depletion. Typical root zone and soil information are in SCS and IFAS publications. Most growers will irrigate between 33-50% depletion.

Site specific conditions affect the "D" value. An example is the drained versus undrained situation. A water table may vary between zero and one foot below the surface. Drainage lowers the water table and increases unsaturated root zones. So, "D" changes and more rainfall is effective,

Field condition(s) and growing practices affect effective rainfall. For tomatoes grown with plastic mulched beds and high water table, the impervious plastic, and the low soil storage capacity increases runoff. Plastic mulched drip irrigation sites have different amounts of effective rain, compared to flat land non-mulched sites. The plant's root zone is in the raised bed. It receives water after the rain first penetrates and then moves up into the root zone by capillary rise. For most sites in the District, the water table is so low that the capillary rise is negligible.

SUPPLEMENTAL IRRIGATION

Moat of Florida's rainfall is in the summer months. Whereas, crop water demands are usually high during the spring growing *season* when rainfall is lacking. So, although the District averages over fifty inches of rain, crops need supplemental irrigation to achieve an economic yield,

Crop yields and economic losses occur when there isn't enough moisture to meet crop water use requirements. If an alternative water supply source is available, increased yields can offset the cost of meeting the crop% water use requirements. Supplemental irrigation is the most used Alternative source of water for crop production.

The amount of supplemental irrigation depends on a crop's economic value, water availability, irrigation system efficiency, crop water use demands, and the amount of effective rainfall. Each grower takes all these factors into account when using irrigation.

Knowledge of rainfall patterns and crop water use needs is used to determine supplemental irrigation requirements. Rainfall information comes from historical data. If limited climatological parameters are available, the Blaney-Criddle method is used to calculate water requirements (U).

Effective rainfall (re) is important in deciding supplemental irrigation requirements. These requirements, are equal to the crop water use requirements minus the effective rainfall. The net supplemental irrigation requirements, does not consider irrigation system efficiencies.

$$SUP = U - re$$

where:

SUP = supplemental irrigation requirement
U = crop water demand found by the Blaney-Criddle method
re = total effective rainfall.

In the permitting process supplemental irrigation requirements are based on an eighty percent rainfall return frequency. This return frequency is the maximum amount of expected rainfall, 80 percent of the time. The irrigation amount corresponds to a 20 percent drought return frequency. The required supplemental irrigation is the minimum amount of water needed, assuming optimum growing conditions, and 100 percent irrigation system efficiency. It is the permitting standard for evaluating all irrigation systems.

GROSS IRRIGATION

Gross irrigation consists of the supplemental irrigation requirements plus any water lost during delivery. These losses include water supply, conveyance system, and application losses. In this part of the report we considered only application losses. Typically in the District the other losses are insignificant when compared to application losses. Application losses involve plant interception, systemuniformity, and other problems associated with mechanically delivering water to the root zone. All these losses are included in system efficiency.

The gross irrigation requirement (GIR) is determined from the following formula:

$$GIR = SUP/EF$$

where:

GIR = gross irrigation requirements
SUP = net irrigation requirements
= U - re
EF = irrigation system application efficiency.

IRRIGATION METHODS

Irrigation methods can be divided into four general categories:

1. Micro-Irrigation
2. Sprinkler Irrigation
3. Surface Irrigation
4. Sub-Irrigation.

The use of a particular method or combination of methods depends on many factors: including crop type, crop production management, soil characteristics, chemical treatment, and economics, to name a few. All methods are not interchangeable. For example, Sub-Irrigation (seepage), is not practical in an area with a deep water table. Also, certain systems are more adaptable. for frost and freeze protection than others.

MICRO-IRRIGATION

Micro-Irrigation includes drip, low volume (jets and spinners), trickle, **misters,** and bubblers. These irrigation methods include all systems that have devices to apply water close to an individual or group of plants. Micro-Irrigation is usually efficient and manageable. The potential high efficiency is due to reduced losses from wind and evaporation during delivery.

Micro-Irrigation is relatively expensive and operation is costly. This irrigation method requires more upkeep and care than any of the others. It is sensitive to clogging and pressure changes. A lot of experience is needed to adapt these systems to specific sites.

IMPACT SPRINKLER

Sprinkler irrigation includes all irrigation that uses the atmosphere to transport water a relative large distance. This method includes overhead and undertree sprinklers, volume guns, and center pivots. Sprinkler irrigation is less efficient than micro-irrigation because more water is apt to be lost to wind, evaporation, and plant interception.

Sprinkler systems are easy to operate and are usually less expensive than micro-irrigation systems. One sprinkler provides water to a large area. The upkeep is not difficult and most problems are easily detectable.

SURFACE IRRIGATION

There are several types of surface irrigation; basin, border, flood, and furrow are the most common. Some of these systems (flood) may not be permitable within the District. While other systems (furrow) may not be practical with Districts soils.

Surface irrigation supplies water directly to a plant by using the soil as a conveyance median. These methods are inexpensive and easy to operate. They are potentially the least efficient irrigation method because of water losses to deep percolation and runoff. Also, the area of exposed water makes it vulnerable to evaporative losses.

SUB-IRRIGATION

A common misnomer is that the semi-closed and open ditch irrigation practiced in the **SWFWMD** are forms of surface irrigation methods. In reality, these methods manage the water table and **are** sub-irrigation. Sub-irrigation, sometimes called seepage, is an irrigation method that artificially maintains a site's water table. A sub-irrigated crop receives moisture from the water table through capillary rise.

Besides being relatively inexpensive growers use sub-irrigation for different crop production reasons. Sub-irrigation keeps a plant's roots at a manageable depth. Sod producers often sub-irrigate so that **it's** easy to harvest.

There are three basic techniques for providing water for sub-irrigation. Open or semi-closed ditch are the most predominant ones used in the District. These methods are similar, except one conveys water to the field in an open ditch while the other uses a closed pipe. Both methods are not efficient because of surface run off and deep percolation. In addition, the saturated soil increases rain runoff and evaporation losses.

Open ditch irrigation has large conveyance losses. In some areas as much as 708 of the diverted water does not reach its target.' Except for pasture irrigation very few growers in the District use open ditch irrigation.

Although limited by the District's surface water rules subsurface drains have sometimes been used to supply sub-irrigation water. Water is conveyed to the subsurface by reversing flow into a drain. The drainage system functions like an exfiltration system. Water moves from the drain tile to the surrounding soil. This method is **very** efficient in providing water. However, because the characteristics of a drain, the water is not always uniformly distributed throughout the field.

Fully Enclosed Subsurface **(FES)** method is a new method of sub-irrigation. It has been tried on vegetables in Manatee and Hillsborough Counties. Buried drip tubes supply water to the water table. FES is efficient because there is no runoff or surface evaporation. Although less uniform than regular drip irrigation, it is more uniform than **other** surface and sub-irrigation.

DUAL SYSTEMS

For some crops, growers need two irrigation systems. Strawberries, irrigated with drip irrigation, need overhead irrigation for crop establishment and cold protection. Vegetables with drip irrigation use seepage for crop establishment. In most cases the second system is used because the primary system can not provide enough water.

PLASTIC MULCH

The use of plastic mulch with the irrigation system is primarily economic. Growers use plastic to stabilize beds, fumigate, and to ensure that the fertilizer remains in the **crop's** root zone. **Also,** it might be used to reduce water use by decreasing evaporative losses and eliminating weeds.

Crops grown under plastic mulch cannot directly receive effective rainfall. The mulch is an impervious surface that covers about half the field. Only a **small** amount of rain infiltrates between beds. This moisture moves to the water table and then through capillary rise to the crops.

IRRIGATION EFFICIENCY

Efficient irrigation is a goal that everyone should strive for. It is not solely system dependent. The human element has a large bearing on irrigation system efficiency. System management and scheduling are the key to irrigation efficiency. Proper scheduling conserves water and saves production costs.

LAND PREPARATION AND CROP ESTABLISHMENT

Some farmers irrigate for land preparation, salt leaching and crop establishment. They irrigate before tilling and bedding to construct compact moist beds, so capillary rise will move water up to the root zone. Also, moisture helps the plowed cover crops decay faster. In addition, during bedding applied irrigation water reduces dust and erosion.

In some regions of the United States growers use irrigation for salt leaching. Areas with high salinity buildup use water to remove damaging salts from a crop's root zone. Due to natural flushing, most sites in Florida have negligible leaching requirements.

Growers use water to establish bare root transplants, soil rooted plants, and to germinate seeds. Increased moisture provides a good environment for root establishment. In addition, this moisture cools the air to eliminate additional stresses on a stressed plant.

CROP PRO-ION

Growers use water to protect their crops from the climate and the soil from eroding. During the winter, growers irrigate to protect crops from convective and radiation freeze damage. When water changes from a liquid to a solid it releases energy as heat. Water changing from a liquid at 32F to a solid at 32F, releases 144 British Thermal Units (BTU) of heat, per pound of water. So, every gallon of water provides over 1200 BTUs of heat. This helps keep the plant's temperature from going below 32F and damaging the crop.

Some irrigation methods are more capable to provide frost and freeze protection than others. Micro-jets and spinners are used extensively for citrus freeze protection. Undertree sprinklers have been successfully used for citrus freeze protection.

Overhead sprinklers have limited use for citrus freeze protection. Water on limbs and leaves turns to ice, that accumulates and breaks limbs. Sprinklers have been used successfully for nursery and strawberry cold protection. The water from sprinklers creates a thermal layer of ice that coats and protects the plants.

Drip irrigation does not provide enough water to be effective for frost and freeze protection. However, some growers have used it with limited success. Portable and traveling guns could be used to wet a field before the cold event. However, they have the same problems am overhead irrigation.

vegetable growers have used seepage irrigation for cold protection. Typically they wet the field before a cold event and the latent heat of the water vaporizing release energy to warm the plants. Since most vegetables in the District are planted in warmer weather AGMOD does not add seepage cold protection quantities.

Growers irrigate to decrease damaging wind erosion. Wind borne soil particles can damage fruit and leafs. Also, some cities have ordinances against the dust created by these particles. Irrigation is used to keep the soil's surface wet so the particles will not be blown away. Soil protection quantities are provided with "Other Water Uses".

OTHER WATER USES

There are several other water uses typical for irrigation systems within the SWFWMD. The two main ones are chemigation and system maintenance. Some growers chemigate and then maintain (flush) their system during regular irrigation while others will do this during non irrigation periods. The District permits these and other non typical uses as a fixed percent of the net irrigation.

CROP WATER REQUIREMENTS

A crop's water requirement consists of three main elements:

$$CWR = GIR + CE + FP + OT$$

where:
- CWR = crop water requirements (production)
- GIR = supplemental irrigation
- CE = crop establishment (pre-plant planting)
- FP = frost and freeze protection.
- OT = other water uses

These elements are functions of location (topography, climate, soil), crop type and irrigation system.

PART II

AGRICULTURAL WATER USE **MODEL V2.0**

INTRODUCTION

The District uses **various** methods to allocate agricultural water use. The Agricultural Water Use Model (AGMOD) is its main tool to find irrigation water requirements. The intent of this part of the paper is to describe how to run AGMOD and to explain assumptions used to develop the model. The instructions in this paper follow the same order as they appear on the computer screen during execution of the model.

AGMOD comes from a Blaney-Criddle model and incorporates water requirements for crop establishment, cold protection, and other water uses. The model uses procedures described in the U.S. Department of Agriculture and Soil Conservation Services Technical Release **#21** and United Nations Food and Agricultural Organization Paper 24. In addition, it includes Dr. **Shih's** solar radiation changes. AGMOD helps the District permit irrigation amounts for specific crops, soils, irrigation system, and climatic conditions.

The District uses AGMOD as a tool to assist in the permitting processes. It was used in the District's 30 year Needs and Sources study, Water Resources Assessment Project (WRAP) and as an alternative method for estimating annual water use. In addition, AGMOD has been used in several other District projects.

AGMOD is made available to the public without technical support. To ensure that disk holders receive updates, only specific entities will distribute disks. If your disk is not registered, and you want to have the latest version contact the District.

ADVANTAGES AND LIMITATIONS

The Southwest Florida Water Management District (SWFWMD) covers **16** counties. Soil types, climate, crop and agricultural practices vary throughout the District. In addition, certain areas have special permitting criteria. AGMOD provides staff with a consistent approach to evaluate site specific agricultural water needs. It is a mechanism to treat Water Use Permit (WUP) applicants on *an* individual basis.

AGMOD comes from the original Blaney-Criddle equation. Changes were made to adjust the procedure to the District. In addition, AGMOD includes irrigation for crop establishment, frost freeze and other water uses. With continued use of the program and increased field data, permitted **quantities** (crop establishment, supplemental irrigation, cold protection, other water uses) need to be evaluated. AGMOD should be reviewed and updated when crop curves for Florida are developed.

Projected water use comes **from** mathematically analyzing historical weather data. Long term climatic data is statistically analyzed to get average **monthly** conditions and the 80 percent rainfall probability. **Since,** it is difficult to determine rainfall distributions, **the model** assumes a reasonable distribution. In actuality the distribution may be different.

Comparing **AGMOD** to available field data shows the estimates are reasonable. **AGMOD** and field data do not match up evenly because the **modeled** values come from normalized long term historical conditions. Whereas, field data are a snap shot in time, with specific seasonal conditions.

The model's user is the key to **its'** success. Computers do not think or rationalize. The human element of reasonability and judgement must always supersede any computed results. Printouts, tables, and results must be compared to known information for consistence with existing practices and procedures.

AGMOD is written and compiled with MICROSOFT's Quick Basic 4.5. The screen routines come from a registered version of Tony Martin's **QBSCR** program. The **executable** documentation is created with **MorganSoft's Asc2Com** program. To save disk space **Bellard's** Public Domain compression program **LZEXE** and **Matsumoto's** Public Domain **DIET** were used.

GETTING STARTED

Before starting any computer program, always copy the original disk and work with the copy. Keep the original disk in a safe place in case something happens to the working disk.

STEP ONE

There are several ways to run the program. For hard disk drive systems, copy all the files on the distribution disk to your hard drive. The model's name may **be** changed. However, all other files must have the same name and be in the model's path directory.

README, START and WHATSNEW are small information files. **README** is a batch file for first time users. It displays the information files, **AGMOD'S documentation** and then runs the program. START has information about permits, AGMOD, and how to read the on line documentation.

WHATSNEW is an **up** to date history of AGMOD. It includes program updates and change information. This file includes information that may not be in the model's documentation.

To run the model for the first time, type:

C>README <RETURN> **or** **A>README** <RETURN>

If you want to view the latest changes and updates, type:

C>WHATSNEW <RETURN> **or** **A>WHATSNEW <RETURN>**

To view **AGMOD'S** documentation, type:

C>DOCS <RETURN> or **A>DOCS <RETURN>**

To run **AGMOD,** type:

C>AGMOD <RETURN> or **A>AGMOD** <RETURN>

MODEL

AGMOD's first **screen** displays the title and program version. Also, it displays a disclaimer about the District and staff liabilities. This program is a permitting tool, provided as is, without support, and without any warranties or claims.

SCREEN1
Title Screen

```
SOUTRWEST FLORIDA WATER MANAGEMENT DISTRICT
Agricultural Water Use Model AGMOD V2.0
```

```
== DISCLAIMER OF WARRANTY
This program was developed to assist the District in its
permitting effort.  The model is being provided on an 'as is'
basis without technical support.  The District specifically
disclaims any warranty, either expressed or implied, including
but not limited to the implied warranties of merchantability
and fitness for a particular use.  The entire risk as to
quality and performance is with the user.  In no event will
the District or its staff be liable for any direct, indirect,
incidental, special, consequential, or other damages, including
loss of profit, arising out of the use of this program even if
the District has been advised of the possibility of such
damage.
```

Press return to continue. After you finish typing a name or value prees enter unless other wise specified. All of the program's yes/no questions default to no. So for **'no'** answers just press return to continue.

The input screen has fifteen variable fields. The withdrawal point (W.P.), date and time are automatically displayed and updated each time the screen appears. The model is designed to work with up to 55 withdrawals for each water use permit (WUP).

SCREEN 2
Input Screen

SOUTHWEST FLORIDA WATER MANAGEMENT DISTRICT Agricultural Water Use Model AGMOD V2.0

Reviewers Name:	WUP Number:	Date: 01-01-91
County:	W.P. 001	Time: 01:01:01
Main Irr.:	Discharge (gpm):	Dia (in):
Aux. Irr.:	Discharge (gpm):	Dia (in):
Soil:	Crop:	Area (ac) :

ADMINISTRATION

Type your name, press return and the cursor moves to the next input **field.** Then type the WUP number, including the period and two digit'extension. AGMOD uses the extension to see if the WUP is new or existing. Quantities for new permits in water use caution areas (WUCA), are based on higher efficiency then existing permits. This is because newer systems should be designed to be more efficient than existing systems.

A window with the District's 16 counties appears. The 6 WUCA counties are listed separately. Select the number corresponding to the location of the WUP. Any number larger than 22 will relist the counties.

By selecting a county, AGMOD uses the corresponding mean temperature, rainfall, solar radiation and 2-in-10 rainfall coefficient for the site's location. To keep track where the climatic data came from the weather station's location appears on the printout, in page one's foot notes. In addition, the years of recorded rainfall are in the same foot notes.

MAIN IRRIGATION

The next line is for the main irrigation system. This system is primarily for supplemental irrigation. A window with the list of the major irrigation types appears. Enter the number corresponding to the site's system. The computer uses the main irrigation system default efficiency and effective rainfall to calculate the site's gross irrigation requirements.

The program's irrigation efficiency is a comprehensive value. It **covers** both the mechanical (system) and human (irrigation management) element of irrigation. By definition the efficiency is "**the** ratio of the volume of water beneficially used to the volume delivered from the irrigation system".

AGMOD uses the irrigation system to determine effective rainfall amounts. For mulched sites with seepage, drip, **or overhead** irrigation the model uses zero effective rainfall. Seepage sites with plastic mulch have high water tables with little soil storage. So most of the rain runs off. Drip and overhead irrigated sites have shallow rooted plants with deep water tables. Therefore, most of the rain infiltrates below the root zone and is too deep for any significant upfluxing.

The main irrigation menu allows **the** user to define the system efficiency and effective rainfall. Select this option to define your own system values, or when you have new uses for expired WUCA permits. Otherwise AGMOD will treat this new use as an existing permit.

After selecting the user defined option a window with two questions appears. The first question asks for the percent efficiency. The second question is a yes or no question, to see if there is effective rainfall. Whenever default values are not used the printout will show that the user defined the option.

The next field is the system's discharge capacity in gallons per minute. **AGMOD** uses this value to see if the system can supply the permitted **quantities.** If the system's capacity is limiting, a note appears on the output saying that quantities are limited by the system. After typing the discharge, the computer continues to the next line.

If the irrigation system capacity is unknown use zero (0). The computer moves to the next field and asks for the system's mainline pipe diameter expressed in inches. The computer will calculate the system's capacity from the continuity equation (flow = (velocity) *(area)]. **AGMOD** uses the pipe's diameter to calculate area, and a five foot per second (fps) velocity. **This** velocity is consistent with manufacturer, SCS, and Florida Irrigation Society recommendations for most irrigation pipes. After typing the discharge, the computer continues to the next line.

AUXILIARY IRRIGATION

The next line is for the auxiliary irrigation system. This system is used for frost and freeze protection or crop establishment. In most cases this is the same as the main irrigation system. However, vegetables with drip or FES systems and some citrus sites may have auxiliary systems.

There are seven auxiliary system options. Including specific system type, the same as the main irrigation system, none, and user defined. The specific system and the same as main irrigation options use **AGMOD's** default values. The **"NONE"** auxiliary system option permits no cold protection or crop establishment quantities.

The auxiliary system **"Same"** option uses the main systems capacity to check cold protection and crop establishment quantities. This option cannot be used if drip is the main irrigation system. Typically drip emitters do not provide enough water or wet enough ground for cold protection or crop establishment. Reviewers can recommend quantities for drip cold **protection** or crop establishsent if the applicant demonstrates the successful use of drip irrigation for these practices.

The **"User** Defined" auxiliary system option bypasses the model's default values. After selecting this option a window appears asking for inches of crop establishment, and cold protection. This option is ideal for double or triple cropping where growers don't need to establish existing beds. After the auxiliary system, the model advances to the discharge capacity field and continues in same manor as with the main irrigation options.

The model allocates frost and freeze protection for citrus, strawberry and nursery production. Citrus protection with **micro-**irrigation (excluding drip **irrigation)** is based on District funded **IFAS** research. A three year research project at Lake Alfred found that micro-irrigated citrus needs between 2000-3000 gallons per hour (gph) per acre for frost freeze protection. **AGMOD** uses the higher value of 3000 gph per acre (2.6 inches) for 24 hours.

In some parts of the District, freeze durations less than 24 hours may be reasonable. To assist the permit reviewer AGMOD prints a 14 hour quantity for micro-irrigation systems. If applicants **request** hours different than the 24 or 14, frost and freeze quantities, then use the user defined **auxiliary** system option.

Citrus overhead or undertree **impact** sprinkler protection, is based on typical system capacities, Most impact sprinkler systems use between **.10** to **.12** inches per hour (iph). **AGMOD** uses the higher value of **.12** iph with 24 hours for undertree sprinklers, and 5 hours for overhead sprinklers. This yields 2.8 inches per day and **.6** inches per day respectively. Undertree systems are given more hours because they operate during a cold event. Whereas, overhead sprinklers are used only before an event to wet the ground.

Strawberry, blueberry and nursery cold protection amounts come from **IFAS** publications, and meeting with industry representatives. Quantities **are** based on **.25** inch of water per hour, for 24 hour events. The three crops get six inches.

All frost and freeze quantities are compared to **system** capacities and the lower of the two is used. These quantities are not part of the annual permitted amounts. However, they are used in peak daily calculations. Permittees need to report this usage to the District.

SOIL TYPE

Soil type **is** the next input field. **AGMOD's** database has over 650 Florid8 soil types with profile depth8 and corresponding **water** holding capacities. The model checks the roils name to see if its in **the database.** If the soil is not found the model prompts for **corrections.**

A site's soil type can be found in S.C.S. county soil surveys. Some site8 will have more than one soil type. There are several approaches for sites with **multi-class** soils. You can use the predominant **soil,** or the most restrictive soil. Or, the site may be divided in subsections, with adjusted areas and system capacities. Sometime8 soil groups have similar characteristics and can be grouped together.

AGXOD uses soil information to **calculate** effective rainfall and crop establishment. Effective rainfall is the amount of rain available for plant use. It depends on the available soil moisture and the **crop's** root zone. The model uses the average water holding capacity and adjusts soil moisture through root zone depth. The model **compensates** for **available** moisture by using minimum root zone depths.

Crop establishment is a quantity that is site and system specific. **For** most crops (except strawberries) AGMOD uses the soil's **top** three feet moisture content, to find crop establishment water requirements. The soil's moisture content comes from the high range of the **soil's** water holding capacity.

For crops that fumigate the first month's ET is added to the water holding capacity. This accounts for soil evaporation while the water table is being maintained. Then an efficiency is used to find the gross crop establishment water requirements.

Crop establishment quantities differ for spring and fall planting. Spring planting comes in the middle of the dry season. Whereas fall planting **comes** after the rainy season when the soil moisture is high. Therefore, for **fall** crop establishment AGMOD uses half the soil profile of the spring planting establishment.

Strawberry producers use water to prepare beds and to relieve bare root transplant stress. **AGMOD** uses fourteen inches for strawberry crop **establishment.** This quantity comes from **IFAS** research at the Dover **station. Comparing** AGMOD strawberry crop establishment quantitie8 to available field information shows AGMOD is a little higher.

CROP TYPE

Crop type is the next input field. At least three letters needs to be **typed or the computer** will not continue. The model has data on 35 different crops. By selecting a crop the computer loads the crop curve8 and root depth. **If** the crop is not in the model, or if **it's** misspelled, a window with the model's crops appears.

The original crop curves come from the arid western U.S. AGMOD uses these crop curves with modifications for our humid climate. For pasture and nurseries the model does not use crop curves. Pasture quantities are based on grass ET values developed from an **IFAS** research project in South Florida.

Nursery quantities are calculated using the full potential ET. The full potential is used because there are so many different plant varieties, that are potted during different times, in various sized containers with different types of potting soils. **Also,** season lengths and planting dates are unknown. Taking all these factors into account AGXOD calculates nursery quantities using full potential ET.

The default value for nursery production assumes a potted shallow root zone. You can use potting soil, or any other type of soil with this root zone as the growing media. For field grown or nurseries that don't meet the default conditions the soil and root zones need to be adjusted accordingly. The adjustment can be done in the soil's change window after the area is entered.

AREA

Acres irrigated is the next input field. AGMOD uses the gross irrigated area. This may over estimate water requirements for systems (drip, low volume) that irrigate only part of the **soil's** surface. On the other hand, the dry middle's oasis effect may cause the irrigated area to need more water. Therefore, the total water required is probably about the same as if the gross acreage was irrigated.

AGMOD uses acres irrigated to keep track of the withdrawals. If a withdrawal irrigates more than one crop, assume a dummy withdrawal adjusting the irrigated acres and other irrigation factors. So, if two crops are grown in one season from withdrawal 001, use withdrawal 002 for the second crop. When using the dummy withdrawal AGMOD assumes two pumps. Therefore, the **pumpage** for each crop may need to be reduced.

CORRECTIONS

After the acres are entered, the user can change any of the fifteen input values. If you answer yes to changes a menu appears. For the first withdrawal you can change any input value by selecting the corresponding menu number. After the first withdrawal you cannot change the reviewers name, permit number, or county. Press the escape key to exit the change option.

If the crop is **"golf** course" or a perennial plant, a new window appears. For golf courses, the user is prompted for tees and greens acreage. The model allocates 50 inches per year for tees and greens irrigation. The rest of the area is treated like a shallow rooted grass. The tees and greens quantity is distributed proportional to the regular irrigation.

For perennial crops the user needs to provide planting and harvesting dates. These dates need to be typed in the same five **(MM/DD)** character **formate** as the screen's example. These dates are **used** to calculate daily water requirements and rainfall. In addition, theme values **are** used to distribute crop establishment.

AGMOD uses the quadratic spline method descried in University of California, Cooperative Extension, Leaflet 21426, to distribute monthly values into daily. The method creates a cumulative curve and finds a specific use by taking the difference in cumulative use between two point. The advantage of this approach is that it does not over estimate use for crops that are planted or harvested in mid month.

Next the soil's information window appears. The first window appears only if the soils name was misspelled or is not in the database. The computer lists all the soils with the same first three letters of the soil type entered. After the soil's name is corrected a window with the soil, **crop**, root zone, and the calculated net depth of application appears. You need to accept or change these values. If you change the values, the new 'calculated crop establishment quantity appears. Press return to accept this value or type a different **one**.

SCREEN3
Output Menu

```
SOUTHWEST FLORIDA WATER MANAGEMENT DISTRICT
Agricultural Water Use Model AGMOD V2.0

OUTPUT OPTIONS

   1   Print Report
   2   Screen Report
   3   Save Report
   4   Next Withdrawal
   5   New Permit
   6   Shell To DOS
   7   Documentation
   8   End Program
```

OUTPUT

Output can be sent to the printer, screen, or stored on disk. You can select one of these options with your cursor or typing the number. After each output option is completed, the program returns to the output menu.

If the print report option is selected the computer asks you to turn the **printer** on and type P to print. For **the** save option you **are** prompted to insert a formatted (non-write protected) data disk into Drive A. Then press S to save or **M** to return to the menu. The **computer saves** the output in a text file using the permit's first five **numbers** a8 the file name. The saved printout can be viewed with any word processor of text editor.

The screen report option displays a summary of a withdrawal point's information. After the screen option is selected, you are asked for the withdrawal point. The screen report is divided into three frames. The first frame shows the **withdrawal's** number, and the basic information. The second frame shows the permitted quantities in inches and gallons. The last frame shows average annual **quantities.** When you are finished reviewing the information you can view another withdrawal by typing **its** number or return to the output menu.

The **"New** Withdrawal" option brings you back to the first input screen. The withdrawal number is increased and the reviewer's name, permit number and **county** appear. You start entering the next withdrawals information. The model keeps the withdrawals@ information until the program is exited, or the new WP option is selected.

The **"New Permit"** option **sends** the model back to the first screen. The program starts from the beginning with withdrawal one. All the new permit's information is requested. Past information is cleared from memory.

Shell to DOS allows the user to temporarily leave the program without losing any data. This option is helpful if you want to use a text editor to view part of the printout or to do something else with the computer. To return from DOS type **"exit"** at the prompt.

Option seven calls the **program's** on disk documentation. The documentation can be printed out by typing ALT-P. You can look something up by pressing **'F'** and the word/subject you want. The first line on the screen will be the next time the word appears in the document. This is helpful if you want some specific information. Escape will return the program to the output menu.

The last option is to end the program and exit to DOS. This option clears the models memory and removes all data. The screen clears and the computer's DOS **prompt** appears.

PRINTED REPORT

The printed report provides the users with documentation of their work. It also provides a piece of paper to follow the models calculation and to examine if the model worked correctly. The **report's** heading lists the WP number, reviewer, date, and county.

Each withdrawal number has **it's** own specific information. This information includes crop, **soil,** irrigated area, irrigation system types, capacities, and irrigation efficiency. For perennial **crop** the heading shows planting and harvesting dates. If the user bypassed any of the model's default values, the heading will show the user defined the value.

The next nine lines deal with monthly permitted quantities. The first line, wan rainfall, comes from the data file. The second line shows calculated evapotranspiration (ET). This value comes from a Blaney-Criddle equation using mean temperature, solar radiation and crop curve.

The third line shows the calculated peak month. This quantity in most cases is based on zero rainfall and is the most irrigation that can be used in a given thirty day period. The peak month value is the highest of either the ET divided by irrigation efficiency or the crop establishment quantity. For crops with effective rainfall **AGMOD** assumes zero rainfall from October to the first of June.

Average effective rainfall **and** average irrigation respectively are the next two lines. **Effective** rainfall comes from the SCS equation and average rainfall probability. Average irrigation is the difference between the average effective rainfall and ET, divided by the system efficiency.

Lines six and seven show the a-in-10 effective rainfall and 2-in-10 irrigation. This **effective** rainfall comes from the average effective rain times the percent chance of occurrence. The irrigation is the difference between ET and this **effective** rain divided by an efficiency. For most crops this irrigation is the permitted irrigation quantity,.

Pasture plants are typically more tolerate to drought stress then other plants. So **AGMOD** uses the 6-in-10 effective rain for pasture irrigation. The **4-in-10** irrigation is calculated the same as described above.

Other water uses is the next line. This quantity is based on the type of irrigation system. Micro irrigation is given 10% of the permitted irrigation, other systems are given 5%. The micro **systems** are given more water because these systems use more water for fertigation, and **flushing.**

The last line is the sum of **all** permitted water use including crop establishment. Where strawberry crop establishment is added to the month of planting and for other crops, it is distributed between the last 31 days before planting.

Next there will be a space and a summary of the withdrawal's values. In the event that the system's capacity limited the permitted quantity, it will be noted before the summary. Monthly values would be adjusted to meet system capacities.

The summary has six lines and four columns. The columns list the values in inches, gallons, **and** gallons per day. It is important to note that this table relate8 'only to the specific withdrawal. The composite value8 may be different than the individual withdrawals.

AGMOD prints two withdrawal8 and the composite summary per page. The composite summary includes an accumulation of the total month water use. The unit8 are listed in the heading. They change according to the highest quantity.

Below the composite water use table is a list of notes. They help explain the print out and give information about the calculations. For example note five tells which version of AGMOD was used and when it was last modified. The last note gives the date and time the program was executed.

The second page consists of a monthly breakdown of total water use. These value8 include crop establishment, supplemental irrigation, and other water uses. Strawberries crop establishment is in the same month a8 planting, while other crop establishment is divided between the 31 days before planting. This table has a set of notes to explain its contents.

The summary box also called the Weber Box has five values. Three are in gallons par day and one in inches. The average annual permitted values is the total water use divided by 365 days. This use includes crop establishment, supplemental irrigation, and the other water use category described in design aid four. The peak month quantity is the value listed in the composite breakdown divided by thirty. This value includes the same water uses listed above. The peak month in inches appears next to the gallon value.

Frost freeze is listed for crops that have this permitted quantity. That quantity is the maximum pumpage for a 24 hour period. For micro-irrigated systems a frost freeze quantity for 14 hours is added to the box.

The output's calculated irrigation requirements are compared to the irrigation system capacities. This capacity is for operating the system 90 percent per day (21.4 hr.) times 365 days. Monthly capacity is calculated by dividing the annual capacity by 30 days. If the capacities are less than the required amounts, permitted values are limited to the system capacities.

LAST WORDS

Computers don't think, people do. Before and after using a computer model, the input and output information must be reviewed for errors and reasonability of the results.

November 3, 1992

REFERENCES

ASAE. "Advances in Evapotranspiration," Proceedings of the National Conference on Advances in Evapotranspiration, December 1985.

ASCE. "Consumptive Use of Water and Irrigation Requirements," September 1973.

Albregts, Howard, "Intermittent Overhead Sprinkler Irrigation to Establish Strawberry Plants in the Fruiting Field," Research Report, Project #9, 1978.

Albregts, Howard, "Water Use in Strawberry Transplant Establishment," Research Report, DOV-1985-2.

Clark, et al. "Water Requirements and Crop Coefficients For Strawberry Production In S.W. Florida (B-23)," Final Project Report, March 1992

Doorenbos and Pruitt. "Guidelines for Predicting Crop Water Requirements, " FAO Irrigation & Drainage paper 24 revised 1977.

Fry, A.W. "Frost Protection By Sprinkler," Rainbird.

Geurink, Jeffrey. "Agricultural Water Use Permitting Procedure," SWFWMD.

Marlowe, G.A., Overman, A.J., Feinberg, S.G. "Results of and Irrigation Survey for Tomatoes and Strawberries in Hillsborough and Manatee Counties, 1979-82," Procedure Florida State Horticultural Society 95:301-304.1982.

Marlowe, G.A., overman, A.J., "A Rationale for Determination of Irrigation Needs for Vegetable Crops Grown With Seep Irrigation," Research Report GC1977-8.

Parsons et al. "Low Volume Micro Sprinkler Undertree Irrigation for Frost Protection of Young Citrus Trees," Procedure Florida State Horticultural Society 94:55-59-1981

Rogers, J.S., Harrison, D.S., "Irrigation Water Requirements For Agronomic Crops in Florida," IFAS, Water Resources Council WRC-5

SJRWMD. "Technical Memorandum 30 Year Mean Blaney-Criddle Supplemental Irrigation Requirements".

SFWMD. "Agricultural Water Use Model," computer disk.

SFWMD. "Permit Information Manual Volume III".

Shih et al. "Basin wide Water Requirements Estimation in Southern Florida, " American Society of Agricultural Engineers

Transactions, 1983.

Shih et al. "Comparison of Methods of Evapotranspiration Estimation," American Society of Agricultural Engineers paper No. 81-2015.

Shih et al. "Evapotranspiration Estimation for Data-Short Environment," Journal of Irrigation and Drainage Engineering, ASCE, February 1991.

Smajstrla et al. "Characteristics of Potential Evapotranspiration in Florida," American Society of Agricultural Engineers paper #FCS-84-003.

Smajstrla et al. "Efficiencies of Florida Agricultural Irrigation Systems," IFAS 88-l.

Snyder, et al. "Determining Daily Reference Rvapotranspiration (ETo)," Cooperative Extension University of California Division of Agriculture and Natural Resources," Leaflet 21426, April 1987.

USDA-SCS. "Irrigation Water Requirement Technical Release No. 21".

USDA-SCS, "S-Conuse Consumptive Use Computer Program," 1987.

Wyllie, Mike. "Final Report Evapotranspiration Study for Southwest Florida Water Management District," The Florida Resources and Environmental Analysis Center.

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ONION	18
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PEAS	18
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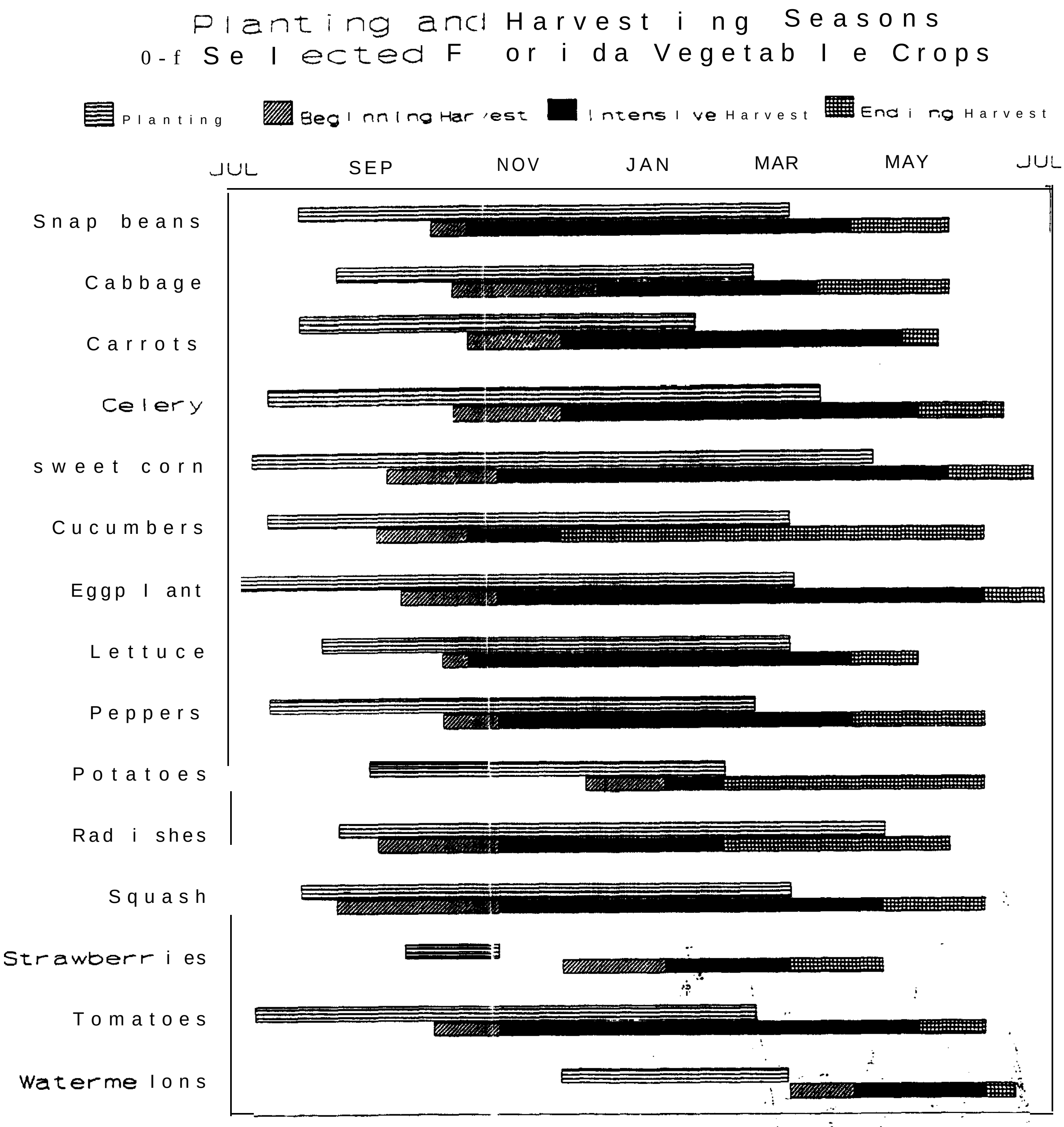
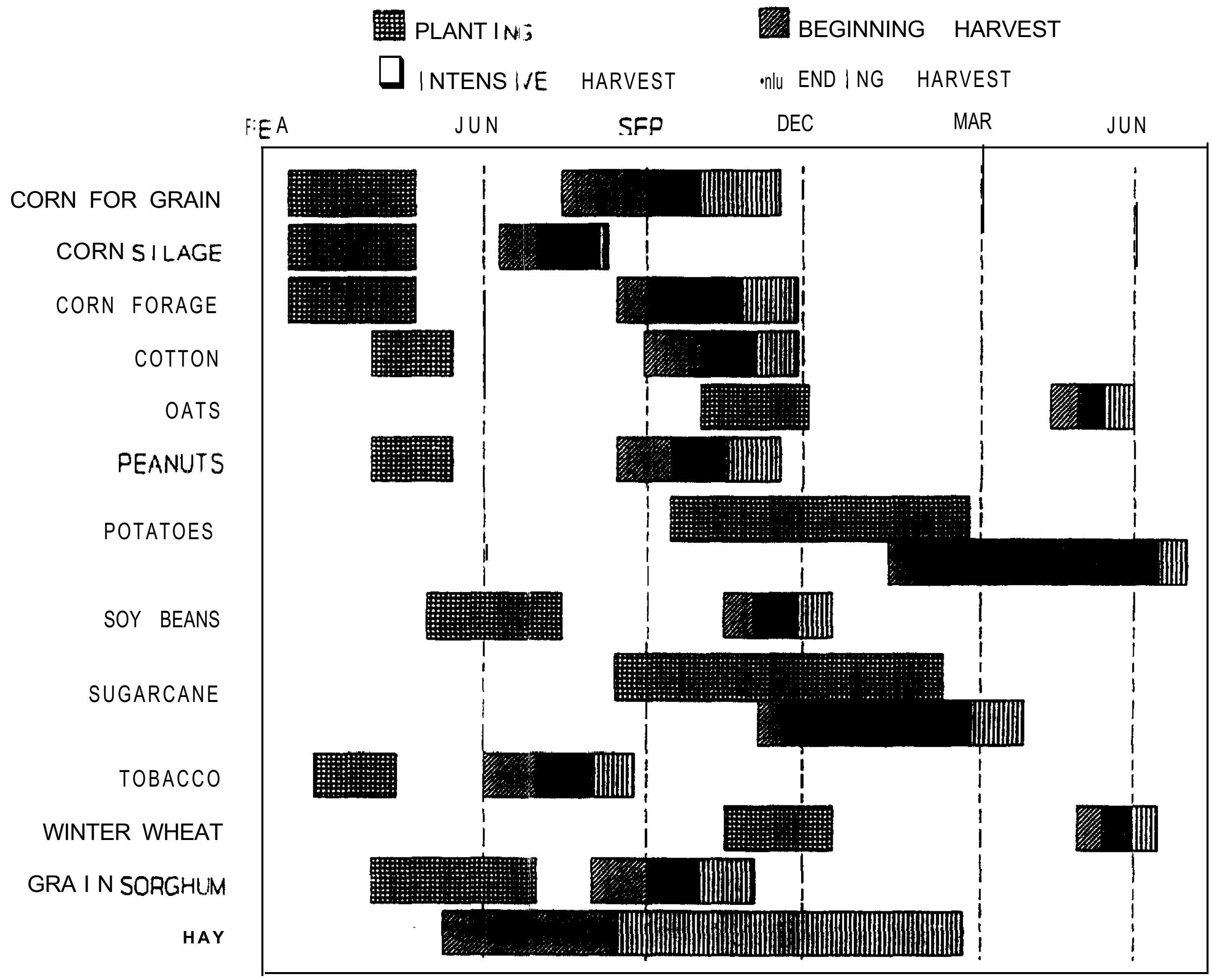

Planting and Harvesting Seasons
of Selected Florida Vegetable Crops
Planting
Beginning Harvest
Intensive Harvest
Ending Harvest
JUL
SEP
NOV
JAN
MAR
MAY
JUL
Snap beans
Cabbage
Carrots
Celery
sweet corn
Cucumbers
Eggplant
Lettuce
Peppers
Potatoes
Radishes
Squash
Strawberries
Tomatoes
Watermelons

EXHIBIT "B"

Planting and Harvesting Seasons of Selected Florida Field Crops



"APPENDIX C"

AGMOD SOILS DATA BASE

ADAMSVILLE
ADAMSVILLE, BD.
ADAMSVILLE VAR.
ALAGA
ALAGA,MOD.WET
ALAPAHA
ALBANY
ALLANTON
ALPIN
ALPIN,OCC.FL.
AMERICUS
ANCLOTE
ANCLOTE,FREQ.FL.
ANCLOTE VAR.
ANGIE
ANGIE
ANGIE VAR.
ANKONA
ANKONA,DP.
APALACHEE
APOPKA
APOPKA VAR.
ARCHBOLD
ARCHER
ARDILLA
ARENTS
ARENTS,MOD.WET
ARENTS,ORG.SUBS.
ARENTS,V.ST.
ARENTS,SAN.LNDF.
ARIPEKA
ARREDONDO
ARREDONDO,BD.
ASTATULA
ASTOR
ASTOR,FL.

BAKERSVILLE
BASINGER
BASINGER,FL.
BAYBORO
BAYBORO, PD.
BAYVI
BENNDALE
BESSIE
BETHERA
BIBB
BIGBEE
BINNSVILLE
BIVANS
BLADEN
BLANTON
BLANTON,OCC.FL
BLICHTON
BLUFF
BLUFF,LM.SUBS.
BOARDMAN
BOCA
BOCA,DP.
BOHICKET
BONIFAY
BONNEAU
BOSWELL
BOWIE
BRADEN
BRADENTON
BRIGHTON
BROWARD
BROWARD VAR.
BULOW
BUSHNELL

CADILLAC
CAHABA
CALOOSA
CANAVERAL
CANAVERAL,ORG.SUBS.
CANAVERAL VAR.
CANDLER
CANDLER,BD.
CANDLER VAR.
CANOVA
CANOVA VAR.
CAPTIVA
CARNEGIE
CASSIA
CASSIA,MOD.WELL DR.
CENTENARY
CHAIRES
CHARLOTTE
CHEWACLA
CHIEFLAND
CHIPLEY
CHIPOLA
CHOBEE
CHOBEE,DP.
CHOBEE,FL.
CHOBEE VAR.
CITRONELLE
CLARENDON
COCOA
COCOA VAR.
COMPASS
CONGAREE
COPELAND
COPELAND,DP.
CORNELIA
COROLLA
COWARTS
COXVILLE
CROATAN
CUTHBERT
CUTHBERT,GRAD.
CUTHBERT,ST.

DADE
DANIA
DAYTONA
DELAND
DELKS
DELRAY
DELRAY,DP.
DELRAY,FL.
DENAUD
DOROVAN
DOTHAN
DUCKSTON
DUETTE
DUNBAR
DUPLIN
DURBIN

EATON
EATON,DP.
EAUGALLIE
EAUGALLIE,BD.SUBS.
EAUGALLIE,DP.
EAUGALLIE,LM.SUBS.
EBRO
ECONFINA
EGLIN
ELECTRA
ELECTRA,BD.
ELECTRA VAR.
ELECTRA VAR,OCC.FL.
ELLABELLE
ELLZEY
ELRED
EMERALDA
ESCAMBIA
ESTERO
ESTO
EULONIA
EUREKA
EUSTIS
EVERGLADES

FACEVILLE
FARMTON
FELDA
FELLOWSHIP
FELLOWSHIP VAR,GRV.
FLEMINGTON
FLEMINGTON VAR.
FLORAHOME
FLORIDANA
FLORIDANA,DP.
FLORIDANA VAR.
FLUVAQUENTS
FORT MEADE
FORT MEADE VAR.
FOXWORTH
FOXWORTH VAR.
FRIPP
FT.DRUM
FT.GREEN
FT.GREEN,BD.
FUQUAY

GAINESVILLE
GALVESTON
GARCON
GARCON , FL.
GATOR
GATOR,FL.
GENTRY
GILEAD
GOLDSBORO
GRADY
GRADY,DR.
GREENVILLE
GRITNN
GUNTER

HAGUE
HALLANDALE
HALLANDALE,DP.
HALLANDALE,SL.
HALLANDALE,TD.
HANDSBORO
HANNAHATCHEE
HAPLAQUENTS,CL
HEIGHTS
HEROD
HILOLO
HOBE
HOLOPAW
HOLOPAW,DP.
HOLOPAW,FREQ.F
HOLOPAW,LM.SUB
HOMOSASSA

HONTOON
HORNSVILLE
HURRICANE
HURRICANE,FL.
HYDRAQUENTS

IBERIA
ICHETUCKNEE
IMMOKALEE
IMMOKALEE,LM.S.
IRVINGTON
ISLES
ISLES ,DP.
ISLES,SL.
ISTOKPOGA
IUKA
IZAGORA

JOHNS
JOHNSTON
JONATHAN
JONESVILLE
JUMPER
JUPITER

KALIGA
KALIGA VAR.
KALMIA
KALMIA,WET SUBS.
KANAPAHA
KANAPAHA,BD.
KENANSVILLE
KENANSVILLE,WET
KENDRICK
KENNEY
KERSHAW
KERSHAW VAR.
KESSON
KINSTON
KLEJ
KLEJ,C.SUBS.
KUREB

LACOOCHEE
LAKE
LAKE,CLY.SUR.
LAKELAND
LAKEWOOD
LAUDERHILL
LAWNWOOD
LAWNWOOD,DP .
LEAF
LEAF VAR
LEDWITH

LEEFIELD
LEON
LEON,FL.
LOCHLOOSA
LOKOSEE
LUCY
LUMBEE
LUTTERLOH
LYNCHBURG
LYNNHAVEN
LYNNHAVEN VAR.
LYNNE

MABEL
MALABAR
MALABAR,FREQ.FL.
MALBIS
MANATEE
MANATEE,DP.
MANDARIN
MANTACHIE
MARGATE
MARLBORO
MARTEL
MASARYK
MASCOTTE
MASCOTTE,DP.
MASCOTTE,OCC.F
MATLACHA
MATLACHA,LM.SU
MAUREPAS
MAXTON
MCKEE
MEGGETT
MICANOPY
MICCO
MILLHOPPER
MILLHOPPER,BD.
MONTEOCHA
MONTVERDE
MOULTRI E
MULAT
MYAKKA
MYAKKA,LM.SUBS
MYAKKA,SH.SUBS
MYAKKA,TD.
MYAKKA VAR.
MYATT

NARCOOSSEE
NARCOOSSEE,SH.
NETTLES
NETTLES,DP.
NEWNAN

NITTAW
NOBLETON
NORFOIX
NORFOLK VAR.
NUTALL
NUTALL,DP.

OCILLA
OCILLA,FREQ.FL.
OCOEE
OCOEE VAR.
OKEECHOBEE
OKEEIANTA
OKEELANTA,DP.
OKEELANTA,FL.
OKEELANTA,TD.
OKEELANTA VAR.
OKLAWAHA
OKTIBBEHA
OLDSMAR
OLDSMAR,BD.
OLDSMAR,DP.
OLDSMAR,LM.SUBS.
OLENO
OLUSTEE
OLUSTEE,THICK SUBS.
ONA
ONA,ORTS.SUBS.
ORANGEBURG
ORLANDO
ORSINO
ORSINO VAR.
ORTEGA
OSIER
OSIER,FL.
OSIER,PD.

PACTOLUS
PAHOKEE
PAISLEY
PAISLEY,BD.
PAISLEY,DP.
PALM BEACH
PALMETTO
PAMLICO
PAMLICO,FL.
PAMLICO,LY.SUBS.
PAMLICO,PD.
PANASOFFKEE
PANSEY
PANTEGO
PAOLA
PARKWOOD
PARKWOOD VAR.

PECKISH
PEDRO
PEDRO VAR.
PEDRO VAR,OCC.FL.
PELHAM
PELHAM,PD.
PELHAM VAR.
PELLICER
PENDARVIS
PENNEKAMP
PENNSUCO
PEPPER
PERRINE
PERRINE VAR.
PICKNEY
PINEDA
PINEDA,DP.
PINEDA,FL.
PINEDA,LM.SUBS.
PINELLAS
PLACID
PLACID,DP.
PLACID,FREQ.FL.
PLACID VAR.
PLANTATION
PLUMMER
PLUMMER,PD.
POCOMOKE
POMELLO
POMELLO,OCC.FL.
POMELLO VAR.
POMONA
POMPANO
POMPANO,FL.
POMPANO VAR.
PONZER
POOLER
POPASH
POPLE
PORTSMOUTH
POTTING SOIL
POTTSBURG
POTTSBURG VAR.
PUNTA

QUARTZIPSAMENTS

RAINS
RAINS,FL.
RAINS VAR.
RED BAY
REDLEVEL.
RESOTA
RIDGELAND
RIVERVIEW
RIVIERA
RIVIERA,DP.
RIVIERA,LM.SUBS.
ROBERTSDALE
ROCKDALE
RUSTON
RUTLEGE
RUTLEGE,PD.

SALERNO
SAMSULA
SAMSULA VAR.
SANIBEL
SAPELO
SATELLITE
SATELLITE VAR.
SAVANNAH
SAWYER
SCOGGIN
SCRANTON
SEEWEE
SEFFNER
SEFFNER,CEM.SUBS.
SELLERS
SHENKS
SHENKS,FL.
SHUBUTA
SMYRNA
SPARR
ST.AUGUSTINE
ST.AUGUSTINE,CLY.S
ST.AUGUSTINE,ORG.SU
ST.JOHNS
ST.JOHNS VAR.
ST.LUCIE
STILSON
STOCKADE
STOCKADE,FL.
STOUGH
SUMTERVILLE
SUNSWEET
SURRENCY
SUSANNA
SUSQUEHANNA

TALQUIN
TANTILE
TARRYTOWN
TAVARES
TAVARES,CEM.SUBS.
TAVARES,OCC.FL.
TEQUESTA
TEQUESTA VAR.

TERM CEIA
TERRA CEIA,TD.
TERRA CEIAVAR.
TIFTON
TISONIA
TOCOI
TOMOKA
TOOLES
TORRY
TROUP
TURNBULL
TURNBULLVAR.
TUSCAWILLA
TYPICHYDRAQUENTS

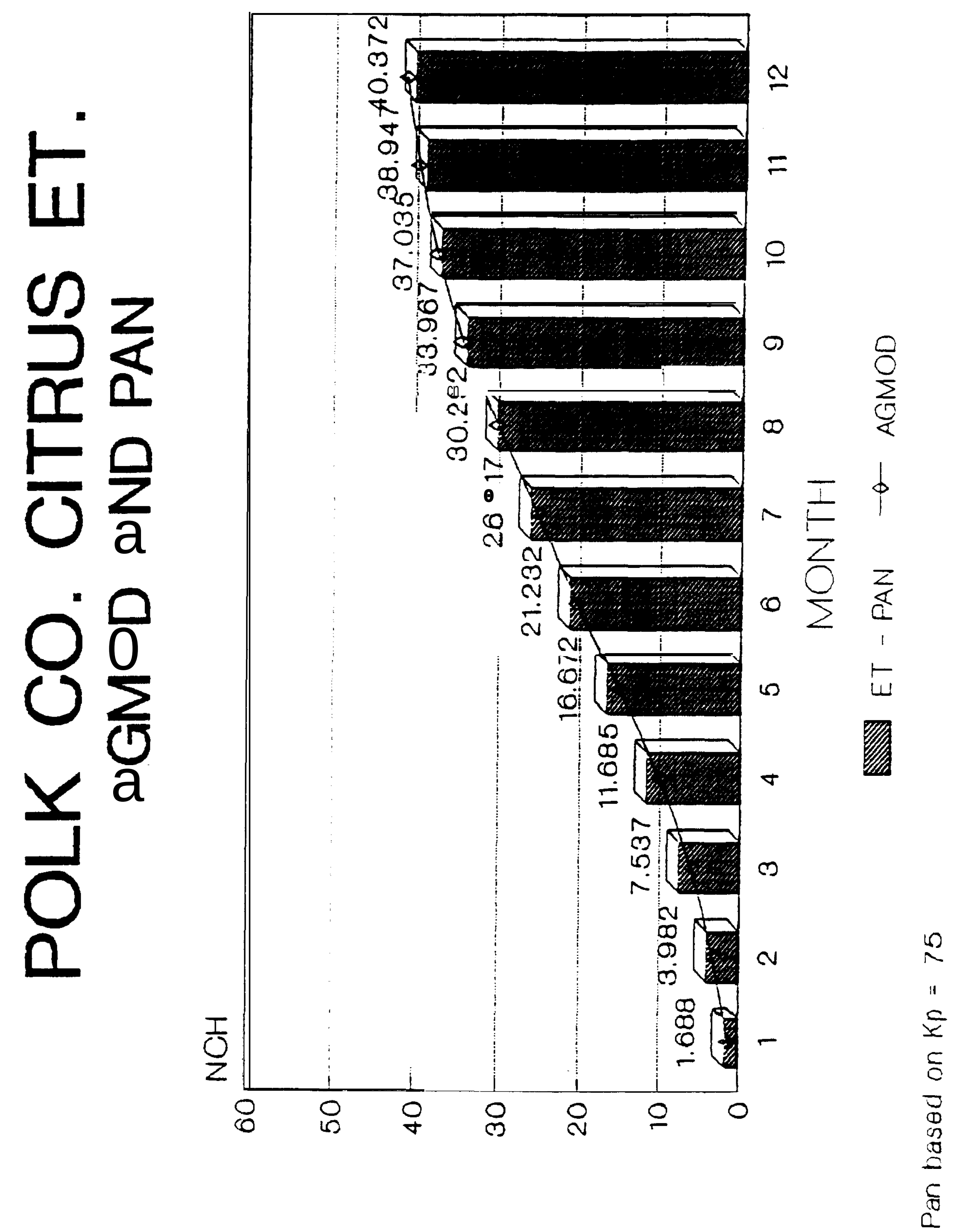
UDORTHENTS
UDORTHENTS,MOD.WET
UDORTHENTS VAR.
UDORTHENTS,.SUBS.

VALKARIA
VALKARIA,DP.
VAUCLUSE
VAUCLUSE,GRV.
VERO
VERO,BD.
VERO,DP.
VERO,LM.SUBS.

WABASSO
WABASSO,DP.
WABASSO,FL.
WABASSO,LM.SUBS.
WABASSO VAR.
WACAHOOTA
WAGRAM
WAHEE
WAKULLA
WAUBERG
WAUCHULA
WAUCHULA,DP.
WAVELAND
WAVELAND,DP.
WEEKIWACHEE
WELAKA
WESCONNETT
WESTON
WICKSBURG
WILLISTON
WILLISTON VAR.
WINDER
WINDER,DP.
WINDER,FL.
WULFERT

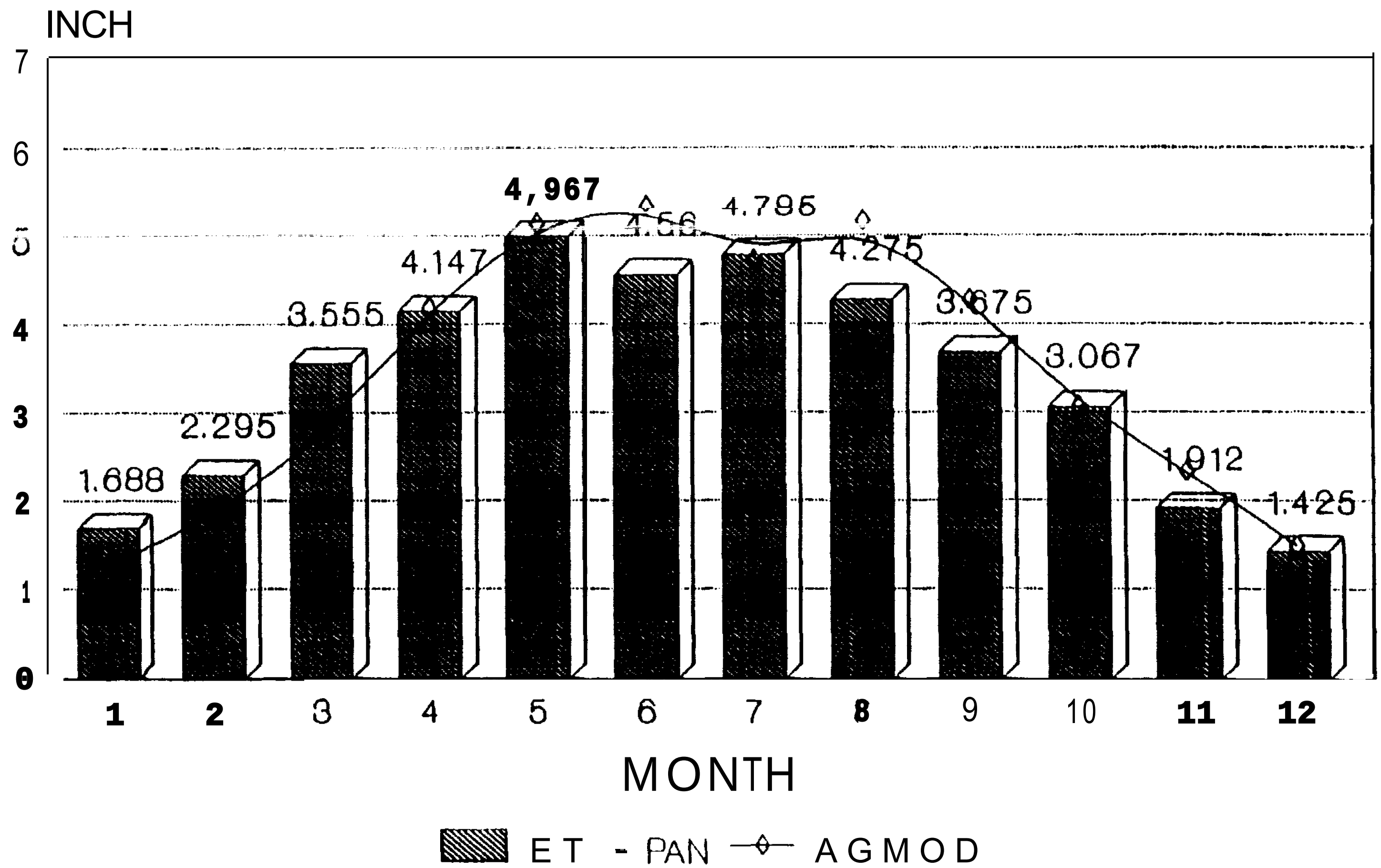
YEMASSEE
YEMASSEE,FL.
YONGES
YONGES,FL.
YULEE

ZEPHYR
ZOLFO
ZUBER



POLK CO. CITRUS ET.
aGMOD aND PAN
NCH
60
50
40
30
20
10
0
1.688
3.982
7.537
11.685
16.672
21.232
26 17
30.282
33.967
37.035
38.947
40.372
1
2
3
4
5
6
7
8
9
10
11
12
MONTH
ET - PAN
AGMOD
Pan based on Kp = 75

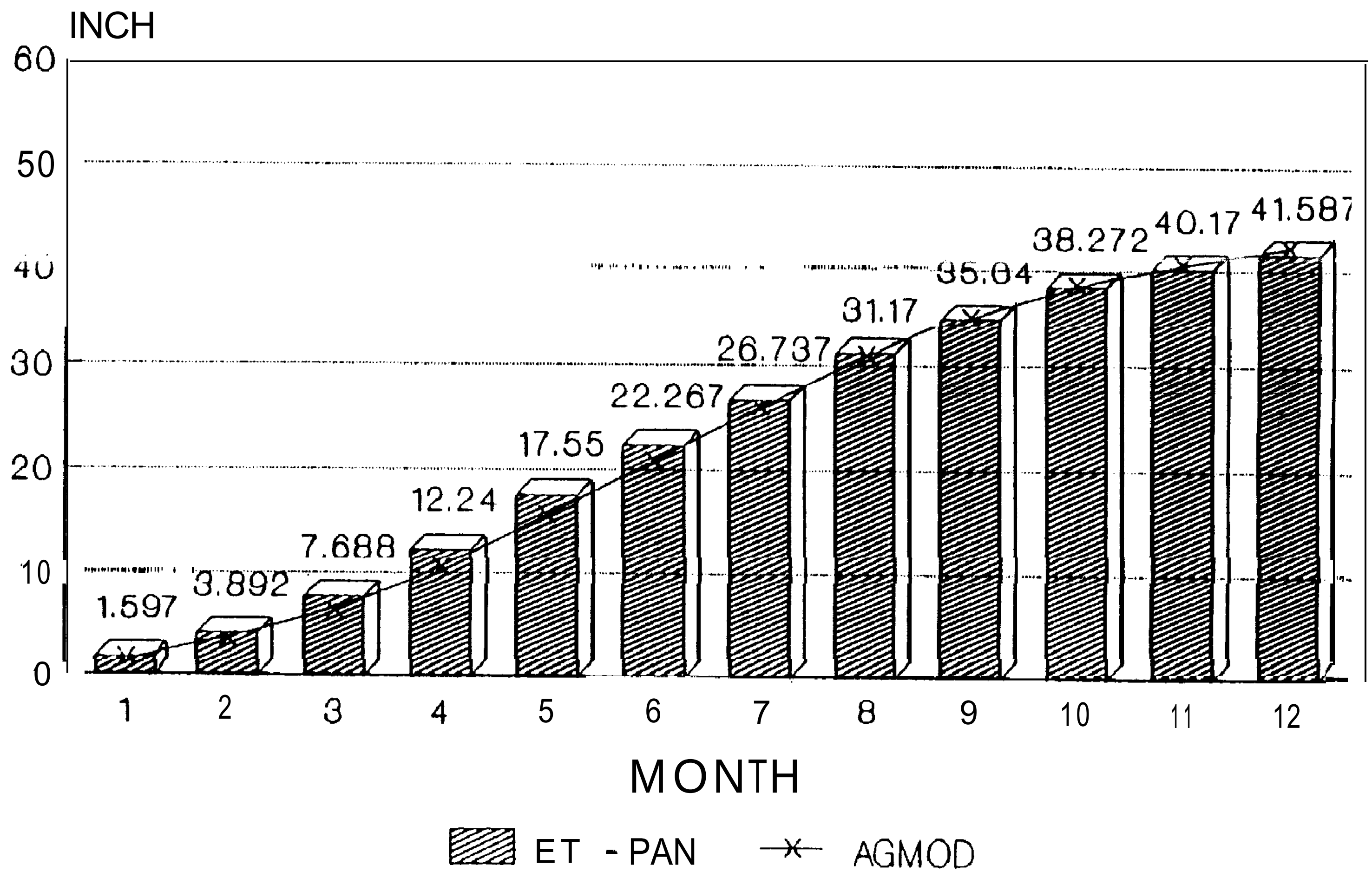
POLK CO. CITRUS ET.
AGMOD AND PAN



Pan based on Kp = .75

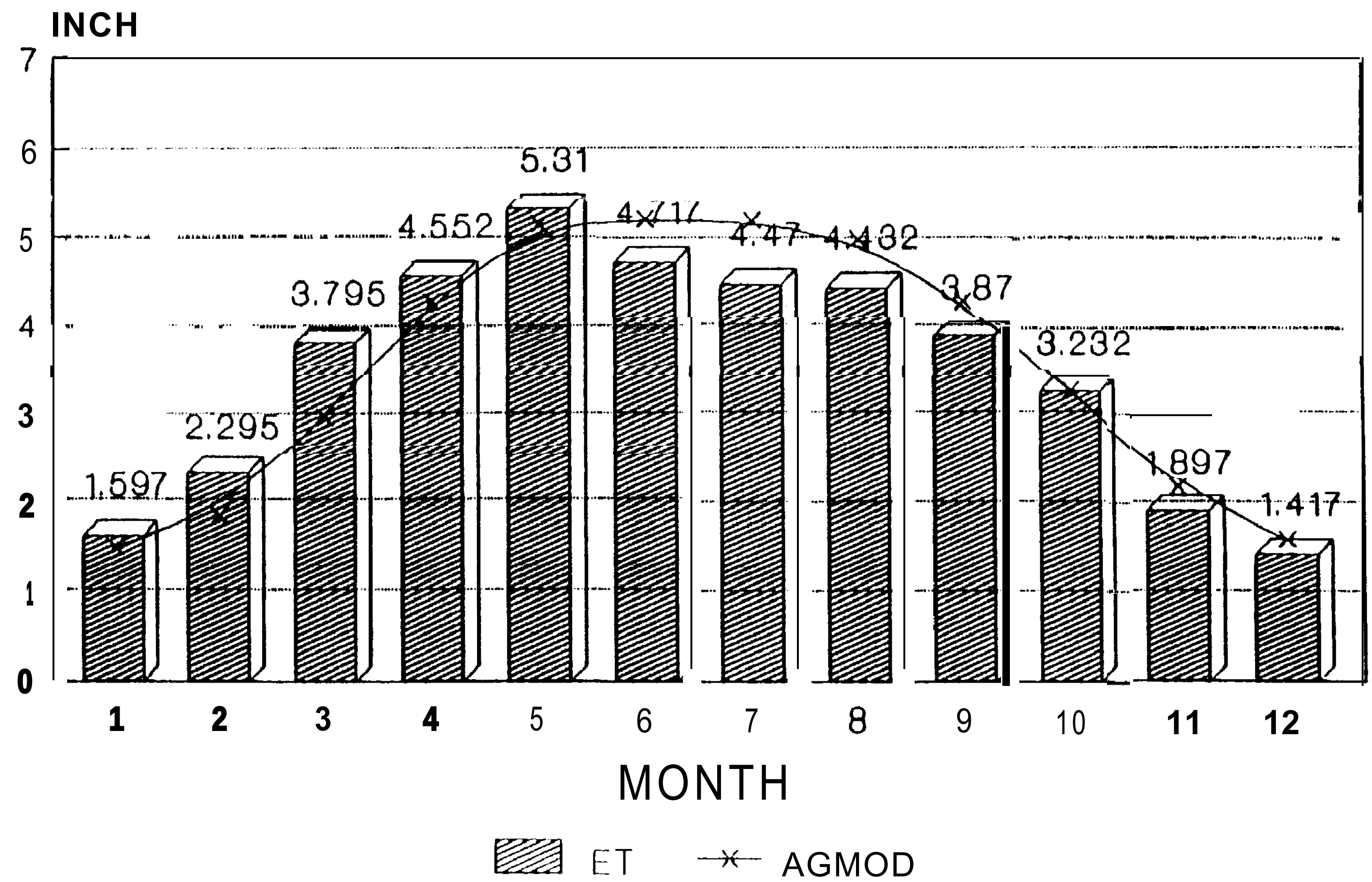
HIGHLANDS CO. CITRUS ET.

AGMOD AND **PAN**



Pan based on Kp = .75

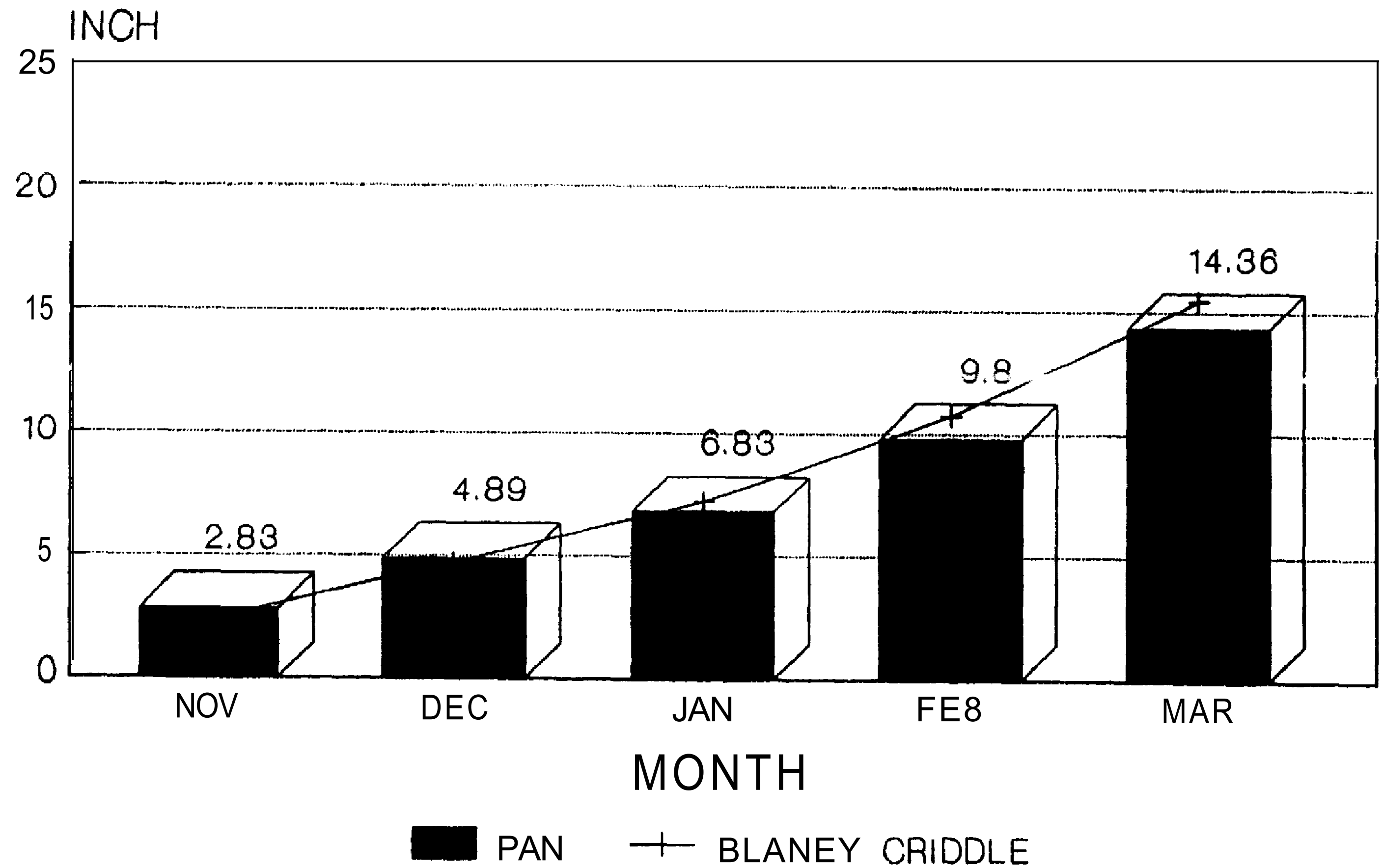
HIGHLANDS CO. CITRUS ET.
AGMOD AND PAN



Fan based on Kp = .75

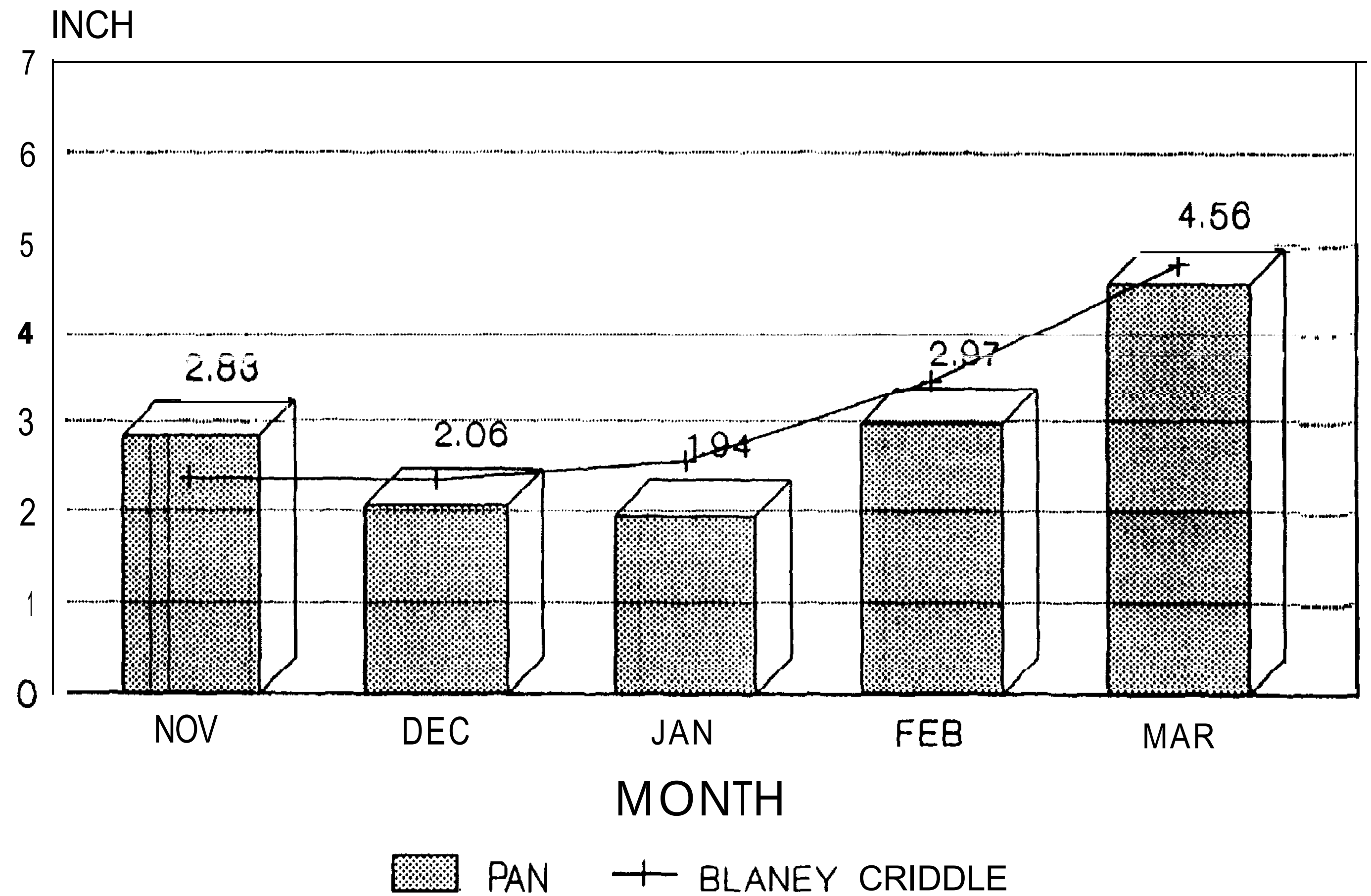
HILLSB. CO. STRAWBERRYET.

AGMOD VS. PAN



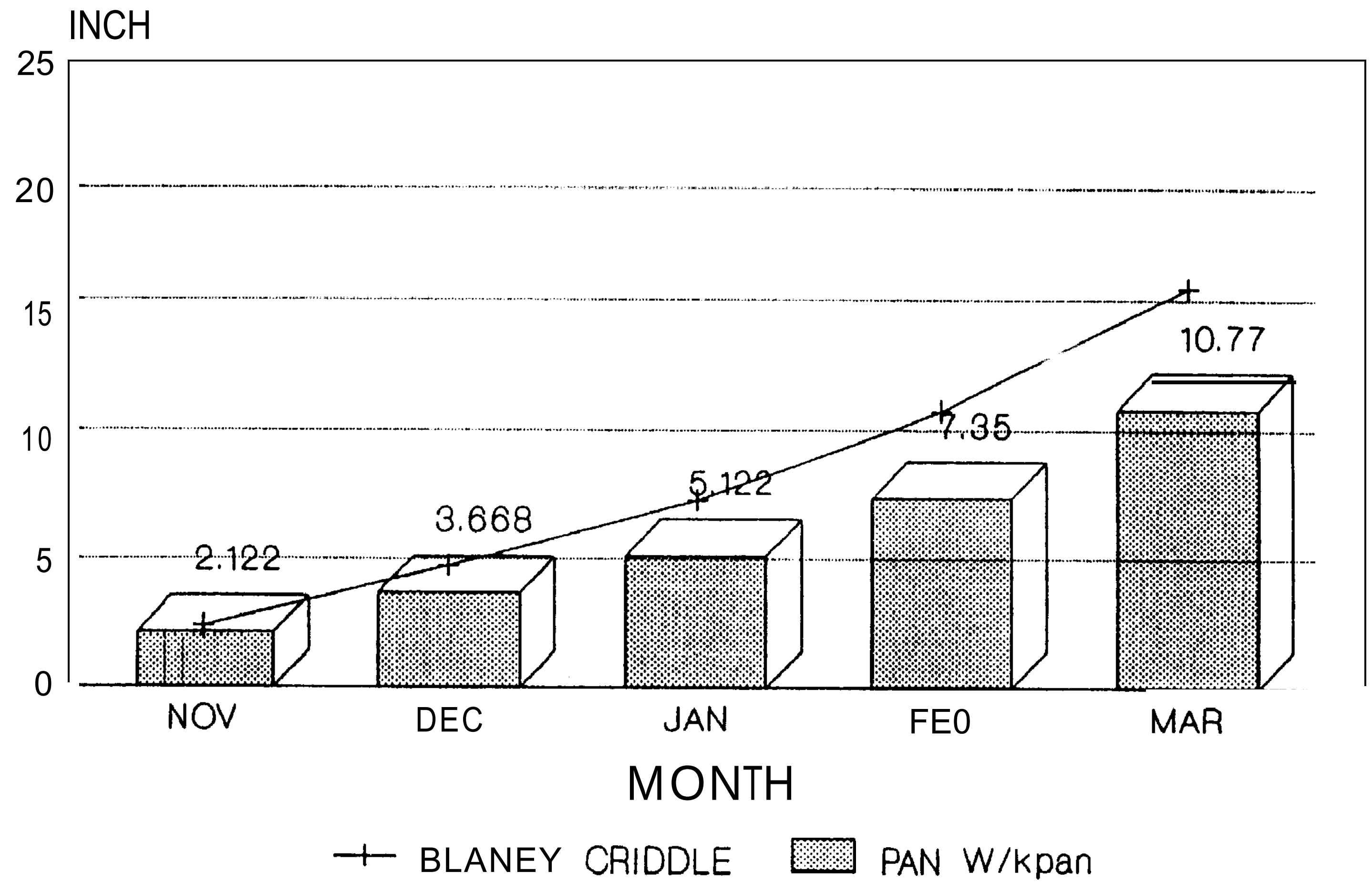
Pan based on Kp = I

HILLSB. CO. STRAWBERRY ET.
AGMOD VS. PAN



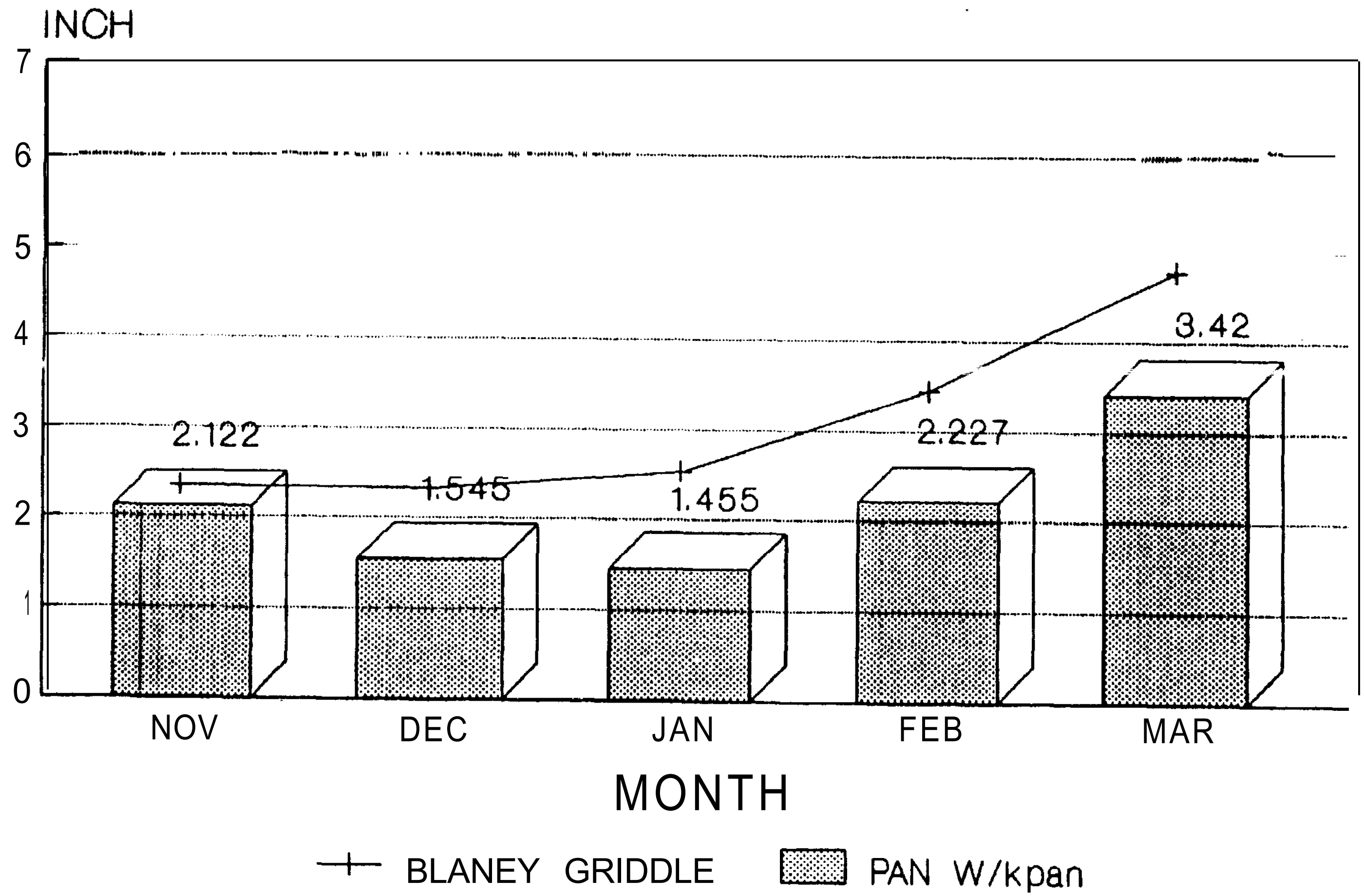
Pan based on Kp = 1

HILLSB. CO. STRAWBERRY ET.
AGMOD VS. PAN



Pan based on Kp = .75

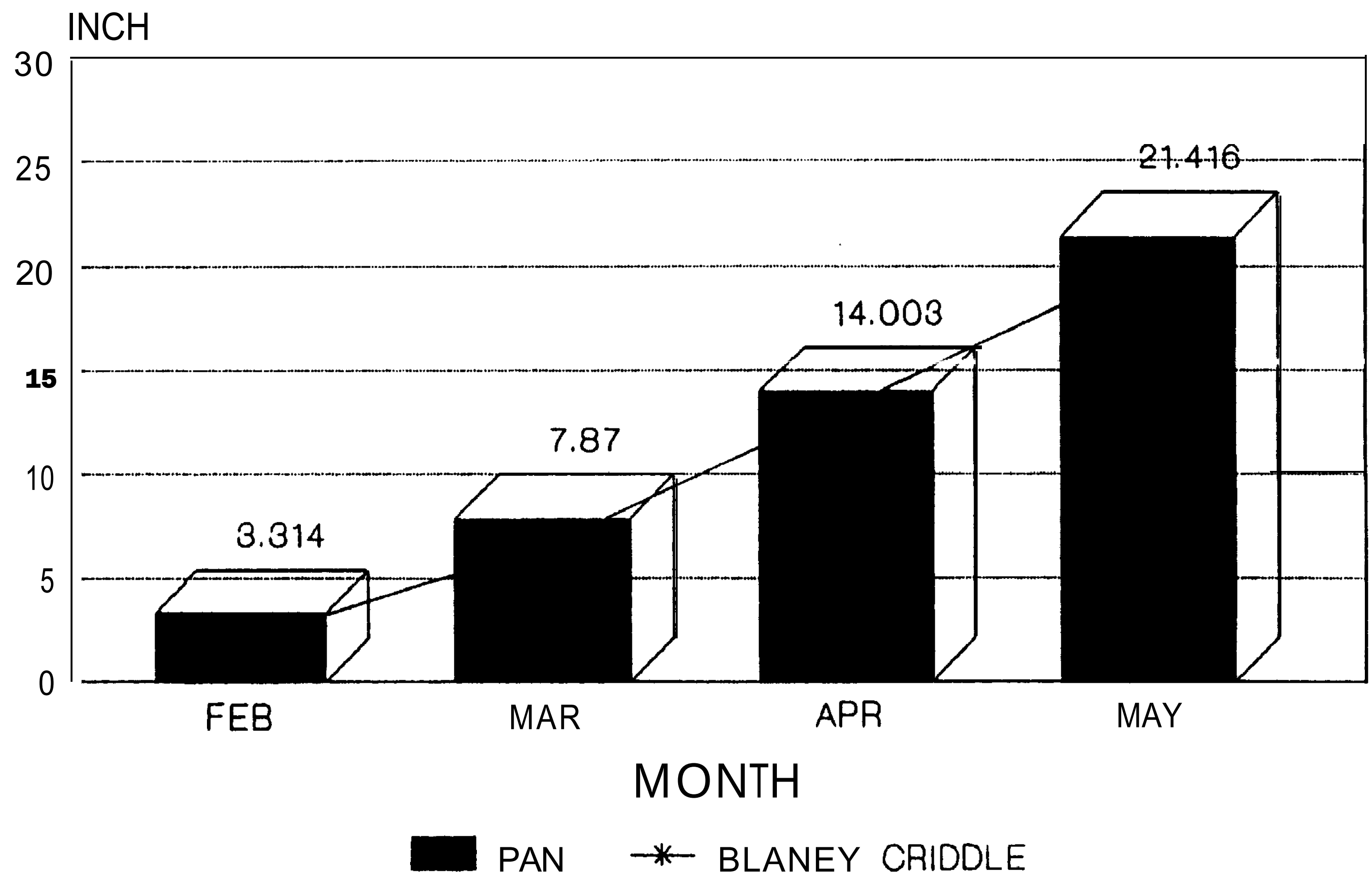
HILLSB. CO. STRAWBERRY ET
AGMOD VS. PAN



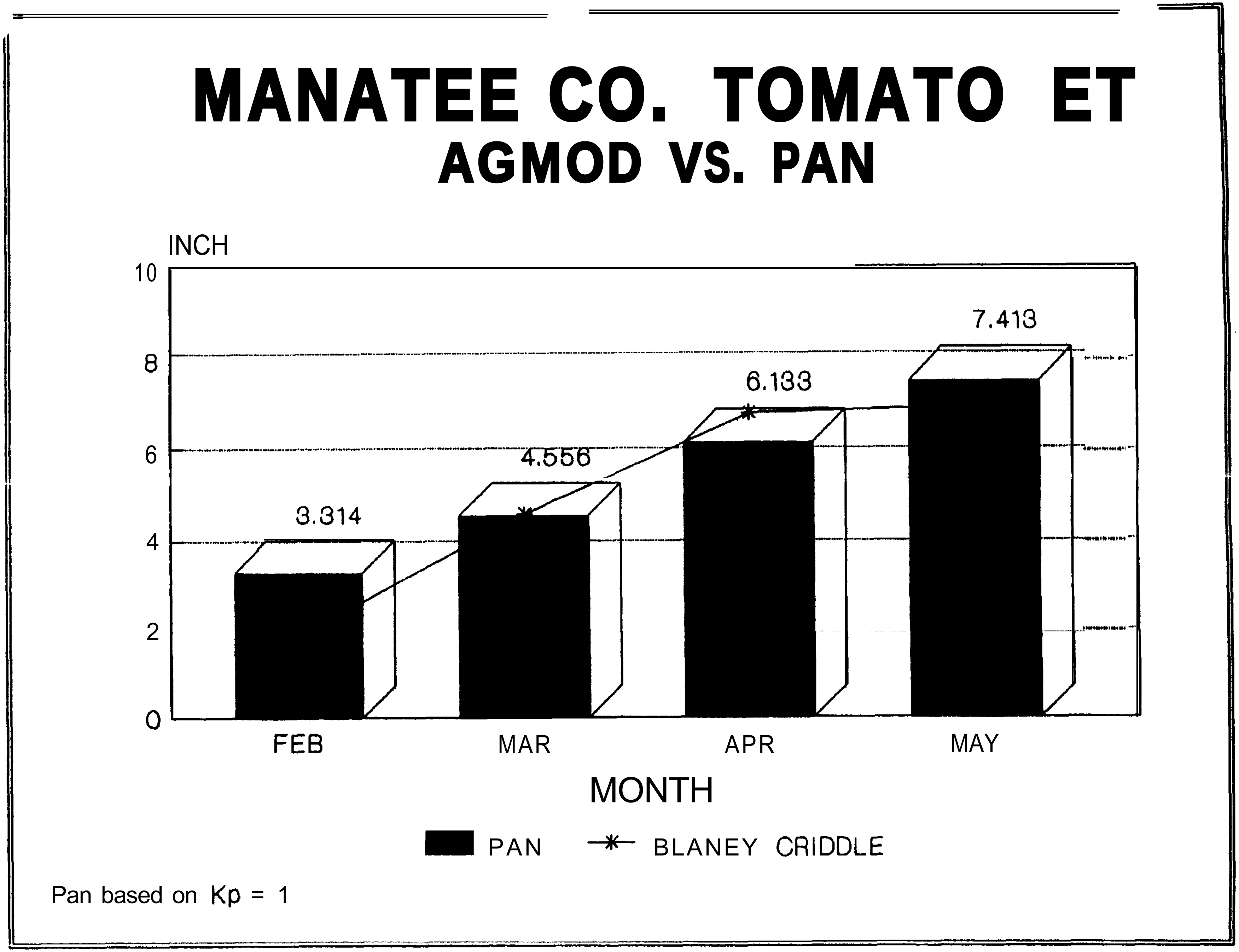
Pan based on Kp = .75

MANATEE CO. TOMATO ET

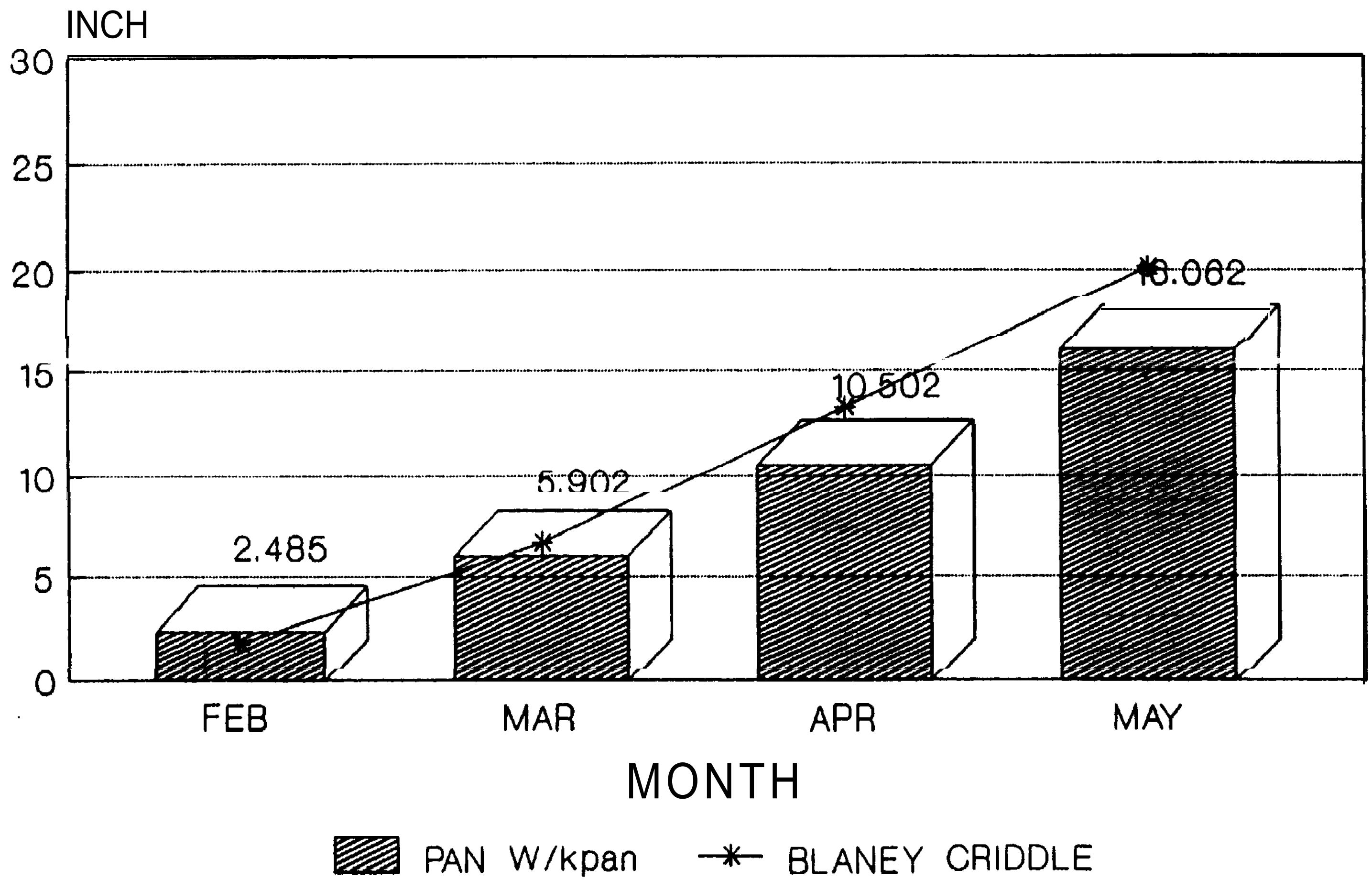
AGMOD VS. PAN



Pan based on Kp = 1

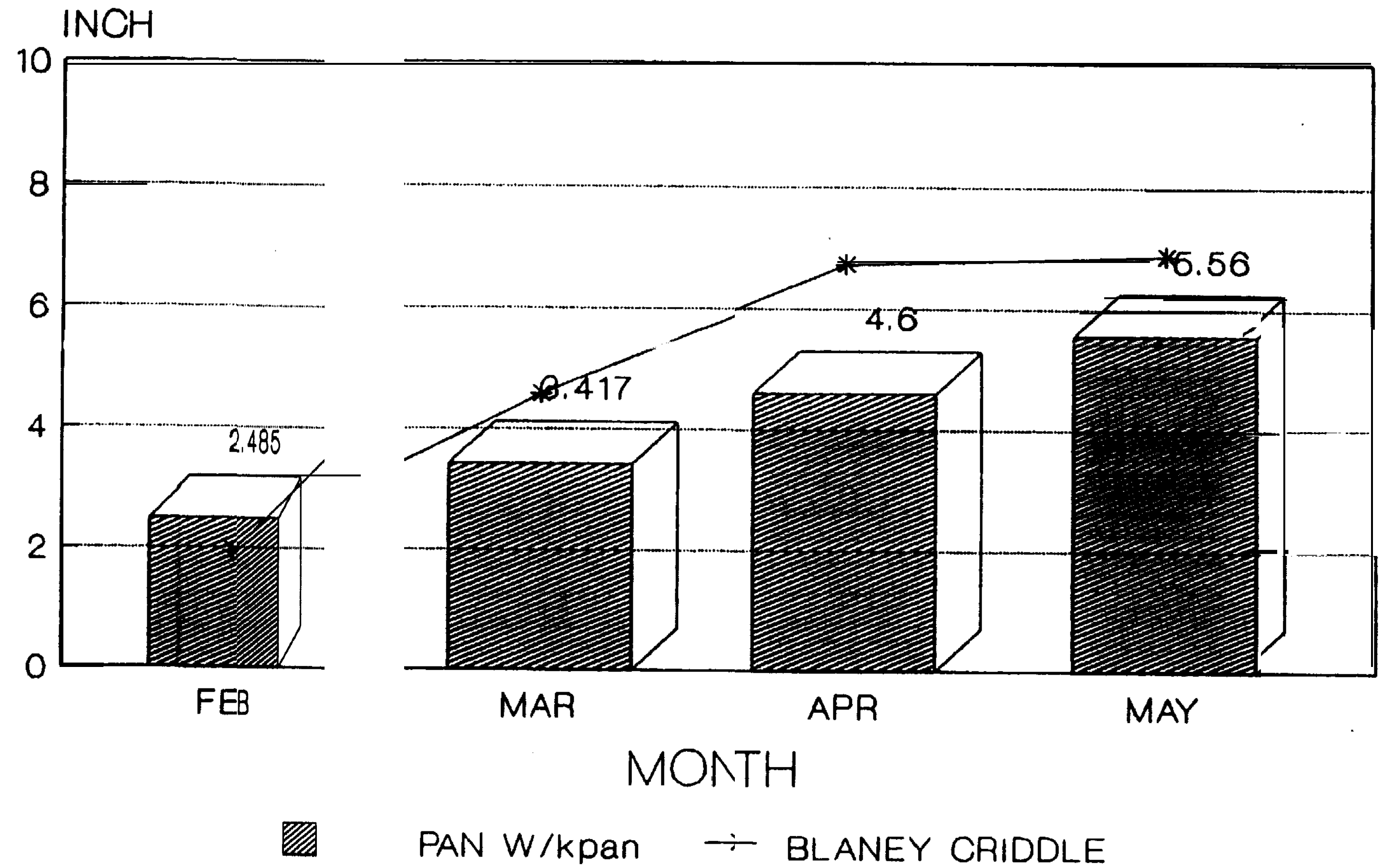

MANATEE CO. TOMATO ET
AGMOD VS. PAN
INCH
10
8
6
4
2
0
7.413
6.133
4.556
3.314
FEB
MAR
APR
MAY
MONTH
PAN
BLANEY CRIDDLE
Pan based on Kp = 1

MANATEE CO. TOMATO ET
AGMOD VS. PAN



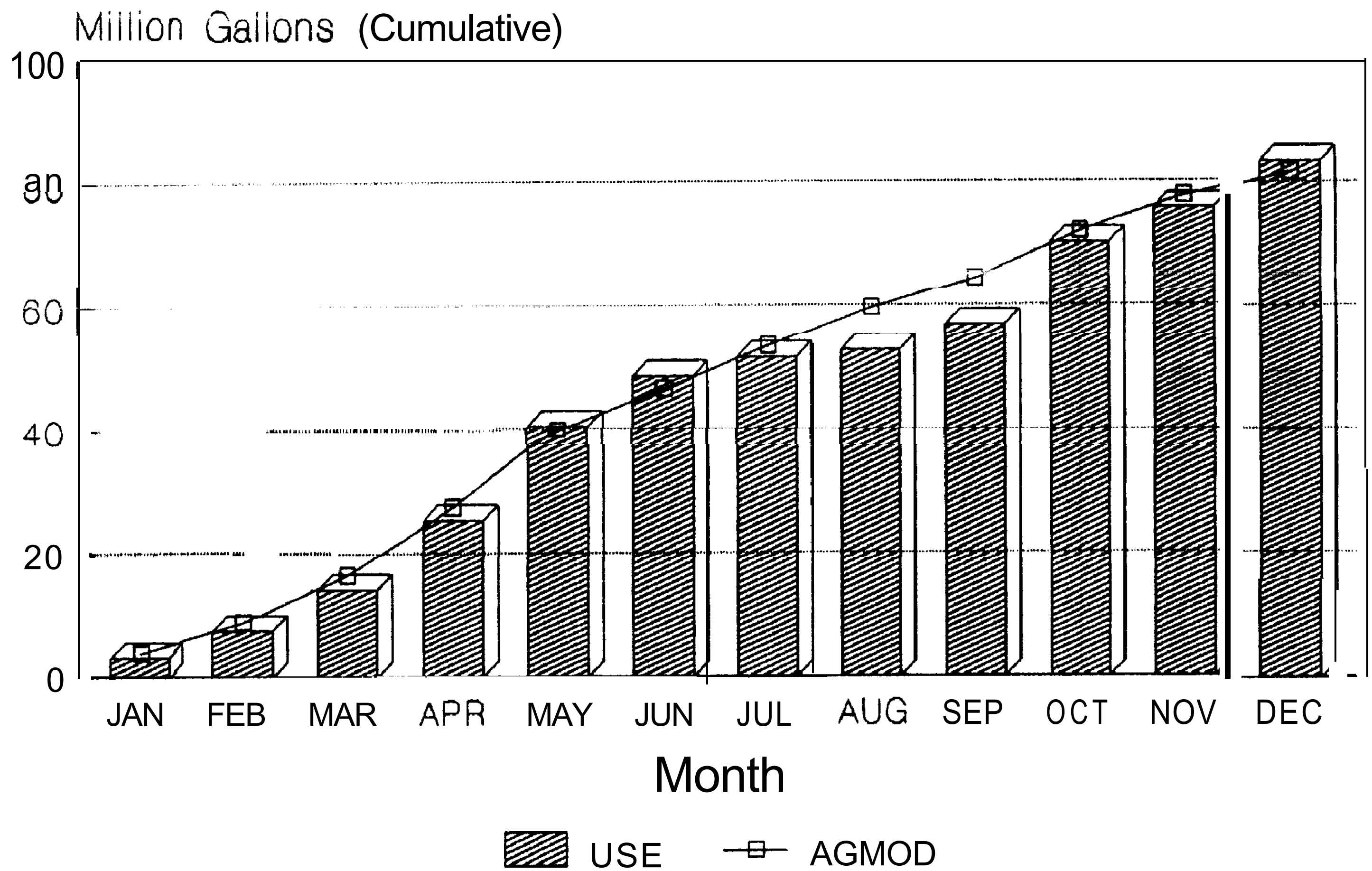
Pan based on Kp = .75

MANATEE CO. TOMATO ET
AGMOD VS. PAN



Pan based on Kp = .75

AGMOD vs. GOLF COURSE
Manatee Co.



Highest Year - 1888

GOLF COURSE - MANATEE CO.

AGMOD vs. GOLF COURSE