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Agricultural and Economic Impact of Consistent Heavy Rainfall and Cloudy Conditions on Watermelon Crop

(By Dr Prem Singh, Roger Brown, Bob Barber)

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Summary

On Guam we have become accustomed to extreme, unpredictable weather. We just clean up afterward and go about our business. Unfortunately, there are some occupations on Guam that depend on decent weather for success. Agricultural Research and Farming are two of them. The Agricultural Engineering Division of the College of Natural and Applied Sciences at the University of Guam began a Watermelon/Irrigation Experiment at the Yigo Agricultural Experiment Station (AES) On May 6, 2004 when three week old watermelon seedlings were transplanted into a one-third acre field. The watermelon plants were large, green, and robust into the first week of June. The plants were flowering and the first fruits were setting. Then in the second to third week of June, a climate of cloud cover and heavy rains began that would eventually lead to a record setting June rainfall. Soil salinity and leachate testing showed that fertilizer was being washed away as fast as it could be applied and when it was re-applied it was into saturated or nearly saturated soil. And then was wash away again. Fungi and insects began attacking the plants, and as with the fertilizer, the fungicide and insecticide sprayed on the plants were immediately washed away more often than not. Then on June 27, Tropical Storm Tingting struck Guam. The on-site weather station recorded over 400 mm of rainfall and wind gusts of 10 to 15 m/s over a two day period. High velocity rain drops and strong winds pounded at the leaves of the watermelon plants causing severe mechanical damage. The storm reduced the crop canopy area from 88 % to 41 %. Yield was poor due to new fruit sets aborting and conditions that did not allow melons to fully mature.

Introduction

A third season/replication field study was begun to determine the Optimal Wetted Soil Volume (OWSV) for growing watermelon in the shallow (19.6cm average soil depth), high pH Guam Cobbly Clay soil of Northern Guam. Watermelon *(Citrullus Lanutus)* variety China Baby was transplanted on May 6, 2004 in a random block design with twelve rows, three replications and four treatments. Treatment numbers reflect drip line per row configurations of 1, 2, 3, and 4 drip lines. Drip line spacing - based on soil wetting pattern field tests – of 20.32cm was used. Plant spacing was 1.22m in rows 3.05m apart. Switching tensiometers were used to maintain a 200 mb soil moisture tension level for all treatments. Pre-plant soil analysis showed a mean pH of 7.32 – 7.80, organic matter was 5 to 6.25%, phosphorous 6.31 – 24 ppm, and potassium 14 -20.23 ppm. Phosphorous was banded at a rate of 280kg/ha for both experiments. Nitrogen and potassium was applied based on soil analysis, Extension Services recommendations, and plant petiole sampling (as in the first two seasons). Total amounts of N and K were to be kept equal for all treatments with projected amounts of N at 140 – 168 kb and a K amount 225kg/ha Black polyethylene plastic mulch was used to control weeds, provide a uniform soil moisture level between irrigations, and to prevent leaching of N and K nutrients during heavy rains. Floating row covers were used until flowering to reduce pesticide use. Twelve stainless steel drainage lysimeters were installed in the middle of each row prior to the first season experiment to monitor deep seepage amounts and collect leachate. Watermelons were harvested for yield data and a refractometer was used to measure percent brix.

Chronological Analysis of Critical Events

June Rains

Rainy conditions began to adversely affect the watermelon crop after the first week of June (Figure 1). Of the 931 mm of rain recorded at Yigo AES Weather Station, 3.5 % fell between June 1-12, 49.5 % between June 13-25, and 47 % between Jun 26-29. Heavy periodic downpours overwhelmed drainage ditches around the field causing flooding of the watermelon crop (Picture 1). Frequently, large daily rainfall accumulations occurred over just a few hours. On June 16, of the 100.6 mm that fell, 46.2 mm fell in only one hour (Figure 2).

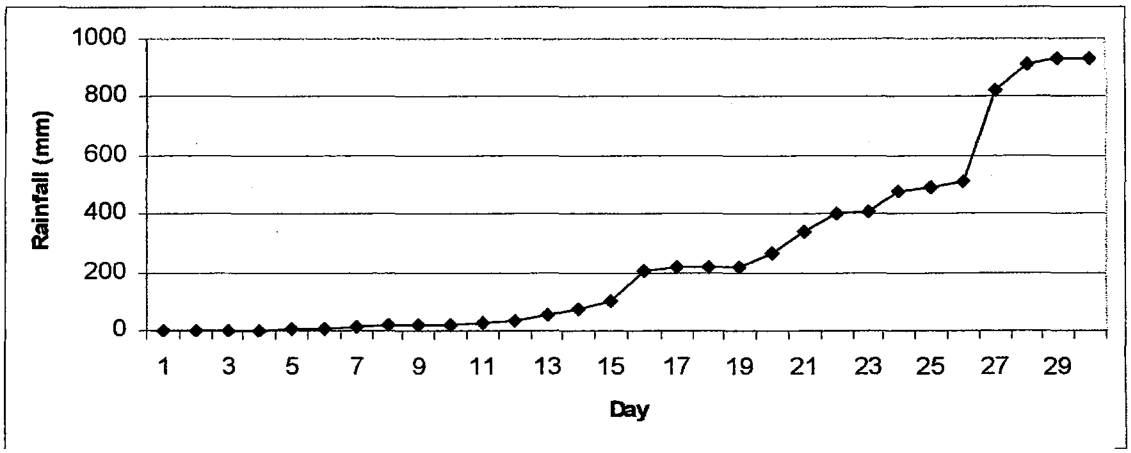


Figure 1: Daily rainfall accumulation for June

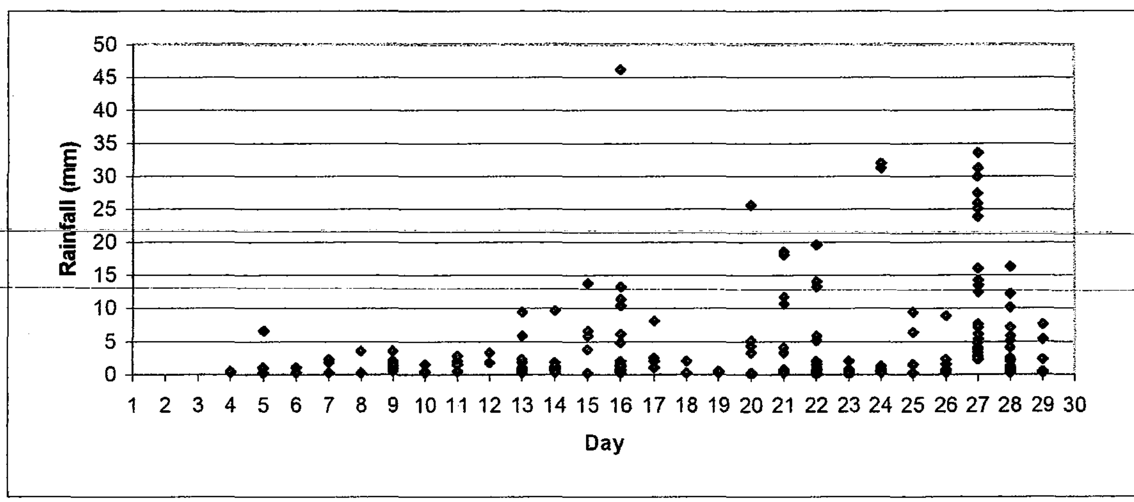


Figure 2: Hourly Rainfall events and amounts for June

Picture 1: Field flooding from June 22 heavy rainfall event. Rain water began to laterally infiltrate the black plastic mulch on June 16th leading to deep seepage and leaching.

Critical Period June 14-26 (DAP 39-54)

The black polyethylene mulch used to control weeds and maintain uniform soil moisture protected the root-zone from rainwater until June 16, when over 100mm of rain fell. On June 14 and 15, despite getting nearly 47mm of rain over those two days, rain water did not breach the root-zone and the automatic irrigation/fertigation system was activated each day when the soil moisture tension reached 200 mb. However, on June 16 the mulch barrier was breached by lateral infiltration, causing a major deep seepage/leaching event. The root-zone was saturated and root-zone average salinity dropped from 0.84 g/L (optimal .8 g/L to 1.2 g/L) on June 14 to 0.69 g/L after the infiltration. Continued rains and deep seepage/leaching continued, keeping the soil moisture tension in the range of 0-110 mb, well below the treatment irrigation/fertigation level of 200. Because of the loss of fertilizer (as detected by field salinity measurements) and the resultant plant nutrient drop (as detected by field cardy-meter petiole analysis), forced fertigation was necessitated. Forced fertigation was done on June 21 and June 24, with the same results – heavy rains, deep seepage/leaching, and a continued drop in soil salinity and plant nutrient levels (Table 1).

Date	DAP	Soil Salinity (g/L)	Rain (mm)	Leachate/ Deep Seepage (L/sq m)	Fertigation method	Petiole NO3- (ppm)	Soil Moisture Tension (mb)
6/14	39	0.84	16.26		automatic (200mb)	5000	194
6/15	40		30.48		automatic (200mb)		207
6/16	41		100.58	30.70		3200	107
6/17	42	0.69	14.73				73
6/18	43		2.29				80
6/19	44		0.76				
6/20	45		42.16	2.28		3100	
6/21	46	0.70	73.66	16.35	manual (forced)	3700	99
6/22	47		66.80	16.55		4100	55
6/23	48	0.57	4.32				55
6/24	49		67.56	10.53	manual (forced)	1600	107
6/25	50	0.45	17.53			2000	67
6/26	51	0.26	17.78	0.48			72
6/27	52		310.64	88.33			47
6/28	53		92.20	25.91			
6/29	54		17.27				47

Table 1: Synopsis of critical events occurring between June 14 and June 28.

During this period problems arose with newly forming fruits and fungus proliferation. This period would coincide with what would normally be second and third harvest fruit setting and maturing. However, young fruits began to abort shortly after the heavy rains began. This is probably due to a combination of factors, including rain, lack of photosynthetic radiation (Figure 3), low evapotranspiration (figure 4), low soil salinity (low amounts of fertilizers in the soil) caused by deep seepage and leaching (see previous paragraph), and the onset of the fungus *Pythium spp*. Normally, spraying of fungicide and pesticide is done once a week after removal of the floating row covers. Fungicide was sprayed on June 14 and repeated on June16 and 17 due to rain beginning during or shortly after spraying. *Pythium spp.* was discovered on June 20 but rains preventing spraying again until June 24th. The arrival of Tropical Storm Tingting prevented further spraying until June 30th.

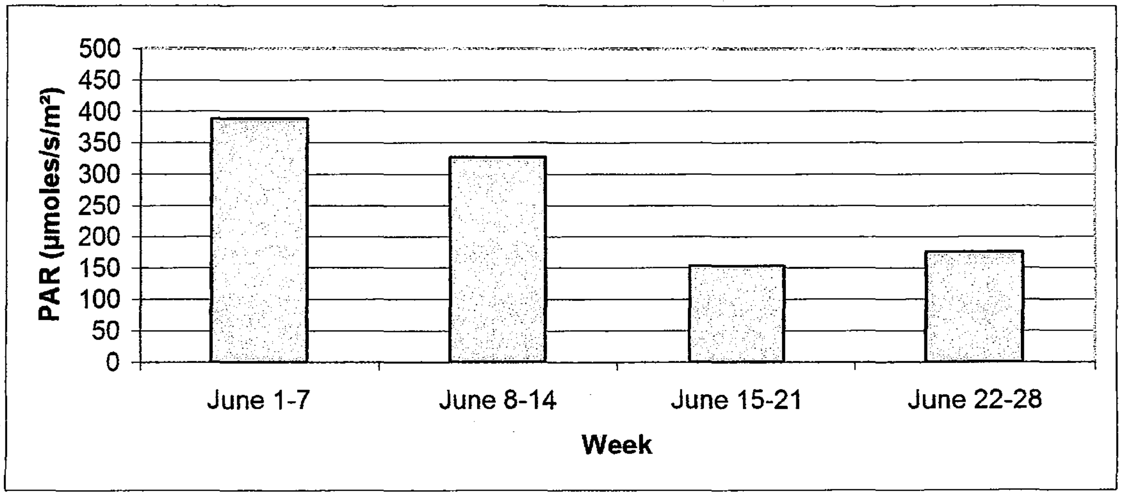


Figure 3: Weekly average Photosynthetically Active Radiation (PAR).

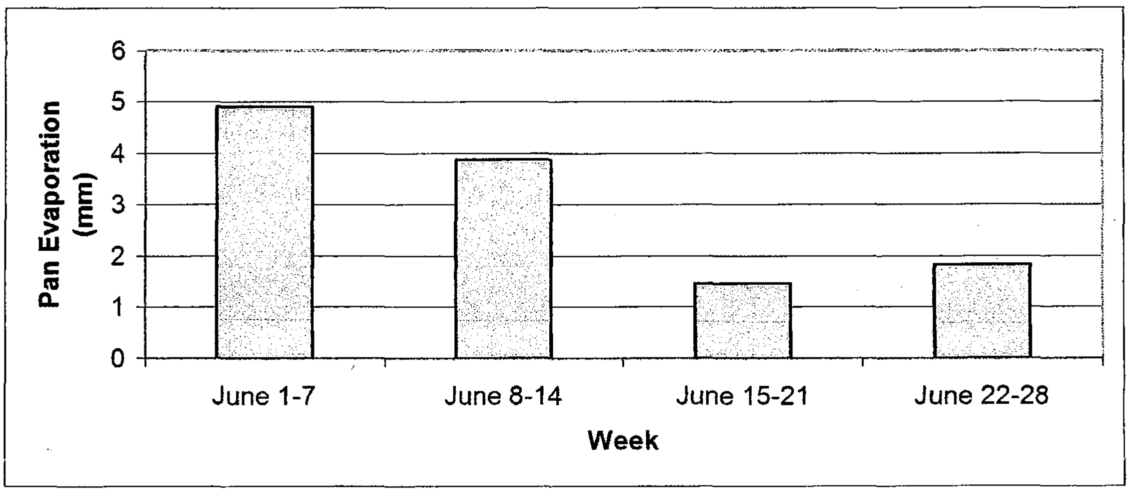


Figure 4: Weekly average Pan Evaporation.

Picture 2: Late June photo showing blackend Pythium spp. contaminated young fruit with larger contaminated fruit (inset)

Tropical Storm Tingting and Aftermath June 27-July 10 (DAP 52-65)

The heavy rains and consistent cloudiness prior to Tropical Storm Tingting were already adversely affecting the watermelon crop when the storm hit. Before the storm it was hoped that the rainy and cloudy weather conditions would subside and the crop would recover to produce a decent yield. It should be noted that had the weather conditions become more favorable the best that could probably be hoped for is the maturing of the first harvest fruits to there full weight and sweetness potential and the setting and maturing of new fruits for one more harvest. However, this was not the case as Tingting reached Guam on June 27th.

The storm dropped over 400mm of rain on Guam over a two day period. Most of the rain, 267mm, fell between 6:00 AM and 8:00 PM on June 27th (Figure 5). Wind Gusts above 14 m/s were recorded over both days, however, these gusts increased in number and intensity between 1:00 AM and 7:00 PM on June 28th, (Figure 6). Field observations on the morning of the 27th revealed wind and high velocity rain drop mechanical damage occurring on the vines and leaves of the watermelon plants.

Most of the plant leaves and some entire plants died out during or within a few days of the storm (Picture 3 and 4). Plant canopy area data from digital camera/computer program analysis show a drop in Canopy percentage from 88% two days before the storm to 39% eight days after (July 6th) the storm (Figure 7).

The rain water from the storm breached the plastic mulch and root zone. Salinity readings after the storm showed that the fertilizer was completely washed out. Forced fertigation was initiated on July 2nd despite low soil moisture tension readings. Soil moisture tension readings continued to remain low after the forced fertigation. Plant water/nutrient uptake was slow or non-existent (Figure 8 and 9). This was probably due to the inability of plants to transpire normally because of leaf loss and because plants were dying due to the overall mechanical damage cause by the storm. Plants were exhibiting signs of micronutrient deficiency and a last forced fertigation with fertilizer containing micronutrients was attempted on July 6th.

A general fungicide and a Pythium specific fungicide was applied to the field on June 30 and July 7. However, attempts to revive the crop proved unsuccessful. Plant water/nutrient uptake remained low and no further fertigations were made.

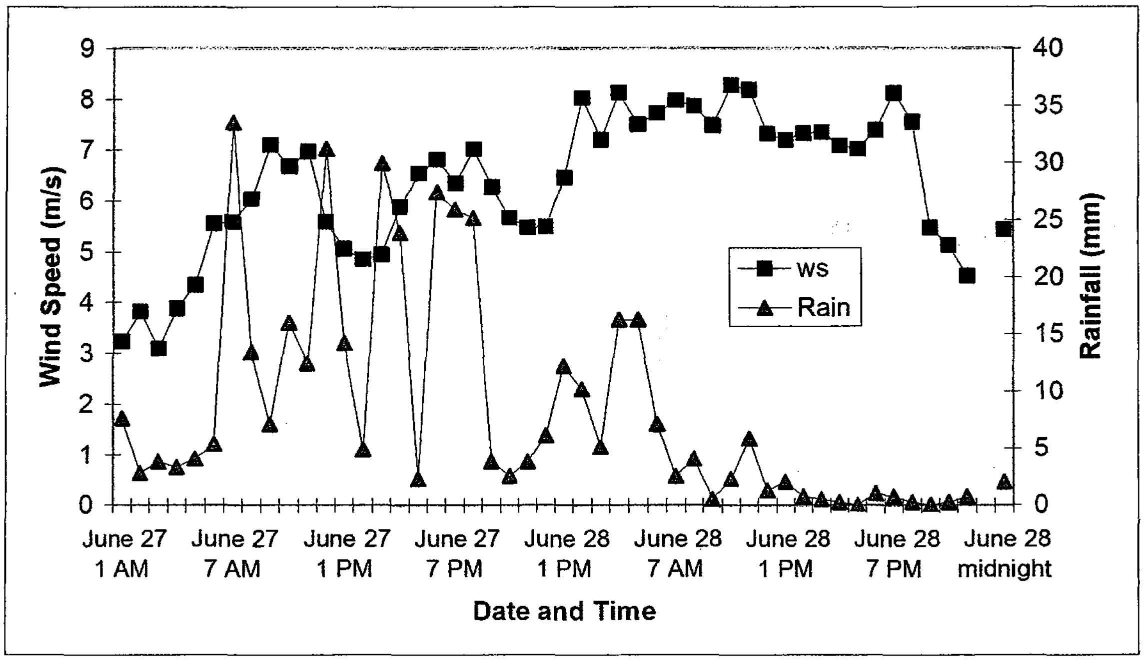


Figure 5: Hourly total rainfall and hourly average wind speed during Tropical Storm Tingting.

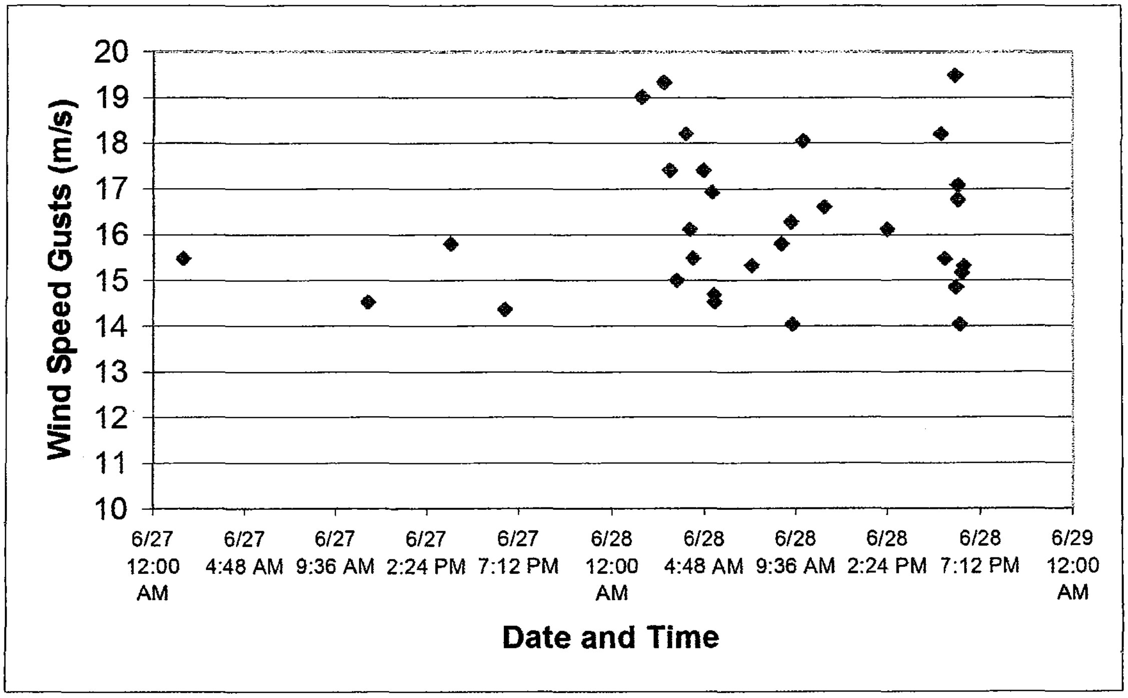
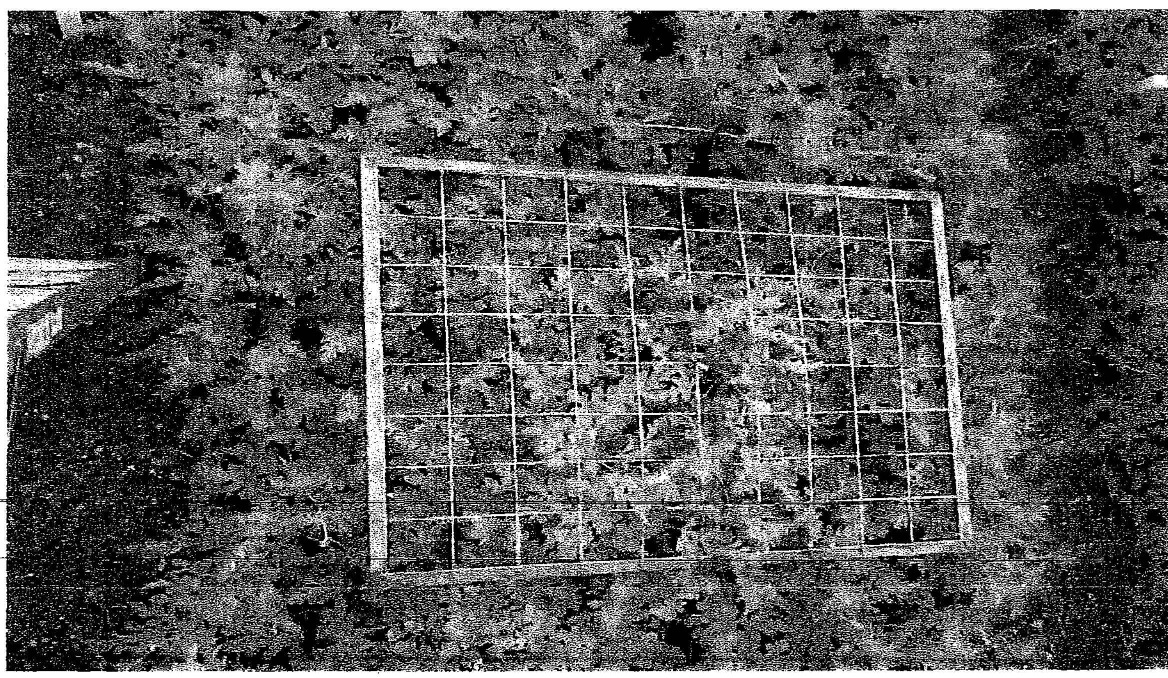
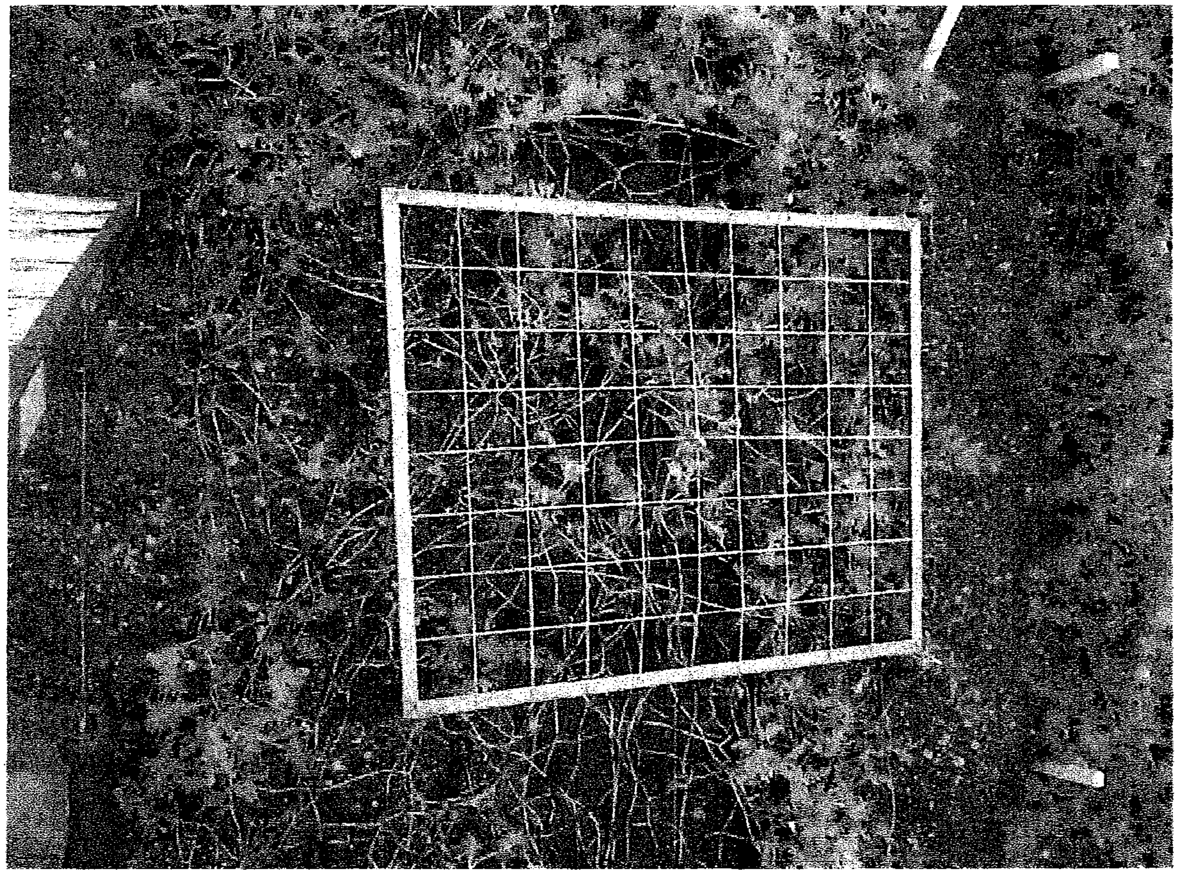


Figure 6: Wind speed gusts above 14 m/s during Tropical Storm Tingting



Picture 3: 6-25-04 grid/canopy digital photo before Tropical Storm Tingting



Picture 4: 7-6-04 grid/canopy digital photo after Tropical Storm Tingting

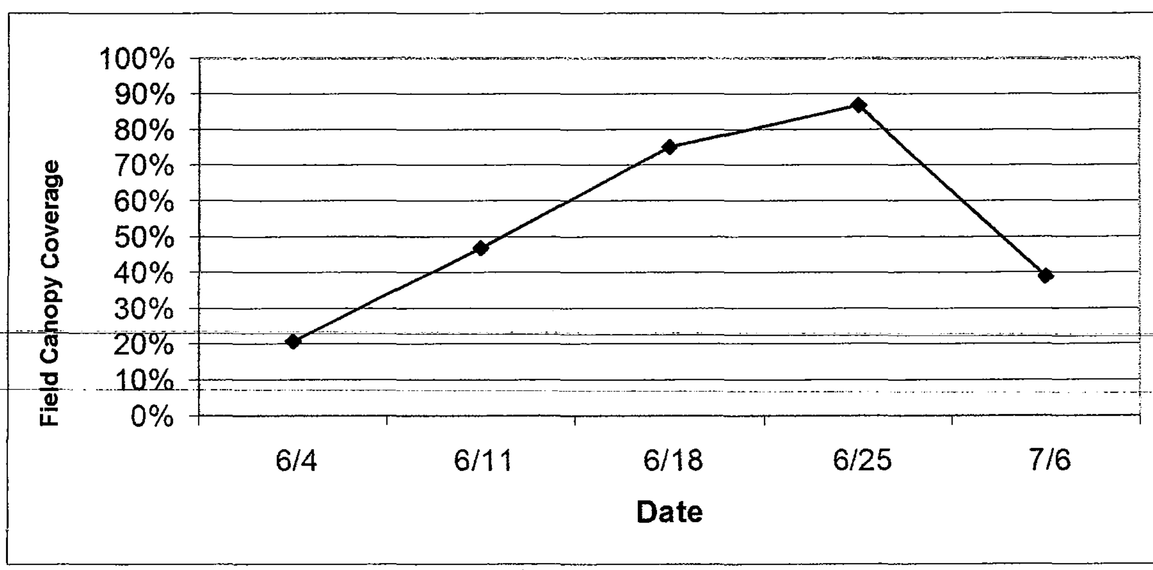


Figure 7: Percent field coverage of plant canopy. Sharp decline on 7/6 is due to mechanical damage caused by Tropical Storm Tingting

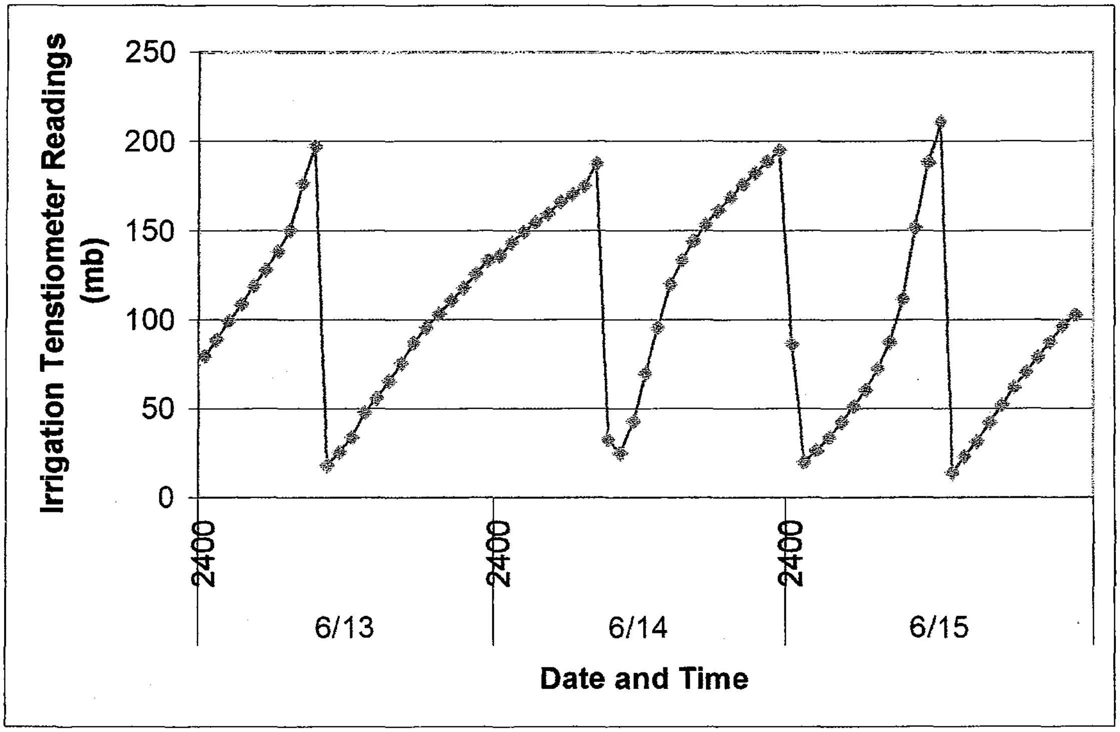


Figure 7: Plant water/nutrient uptake pattern over three days prior to Tropical Storm Tinting. Automatic irrigation/fertigation commences at 200 mb.

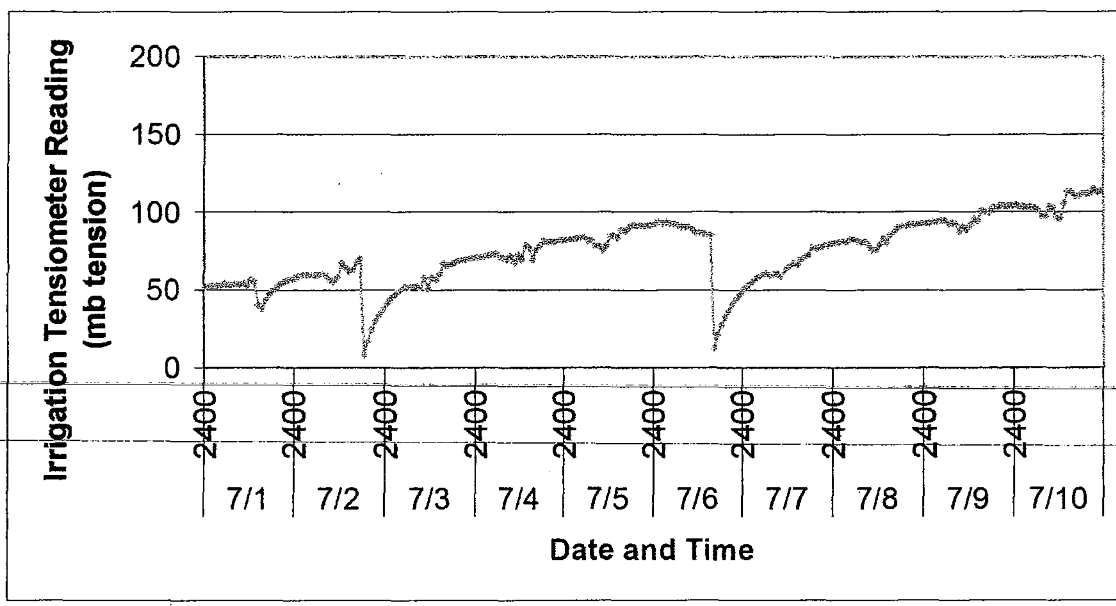


Figure 9: Plant water/nutrient uptake pattern over a 10 day period after Tropical Storm Tinting. Sharp declines in soil moisture tension represent forced fertigation events.

Fruit Development and Yields

Fruit development begins with the removal of floating row covers and the pollination of flowers. This occurred three to four weeks after transplanting the two to three week old seedlings. Days After Planting (DAP) commences after the seedlings are transplanted to the field. Each week after fruit development begins, fruits over 10 cm in length are flagged with a different color flag representing the week they developed to this stage. First week fruits numbers are actually those fruits which develop during the second week after row covers are removed and fruits which developed earlier due to pollinating insects breaching the floating row covers. Therefore, for the 2004 crop, first week flags were those fruits that developed prior to June 14th (DAP 42). The number of first week fruits marked for 2004 were exactly the same as for 2003, 372 fruits per hectare. However, at the beginning of the second week a period of heavy rains and cloudy conditions began (see "Critical Period June 14-16, previous section). From this point onward few fruits would reach the 10 cm limit for marking. Many would develop then abort before they reached this length. Second week fruits over 10 cm were only 295 fruits per hectare, compared to 2787 and 3139 second week fruits per hectare for 2002 and 2003 respectively. Third week fruit development faired no better for this crop, and fourth week development was zero due to Tropical Storm Tingting. The total number of marketable fruits – fruit greater than 4.5 kg with no disease or deformity – was only 308 fruits per hectare for 2004 compared to 3268 and 3473 fruits marketable fruits per hectare for 2002 and 2003 respectively (Table 2).

The few fruits that reached marketable specifications in 2004 were smaller than and not as sweet as the previous season's fruits. This is obviously due to the fruit not maturing fully. First week fruits exhibited a slower than normal growth after the rains began and Tropical Storm Tingting cause most fruits to stop maturing completely. The tendrils one the plant vines closest to the watermelon typically turn brown when the melon is ripe. However, it was noted that tendrils that should not have turned brown yet did so immediately after the tropical storm, probably due to the severe mechanical damage inflicted on the plants. The average weight for 2004 marketable fruits was over 2kg lower over all and nearly 5 kg lower than 2002 for first week fruits (Table 3).

The sweetness of the marketable size fruits also show that fruits failed to ripen/mature fully. Refractometer testing of week one fruits show that percent brix declined in 2004.

Table 2: Weekly fruit development and marketable fruits, per hectare, for the 2002, 2003, and 2004 seasons. Fruits for a given week are those newly developing fruits having reached at least 10 cm in length.

	New fruits developing (over 4")			Marketable Fruits at Harvest		
Week	2002	2003	2004	2002	2003	2004
1	551	372	372	519	352	263
2	2787	3139	295	1800	1993	45
3	1121	1339	199	730	762	0
4	718	1640	0	218	365	0
Total	5177	6490	865	3268	3473	308

Table 3: Weekly yield data and average fruit weight for 2002, 2003, and 2004

	Marketable Yield (Mg/ha)			Average Fruit Wt. (kg)		
Week	2002	2003	2004	2002	2003	2004
1	5.34	3.05	1.45	10.29	8.65	5.51
2	13.73	15.66	0.23	7.63	7.86	5.10
3	4.99	5.56	0.00	6.83	7.29	0.00
4	1.55	2.31	0.00	7.09	6.33	0.00
Total	25.61	26.58	0.00	7.84	7.65	5.31

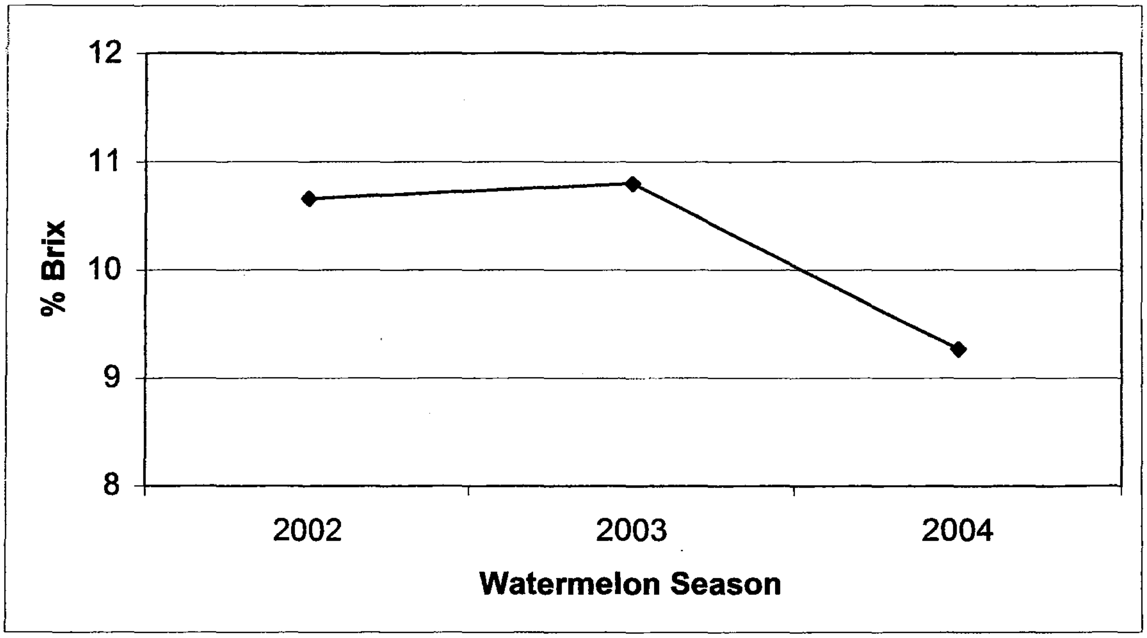


Figure 10: Percent brix for 2002, 2003, and 2004 seasons.

<u>Economic Impact</u> (Bob Barber)