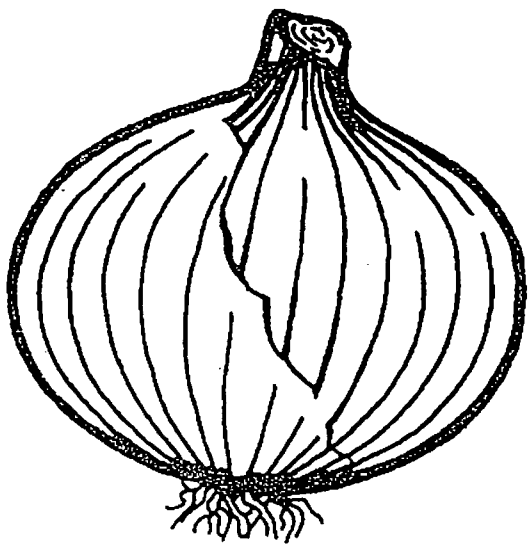
1995 Georgia Onion Research - Extension Report



THE UNIVERSITY OF GEORGIA - U.S. DEPARTMENT OF AGRICULTURE COOPERATING,
TIFTON, GEORGIA

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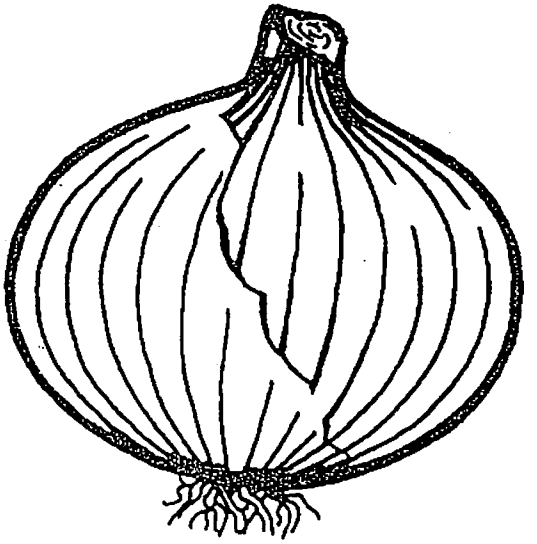

THE UNIVERSITY OF GEORGIA - U.S. DEPARTMENT OF AGRICULTURE COOPERATING,
TIFTON, GEORGIA

1995 GEORGIA ONION RESEARCH - EXTENSION REPORT

(Summary Report of 1995 Data)

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THE 1995 ONION RESEARCH-EXTENSION REPORT

Georgia's onion industry is primarily based upon the production of sweet onions, so called because of a mild pungency level of the varieties grown. Georgia's sweet onion industry originated on a farm two miles East of Vidalia, more than 60 years ago. During 1995 approximately 250 growers harvested over 12,500 acres of onions. The industry has a farm value in excess of $30 million.

The University of Georgia and USDA/ARS provide information on many aspects of production and handling to the onion industry through Research and Extension programs. This information may be progress reports of research underway or reports of conditions in the field. This Onion Research-Extension Report is intended to convey present information and should not be considered as the final authority.

BACTERIAL DISEASES OF VIDALIA ONIONS-1995

Ron D. Gitaitis, Research Plant Pathologist

Granex 33 onions were harvested at the Coastal Plain Experiment Station, Blackshank Farm, on May 10, 1995, when approximately 80% of plant leaves failed to return upright after gently sweeping across the plant tops. During harvest, onion foliage and roots were removed using standard clipping techniques. A subset of onions were clipped using shears dipped in a suspension of *Pseudomonas viridiflava (Pv)*, causal agent of bacterial streak and bulb rot or *Burkholderia cepacia (Bc)*, and causal agent of sourskin. Onions were segregated by treatment and cured with forced hot air for 48-72 hrs. After curing, onions were graded, culls removed, and those not receiving the clip-inoculation treatment were inoculated with a dissecting needle dipped either in sterile water, *Pv*, or *Bc*. The needle penetrated approximately 1/2 in. in to the bulb. All onions were bagged by treatment and placed in to storage. Onions were stored for 10 or 15 wks under CA or standard cold-room storage conditions (the fire at the Onion/CA Lab caused these treatments to be confounded as the latter portion of the 15 wk CA storage treatment had to be in a cold room.)

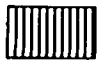
Decay caused by *Pv* appeared to be inhibited somewhat by CA, as after 10 wks 40% of the bulbs were marketable from CA and only 15% were marketable after 10 wks in cold room storage, $n = 20$ (Fig.1). However, in both instances, control onions had 90 and 85% marketable onions from CA and cold room storage, respectively. Onions inoculated by clipping leaves and roots with shears, contaminated with either *Pv* or *Bc* had no more rot than controls in either CA storage or in a standard cold room. Surprisingly, onions inoculated with *Bc*, the sourskin pathogen, had a higher percentage of marketable onions from those in cold room storage than those in CA (Fig.1). Analysis of onions after 1 week on the shelf after removal from storage indicated that there was little increase, if any, in onions inoculated with *Bc*, whereas, onions stab-inoculated with *Pv* and stored in CA had a decrease in number of marketable bulbs after 1 wk on the shelf.

In conclusion, clipping mature onions with contaminated shears does not increase the risk of postharvest decay. This is in contrast to the postharvest decay of "immature" onions, observed earlier. In this study, bacteria did not colonize down the leaf or up the roots to initiate bulb rot, nor was there bulb-to-bulb contamination while in storage despite inoculum present on the surfaces of the clipped stems and roots. Wounded bulbs, on the other hand, displayed more decay in both CA and cold room storage. As in the case Pv, Bc caused more decay when stabbed than when clip-inoculated. This demonstrates the importance of not wounding bulbs during or after harvest to avoid bacterial decays. Decays caused by *Bc* appeared to be enhanced during CA storage compared with cold room storage. This was totally unexpected and deserves further study and under conditions where the CA treatment is not interrupted as it was in 1995.

Fig. 1. Percent marketable onions after inoculation with *Pseudomonas viridiflava, Burkholderia cepacia*, and a control of sterile water using two inoculation methods. Onions were stored under either standard CA conditions or in a standard cold room. Evaluations were made upon removal of onions after 10 and 15 wks and again after one week of storage at room temperature on the shelf.

Legend


Control (Sterile water)


Pseudom onas viridiflava (Pv)
[Bacterial Streak & Bulb Rot]


Burkholderia cepacia (Bc)
[Sourskin]

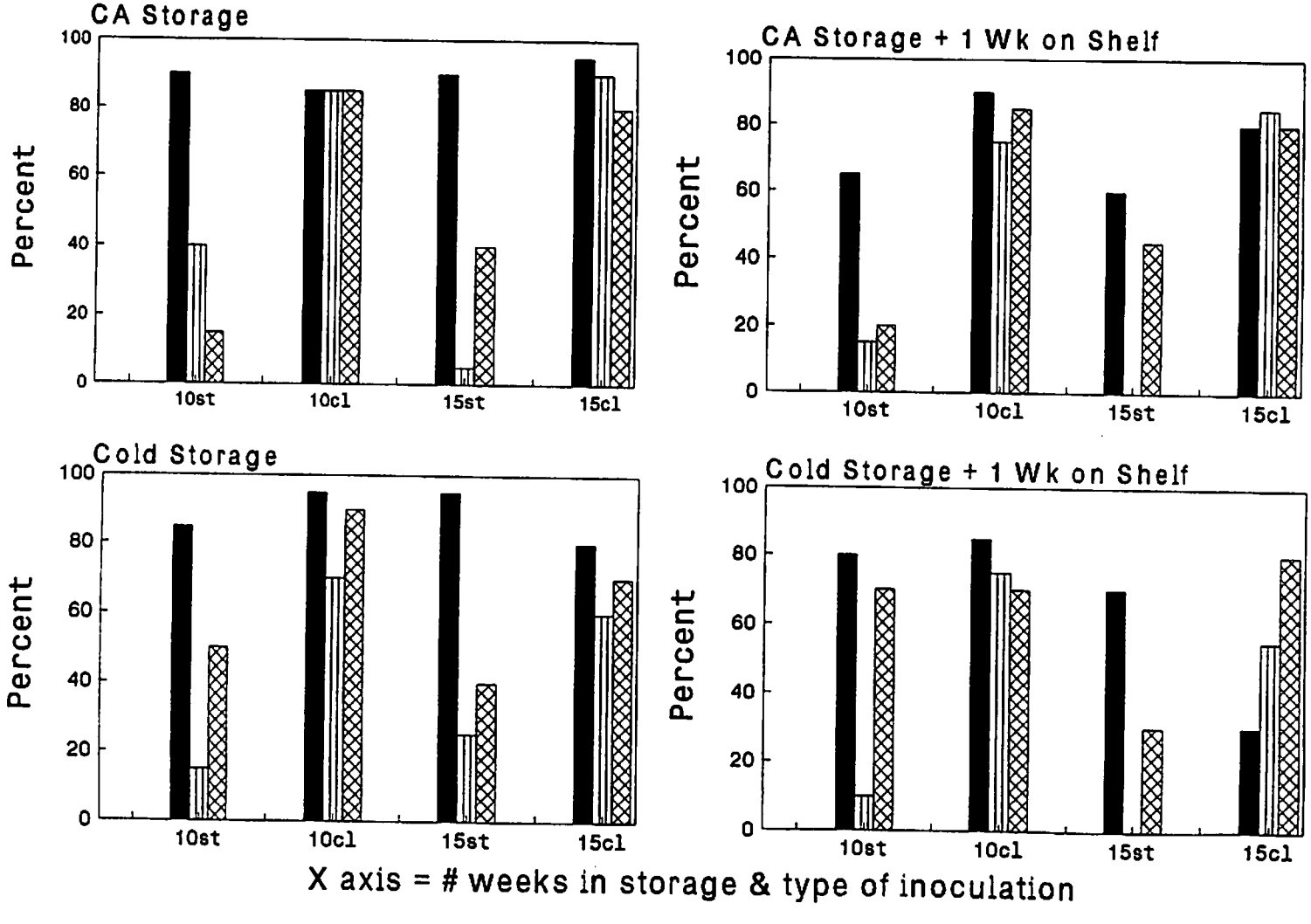
Trt 10st = 10 weeks of storage & inoculated by dissecting needle inserted 1/2 in. in to the bulb.

Trt 10cl = 10 weeks of storage & inoculated by clipping leaves and roots at harvest.

Trt 15st = 15 weeks of storage & inoculated by dissecting needle inserted 1/2 in. in to the bulb.

Trt 15cl = 15 weeks of storage & inoculated by clipping leaves and roots at harvest.

Percent Marketable Onions



X axis = # weeks in storage & type of inoculation

PHYSICAL PROPERTIES AND QUALITY OF VIDALIA ONIONS STORED UNDER DIFFERENT CONDITIONS

Yen-Cong Hung, Research Food Scientist
E.W.(Bill) Tollner, Research Agricultural Engineer
Bryan W. Maw, Research Agricultural Engineer

Introduction

To increase the market share and sales of Vidalia onions, maintaining a year round supply of high quality onions is critical. Background information on quality and physical properties of Vidalia onions during storage is needed to assist the evaluation and identification of storage methods/conditions for shelf life extension.

To gain better understanding of the physical properties and quality of onions during storage, Vidalia onions were collected and evaluated. The overall objective of the study in 1995 was to evaluate the effect of storage condition (refrigeration and controlled atmosphere (CA) plus refrigeration) on the physical properties and quality of Vidalia onions.

Materials and Methods

Coated Granex 33 onion seeds were planted at Coastal Plain Experiment Station at Tifton, Georgia. A standard fertilizer program was adopted based on the UGA recommended rate consisting of 1,000 lbs/A 5-10-15 preplant plus 200 lbs/A 10-34-0 at planting with 150 lbs/A 15-0-14 at 8 and 12 weeks and 150 lbs/A 15.5-0-0 at 16 and 20 weeks.

Onions were harvested at optimum maturity stage. At harvest, onions were undercut, clipped, weighed, and cured. About 130 medium size cured onions were put into either refrigerated (34°F) or CA (3% O_2, 5% CO_2, 92% N_2 and 34°F) storage conditions. The Vidalia onion research laboratory at Tifton was used for the CA storage study. Three bags of ten onions each were evaluated every three months from both storage conditions. Nondestructive quality parameters (weight, shortest and longest diameters, shape, amount of surface damage) of each onion were recorded first. An axial ratio (a shape factor) was calculated by dividing the shortest diameter with the longest diameter. The shape of onions was assigned as 1 for disk shape, 2 for conical shape, 3 for semi-round and 4 for round shape. Number of surface damage (like blemish) for the whole onion was recorded by manually evaluate the whole onion surface and if the onion was rotted then a score of 99 was assigned.

Firmness of onions was then measured as the force (Newton) required for a 3.2 mm diameter puncture probe to penetrate the first and second ring of onion from the shoulder using an Instron universal testing machine. After the firmness evaluation, each onion was then destructively evaluated for internal color, number of internally rotted spots and number of rings as affected by Botrytis neck rot. A completely affected ring (with visible dark discoloration going all around the ring) was counted as two. Onion color on the cut surface was measured using a Gardner colorimeter.

Data presented in this report represents the means of values obtained from the combination of 3 replicated bags and 10 replicated samples. Statistical analysis of data was performed using ANOVA and Duncan's Multiple Range Test procedures of Statistical Analysis System (SAS).

Results and Discussion

Three months into the CA storage study, the CA storage facility was damaged and the storage study was terminated. Data presented in this report only represent the results from samples before storage and after the first three-month of storage.

Shape, weight, and axial ratio results are presented in Table 1. There was no difference among all the samples on these three physical properties and demonstrated that onions used for the current study all had similar physical properties and quality. If different exist on other measured properties or quality parameters, storage time and condition must be the contributing factors.

Color lightness was measured on a 0 to 100 scale and the higher the number the lighter the color. Storage time and condition had no significant effect on the number of rotted spots and lightness of onions. Number of surface damages increased significantly with the storage time. Although the difference between different storage condition was not significant, onions stored under CA had smaller number (64.35) than onions stored under refrigerated (74.25) condition (Table 2). Similar results were observed for the number of rings affected by Botrytis

neck rot. Onions before storage had fewer number of rotted rings than onions stored for 3 months. Although the difference between different storage condition was not significant, onions stored under CA had smaller number of affected rings (1.4) than onions stored under refrigerated (1.7) condition. Onions stored under CA condition also retained their firmness better than onions stored under refrigeration. Onions stored under refrigerated condition required smaller force (softer) to penetrate the first and second rings than onions stored under CA condition (Table 2).

We will repeat the experiment next year and should be able to report the effect of different storage conditions on the physical properties and quality of Vidalia onions over the entire storage periods at our next year's report.

Table 1. Effect of storage time and condition on weight, shape and axial ratio of Vidalia Onions.

Storage Time (Month)	Storage Condition	Weight (g)	Shape	Axial Ratio
0		208	2.1	0.58
3	Refrigerated	221	2.1	0.56
3	CA Storage	258	2.2	0.59

Table 2. Effect of storage time and condition on the quality of Vidalia Onions.

Storage Time (Month)	Storage Condition	# of Surface Damage	# of Rotted Spots	# of Rings Affected by Botrytis Neck Rot	Puncture Force, First Ring (N)	Puncture Force, Second Ring (N)	Lightness
0		0.15a	0.15a	0.3b	27.8a	24.0a	76.3a
3	Refrigerated	74.25b	1.21a	1.7a	25.3a	19.4b	73.3a
3	CA Storage	64.35b	0.95a	1.4a	29.6a	22.0a	77.1a

a-b Means in the same column with the same letter are not significantly different at 0.05 level.

WEED CONTROL TRIALS FOR SWEET 'VIDALIA TYPE' ONIONS

Greg MacDonald, Extension Weed Specialist
Reid Torrance, Tattnall County Extension Director
Rick Hartley, Toombs County Extension Director

Several weed control studies were conducted in Tattnall and Toombs counties on 'Vidalia type' onions. These included 2 experiments performed on direct seeded onions and 2 on transplanted onions.

Direct Seeded Onions

The first study on direct seeded onions was conducted in Tattnall county. These onions were being grown for transplant purposes. Treatments were applied on 10/15/95 to 5" tall onions that were heavily infested with many annual weeds. these included annual grasses (goosegrass, crabgrass), pigweed, and yellow nutsedge. Treatments and weed control ratings are listed in Table 1.

Acceptable nutsedge control was only achieved with halosulfuron, however this treatment also resulted in severe onion injury. Gramoxone Extra provided moderate control of nutsedge, pigweed and grass but also caused some injury, primarily as tip burn and leaf necrosis. Goal at 0.10 lbs-ai (8 oz./A) provided approximately 50% control of yellow nutsedge with minimal onion injury but gave only 30 and 37% control of pigweed and grasses, respectively. Other treatments caused minimal injury but provided little weed control.

A second experiment was conducted in Toombs county on direct seeded onions grown for transplants. Treatments were applied on 11/13/95 to onions with 4-6 leaves. The entire area was heavily infested with cutleaf evening primrose approximately 6-8 inches in diameter. There was also a moderate infestation of swinecress and yellow nutsedge however these weeds were not present in sufficient levels to perform an accurate control rating. Treatments and weed control ratings are listed in Table 2.

Several treatments showed severe injury to the onions including Broadstrike, Gramoxone Extra, MCPA, and Blazer. Lentagran provided acceptable primrose control at 5 weeks but caused severe burn to the onions. However, the onions were able to recover to some extent after 5 weeks. Goal at either rate did not cause significant injury and provided moderate control after 2 weeks, however the primrose was able to recover. It is possible that multiple low rates would be able to give primrose control without injury to the onions.

In a side note, there were several plots of soil fumigants near the test site. Of these treatments, Telone C-17 provided excellent control of the primrose. Normally this fumigant does not perform as well as methyl bromide or metam sodium as far as weed control, however, primrose may be sensitive to this particular fumigant.

Transplanted Onions

Two studies were established in Tattnall/Evans county on transplanted onions. Treatments were applied 2-3 days after transplanting as a pre-emergence type of treatment. Studies were similar to experiments performed last year to observe the effect of several compounds for onions weed control and potential for onion injury. In addition, the effect of Dual herbicide was evaluated. Treatments are listed in Tables 3 and 4 for the first and second experiments, respectively.

In the first study, no treatment caused significant injury at either observation. Unfortunately, there was not suitable weed pressure to evaluate weed control in either test. In the second study there was a great deal of variability between plant survival due to the cold weather. This is reflected in the amount of injury rated on the onions. There appeared to be significant injury from Dual at the 2.0 lb-ai rate but this was not seen in the Goal + Dual combinations. The combination of Prowl + Goal (0.5 + 0.3 lbs-ai) resulted in severe injury but this also was not observed in any of the other combinations. There also appeared to be greater injury at the later observation - probably due to the cold weather. We hope to obtain yield information from these two studies and this may provide a clearer picture of actual onion damage and/or herbicide injury.

Table 1. Postemergence weed control (primarily yellow nutsedge) in direct seeded onions 3 weeks after treatment.

Herbicide	Rate	Onion	Nutsedge	Pigweed	Grass
	lbs-ai/A	% injury	---------- % control ----------		
Basagran	0.50	7	30	8	3
Lentagran	0.45	0	10	15	10
Lentagran	0.90	3	23	30	17
Lentagran	1.80	10	30	30	20
Goal	0.05	5	30	--	28
Goal	0.10	8	50	30	37
halosulfuron[1]	0.008	95	88	90	3
halosulfuron[1]	0.016	95	92	90	7
Gramoxone Extra	0.04	25	37	30	63
Gramoxone Extra	0.08	20	40	50	47
glufosinate	0.03	7	5	7	8
glufosinate	0.06	15	10	25	13
Buctril	0.125	3	10	22	15
Buctril	0.25	13	22	18	23
untreated	-----	0	0	0	0

[1] Treatments included a non-ionic surfactant at 0.25% v/v.

Table 2. Postemergence cutleaf evening primrose control in direct seeded onions.

Herbicide	Rate	Onion		Primrose	
		2 weeks[1]	5 weeks	2 weeks	5 weeks
	lbs-ai/A	------- % injury --------		------ % control ------	
Broadstrike + Treflan	1.44	7	93	27	90
Buctril	0.38	43	15	65	57
Gramoxone Extra	0.08	82	93	45	42
Goal	0.20	15	15	63	35
Goal	0.30	15	17	63	48
Basagran	1.00	25	33	53	55
Lentagran	1.80	33	40	68	82
Lentagran	3.60	43	28	83	90
Blazer[2]	0.25	90	85	85	80
Cobra	0.20	27	40	52	37
MCPA	0.25	35	60	53	88
Stinger[2]	0.10	22	35	20	13
Stinger[2]	0.20	22	22	27	5

[1] Weeks after application.

[2] Treatments included a non-ionic surfactant at 0.25% v/v.

Table 3. Weed control and injury in transplanted onions.

Herbicide	Rate (*lbs-ai/A*)	Onion Injury (%) 2 weeks[1]	10 weeks
Goal	0.3	12	0
Prowl	0.6	5	0
Dacthol	6.0	7	2
Kerb	0.5	8	0
Goal + Prowl	0.3 + 0.6	6	0
Prefar	4.0	7	0
Prefar	6.0	8	0
Goal + Dacthol	0.3 + 3.0	6	3
Dual	1.5	6	3
Goal + Dual	0.3 + 1.5	6	3
Untreated	----	0	0

[1] Weeks after application.

Table 4. The effect of Prowl, Dual and Goal combinations for weed control and potential injury in transplanted onions.

Herbicide	Rate (*lbs-ai/A*)	Onion Injury (%) 2 weeks[1]	10 weeks
Prowl	0.5	0	12
Prowl	0.75	0	3
Dual	1.5	0	10
Dual	2.0	3	65
Goal	0.3	0	0
Goal	0.4	2	0
Goal + Prowl	0.3 + 0.5	2	70
Goal + Prowl	0.3 + 0.75	2	13
Goal + Dual	0.3 + 1.5	5	28
Goal + Dual	0.3 + 2.0	8	23
Goal + Prowl	0.4 + 0.5	0	22
Goal + Prowl	0.4 + 0.75	0	33
Goal + Dual	0.4 + 1.5	0	16
Goal + Dual	0.4 + 2.0	0	32
Untreated	----	0	0

[1] Weeks after application.

THE SHELF LIFE OF VIDALIA ONIONS FOLLOWING HARVEST

Bryan W. Maw, Research Agricultural Engineer
Stevan S. LaHue, Research Technician

Abstract

Sweet onions were harvested at one of three levels of maturity: early, optimum or late; cured at one of four durations: 24, 48, 72 or 96 h; and stored for 30 weeks under four conditions: either air conditioned at a low humidity, air conditioned at a high humidity, cold + air conditioned at a low humidity, or controlled atmosphere + cold + air conditioned at a low humidity. The loss of weight and rate of decay of onions under the different storage conditions identified the hospitality of those conditions and in order of hospitality were found to be in reverse order of the list described above.

Introduction

Sweet onions may be stored in different ways to provide onions for market windows at different times of the year. There is a fresh market window when onions may be sold directly from the field. There is an early market window for which onions may be held in a well ventilated place, protected from the rain. There is a mid-season market window for selling onions that have been kept in an air conditioned environment similar to conditions found in a dwelling house. There is a late market window for selling onions that have been stored in a cold room and, finally, a Controlled Atmosphere (C.A.) market window where onions may be sold from C.A. storage. There is no need to use a storage technique that is more expensive than required for the market window concerned.

Sweet onions may be stored entirely under one set of conditions or they may be stored under a combination of conditions. Continuing the study of curing and storage for sweet onions it was the objective for this year to explore the survivability of onions under a combination of different storage conditions, after having been harvested at different levels of maturity and cured for different durations.

Materials and Methods

Sweet onions (Granex 33) were harvested at three levels of maturity, early, optimum and late (Table 1), as indicated by the erection of the tops. They were cured at one of four depths and one of four durations (Table 2) in curing boxes as in the previous year (Maw, 1994).

Following curing, the onions by harvest and curing treatment were assigned a curing index, on a scale of 1-5 (Table 3) with 1 being an incomplete and 5 being a complete cure. Onions from each sample were graded by size (small passing through a 1.5 in. diameter mesh, medium passing through a 2.5 in. diameter mesh, large passing through a 3.5 in. diameter mesh or jumbo passing over a 3.5 in. diameter mesh).

Samples of onions from the different harvest and curing treatments were placed in 12 lb capacity sacks. These onions were then placed into one of four storage combinations for 30 weeks. These were: air conditioned (AC) with a high humidity (ACH); AC with a low humidity (ACL); cold (C) + ACL; and Controlled Atmosphere (CA) + C + ACL.

For the air conditioned environment, at a low or a high level of humidity, an insulated storage room (12 x 8 x 6.5 ft) was divided into two sections by a thin polyethylene film. In one section an 8000 BTU air conditioner was set to run at or above a temperature of 72 ^{0}F. The humidity of that section was reduced according to the capabilities of the air conditioner while lowering the temperature. This constituted AC at a low humidity (ACL). The temperature of the second section equilibrated with the temperature of the first section through the polyethylene film, but the humidity was that generated by the onions within the sealed section of the room. This constituted AC at high humidity (ACH). For cold storage, refrigeration kept the room and thus the produce at 34 ^{0}F with 70 % rh. For CA, an 8 x 8 x 8 ft room was sealed and maintained at 3 % O_2, 5 % CO_2 and 92 % N with 70 % rh.

Onions were placed in cold storage until onions from all three harvests had been cured. They were then cured, graded and sorted, leaving only good onions before being put into one of the storage conditions. The 30 week storage period began the week of June 12th (week 0). During storage, the onions were visually examined at biweekly intervals. Those going rotten were removed. The rotten ones were weighed. The remaining onions were weighed and counted. As part of each sample a subsample of onions had each onion graded and weighed at the same biweekly intervals, to examine for shrinkage

and thus a possible change in grade during storage, excluding discarded onions. These onions were individually identified with adhesive colored labels according to grade. Following examination, the remaining onions were returned for continued storage. A modification to the biweekly interval existed for those onions under CA. It was not considered practical to break the seal of the room so frequently and so onions under CA were examined at 4 weeks and at 10 weeks. Onions under CA were transferred to C during week 10. Onions under C were transferred to AC during week 16.

The temperature and humidity of the AC room sections were monitored with a Campbell Data Logger 21X throughout the duration of storage. The fluctuation of temperature and relative humidity for each section depended upon the external atmospheric conditions, the air conditioner merely modifying the room conditions as prescribed. The air conditioner was set to begin running at or above 72 ^{0}F. An air conditioner of 8000 BTU was chosen, so that by running more often than a larger capacity air conditioner the relative humidity as well as temperature would be reduced.

Results and Discussion of Results

The assigned curing indices for all onion samples from the three harvest maturities after they had been cured for four different periods at four different depths are given in Table 4. The amount of curing that benefitted the onions depended upon the maturity at harvest. Onions of the early harvest maturity were incompletely cured even after 96 h (Table 5), but with no significant difference occurring between 72 and 96 h. Onions of the optimum harvest maturity began at a higher index and still benefitted from extensive curing, 96 h being significantly different from 72 h of curing. Onions of the late harvest maturity, 48-72 h of curing was sufficient, there being no significant difference between 72 and 96 h of curing. Overall, however there was a significant difference in the curing index between onions cured for each of the curing periods and between onions of each harvest maturity.

Harvest maturity influenced the curing index of onions more so than the depth of onions in a stack (Table 6). However there was, with respect to depth of cure, a significant difference between all curing periods and between all depths, and for the overall means. The top onions received significantly less curing than those below. Nevertheless, an onion could not be cured until the drying front had passed by.

The estimated weight loss for individual onions after fifteen weeks under different storage conditions is given in Table 7. ACH caused significantly greater loss of early and optimally harvested onions, than for the other three conditions. For optimally harvested onions, ACL caused significantly greater loss than CA, with C related to ACL and CA. Then for late onions, ACH and ACL caused significantly greater loss than CA or C. Considering period of cure: at 24 h, ACH caused significantly greater loss than CA or C with ACL related to the extremes; at 48 h, ACH caused significantly greater loss than all others with ACL greater than CA and C related to ACL and CA; at 72 h, ACH caused significantly greater loss than all others; and at 96 h, ACH and ACL were significantly greater than C or CA. Considering the size of onions: for small onions, ACH caused significantly greater loss than all others and ACL greater than CA, while C was related to ACL and CA; at medium and jumbo, ACH caused significantly greater loss than C or CA, with ACL different from all others; and at large onions, ACH caused significantly greater loss than all other conditions of storage. Overall, there was a general trend of more loss to less loss from ACH -> ACL -> C -> CA. By week fifteen the weight loss under CA was 11.5 %, C was 12.8 %, ACL was 16.9 and ACH was 20.8 % The variances were lowest for CA, next for C, more for ACH and most for ACL.

The estimated rate of weight loss (% / week) at week fifteen for individual onions under different storage conditions, is given in Table 8. For early and optimally harvested onions, CA, C and ACL caused rates significantly lower than for ACH; and for late harvested onions, CA caused a rate of weight loss significantly lower than all other conditions. At 24 h of curing, there were no significant differences between conditions of storage. At 48 h, ACH was significantly higher than all others. At 72 and 96 h, ACH caused a rate of weight loss significantly higher than for CA with the other two related to each extreme under 72 h and C related to either extreme. For small onions, ACH caused a significantly higher rate of weight loss than ACL or CA, with C related to either extreme. For medium and jumbo onions there were no significant differences between storage conditions. For large onions, ACH caused a significantly higher rate of loss than the other conditions. Overall, there was a general trend of a higher rate of loss to a lower rate of loss from ACH -> ACL -> C -> CA, except for jumbo onions. The variances were lowest for CA and comparable for the other three. From observation of the onions, the rate of decay was related to the grade of the onion and increased in this order of grade: jumbo,

large, medium and small. This order is contrary to the order of decay when the number of onions is considered.

An analysis of variance, covering the percentage of onions remaining by number, is given in Table 9. There were five main effects: harvest maturity, period of cure depth of cure, storage condition and time in storage (shelf life). Of those, the most pervasive effect on storage of sweet onions was their eventual loss over time (shelf life, 87 % of the variation among the means) no matter what conditions of storage were provided. Among the four storage conditions (3 % of the variation among the means), two were more hospitable. At each storage condition, the eventual loss of good onions was different, as evidenced in figure 1. This variability accounted for another 2 % of variation among the means. The other effects, which included interactions, were significant but minor compared with the previous three. Overall, early harvested onions performed significantly better than both optimum or later harvested onions. All the storage regimes were different with CA-> C-> ACL-> ACH. The percentage of good onions by number remaining at any particular week was significantly different from the week before or week after.

In conjunction with the analysis of variance (Table 9), the change in loss of good onions is visible in Figure 1. CA and C provided a significantly more hospitable environment than ACH and ACL during weeks 2-18, with CA being significantly more hospitable than C during weeks 10-28. ACL was significantly more hospitable than ACH during weeks 6-12. After week 22, the spread between surviving onions under different storage conditions is much narrower than at earlier weeks. From the observation of individual onions in the samples the rate of decay was related to the grade of the onion and took place in order of grade: jumbo, large, medium and small.

Considering harvest maturity under various storage conditions (Figure 2), for CA the spread by harvest maturity widened after week 8 and began to narrow after week 24. The early harvested onions performed the least desirably before week 16, but after week 16 performed equally well or better than the other harvest maturities. For C, the spread increased after week 8 and narrowed after week 24. Early harvested onions performed less desirably before week 16 and then more desirably after week 16. Under ACL, the increase in spread did not occur until week 14 and narrowed before week 24. The early harvested onions were the best through week 24. Under CA or C the later harvested onions appeared to do better but after being transferred to AC (less hospitable environment) they began to perform more poorly. Later harvested onions benefitted from a more hospitable environment.

Under general observations, cold storage onions became discolored from the shoulder towards the base. This discoloration went through to the second layer. This discoloration was not present in CA onions of the same age. Cold storage onions shrivelled on the surface to give a wrinkled appearance. It is acknowledged that onions can certainly go into storage without having been cured, curing however will then take place in storage as the outer skin is dried by dehumidified air. It is a matter of choice as to where curing is required to take place. It is quicker and less expensive to cure using natural sunshine or heated air in curing bins than by using dehumidified air in AC, C or CA storage. While in storage sprouting of the onions began after week 10 and in earnest by week 14, the larger onions beginning first. The first ones to sprout seemed to be multiple centers.

For over mature onions (later harvested) and for onions subjected to a high incidence of disease, curing appeared to enhance the development of disease in onions where it had been present, to the extent of the effects of the disease becoming visibly evident within the onion bulb. For example, in 1995 an estimated 15 % of the individual onions were culled between harvest and the beginning of storage. Thus, for over mature onions, curing may be used as part of a screening technique to help cull onions that may contain disease, thus preventing them from going to market.

Conclusions

* Sweet onions were harvested at one of three levels of maturity, cured at one of four depths and at one of four periods and then stored under one of four conditions. The interactions amongst the effects are discussed.

* The amount of curing that benefitted the onions depended upon the harvest maturity with 96 h being insufficient for early harvested onions and 48-72 h being sufficient for late harvested onions.

* Onions on top of the stack received significantly less curing than those below, when heated air was passed from bottom to top of the stack.

* As described by the weight loss at 15 weeks of storage and the rate of weight loss in storage, the storage conditions in order of hospitality were controlled atmosphere, cold, air conditioned low humidity and air conditioned high humidity. The extent to which differences were significant depended upon the harvest maturity and period of cure.

* The most pervasive effect of onion storage was their eventual deterioration regardless of the storage conditions. Although controlled atmosphere and cold storage regimes initially retarded the loss of good onions even with these regimes, eventual loss was inevitable. Later harvested onions seemed to do better in these two storage regimes early in the storage period. Early harvested onions seemed to do better in the other two storage regimes: air conditioned with either low or high humidity.

Acknowledgement

The authors wish to recognize Mr. Ben. Mullinix for assistance with the statistical analysis and Dr. Don Sumner and Ron Gitaitis for the availability of onions.

Reference

Maw, B.W. 1995. The shelf life of Vidalia onions following harvest. 1994 Onion Research-Extension Report, Cooperative Research-Extension Publication No. 3-95.

Table 1. Harvest dates and maturity of the onions at harvest in 1995.

Harvest	Date	Condition
early	4/20/95	0% tops down, hard necks
optimum	5/09/95	7% tops down
late	5/23/95	100% tops down

Table 2. A description of all the treatment variables.

Harvest maturities	Depth of cure (ft)	Length of cure (h)	Storage
early	0-1 ft	24	Air conditioned high humidity
optimum	1-2 ft	48	Air conditioned low humidity
late	2-3 ft	72	Cold
	3-4 ft	96	Controlled Atmosphere

Table 3. Curing indices assigned to samples of onion bulbs.

Cure Index	Description
1	- Neck un dried
1 1/2	- Neck internally un dried, outer scales of the neck dry
2	- Neck beginning to internally dry
2 1/2	- " , bulb skins crisp
3	- Neck internally dry to 1/2 in. from bulb except for moisture escaping
3 1/2	- " " with no moisture escaping
4	- Neck internally dry to 1/4 in. from bulb
4 1/2	- Neck will easily bend and flatten onto the bulb, not completely lifeless
5	- Neck will easily bend and flatten on the bulb, is completely lifeless

Table 4. Curing Indices as assigned to samples of onions from each treatment combination in 1995.

Harvest Maturity	Date	Period of cure (h)	Depth 1B	2	3	4T
early	04/20/95	24	2.5	2.5	2.0	1.75
		48	3.25	3.0	2.5	2.5
		72	4.0	3.75	3.75	3.25
		96	4.0	4.0	3.75	3.25
optimum	05/09/95	24	4.0	3.5	3.25	3.0
		48	4.25	4.0	3.5	3.5
		72	4.25	4.0	4.0	3.75
		96	4.5	4.25	4.25	4.25
late	05/23/95	24	4.5	4.0	3.5	3.5
		48	5.0	4.5	4.5	4.25
		72	5.0	5.0	5.0	4.5
		96	5.0	5.0	5.0	5.0

Table 5. Curing indices for onions with respect to harvest maturity and period of cure in 1995.

Harvest Maturity	Period of Cure (h) 24	48	72	96	Mean (LSD=0.103)
early	2.19 aA	2.81 bA	3.69 cA	3.75 cA	3.11 A
optimum	3.44 aB	3.81 bB	4.00 bB	4.31 cB	3.89 B
late	3.88 aC	4.56 bC	4.87 cC	5.00 cC	4.58 C
Means (LSD= 0.119)	3.17 e	3.73 f	4.19 g	4.35 h	

For internal numbers: LSD = 0.205 (not significant, vertically and horizontally).
Values with different letters (a, b, c) in each row are significantly different at P=0.05.
Values with different letters (A, B, C) in each column, are significantly different at P=0.05, within a treatment variable.

Table 6. Curing Indices for onions with respect to period of cure and depth of cure in 1995.

Depth of Cure (ft)	Period of Cure (h) 24	48	72	96	Mean (LSD=0.119)
1 Bottom	3.67 aC	4.17 bC	4.42 cB	4.50 cB	4.19 D
2 Middle	3.33 aB	3.83 bB	4.25 cB	4.42 cAB	3.96 C
3 Middle	2.92 aA	3.50 bA	4.25 cB	4.33 cAB	3.75 B
4 Top	2.75 aA	3.42 bA	3.83 cA	4.17 dA	3.54 A
Means (LSD= 0.119)	3.17 e	3.73 f	4.19 g	4.35 h	

For internal numbers: LSD = 0.237 (not significant, vertically and horizontally)
Values with different letters (a, b, c) in each row are significantly different at P=0.05.
Values with different letters (A, B, C) in each column, are significantly different at P=0.05, within a treatment variable.

Table 7. Estimated weight loss (%) for onions after fifteen weeks under different storage conditions in 1995.

Treatment Variable	ACH	ACL	C+ACL	CA+C +ACL	Weighted Mean	LSD
Harvest Maturity						
early	19.4 bA	14.3 aA	12.3 aAB	13.0 aB	14.7	4.1
optimum	19.3 cA	14.4 bA	11.0 abA	10.1 aA	13.7	3.7
late	23.6 bA	21.9 bB	15.1 aB	11.8 aBA	17.9	3.8
LSD	4.4	4.9	3.7	2.1		
Curing Period (h)						
24	19.1 bA	15.0 abA	13.3 aA	10.8 aA	14.5	4.5
48	21.7 cA	16.5 bA	11.9 abA	10.6 aA	15.1	4.5
72	23.0 bA	15.9 aA	14.2 aA	12.9 aA	16.4	4.5
96	19.7 bA	19.7 bA	11.8 aA	11.6 aA	15.7	4.3
LSD	5.1	5.6	4.2	2.4		
Size						
Small	23.7 cB	18.4 bA	16.4 abB	13.4 aB	17.9	4.2
Medium	19.3 bAB	18.6 bA	12.9 aAB	11.7 aA	15.6	4.1
Large	21.6 bAB	14.0 aA	10.9 aA	9.9 aA	14.0	4.2
Jumbo	16.9 bA	16.4 bA	9.5 aA	10.6 aA	13.2	5.5
LSD	5.3	5.8	4.3	2.4		

Values with different letters (a, b, c) in each row are significantly different at P=0.05.
Values with different letters (A, B, C) in each column, are significantly different at P=0.05, within a treatment variable.
ACL Air Conditioned at low humidity.
ACH Air Conditioned at high humidity.
C Cold.
CA Controlled Atmosphere.

Table 8. Estimated rate of weight loss (%) for onions under different storage conditions in 1995.

Treatment Variable	ACH	ACL	C+ACL	CA+C +ACL	Weighted Mean	Weighted LSD
Harvest Maturity						
early	1.32 bA	0.91 aA	0.89 aA	0.86 aA	0.99	0.37
optimum	1.40 bA	1.04 aA	0.89 aA	0.88 aA	1.05	0.33
late	1.63 bA	1.50 bB	1.43 bB	0.97 aA	1.37	0.35
LSD	0.37	0.37	0.42	0.16		
Curing Period (h)						
24	1.31 aA	0.90 aA	0.93 aA	0.91 aA	1.01	0.41
48	1.63 bA	1.20 aA	1.07 aA	0.88 aA	1.19	0.42
72	1.51 bA	1.19 abA	1.26 abA	0.93 aA	1.22	0.41
96	1.39 bA	1.31 bA	1.05 abA	0.89 aA	1.16	0.40
LSD	0.43	0.42	0.48	0.18		
Size						
Small	1.71 bB	1.22 aA	1.42 abB	1.12 aB	1.37	0.37
Medium	1.30 aAB	1.26 aA	1.06 aAB	0.91 aA	1.13	0.37
Large	1.55 bB	1.02 aA	0.95 aAB	0.75 aA	1.06	0.39
Jumbo	1.10 aA	1.11 aA	0.72 aA	0.78 aA	0.92	0.49
LSD	0.44	0.44	0.50	0.19		

Values with different letters (a, b, c) in each row are significantly different at P=0.05.
Values with different letters (A, B, C) in each column, are significantly different at P=0.05, within a treatment variable.
ACL Air Conditioned at low humidity.
ACH Air Conditioned at high humidity.
C Cold.
CA Controlled Atmosphere.

Table 9. Analysis of variance on the percentage of good onions by number in 1995.

Source of Variation	Degrees of Freedom	Mean Square	F.Test[a]		Error[b] df	Error[b] ms	Explained[c] %
Harvest	2	6,752	6.2		18	1109	
Period	3	284	0.3	ns	18	1109	
Depth	3	677	0.9	ns	18	1109	
Storage	3	36,139	794.7		810	45	3
Shelf Life	15	219,945	4836.7		810	45	87
Storage x Harvest	6	2108	46.4		810	45	2
Storage x Period	9	306	6.7		810	45	
Storage x Depth	9	359	7.9		810	45	
Storage x Shelf Life	45	1783	39.2		810	45	
Shelf Life x Harvest	30	473	10.4		810	45	
Shelf Life x Period	45	58	1.3	ns	810	45	
Shelf Life x Depth	45	68	1.5	[d]	810	45	
Stor x Period x Depth	27	472	10.4		810	45	
Stor x har x period	18	714	15.7		810	45	
Stor x har x depth	18	584	12.8		810	45	
Har x Period x Depth x Stor	54	419	9.2		810	45	
Other Interactions	1929	102	2.2		810	45	

[a]All F-tests show significance at 1% (P=0.01) except for those marked ns, non-significant, or [d] (P=0.05).
[b]Error df and ms are appropriate terms used from ANOVA.
[c]Percentage of the total variation among the means.

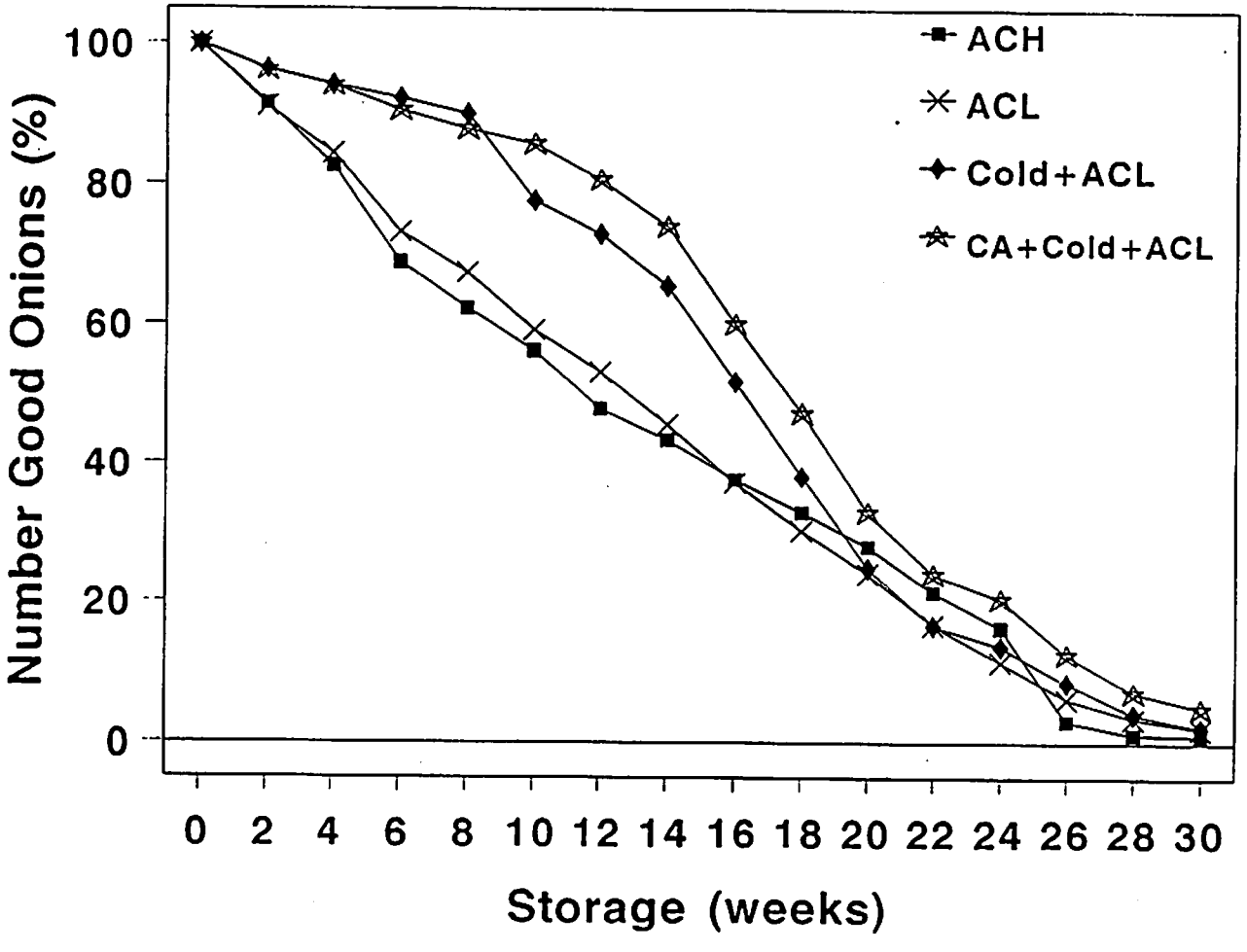
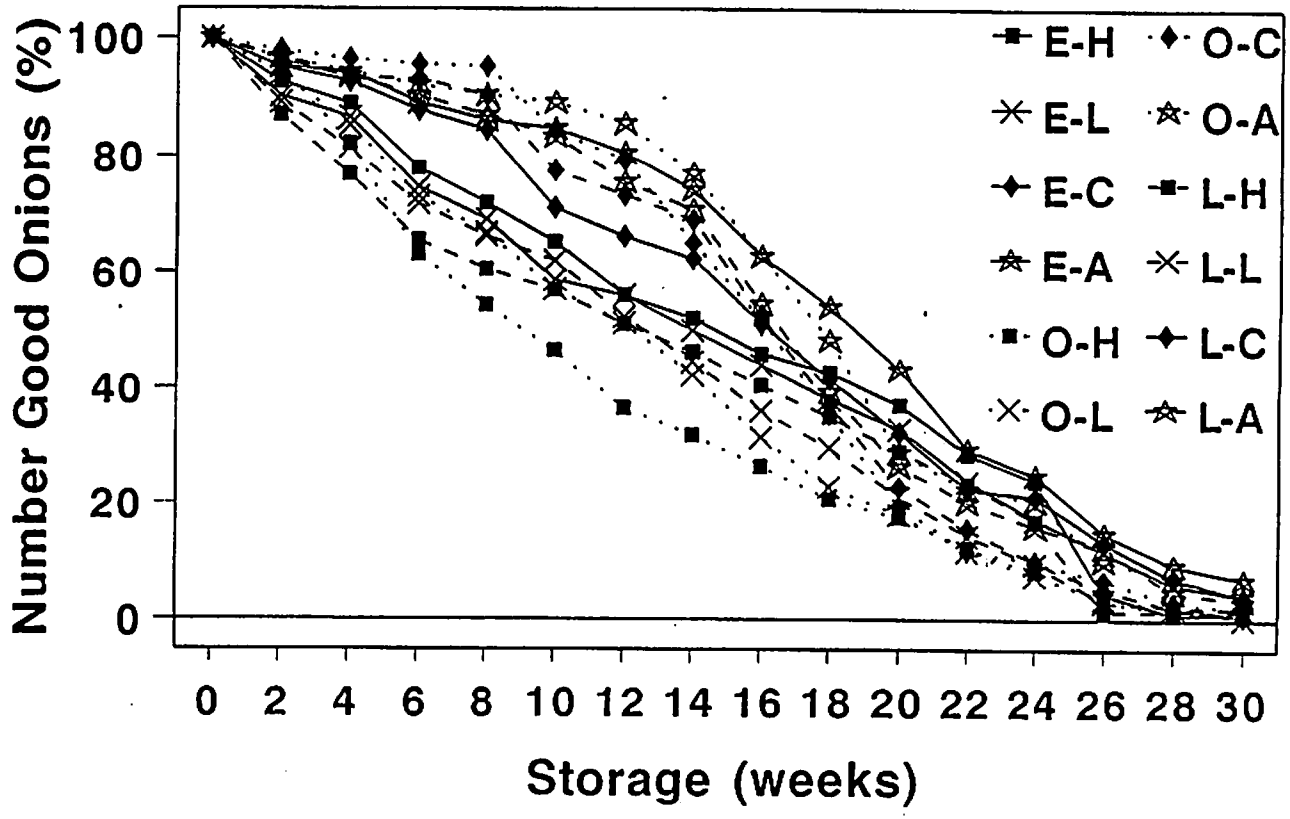


Figure 1. Available good onions as a percentage of the original number in the sample, over all harvests, depths of cure and curing periods as influenced by different conditions of storage.



Harvest Maturities: E=Early, O=Optimum, L=Late
Storage Regimes: H=ACH, L=ACL, C=Cold+ACL, A=CA+Cold+ACL

Figure 2. Available good onions as a percentage of the original number in the sample, over all depths of cure and curing periods as influenced by harvest maturity and different conditions of storage.

1995 ONION STORAGE STUDIES

Albert C. Purvis, Research Horticulturalist

"It was the best of times; it was the worst of times", the words of Charles Dickens in his classic, A Tale of Two Cities, describes 1995. It was the best of times when the Vidalia Onion Research Laboratory was constructed at the Coastal Plain Experiment Station and the first experiments were initiated in May 1995. It was the worst of times when an arsonist set fire to the laboratory on the morning of August 21, 1995. Fortunately, the building sustained only minor damage, other than smoke damage, and we were able to salvage most of the experiments in progress, albeit after a much shorter storage period than we had planned.

The major experiments conducted the first year compared onions grown on four different farms (i.e. different cultural practices and/or varieties) and eight different storage atmospheres on the subsequent shelf life. The shelf life of onions that had been physically abused during harvesting and handling was compared with the shelf life of sound onions from the same farm. The shelf life of medium onions was compared with the shelf life of large onions from the same farm. In addition to shelf life, pungency and soluble solids were also determined.

Materials and Methods

Onions which had been harvested, cured, graded and bagged in 25-pound bags were taken from the packing sheds and transported directly to Tifton. The onions were stored at 34°F (1°C) and 75% relative humidity until all of the onions had been obtained. The bags were then labelled, weighed and randomly placed in the CA cells in which the temperature and relative humidity had been established at 34°F (1°C) and 75%, respectively. The hatch doors were sealed with petroleum jelly and atmospheres were established by flushing the sealed cells with nitrogen gas. The atmospheres were: 0% CO_2 + 21% O_2 (air), 0% CO_2 + 1% O_2, 0% CO_2 + 3% O_2, 5% CO_2 + 3% O_2, 5% CO_2 + 21% O_2, 10% CO_2 + 1% O_2, 10% CO_2 + 3% O_2, and 10% CO_2 + 21% O_2. Temperature, relative humidity, and CO_2 and O_2 concentrations of each cell was determined hourly and corrected as necessary. After the fire on August 21, 1995, the onions were removed to a 60°F (15°C) storage room and shelf life determinations were made at weekly intervals. Samples for pungency and soluble solids determinations were stored at 34°F (1°C) until determinations were made.

Results

Effects of cultural and handling practices on storability and shelf life

Onions from farm A stored better in all atmospheres than onions from the other farms. Onions which had been physically abused during harvesting, curing and grading (farm C-X) did not store as well as sound onions from the same farm (farm C). Both medium (D-Md) and large (D-Lg) onions from farm D had a shorter shelf life than onions from other farms. Some of the differences observed in shelf life may be attributed to variety as well as to cultural practices since the onions were not of all one variety. Onions from farm D were grown primarily for immediate marketing, whereas those from farms A and C were grown for both immediate marketing and CA storage.

Effects of atmosphere on storability of onions

Storage atmosphere greatly influenced the shelf life during 3 months of storage. Onions stored in air (21% O_2 + 0% CO_2) had a shorter shelf life than those stored in either 3% or 1% O_2. Increasing the CO_2 to 5% or 10% did not improve storability in air and in fact, 5% and 10% CO_2 in air was more detrimental than air alone. Onions stored in air with 10% CO_2 developed several brown rings during storage. There was very little difference in the shelf life of onions stored in 3% and 1% O_2. The high CO_2 injury observed in air storage appeared to be somewhat mitigated by low O_2 concentrations.

Effects of cultural and handling practices and storage atmosphere on onion quality

All onions had low pungency when placed in storage and with the exception of farm B, all had about the same level of pungency. Pungency increased in all storage regimes. Pungency of onions from farm B and the medium onions from farm D generally increased less than in those from other farms. The increase in pungency was generally less in onions that were stored in the highest CO_2 concentrations.

Storage had little effect on the soluble solids. The small increase in soluble solids observed may result from a concentrating effect due to moisture loss

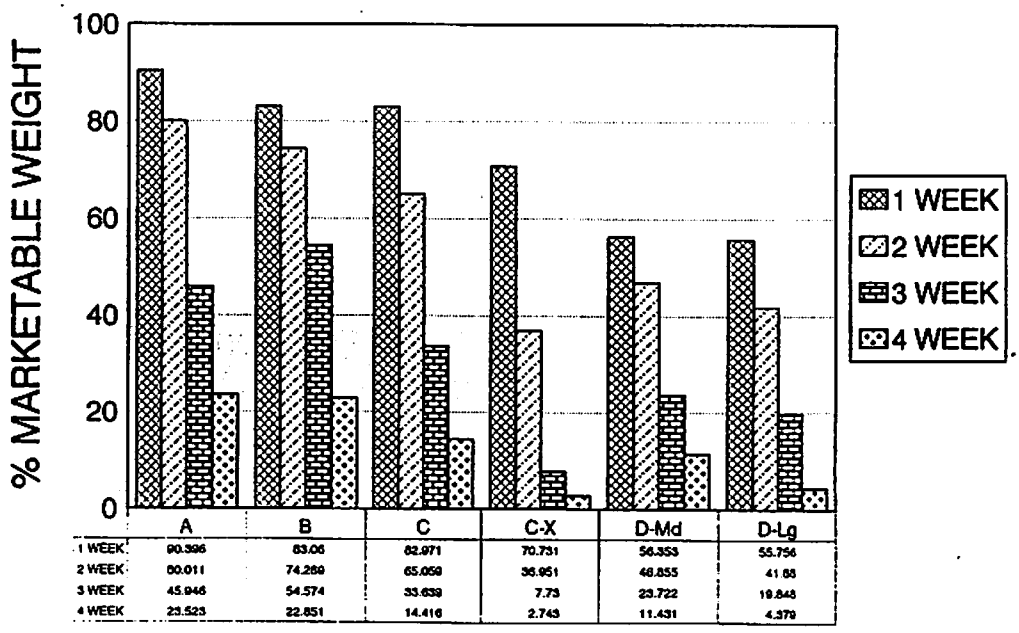
during storage. No pattern of atmosphere effect on soluble solids was obvious.

Conclusions

Although there were some striking differences among storage treatments, the results should be viewed with caution since the experiments were not replicated and adverse conditions prevailed when the experiments were terminated. Storage atmosphere appeared to have an effect on the shelf life of onions after they are removed from storage. Lowering the O_2 concentration in the atmosphere seemed to be more important than increasing the CO_2 concentration. In fact, increasing the CO_2 without lowering the O_2 concentration was more detrimental than storage in air alone. The experiments were not of sufficient length to assess the effects of atmospheres on maintenance of dormancy i.e., inhibition of sprouting. Most of the decrease in shelf life was due to softening of the bulbs, especially in the area around the neck, and some of the differences seen among the farms may have been due to the maturity of the onions at harvest, on how closely the tops were clipped and on the effectiveness of the field curing operation. None of these were evaluated in the present experiment.

Nevertheless, the results suggest that cultural practices greatly impact the storability and shelf life of onions and that onions destined for storage and later marketing may have to be grown and harvested and handled differently from those which are to be marketed immediately after harvest.

ONION SHELF LIFE AFTER CONTROLLED ATMOSPHERE STORAGE



	A	B	C	C-X	D-Md	D-Lg
1 WEEK	90.396	83.06	82.971	70.731	56.353	55.756
2 WEEK	80.011	74.289	65.059	36.951	46.855	41.65
3 WEEK	45.946	54.574	33.639	7.73	23.722	19.848
4 WEEK	23.523	22.851	14.416	2.743	11.431	4.379

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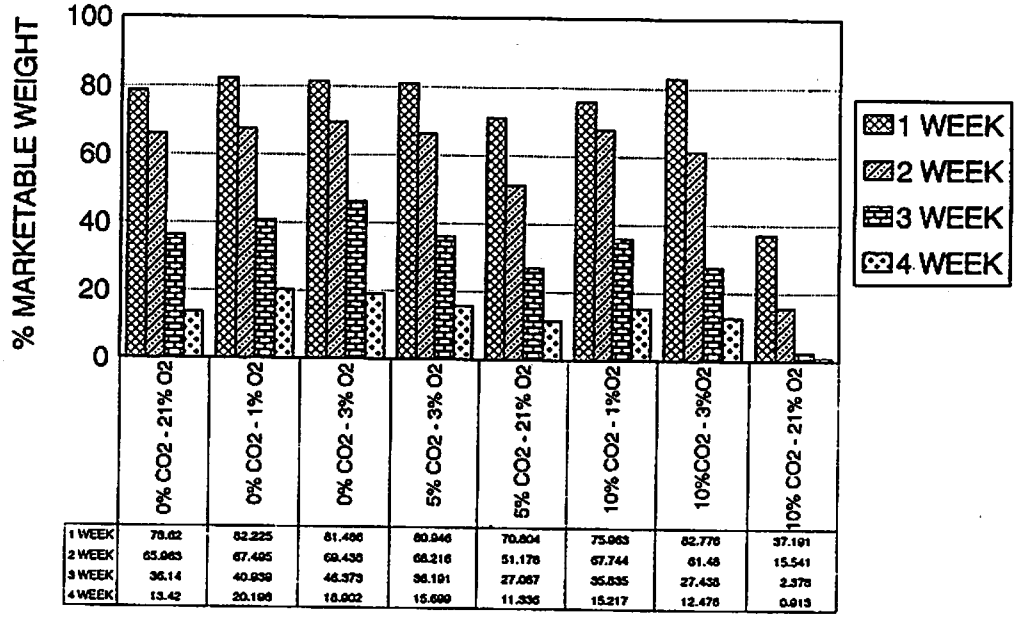
ONION SHELF LIFE AFTER CONTROLLED ATMOSPHERE STORAGE



	0% CO2 - 21% O2	0% CO2 - 1% O2	0% CO2 - 3% O2	5% CO2 - 3% O2	5% CO2 - 21% O2	10% CO2 - 1%O2	10%CO2 - 3%O2	10% CO2 - 21% O2
1 WEEK	78.02	82.225	81.486	80.946	70.804	75.963	82.776	37.191
2 WEEK	65.963	67.495	69.436	66.216	51.176	67.744	61.48	15.541
3 WEEK	36.14	40.939	46.379	36.191	27.057	35.835	27.436	2.376
4 WEEK	13.42	20.196	18.902	15.699	11.336	15.217	12.476	0.913

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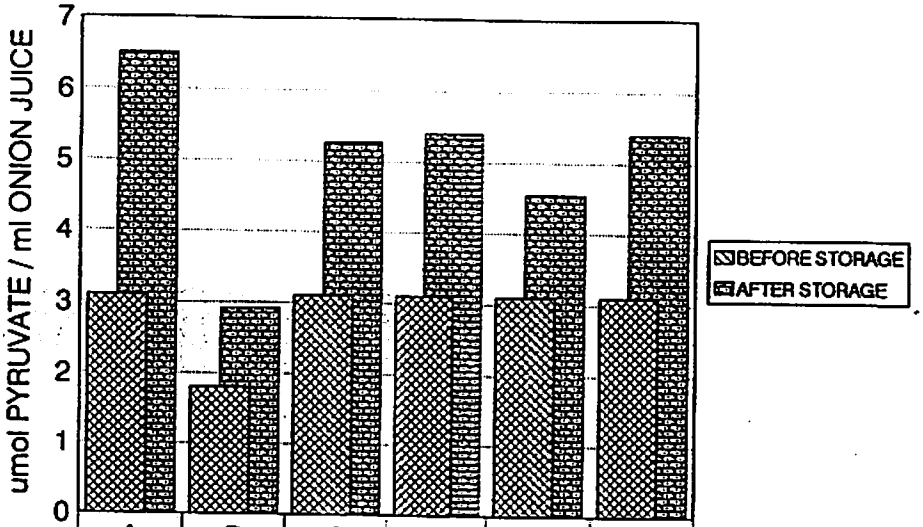
ONION PUNGENCY BEFORE AND AFTER CONTROLLED ATMOSPHERE STORAGE

0% CO2 -21% O2 (AIR)

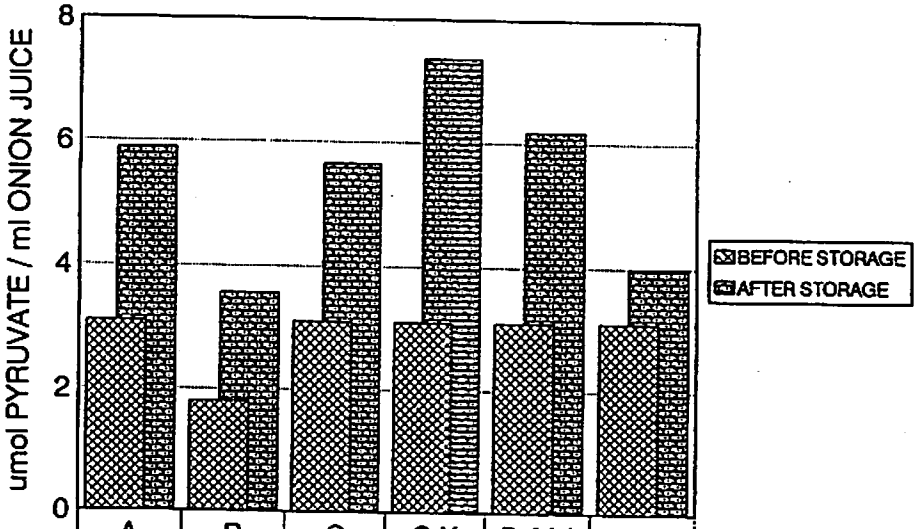


	A	B	C	C-X	D-Md	D-Lg
BEFORE STORAGE	3.1	1.8	3.1	3.1	3.1	3.1
AFTER STORAGE	6.51	2.91	5.265	5.4	4.55	5.4

ca95rptc

ONION PUNGENCY BEFORE AND AFTER CONTROLLED ATMOSPHERE STORAGE

5% CO2 - 3% O2

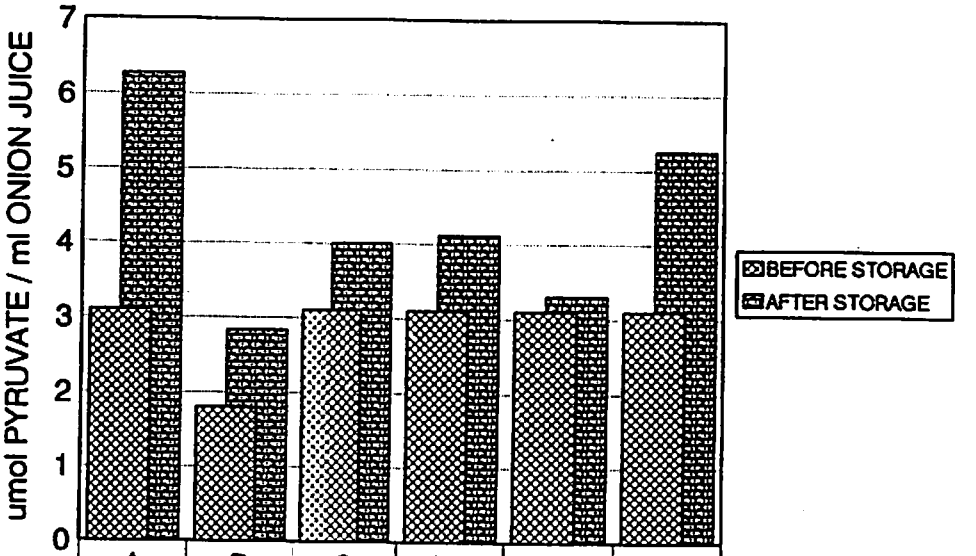


	A	B	C	C-X	D-Md	D-Lg
BEFORE STORAGE	3.1	1.8	3.1	3.1	3.1	3.1
AFTER STORAGE	5.89	3.56	5.65	7.365	6.175	4

ca95rptg

ONION PUNGENCY BEFORE AND AFTER CONTROLLED ATMOSPHERE STORAGE

10% CO2 - 21% O2



	A	B	C	C-X	D-Md	D-Lg
BEFORE STORAGE	3.1	1.8	3.1	3.1	3.1	3.1
AFTER STORAGE	6.27	2.835	4.005	4.115	3.305	5.25

ca95rptf

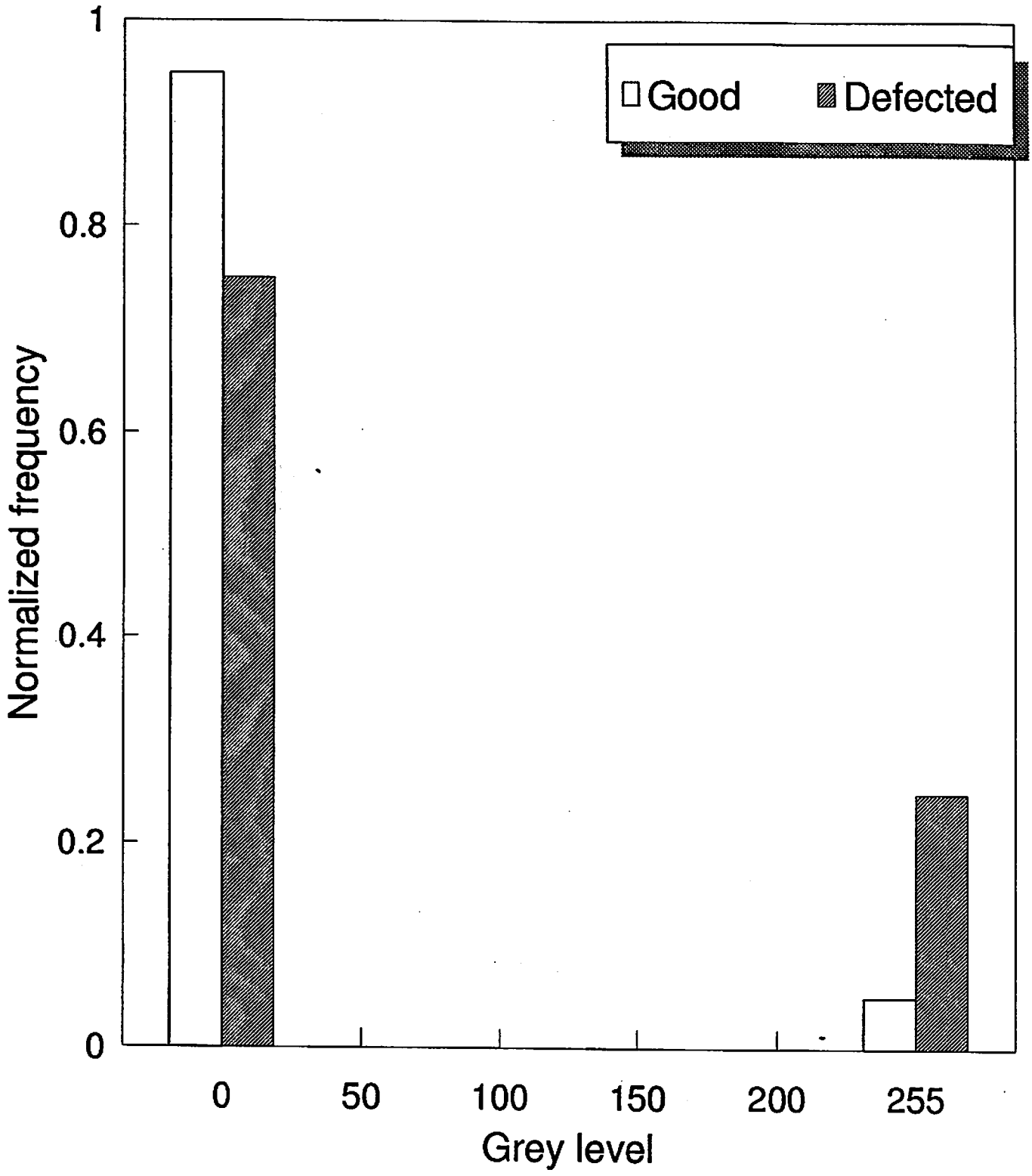
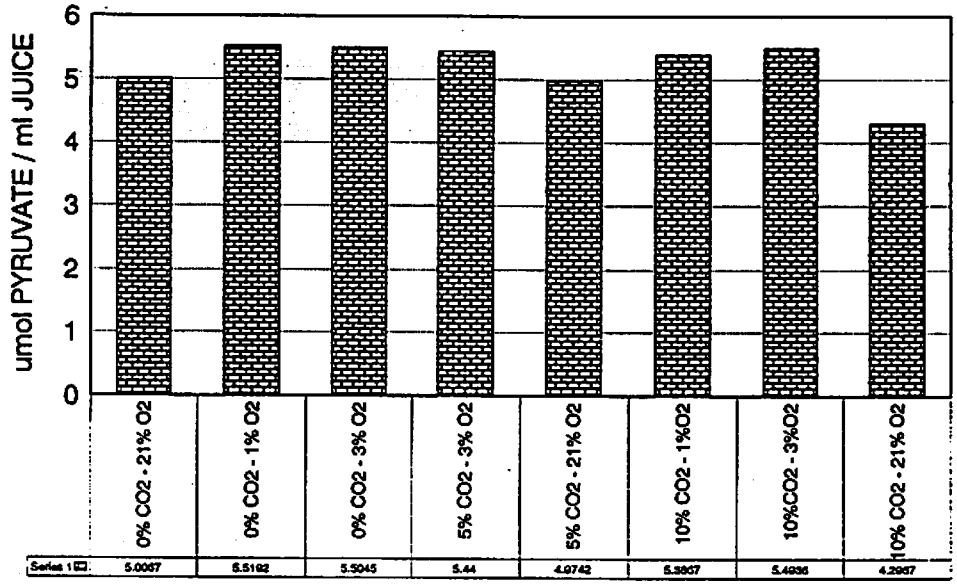


Figure 2: Histograms of good and bad onions.

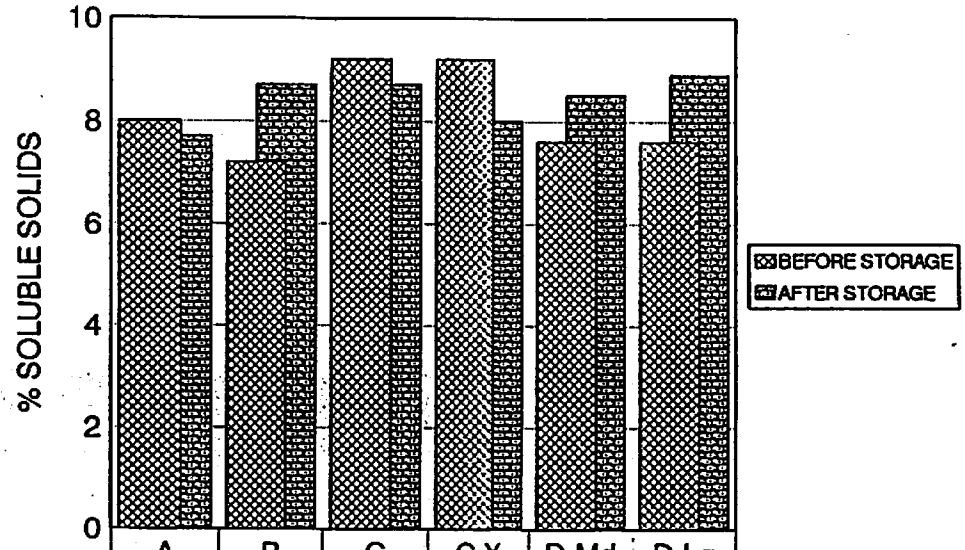
ONION PUNGENCY AFTER CONTROLLED ATMOSPHERE STORAGE



1995

ONION % SOLUBLE SOLIDS BEFORE AND AFTER CONTROLLED ATMOSPHERE STORAGE

0% CO2 - 21% O2

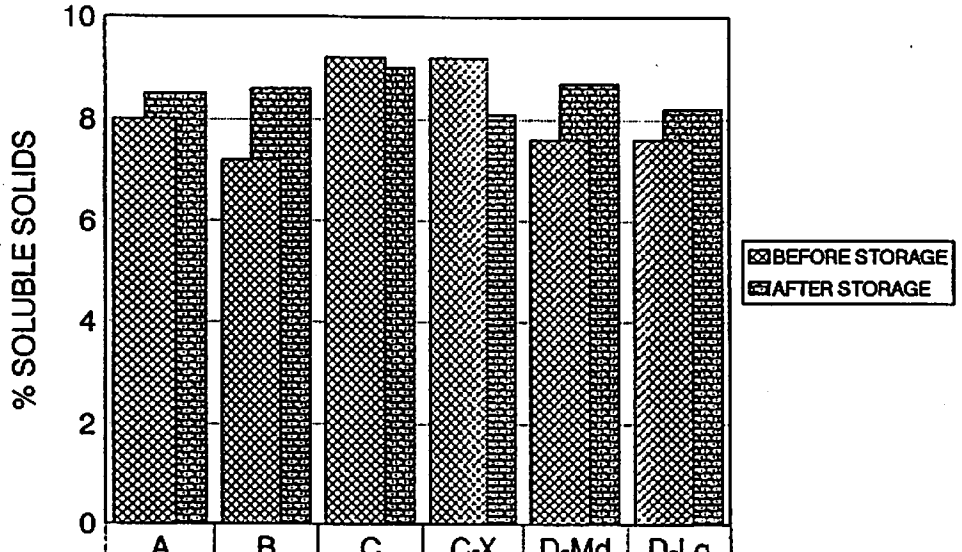


	A	B	C	C-X	D-Md	D-Lg
BEFORE STORAGE	8	7.2	9.2	9.2	7.6	7.6
AFTER STORAGE	7.7	8.7	8.7	8	8.5	8.9

ca95rpc

ONION % SOLUBLE SOLIDS BEFORE AND AFTER CONTROLLED ATMOSPHERE STORAGE

5% CO2 - 3% O2



	A	B	C	C-X	D-Md	D-Lg
BEFORE STORAGE	8	7.2	9.2	9.2	7.6	7.6
AFTER STORAGE	8.5	8.6	9	8.1	8.7	8.2

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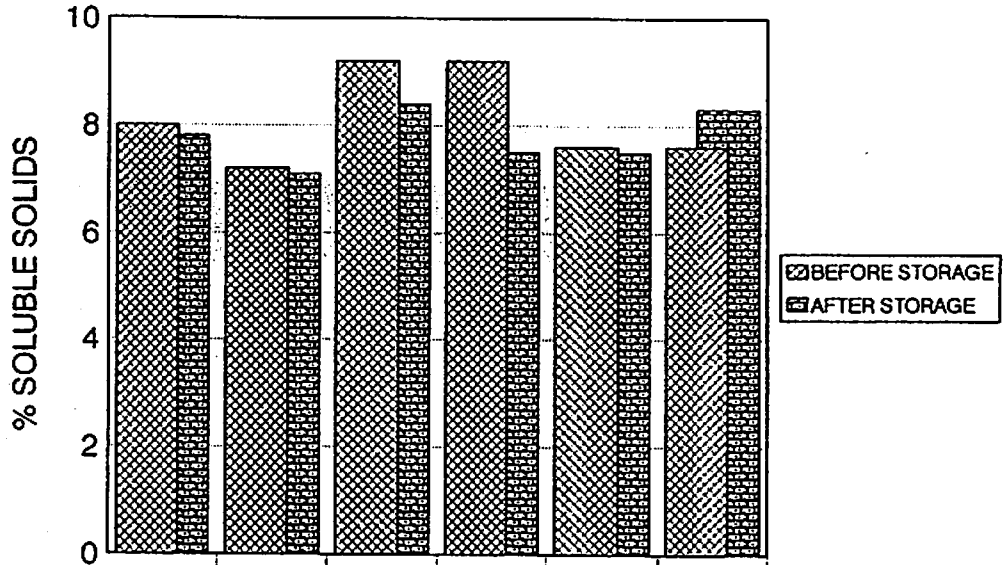
ONION % SOLUBLE SOLIDS BEFORE AND AFTER CONTROLLED ATMOSPHERE STORAGE

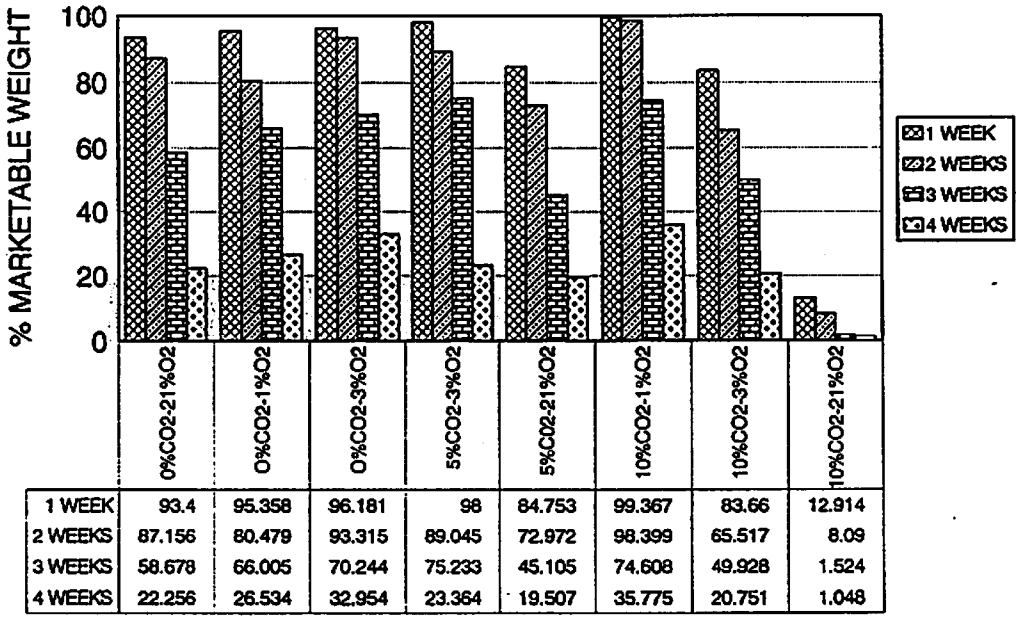
10% CO2 - 21% O2



	A	B	C	C-X	D-Md	D-Lg
BEFORE STORAGE	8	7.2	9.2	9.2	7.6	7.6
AFTER STORAGE	7.8	7.1	8.4	7.5	7.5	8.3

ca95rpf

ONION SHELF LIFE AFTER CONTROLLED ATMOSPHERE STORAGE



	0%CO2-21%O2	0%CO2-1%O2	0%CO2-3%O2	5%CO2-3%O2	5%CO2-21%O2	10%CO2-1%O2	10%CO2-3%O2	10%CO2-21%O2
1 WEEK	93.4	95.358	96.181	98	84.753	99.367	83.66	12.914
2 WEEKS	87.156	80.479	93.315	89.045	72.972	98.399	65.517	8.09
3 WEEKS	58.678	66.005	70.244	75.233	45.105	74.608	49.928	1.524
4 WEEKS	22.256	26.534	32.954	23.364	19.507	35.775	20.751	1.048

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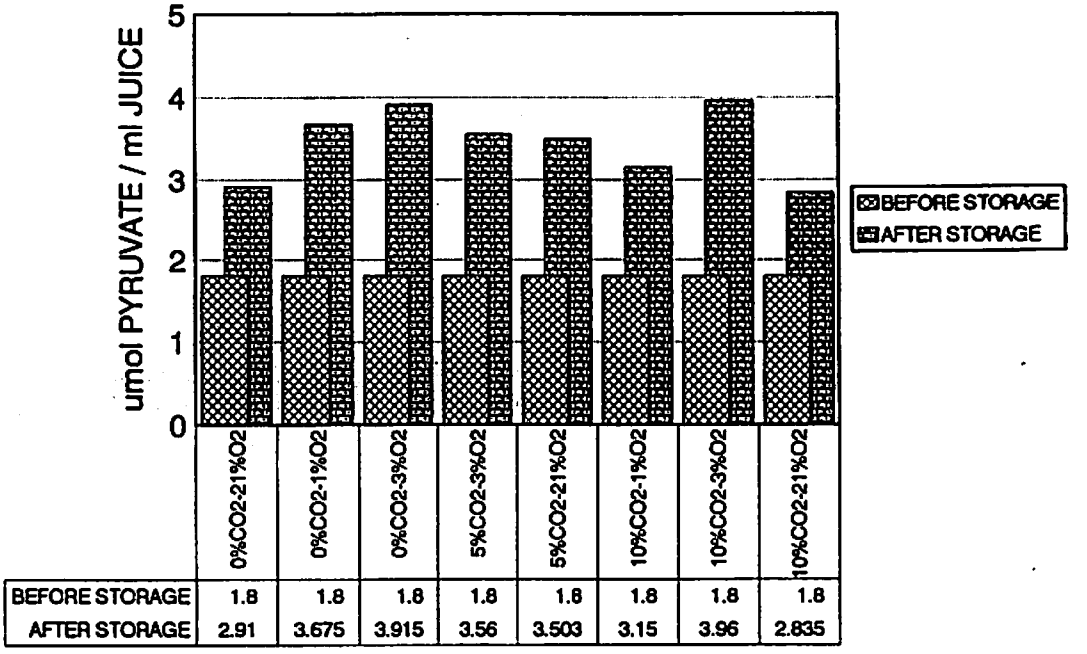
ONION PUNGENCY BEFORE AND AFTER CONTROLLED ATMOSPHERE STORAGE



	0%CO2-21%O2	0%CO2-1%O2	0%CO2-3%O2	5%CO2-3%O2	5%CO2-21%O2	10%CO2-1%O2	10%CO2-3%O2	10%CO2-21%O2
BEFORE STORAGE	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
AFTER STORAGE	2.91	3.675	3.915	3.56	3.503	3.15	3.96	2.835

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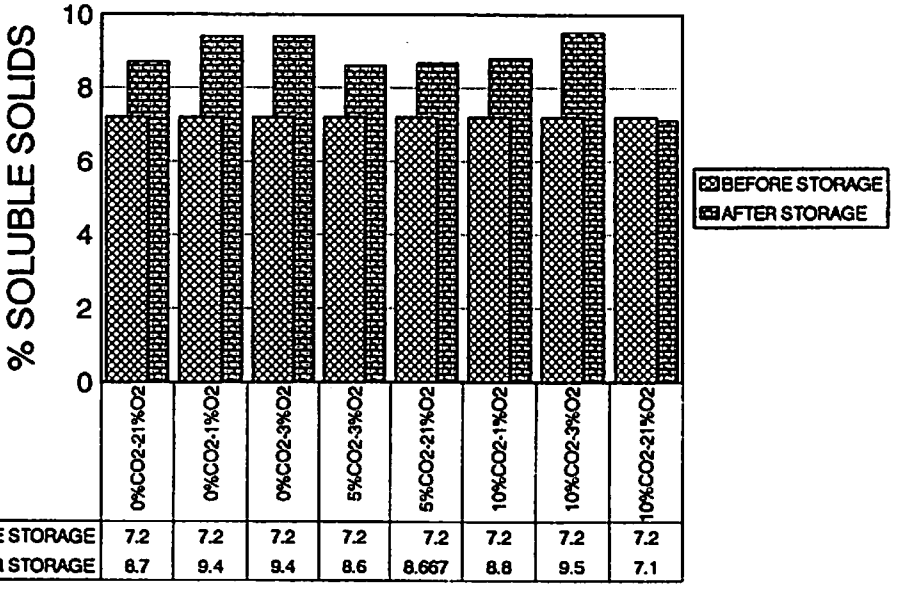
ONION % SOLUBLE SOLIDS BEFORE AND AFTER CONTROLLED ATMOSPHERE STORAGE



	0%CO2-21%O2	0%CO2-1%O2	0%CO2-3%O2	5%CO2-3%O2	5%CO2-21%O2	10%CO2-1%O2	10%CO2-3%O2	10%CO2-21%O2
BEFORE STORAGE	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2
AFTER STORAGE	8.7	9.4	9.4	8.6	8.667	8.8	9.5	7.1

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THE RELATIONSHIP OF THE PUNGENCY AND CONCENTRATION OF FLAVOR CHEMICALS OF GROWING ONIONS TO HARVESTED ONIONS

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Abstract

Research was performed on seven different onion fields with the intent of being able to determine the pungency of the onions when they are harvested well in advance of harvest. In this work the two main factors which were measured are the onion pungency (concentration of pyruvic acid) and the concentration of the lachrymatory factor (LF) in onions. The LF is the chemical in onions which makes your eyes water. It was found that both the pungency and the LF levels of the onions varied greatly during the 16 week study. It was found that the final pungency was within one standard deviation of the average pungency for six of seven onion fields studied. It was also found that there was a linear correlation between the average LF produced and the final pungency. Finally, it was found that a linear correlation was found between the final pungency and the highest level of the LF produced.

Introduction

Recommendations have already been set forth by the University of Georgia Cooperative Extension Service for the amount of sulfur to be applied to fields. However, due to variations in rainfall and the exact location of sulfur application relative to the onion plant, the amount of sulfur absorbed by the onion can vary considerably. Growers then tend to err on the high side to ensure a large onion. This however results in a hotter onion and consumer complaints. If it can be determined early that onions have sufficient sulfur, then growers will realize that more sulfur is not needed.

The reactions involved in the production of flavor chemicals are rather involved. However, they can be simplified. When an onion is cut or crushed the flavor precursors are converted into flavor chemicals. These flavor chemicals include pyruvic acid, the LF and various thiosulfinates. This reaction can be simplified to: Flavor Precursors ---> Pyruvic acid + LF + thiosulfinates Pyruvic acid has been the most studied flavor chemical thus far. This study focused on the LF and the pyruvic acid. Generally the concentrations of the thiosulfinates is much lower than that of the LF and the pyruvic acid. It is believed that the thiosulfinates do have a significant effect on onion flavor even with a very low concentration but they are harder to analyze.

Materials

Onion samples were obtained from local onion growers and were grown under standard field conditions. HPLC grade methylene chloride was obtained from Fisher Scientific and was used as received. All other chemicals were obtained from Aldrich Chemical Company and were of reagent grade or superior. No further purification was performed on these chemicals.

Equipment

An onion crusher was constructed by a local machine shop. This crusher contained a cylinder into which the sample was placed. A piston was then pushed down upon the sample using a manual lever. Screens were placed in the bottom of the cylinder to separate the onion solids from the juice. The juice was directed out of the cylinder with a slot in the bottom of the cylinder into a waiting beaker.

A Hewlett-Packard 5890 Series II Gas Chromatograph was employed with a cold on-column injection port, a 5 m x 0.54 mm i.d. OV-1 column, and 99.999% He carrier gas at 1.0 PSI. The GC oven temperature was set isothermal at 60 °C for 1 min and then increased at 5 °C/min to 200°C. The carrier gas flow rate was 8.5 mL/min. The injector temperature was maintained at 3 °C greater than the oven temperature (oven tracking). The detector was a flame ionization detector (FID) maintained at a temperature of 250 °C.

Procedure

An onion sample consisting of several onion bulbs or wedges is placed in the crusher. The sample is then crushed and the juice collected in a beaker. Time is then allowed for the *alliinase* to react with the flavor precursors. 5 mL of juice is then extracted a single time with 4 mL of methylene chloride and 1 mL of 0.0100% (v/v) *p*-cymene in methylene chloride. The extract is then centrifuged and the lower organic layer is concentrated by blowing it down to approximately 0.5 mL with compressed air. The concentrated sample is immediately placed in an ice bath and a 1.0 μL sample is injected onto the GC within an hour. The crusher was thoroughly cleaned between each sample to prevent contamination.

Onion pungency of the same samples was determined by the modified method of Schwimmer using a microwave oven to heat the sample and inactivate the enzyme. Using a 600 W microwave oven it was found that 1.5 s of heating per gram of onion gave the lowest pyruvate background.

Results and Discussion

The pungency of the onions throughout the growing season is given in Table 1. It was found that there were wide variations in the pungency of the onions throughout the growing season. These variations are believed to be due to fertilizer application, rain and experimental error. It was found that the final pungency was related to the average pungency of the onions throughout the growing season. One is unable to determine the final pungency by taking an individual sample early in the growing season due to variations in results. If one were to take perhaps periodic samples the pungency could be predicted although not very accurately.

The concentration of the LF of the onions throughout the growing season is given in Table 2. Wider variations in the concentration of the LF were observed than those of the pyruvic acid concentration. However, it was found that the final pungency was related to the average concentration of the LF from onions throughout the growing season. A graph of this data is given in Figure 2. Samples 2 and 3 appeared to deviate from a linear response. One is unable to determine the final pungency by taking an individual sample early in the growing season due to variations in results. If one were to take periodic samples the pungency could be estimated.

It was also observed that the final pungency was related to the highest concentration of the LF observed for an onion sample throughout the growing season. This means that the higher the concentration of the LF that a field had throughout the study, then the final pungency would be higher. These results are shown in Figure 3. Sample 4 appeared to deviate from a linear response. These results indicate that to have low pungency values the concentration of the LF should stay low. Observe for samples 3 and 4 that a large increase is observed in the LF concentration directly after an application of fertilizer at weeks 1 and 3. This implies that low concentrations of fertilizer should be applied at a single time on growing onions.

Although one could determine the final pungency if one knew the highest level of the LF obtained from onions during the growing season, this would not be practical. One would need to sample the onions many times to find the highest concentration of the LF.

Another significant result is that the last two onion samples analyzed have virtually the same pungency (3.0 and 3.2), however the taste and levels of the LF varied significantly. Sample 2 had a mild flavor and a low level of the LF. However, sample 4 had a stronger flavor and a much higher level of the LF. These data indicate that the pungency analysis may not be the best means of determining onion flavor. It is recommended that research continue in the area of gas chromatography (GC) analysis and that GC data be reported with pungency data. Apparently GC analysis provides more information regarding taste than does the pungency analysis. However, pungency analysis is rather easy and an established method of comparing onions.

A final comment should be made about different cultivars. Fields 1,2 and 5 were Granex 33 onions. Fields 3 and 7 were Sweet Dixie onions. Fields 4 and 6 were Sweet Vidalia Onions. Fields 3 and 4 showed large increases in the LF concentrations upon fertilization. The Sweet Vidalia field remained mild at harvest time while the Sweet Dixie field increased in pungency at harvest time. Field 1 was purposely fertilized more heavily than field 2 and this resulted in an onion which was higher in pungency at harvest (5.2 vs

3.0). However, it should be noted that the fact that Field 1 was harvested earlier that field 2 could have had a great effect. When Field 1 had a pungency of 5.2 field 2 had a pungency of 4.7. By waiting two more weeks the pungency of field 2 dropped to 3.0. The time of harvest has a LARGE effect on final pungency.

Conclusions

This study has been unable to determine the final pungency based upon data obtained during the growing season. However, it has been found that applications of fertilizer on growing onions tend to greatly increase the final pungency.

We have also learned that onion pungency does not appear to necessarily be related to onion flavor. This requires further study.

Sweet Dixie onions appear to be hotter than other cultivars studied and get hotter at the end of the season. Sweet Vidalia onions on the other hand appear to be more mild than other cultivars studied and stay mild at the end of the season. When growers rush to get their onions to market first this will probably result in a hotter onion.

Acknowledgment

The authors wish to thank the Vidalia Onion Committee and Department of Chemistry at Georgia Southern University for financial support. The support of onion growers in Bulloch County is greatly appreciated as is the support of Reid Torrence of Tattnall County.

TABLE 1

PUNGENCY

Sample #	1-12	1-28	2-09	2-23	3-10	3-21	4-06	4-20	4-28	5-06
1	---	6.7	3.8	5.6	3.5	4.2	2.6	5.2		
2	3.2	5.1	2.4	3.4	1.8	3.4	2.8	4.7	3.1	3.0
3	5.9	7.2	5.4	5.8	2.7	4.6	4.0	8.4		
4	3.9	3.8	3.1	3.8	4.6	2.4	3.4	4.8	3.8	3.2
5	4.9	3.2	4.9	6.1	1.0	3.5	3.6	4.4		
6	5.6	3.0	5.4	4.6	4.1	4.6	3.6	4.7		
7	4.9	2.1	4.9	5.1	0.5	3.3	2.3	3.6		

TABLE 2

L F RATIO

Sample #	1-12	1-28	2-09	2-23	3-10	3-21	4-06	4-20	4-28	5-06
1	6.5	10.6	3.3	3.9	6.6	3.2	4.2	5.7		
2	1.8	2.2	0.9	1.6	6.1	1.3+	2.7	4.6	3.7	1.0
3	3.4	19.8	5.2	4.5	3.5	3.4	3.5	7.8		
4	2.3	3.9	21.5	0.9	5.0	1.7	1.2	4.8	5.0	4.4
5	3.4	3.2	12.0	11.5	2.4	2.7	6.6	4.2		
6	1.8	2.7	8.5	1.6	---	1.8+	5.3	5.7		
7	3.3	2.7	6.9	1..0	2.0	2.8	5.5	5.2		

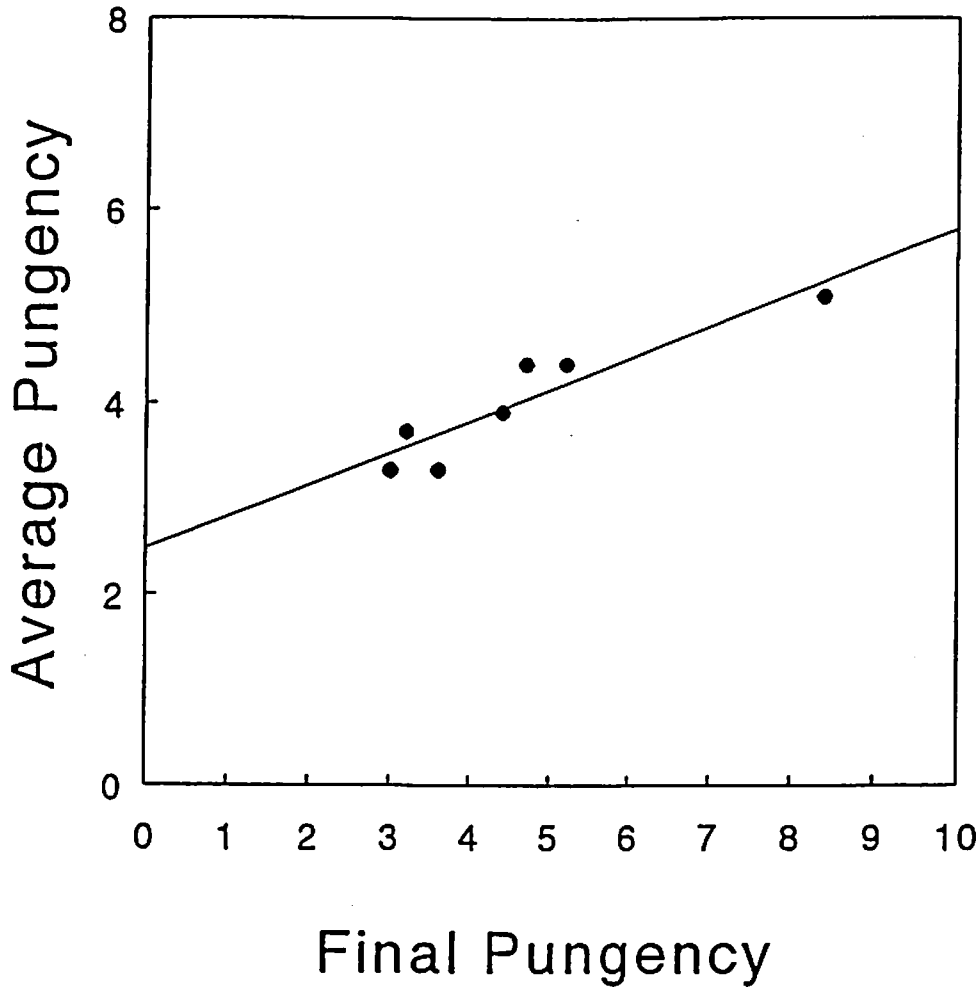

Figure 1. Prediction of pungency from average pungency.

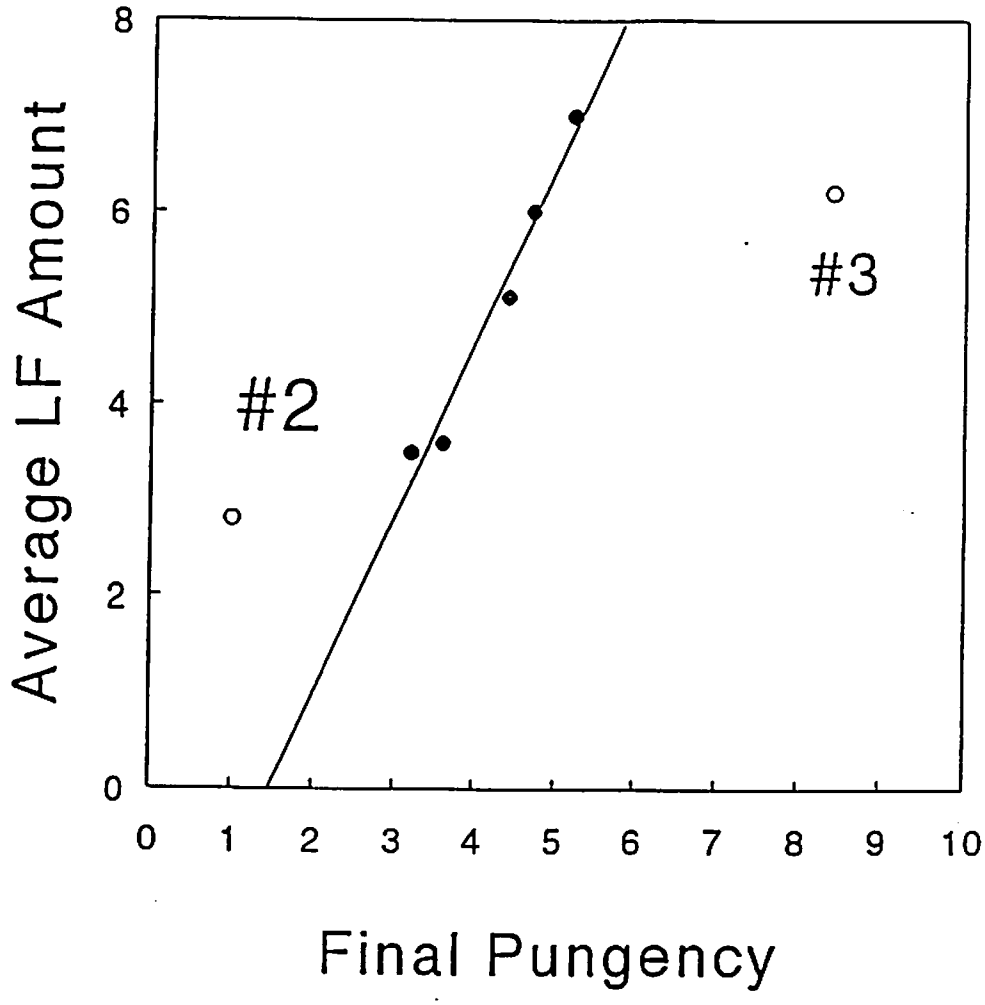

Figure 2. Prediction of pungency using LF amount.

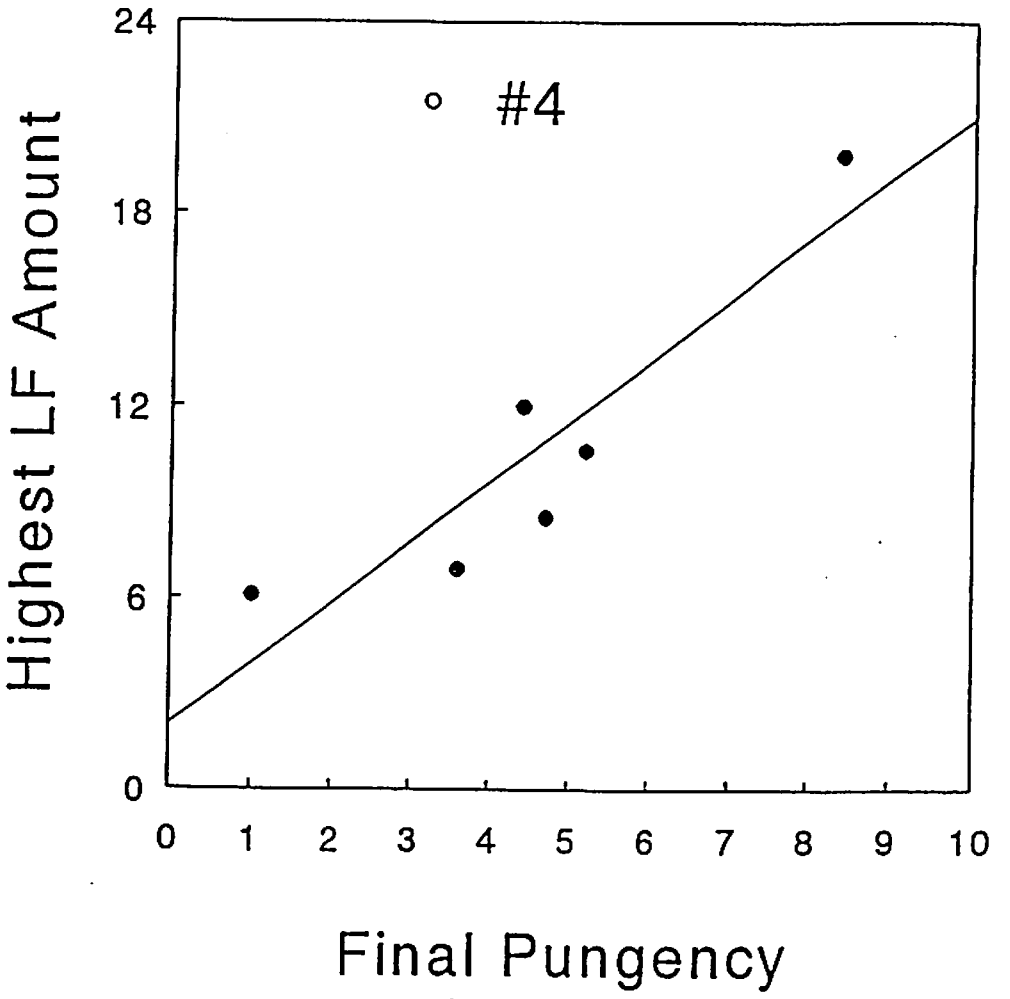

Figure 3. Prediction of pungency from highest LF amount.

RESEARCH ON DISEASES INDUCED BY FUNGI
1994-1995

Donald R. Sumner, Research Plant Pathologist
J. Danny Gay, Extension Plant Pathologist

Summary

Seedbeds in Site A in Toombs county were fumigated with Telone II (10 gal/A), Telone C-17 (15 gal/A), Sectagon (32.7%, 70 gal/A), MC 33 (225 lbs/A, under plastic), or nonfumigated August 31 or September 1, 1994. Onions were planted September 21st. Fumigation with Sectagon and MC 33, but not fumigation with Telone II or Telone C-17, reduced populations of *Pythium* spp. in soil, and increased plant weight at transplanting, compared with nonfumigated soil. Soil fumigation did not reduce populations of the pink root pathogen or *Fusarium* spp. significantly in soil. At Site B at the Coastal Plain Experiment Station onion had been grown for 14 consecutive years. Soil was fumigated with Telone II, Telone C-17, Vapam (50 or 100 gal/A), or nonfumigated in mid-September, and onion was direct-seeded October 7th. Soil fumigation with Vapam (both rates) and Telone C-17, but not with Telone II, reduced populations of *Pythium* spp. in soil and increased yield of bulbs. The fumigants did not increase plant stand or reduce populations of the pink root pathogen, and had a variable effect on other soil fungi.

In Site C in Tattnall county fungicide treatments were applied as foliage sprays or soil drenches to control foliage diseases and *Botrytis* neck rot. There was very little *Botrytis* leaf blight or purple blotch in the field. However, there were fewer leaves with dead leaf tips in plots sprayed with Rovral or Rovral + Bravo 720 than in nonsprayed plots April 3rd. There were no differences among treatments in total yield, or in bulbs with internal or external decay. May 31, 50 bulbs from each plot were placed in CA storage. After 82 days they were removed, cut, rated for internal and external and internal decay, and fungi isolated and identified. There were no differences among treatments when bulbs were removed from CA storage.

Soil Fumigation in Seedbeds, Site A, Toombs County

The field had been in onion production for several years. A latin square design with five replications was used. Each plot was 50 feet long and 6 ft (one bed) wide, with an untreated alley (10 ft) between plots. Plots were fumigated with Telone II,Telone C-17, or MC-33 August 31, and with Sectagon September 1, 1994 (Table 1); control plots were not fumigated. Telone II and Telone C-17 were injected 8-10 inches deep with chisels 10 inches apart. Sectagon was applied with a power-driven rototiller and incorporated 4-6 inches deep. Plots fumigated with MC-33 were covered with plastic, but other treatments were not covered. All plots were irrigated with overhead sprinklers September 1 after fumigation was completed. Seedbeds were planted September 21st. Soil samples were taken (10 cores,4 inches deep, 1 inch in diameter) in each plot before fumigation, and at 19 and 71 days after fumigation. Soil was assayed for *Pythium* spp., *Rhizoctonia solani*, *Fusarium* spp., the pink-root pathogen (*Phoma terristris*), and several soil-inhabiting saprophytic fungi.

On October 4 seedlings were dug at random in each plot, and fungi were isolated and identified from 20 surface-disinfested seedlings in each plot. Plants in four 30-cm sections of row (1.2 m, 3.94 ft) were counted 13, 27, 35, and 54 days after planting, and post-emergence damping-off was calculated. On November 14 plants in the four 30-cm sections of row in each plot were dug, counted, weighed, and rated for root and stem discoloration and decay; and the number of plants 5-mm (0.2 in.) in diameter were counted and weighed.

Fumigation with Sectagon and MC-33, but not fumigation with Telone II and Telone C-17, increased plant weight and reduced population densities of *Pythium* spp. in soil compared with no fumigation (Table 1). Soil fumigation did not reduce populations of *P. terristris*, *Fusarium* spp., or total populations of fungi in soil September 19th. Fewer cultures of fungi were isolated from seedlings in plots fumigated with Sectagon and MC-33 than from seedlings in nonfumigated plots, but seedlings in plots fumigated with Telone II and Telone C-17 were not different from seedlings in nonfumigated plots. None of the soil fumigation treatments increased plant stands, or the number of plants 5 mm or greater in diameter. Post-emergence damping-off was low (average of 8 %), and not different among treatments.

Soil Fumigation at the Coastal Plain Experiment Station

In Site B at the Horticulture Farm in Tifton onion had been grown continuously for 14 years, with soybean or cowpea planted between onion crops. In 1994, soybean was planted June 3, the soybean plants mowed and disked August 1 and 2, and the soil turned with a moldboard plow August 11th. A latin square design with 5 replications was used. Plots were 50 feet long and 6 ft wide, with nonfumigated allies 10 ft wide between plots. Plots were fumigated with Telone II or Telone C-17 September 17, or with Vapam September 21, or nonfumigated (Table 2). Telone II and Telone C-17 were injected 6.0-6.5 inches deep with chisels spaced 8.5 inches apart. Vapam was incorporated 6-7 inches deep with a Marchetti tractor-powered rototiller with 7 nozzles spaced 9.5-10.5 inches apart spraying the fumigant on the soil surface directly ahead of the rototiller. All plots were irrigated with 0.5 inches of water with overhead sprinklers each day after treatments were applied. Fertilizer (1000 lbs/A 5-10-15) and Diazinon was applied pre-plant and the beds rototilled. Granex 33 onion was direct-seeded in four double-rows/bed (rows were 3 inches apart with plants spaced 5.6 inches in the row) with a Stanhay planter October 7th. Dacthal and 200 lbs/A 10-34-0 were applied after planting.

Additional fertilizer applied after emergence was as follows: November 14, 50 lbs/A ammonium nitrate; December 7, January 10, and February 23, 200 lbs/A 15-0-14 each date; and March 27, 200 lbs/A calcium nitrate. Total fertilizer applied to the crop was 211 lbs/A N, 168 lbs/A P, and 234 lbs/A K. Plots were sprayed with Bravo 720 or Rovral six times from January 12 until April 10 to control purple blotch, *Botrytis* diseases, and other foliar diseases. Soil was collected from each plot September 12, October 5, and January 27 and assayed as described for Site A. Plants in four 1-m sections of row (13.1 ft) were counted weekly from 2 to 5 weeks after planting, and bi-weekly until mid-March, 1995. Plants from each plot were collected and weighed December 19 and March 21, and fungi were isolated from roots and lower stems of plants December 19th.

Twenty bulbs from each plot were collected at harvest and after curing. Bulbs were cut and rated for both external and internal decay, and fungi were isolated from internal tissues and identified. Plots were dug April 28, were allowed to cure in the field 3 days, and bulbs in the middle 20 ft of each plot (120 ft^2) were harvested May 1st. An additional 10 bulbs from each plot were rated for pink root and cut and rated for decay. Harvested bulbs were cured 3-4 days at 99 F with forced air, and stored at 34 F. On May 29 they were graded, and 20 bulbs were cut and rated for decay.

Soil fumigation with Vapam and Telone C-17, but not with Telone II, reduced population densities of soilborne *Pythium* spp. and increased yield of onion bulbs (Table 2). The fumigants did not reduce populations of the pinkroot pathogen significantly, and had a variable effect on other soil fungi. Soil fumigation did not increase plant stand, and did not increase plant weight December 19th.

There were no differences in the percentages of total bulbs with internal or external decay, before or after curing, among treatments. An average of 17 % of the bulbs had visible symptoms of pink root at harvest. When bulbs were cut at harvest, an average of 25 % of the bulbs had symptoms of basal stem rot, and 28 % of the bulbs were decayed. *Fusarium oxysporium*, *F. solani*, and *Pythium* spp. were isolated most frequently from decayed bulbs. After curing and grading, 20 % of the bulbs had some visible discoloration or decay, and 11 % had symptoms of basal stem rot. The fungi isolated most frequently from discolored or decayed tissues were *Aspergillus niger*, *F. oxysporium*, and *F. solani*. Fifty bulbs from each plot were placed into controlled atmosphere (CA) storage May 31st. Bulbs were stored for 82 days, and then were moved to cold storage because of a fire in the control room of the CA storage facility. On August 23 bulbs were cut, external and internal decay recorded, and fungi isolated and identified.

Foliage Disease and Neck Rot Control, Site C, Tattnall County

In an experiment within an onion field in Tattnall county, fungicide treatments were applied as foliage sprays or soil drenches to control foliage diseases and *Botrytis* neck rot (Table 3). A randomized complete block design with four replications was used. Plots were 50 ft long and one bed (6 ft) wide with a nonsprayed alley (5 ft) between plots within each bed. There were no border beds between sprayed plots, but the experimental area was surrounded by a nonsprayed border bed that separated it from the rest of the grower's field. Onions were transplanted December 9 with 4 rows/bed and plants spaced 7.5 inches in the row (46,500 plants/A). Sprays were applied with a boom-type plot sprayer using six D4 hollow cone nozzles. Sprays were applied with 65 psi in 40 gal. water/A, except Ronilan was applied in 100 gal. water/A as a drench. Ronilan was applied

December 16, January 30, and March 30; the other fungicide treatments were applied 6 times bi-weekly from January 30 through April 17th.

On February 21, 10 plants were removed from the outside rows in each plot and rated for foliage disease severity and bulb rot, and plots were rated for foliage diseases April 4th. Leafspots and discolored tissues were removed and examined with a microscope periodically, and fungi were isolated from diseased tissues.

Bulbs in the middle 30 ft from the two center rows (90 ft^2) were dug April 25, cured in the field two days, and harvested April 27th. Twenty additional onions were collected from each plot and rated for internal and external decay. Onions were transported to Tifton, stored at 34 F for 1-3 days, cured with forced air at 99 F for 2-3 days, weighed, and stored at 34 F. From each plot on May 18, 50 bulbs were selected for CA storage, and 20 bulbs were cut and rated for internal discoloration.

There was very little *Botrytis* leaf blight and purple blotch in the field. *Alternaria* spp. and *Stemphylium* spp. were identified sporulating on lesions and were isolated from diseased tissues, but *Botrytis* spp. were not identified on diseased tissues. On April 3 there were more leaves with dead tips in control plots than in plots sprayed with Rovral or Rovral + Bravo 720 (Table 3). There were no differences among treatments in total yield or in bulbs with internal or external decay at harvest (Table 3). Few cultures of fungi were isolated from discolored tissues. On May 31, 50 bulbs from each plot were placed in CA storage. Because of the fire in the control room of the CA storage facility, bulbs were moved to cold storage on August 21 (82 days). On August 23 they were cut, rated for external and internal decay, and fungi were isolated and identified from diseased tissues.

There were no significant differences in discoloration and decay among bulbs from different treatments after CA storage (Table 4). There was very little *Botrytis* neck rot, and *Botrytis* spp. were isolated rarely from bulbs. The primary fungi isolated were *Aspergillus niger*, *Penicillium* spp., and *Fusarium oxysporium*.

Table 1. Soil fumigation in seed beds in Site A, Toombs county, August 31, 1994

Treatment	Rate/A	Plant weight[x] (g)	Populations in soil Sept. 19[y] *Pythium* spp.	*Phoma terristris*	*Fusarium* spp.
Telone II	10 gal.	452 c[z]	18 ab	6	1667
Telone C-17	15 gal.	553 bc	6 abc	4	391
Sectagon (32.7%)	70 gal.	778 a	0 c	2	119
MC 33 (under plastic)	225 lbs	705 ab	8 bc	0	1326
Control	--	500 c	14 a	3	1480

[x] Grams fresh weight per 1.2 meter (3.94 ft) of row 75 days after planting.

[y] Colony forming units/g of oven-dry soil.

[z] Numbers followed by the same letter are not different according to Tukey's studentized range (HSD) test, P = 0.05. No letters indicates no significant differences.

Table 2. Soil fumigation in plots at the Horticulture farm (Site B), Coastal Plain Experiment Station, Tifton, September 1994[x]

Treatment	Rate/A	Yield 50 lb bags/A	Populations in soil[y]			
			Sept. 12 *Pythium* spp.	Oct. 5 *Pythium* spp.	Sept. 12 *Phoma territris*	Oct 5 *Phoma territris*
Telone II	10 gal.	456 ab[z]	23	19 ab	16	4
Telone C-17	15 gal.	507 a	33	4 b	9	0
Vapam	50 gal.	502 a	61	1 b	15	2
Vapam	100 gal.	510 a	18	9 b	9	7
Control	--	342 b	55	66 a	17	12

[x] Plots were in onion production for 14 consecutive years. Telone II and Telone C-17 were applied Sept. 13 and Vapam Sept. 21. Onion was direct-seeded Oct. 7, 1994.

[y] Colony-forming units/g of oven-dried soil.

[z] Numbers followed by the same letter are not different according to Tukey's studentized range (HSD) test, P = 0.05. No letters indicates no significant differences.

Table 3. Foliage disease severity April 3, and bulb rot and yield at harvest in onion in Tattnall county

necrotic apices Treatment	External Rate/A	Leaves with brown,[y] Internal April 3 (%)	Bulb rot at harvest Gray neck (%)	Bulb rot at harvest yield (%)	Bulb rot at harvest rot (%)	Marketable 50 lb bags/A
Rovral 4SC plus Kinetic 8.33 EC	1.5 pts 0.125% v/v	25.0 bcd[z]	1.2	7.6	2.5	517
Bravo 720 6SC plus Rovral 4SC plus Kinetic 8.33 EC	1.0 pt 1.5 pt 0.125% v/v	7.5 d	3.7	7.3	4.9	530
EXP 10673A 4SC	3.0 pts	25.0 cd	5.0	8.8	7.5	539
Botran 75WP	1.0 lb	52.5 ab	0.0	5.0	2.5	535
Bravo 720 6SC	1.0 pt	46.2 abc	0.0	7.6	0.0	539
Ronilan 50 DF alternated with Bravo 720 6SC	2.0 lbs 1.0 pt	51.2 ab	1.2	3.9	2.5	537
Control	-	60.0 a	1.2	11.3	8.8	553

[y] Induced by *Alternaria* spp. and *Stemphyllium* spp.

[z] Numbers followed by the same letter are not significantly different according to t-tests (LSD), P = 0.05.

No letters indicates no significant differences.

Table 4. Decay and discoloration in onion bulbs removed from controlled atmospheric storage, August 28, 1995[y]

Treatment	Rate/A	Bulbs with discoloration and decay %	Gray neck rot %	Tan discoloration %	Soft rot %	Decayed bulbs[z] yielding cultures of fungi %
Rovral 4SC + Kinetic 8.33 EC	1.5 pts 0.125% v/v	20.5	7.5	7.0	6.0	13.5
Bravo 720 6SC	1.0 pt	15.5	5.0	7.5	2.5	25.6
Rovral 4SC + Bravo 720 6SC + Kinetic 8.33 EC	1.5 pts + 1.0 pts 0.125% v/v	13.0	3.5	6.0	3.5	27.5
Botran 75WP	1.0 lb	22.5	8.5	11.5	2.5	6.2
Ronilan 50DF alternated with Bravo 720 6SC	2.0 lb 1.0 pt	14.0	5.5	5.5	2.5	0.0
Exp 10673A 4SC	3.0 pts	10.0	3.5	2.5	3.0	10.8
Control		17.0	3.0	9.0	3.5	15.4

[y] There were 50 lbs stored from each of four replications of each treatment.

[z] The primary fungi isolated were *Aspergillus niger*, *Penicillium* spp., and *Fusarium* spp. There were no significant differences among treatments in any of the variables.

IMAGE ANALYSIS TECHNIQUE FOR ONION QUALITY DETERMINATION

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Several onion images were analyzed for quality determination using OPTIMAS. Enhanced images obtained by subtracting the convolved image from the original image were used. Quality determination was based on the simple idea of histogram comparison. Bright pixels in the enhanced image correspond to defects in the product. Enhanced line scan image of differing quality onions and their corresponding histograms are shown in Figures 1 and 2, respectively. The following scheme was followed to detect the number of pixels corresponding to the total defected area.

1. Exclude the middle portion of the image that corresponds to the onion sprout from the analysis. This area is always bright whatever the quality of the bulb.
2. Perform morphological opening (erosion followed by dilation) on the ROI containing the image of one bulb at a time using a mask. The opening operation is supposed to eliminate isolated noisy pixels keeping the true signal in tact.
3. Histogram the ROI.
4. If the histogram contains a "significant" peak corresponding to the bright pixels, classify the bulb as bad. Otherwise, classify it as good.

Finding the significance of the peak corresponding to the bright pixels is a critical issue and needs careful attention. A ratio of the dark pixels to bright pixels can be a good choice. However, more alternatives need to be explored.

A 3x3 mask was used to perform the opening operation. Many images of "good" and "bad" bulbs were analyzed. Histogram of defected bulbs contained a significant peak for bright pixels whereas, insignificant or no peaks were observed in case of good bulbs. The difference in peaks was examined visually and seemed obvious. Therefore, good and very deficient quality onions can be separated based on histogram comparison.

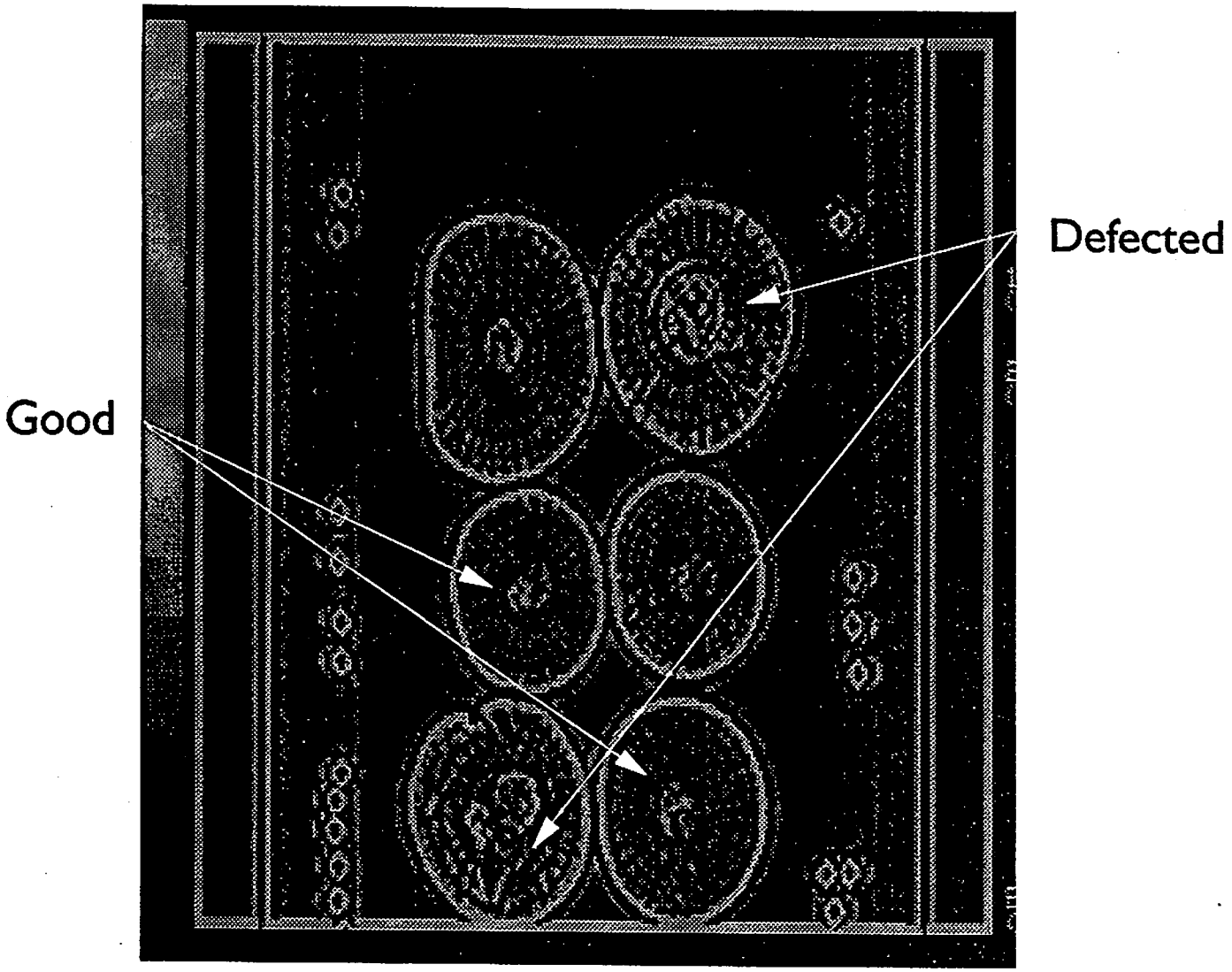

Figure 1: Enhanced line scan image showing good and defected oinons.