transplanting (Table 3). Damage to seedlings from preemergence applications of oxyfluorfen ranged from stunting and leaf twisting to death of plants. Preemergence applications of cinmethylin resulted in delayed development of the first true leaves and in seedling death.

The primary broadleaf weed at Boynton Beach was lived amaranth (*Amaranthus blitum* L.). All herbicide treatments provided acceptable broadleaf weed control except napropamide and cinmethylin. Jungle-rice (*Echinochloa colonum* (L.) Link) and goosegrass (*Eleusine indica* (L.) Gaertin) were the primary grasses present and all herbicide treatments provided acceptable control. The postemergence application of fluazifop was applied after the weed rating was made.

At Gainesville broadleaf weeds present were 50% redroot pigweed (*Amaranthus retroflexus* L.), 30% evening primrose (*Oenathera* sp.) and 20% other species. Goosegrass and yellow nutsedge (*Cyperus esculentus* L.) were also present. All herbicide treatments provided excellent broadleaf and grass weed control. Metolachlor, diethatyl, and cinmethylin also suppressed nutsedge development.

Crop yields with the herbicide treatments at Boynton Beach were equal to that with the hoed and unhoed check treatment except for cinmethylin which significantly reduced broccoli plant stand and average head weight and the average weight per head of napa (Table 2). Although plant vigor 20 days after planting was reduced by oxyfluorfen, plants grew out of the stunting and yields were equivalent to the check treatments.

At Gainesville yields with all herbicide treatments were similar to the two check treatments except with oxyfluorfen and the higher rate of thiobencarb which reduced marketable yields of bok choy (Table 3). Crop injury was unacceptable for cinmethylin as a preemergence treatment at 0.75 lb./acre, but crop growth and weed control were excellent with cinmethylin as a posttransplant treatment at 0.5 lb./acre. Weed control was acceptable for most of the herbicides used in this study; however, more work is needed to determine acceptable rates and timing to reduce crop injury for some herbicides.

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OBSERVATIONS ON DOUBLE-CROPPING BELL PEPPER AND CONTROL OF BACTERIAL LEAF SPOT IN PALM BEACH COUNTY

JOHN N. SIMONS
JMS Flower Farms, Inc.
1105 25th Avenue
Vero Beach, FL 32960

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Abstract. **Fall grown pepper (*Capsicum annuum* L.) crops in Palm Beach County, Fla. are usually followed with a second crop, generally cucumber or squash. Pepper is not replanted because of the belief that nutritional, nematode, and virus disease problems make the practice impractical. Pepper (cu. Jupiter) was seeded in early Jan., 1987 on 15 acres which had been in peppers earlier. Fertilizer was provided as liquid-injected material (12-0-4). Bacterial leaf spot, *Xanthamonas campestris* pv. *vesicatoria* (Doidge) Dye, was controlled with maneb + Zn ion sprays supplemented on three occasions by addition of liquid Cu. Virus control was effected by use of oil (JMS Stylet-Oil) sprays. Approximately 20% stand loss resulted from degradation of the plastic mulch and 2-3% loss resulted from infection with *Phytophthora* root rot, *Phytophthora capsici*. Yields of 600 bushels/acre of 55-65 count pepper were produced. Observations over the past 10 years strongly suggest that plant stress is a major component in the epidemiology of bacterial leaf spot. Stresses which appear important include 1) sudden increases in soluble salts, 2) repeated instability of the water table, 3) lack of adequate nutrients, and 4) use of tank-mixes of pesticides which have high electrical conductivities. Reducing use of high analysis fertilizers (18-0-23 N-P-K) from 1,800 lb./acre to 1200 lb./acre appears to have mitigated outbreaks of BLS. Copper toxicity is a problem where excessive spraying with fixed-Cu fungicides is practiced, especially in cold weather. Extensive use of Cu fungicides is causing accumulations of Cu in the soil which is showing as Fe deficiency. Suggestions are made as to how to reduce the amount of Cu being used for control of bacterial leaf spot.**

The current economics of bell pepper production in Palm Beach County are such that many growers are barely remaining profitable. They all depend on the occurence of an extraordinarily high market ($18.00/bushel or higher) during some period of the year to make up for the average price of $5-6.00/bushel which typifies the market most of the time. With yields averaging 8-900 bushels/acre, and costs averaging $4-4500 to 4,500/acre, there are many years when profitability is marginal at best.

To maximize return per acre, most growers plant a second crop of vegetables on the land on which the fall pepper crop was produced. Cucumber is generally the crop used although some squash is grown. Both of these crops can be grown with minimal residual fertilizer in the beds by using foliar sprays of urea and epsom salt. There is generally enough K and P remaining under the plastic to carry these crops. Returns from cucumber or squash are often marginal because of over supply. In addition, the temperatures during Jan.-Feb. are too cold for optimal growth of Cucurbitaceous crops.

Production of a second crop of peppers should represent a much better potential for optimization of return on investment. There is frequently a strong pepper market in Apr. and growing conditions for peppers are better than for cucurbits. Attempts to grow a second crop of peppers have generally been unsuccessful because of 1) inability to provide supplemental fertilization through the plastic, 2) development of nematodes to damaging levels, and 3) virus disease pressure encountered in the Spring. Recent developments in technology have made it possible to mitigate the effects of all of these problems. Fertilizer can be applied through the plastic as a liquid; fumigation with methyl bromide provides year long protection against nematodes; and, mineral oil sprays will control aphid transmitted viruses.

Bacterial leaf spot (BLS) incited by *Xanthamonus campestris* pv. *vesicatoria* is the most destructive disease affecting pepper production in Palm Beach County. The author has been observing the disease for the past 10 years. This paper will present observations on BLS as well as information on double-cropping bell peppers.

Double-cropping Peppers

During the Spring of 1987 an attempt was made to grow a second crop of bell pepper following directly behind a first crop. The original crop was killed by injecting a mixture of metam-sodium (Vapam 8 gal/acre) and liquid fertilizer (30 gal/acre of 12-0-4 N-P-K) into the beds. Injections were made directly into the row area after the pepper plants had been mowed to a heighth of a few inches. Three weeks later (early Jan.) the plastic was repunched on 11 inch centers and the standard JiffyMix planting mix medium was used to replant the field with Jupiter var. pepper. New holes were punched between existing holes and two rows were used on each bed.

As soon as the plants appeared, mineral oil sprays (JMS Stylet-Oil) were started and continued at weekly intervals over 14 weeks. Oil was applied using the recommended procedures for nozzles, spray pressure and concentration. Oil was sprayed with methomyl (1 pt/100 gal). Plants were thinned when they were at the 4-leaf stage using scissors. One plant was left per hole. After thinning, sprays for BLS were begun. Maneb ... Zn ion (Manex) at the rate of 1 qt/100 gal was added to the oil plus methomyl mixture. During a wet period in March there were 3 applications in which liquid Cu (Copper Count-N) was added to the tank mix at the rate of 1 qt/100 gal. Fertilizer (25 gal of 12-0-4 = 30 lb N/acre) was injected into the center of the bed (where the hot mix had been originally) twice, once in late Feb. and once in mid-March. A third application using the same rate was made in late Mar. This final application was made at the base of the shoulder of the bed because plant growth prevented using the center of the bed.

Plant growth was excellent with the plants reaching about 28 inches of heighth at picking time. Most of the fruit picked were crown set and averaged 55 count/bushel in the first picking and 65 count/bushel in the second harvest. Total yield was about 600 bushels/acre. Prices were excellent during this period with the average price being $18/bushel. Costs of growing the crop are given in Table 1. Disease control was excellent for both virus and BLS. The field in which the crop was grown was in an area known for problems with virus. There was a devastating outbreak of virus in Palm Beach County last Spring, thus these results are very encouraging. Control of BLS was excellent with no disease observed. By way of contrast, there were several neighboring pepper fields in which BLS was epidemic, this in spite of heavy spraying with Cu. There was about a 2% loss of plants to *Phytophthora* root rot. The most serious problem was loss of stand because of deterioration of the plastic mulch. Approximately 20% loss of stand was incurred. It is not possible to grow a crop where the plastic has disappeared. Quality of plastic mulch is deteriorating each year and has become a serious problem to growers.

Table 1. Production costs (per acre) for second crop pepper.

1. Killing previous pepper crop	$45.00
2. Seed, plug mix and planting	330.00
3. Thinning	120.00
4. Fertilizer—4 injections of 12-0-4 @ 25 gal each	75.00
5. Fungicides—14 applic of Manex (1 qt/100 gal) plus 3 applic. of Copper Count-N (1 qt/100	27.00
6. Insecticides—14 applic. methomyl (1 pt/100 gal)	25.00
7. Virus control—14 applic. JMS Stylet-Oil (3 qt/100)	40.00
Total	$662.00

Observations on Bacterial Leaf Spot

Bacterial leaf spot is the most important disease affecting pepper in Palm Beach County. It is favored by warm, wet and windy weather and is generally most destructive during the months of Sept.-Nov. In direct seeded pepper it is unusual to observe symptoms before the plants have reached the 8-12 leaf stage of growth. Disease usually appears first as small, isolated areas of infection which are distributed randomly on the farms. One area of infection per 10 acres of planting is not uncommon. In these isolated areas, one often finds a single plant with severe infection from which spread to adjacent plants has occurred. Under favorable weather conditions, i.e., warm, wet and windy, the disease can involve an entire block of several acres in less than 3 weeks. Infected leaves and young fruit readily absciss, leaving the plastic strewn with dead leaves and small fruit. Frequently, most of the first set fruit (crown set) absciss. Fig. 1 illustrates a typical isolated infected plant. It is severely afflicted with many lesions present. The plants on either side of it have one or two leaves with lesions. All the other plants appear healthy.

Since BLS is known to be seedborne (6) this pattern of early infection strongly suggests that seedborne infection is involved. The fact that plants remain symptomless until they have reached a size of 8-12 leaves, notwithstanding the fact that they have been growing during times when conditions for disease development are optimal, suggests that the bacteria are systemic in seedborne infections and symptoms are not produced until certain highly specific conditions are present. If we were dealing with cabbage black rot, incited by *Xanthamonus campestris* pv. *campestris* (Pam.) Dows. in cabbage I doubt that there is a Plant Pathologist anywhere who would not conclude that seedborne infection was being observed. Schultz and Gabrielson (16) have recently reported findings with black rot in Washington State which have shown seed transmission without presence of symptoms in seed fields. They have also shown that the organism is capable of multiplying systemically in the cabbage plant.

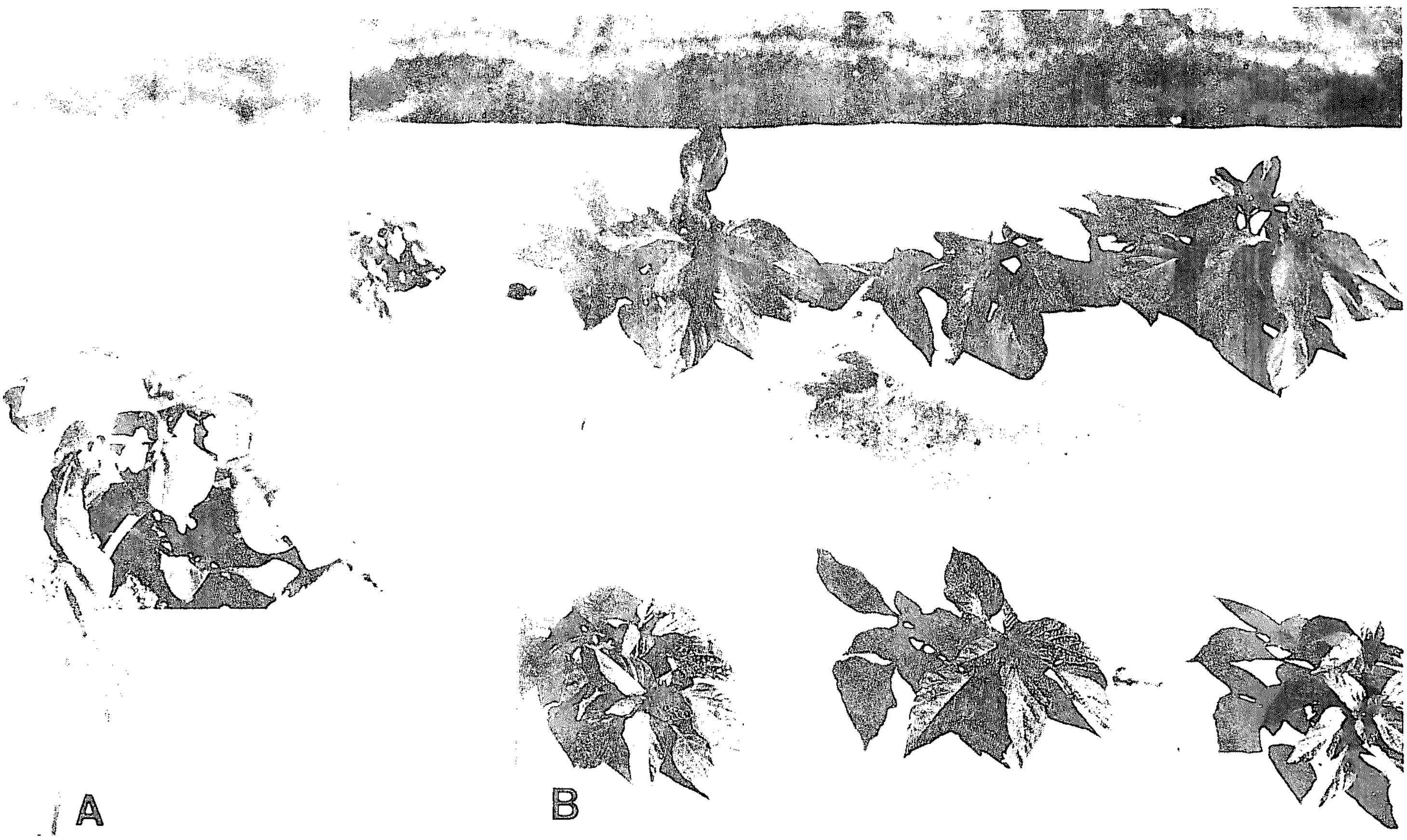

Fig. 1. A) Massive symptoms of bacterial leaf spot in an isolated pepper plant, B) Same plant (upper left) as it appeared with healthy plants all around it. There was minor symptom development on the plants on either side of it.

Once bacterial leaf spot has become epidemic, it is very difficult to bring under control. Spraying with Cu fungicides, even at high dosages and at intervals as frequent as every 48 hours, will not bring the disease under control. Only the advent of dry, and or cool weather seem to be helpful in causing subsidence of the epidemic.

In individual fields it is common to observe that the same areas of a field will be affected by disease each year. These areas typically are either low spots or areas with poor drainage. Farms which are underlain in part with rock, and thus have poor capillarity and drainage, invariably have more problems with BLS where the rocky substrate is present. Areas where the capillarity is poor because of the presence of light, fine sands often show increased disease.

After pepper plants produce a crop of fruit there appears to be a reduction in susceptibility to BLS. Old plants can endure periods of weather favorable for bacterial leaf spot with little recurrence of BLS even though there had been an epidemic during the rapid growth phase of development. This, in spite of the presence of heavy vegetative growth which makes for relatively poor coverage from spray applications. The plants seem to have become quite resistant to BLS at this stage of growth.

Observations of bacterial leaf spot on young plants in the Spring months, when environmental conditions, i.e., temperature and rainfall, are less favorable for disease, indicate that horticultural practices such as water control and fertilizer usage are important. Fields in which BLS is epidemic consistently show indications of having been stressed as a consequence of either a flooding episode or failure to maintain a uniform water table. Oftentimes bacterial leaf spot incidence will appear somewhat random in distribution with significant disease present in only portions of the field. Inspection of the beds for fertilizer residue consistently reveals that the areas where BLS is serious do not have residual fertilizer whereas nondiseased areas do. If fertilizer is present under the plastic, and bacterial leaf spot is serious, one will find evidence of lack of water because of poor capillarity.

Evidence for seed transmission of bacterial leaf spot—I have indicated above that BLS is known to be seed transmitted (6, 10, 12). Florida researchers have downplayed this aspect of BLS epidemiology (12). They tested 53 seedlots using a 6 g sample from each seedlot and found one lot to be infected. Assuming that this assay was 100% accurate, a sample of 318 g would contain approximately 780,000 seeds which is the quantity of seed used in direct seeding 7 acres of pepper. I have never seen more than one primary infector plant per 10 acres of planted crop, thus this level of contamination could easily account for the disease that shows in th field. I frequently see no more than one primary infection in every 40 acres of crop. These primary loci of infection do become the acres large patches of infection which devastate the crop.

There is no question that volunteer plants can serve as resorvoirs for bacterial leaf spot. Farms on which I have observed apparent seed- borne infection are characterized by impeccable sanitation programs including flooding of the land for several weeks during the summer. There are no volunteer pepper plants on these farms.

Evidence for carryover of bacteria in the soil indicates that this is unlikely in Florida soils so long as sufficient time has elapsed to insure rotting of infected crop refuse (12). This certainly is the case on the farms I am referring to. Not only are the fields flooded, but rotation of crops is practiced with pepper being planted every other year on a given site.

Occasionally, I see evidence of bacterial leaf spot having been introduced into a field as a result of windborne inoculum. In such case the disease appears on the edges of fields which border infected fields. Distribution of bacterial leaf spot is general along the contiguous border, with a gradient extending out into the field. This is completely unlike the epidemiology observed where seedborne transmission is suspected.

Chemical Control—The mainstay of chemical control for BLS is Cu, usually applied in combination with either maneb or mancozeb (3, 4, 5, 10, 11). Copper formulations used include Cu hydroxide (Kocide), basic Cu sulfate (Tribasic copper) and Cu ammonium carbonate (Copper Count-N). Conover and Averre (3) first showed that the combination of maneb or mancozeb with Cu was more effective than Cu used alone. Mancozeb appears to be more active than maneb when used with Cu, probably because mancozeb contains Zn ion and Zn ion has been shown to be bactericidal against bacterial leaf spot (1).

Various explanations have been brought forth to explain the enhancement of Cu + maneb or mancozeb mixtures (2, 11, 14, 15). None of the explanations take into account the fact that a mixture of Cu ion and either maneb, mancozeb or zineb will result in the substitution of Cu for the Mn or Zn in the dithiocarbamate molecule, this because the Cu carbamate has a stronger stability constant than the Mn or Zn carbamates. The reaction would be expected to proceed at a rapid rate, depending primarily on the concentration of Cu ion. I have talked at length with Dr. Myron Sasser of the University of Delaware about his work on this substitution phenomenon. Dr. Sasser has obtained infrared spectral data on the rate of formation of the Cu carbamate and expressed the opinion that it appeared to be a first-order chemical reaction rate. He has told me that when using high concentrations of Cu ion (derived from $CuSO_4$) the reaction went so rapidly that the dithiocarbamate moeity was destroyed.

Marco and Stall have reported (14) that mixtures of Cu (from Kocide) and mancozeb (from Dithane M-45) result in an almost 9-fold increase in Cu in solution after 8 hours as compared to Kocide alone. They apparently concluded that the Cu was Cu ion. The technique used for determining Cu concentration, atomic absorption spectrophotometry, is an excellent one but would not distinguish between Cu ion and Cu carbamate.

The fact that a new chemical, a Cu carbamate, and not increased Cu ion formation results from mixing Cu and mancozeb is of considerable significance in understanding why the mixture of chemicals is more efficaceous in controlling bacterial leaf spot than Cu alone. This information is also of relevance in explaining why the mixture is less efficaceous in controlling late blight, *Phytophthora infestans* (Mont.) dBy.) and gray leaf spot, *Stemphyllium weber* Wber. of tomato than maneb or mancozeb alone (4). More recently, Jones and Jones have reported (13) that mancozeb + tribasic $CuSO_4$ sprays were more efficaceous in controlling early blight, *Alternaria solani* (Ell. & Mart.) Jones and Grout, on tomato than either chemical alone, information which supports the hypothesis that a reaction product is being utilized.

One of the obvious questions which arises has to do with the use of an appropriate amount of inorganic Cu in the tank-mix as a substitute for the large quantities of expensive Cu fungicides which are currently being used. There is no question that we are slowly poisoning our soils with Cu. Soil analysis from old farms in Palm Beach County frequently show levels of Cu in the 40-50 ppm range. The presence of high soil pH's (7.0 and above) is the only mitigating factor in accounting for the lack of a more serious Cu toxicity problem. Solubility of Cu is sufficiently low at these pH's so that the Cu is unavailable to the plants. Notwithstanding this, I am aware of several farms in which high soil levels of Cu are present and Fe deficiency has become a problem. There is no reason to believe that inorganic Cu could not be used in place of Cu fungicides in the tank mix with mancozeb. Substitution of an appropriate amount of inorganic Cu, e.g., $CuSO_4$, would reduce the Cu pollution by a factor of at least 10 as well as eliminate any necessity for premixing Cu and mancozeb.

Since solubility of Cu is strongly affected by pH, research needs to be done on the effect of pH of the water used in spraying on formation of the Cu carbamate.

Impact of Plant Stress on Susceptibility to Bacterial Leaf Spot—We are all aware of the dramatic effect that warm, wet weather has on development of BLS. The conclusion reached as to the cause of this has been that such weather favors multiplication of bacteria. This is unquestionably true, but is likely only part of the explanation. Concurrent with favorable conditions for multiplication of bacteria, wet conditions oftentimes cause severe stresses to plants. Where the plastic mulch system is used the stress is frequently the result of rapid solubilization of fertilizer salts which causes both direct damage to roots as well as enhancement of growth without a concommitant expansion of the root system. If the flooded condition persists for more than a few hours, there is also a likelihood of O_2 depletion in the root zone, a phenomenon which will result in severe stress. Once the water table has been restored to normalcy, the beds have generally lost much of the reserve dry fertilizer which the crop ultimately will need, this because it has been leached away. Although the immediate impact is to cause excessive top growth, before long there is a shortage of nutrients available to the plants. Severe stress is the consequence of each of these happenings. Geraldson (7, 8, 9) has done some very interesting research on the impact of fluctuating water tables and sudden changes in fertilizer availability with regard to productivity of peppers and tomatoes and has observed serious stress problems.

If the above is true, then it should be possible to mitigate the effects of fluctuating water levels by using only as much high analysis fertilizer as is needed for crop production. Reducing the amount of fertilizer will lower the potential for disastrous increases in soluble salts following sudden raising of the water table as occurs in heavy rain storms. A second procedure which should have mitigating effects on the ability of plants to adjust to sudden changes in osmotic pressure on the roots is to incorporate the low analysis fertilizer, generally about 500 lb. of 6-6-6/acre, into the bed at the time of bed formation rather than banding it on the shoulders of the bed. Plants grown under the osmotic stress found where the low analysis fertilizer has been incorporated into the bed will adapt to increased osmotic pressure on the roots more easily than plants which have been grown in a bed in which less background salt is in the root system growth zone because they will already be acclimated to a significant amount of osmotic stress. It should be emphasized that plants can grow normally under conditions of high osmotic root stress if they have sufficient time to adapt to the high osmotic level. It is only when sudden increases in osmotic tension occur that the plant suffers inability to manage water efficiently.

We have been experimenting with the use of reduced amounts of high analysis (18-0-23) fertilizer for the past 3 years. Where 1,800-2,000 lb. of 18-0-19/acre were formerly used, we are now using 1,000-1,200 lb. In addition, the 500 lb./acre of low analysis fertilizer (6-6-6) is being incorporated into the bed at planting time rather than being banded on the shoulders of the bed. The results of these practices, with respect to severity of bacterial leaf spot, have been very encouraging. There have been no farms on which these practices have been used in which BLS has been unmanageable when combined with a good spray program. These are farms on which a lengthy history of severe BLS existed. No other horticultural practice has been manipulated on the farms. Farms on which the use of high levels of fertilizer is practiced continue to have severe problems with bacterial leaf spot.

Use of an excessive quantity of fertlizer is only one of the important inducers of stress. Failure to maintain a uniform water level is another common cause of stress. Repeated oscillations in water table in a field will result in damage to root systems as well as ultimate loss of most of the fertilizer. If either of these occur the impact on BLS severity can be significant. I have seen fields in which a single episode of flooding has resulted in the loss of most of the fertilizer from the beds and subsequent growth of peppers has shown symptoms of N deficiency ranging from severe to none. Areas in the field which had lost the fertilizer were severely infected with BLS while adjacent areas in which fertilizer was still available (as evidenced by inspection of the remaining fertilizer under the plastic) showed almost no bacterial leaf spot. These fields were growing during the Spring when bacterial leaf spot pressure is only moderate and it is unusual to find the disease at high levels.

Maintenance of a uniform water table is probably more important in preventing stress than the actual heighth of the water table. Laser leveling is a practice which minimizes variations in water table and which is well worth the cost in terms of economic benefit. The actual heighth of the water table, as well as the bed heighth, must be adjusted for the local conditions prevailing on a farm.

The use of liquid-injected fertilizer can cause severe stress on plants and an enhancement of incidence of both BLS as well as soft rot of fruit. I have observed this in a field which was being regrown following a freeze. The liquid fertilizer (50 lb. N/acre) was injected into the mid-point on the shoulder of the beds which placed it squarely in the root system. Water supply was marginal in the field and consequences were serious for both diseases. In our own efforts to use liquid fertilizer in growing a second crop of peppers, we injected fertilizer first into the rows where seeding took place, and then into the center of the bed as long as plant growth allowed us to. The last (fourth) application of fertilizer was injected into the shoulder at the base of the bed in order to prevent root damage. We never used more than 30 lb of N/acre per application.

Mechanical Transmission of Bacterial Leaf Spot—Although it has long been recognized that weather caused wounding can cause increased spread of bacterial leaf spot (17), relatively little concern has been shown for the possible importance of mechanical transmission from handling plants or by exposure to contaminated farm equipment of BLS. Pohronezny and Shuler (personal communication) have recently suggested that mechanical transmission of BLS can be of significance with tomato culture. They found that BLS increased very rapidly in a field shortly after thinning had taken place. I have observed on a number of occasions that peppers develop BLS in the tops of the plants a few days after the first picking has occurred. This has happened in fields which have been virtually free of the diseases prior to the picking operation. Bacterial leaf spot is normally most prevalent in the bottoms of pepper plants, thus when it appears suddenly and abundantly in the tops of the plants and is not observed in the bottoms one has to be suspicious of mechanical transmission. I would expect that picking during the early morning hours when there is dew on the plants would be particularly bothersome. I have also observed instances where spray machinery (herbicide equipment) had been dragged through the tops of the pepper plants there appeared to have been spread of bacterial leaf spot. I have not observed any evidence that thinning peppers can cause spread of BLS but there is no reason that this could not happen if there is active disease in the field. I believe that handling plants when they are wet, regardless of the operation involved, should be avoided.

Effect on BLS from spraying peppers with strong tank-mixes of chemicals—I am not aware of any reports on the enhancement of BLS as the result of use of tank mixes of chemicals which can cause injury to the pepper plants. I have observed instances in which this has apparently happened, however. This has involved the use of "hot" tank mixes of spray chemicals and sudden appearence of bacterial leaf spot without benefit of weather conditions which were favorable for disease development.

Value of roguing BLS infected peppers from fields—If primary introduction of bacterial leaf spot is from seedborne infections, there might be some value in roguing the small patches of infection which occur early. We have tried this on several occasions during the past several years and have found that it is highly effective in removing the disease from a block of pepper. All plants showing symptoms of bacterial leaf spot are rogued twice from an area of infection, usually at weekly intervals. The area which has been rogued typically comprises a group of no more than 50 plants, sometimes as few as 25. These rogued areas have remained free of BLS for the remainder of the crop season.

Suggestions for testing Cu for control of bacterial leaf spot—Florida researchers (3, 4, 10, 11, 12, 13) have worked extensively on control of BLS through the use of Cu sprays. Their work has not indicated that any particular type of

Cu was superior in effectiveness. My observations on commercial fields where various Cu formulations have been used would suggest that liquid Cu plus maneb + Zn ion is more active than fixed Cu's plus maneb + Zn ion or mancozeb. Failure of spray programs appears to be related to 1) increased susceptibility of stressed plants, and 2) poor spray practices with regard to coverage and timing. Growers usually blame the chemicals they are using for their failures and are generally unreceptive to proposals which involve efforts to improve coverage or to adjust horticultural practices which are aggravating the bacterial leaf spot problem. I believe that demonstration experiments in which stress-limiting practices are utilized could be carried out with a good likelihood of grower acceptance. I am skeptical whether this could be done under small-plot conditions.

The Cu toxicity problem is so serious that every effort should be made to develop practices which result in curtailment of Cu application. This would include 1) utilization of inorganic Cu in a tank mix, and 2) use of nozzles which are more efficient in providing uniform coverage, e.g., the Spray Systems Co. TX series of hollow cone nozzles which we use so successfully for applying oil and protectant fungicides on melons in Central America. Most growers are convinced that overspraying with Cu is necessary in order to control bacterial leaf spot. Plants are often sprayed with such copious amounts of Cu that they literally appear blue-green to the observer. The deleterious affect on growth of pepper from excessive Cu is known to the grower but the toxicity is accepted as a necessary consequence of the BLS control program. There is still a lot of "if 2 lb./100 gal is good, then 4 lb./100 gal should be twice as good" mentality amoung growers. Fixed Cu formulations are viewed more favorably than liquid Cu because there is more Cu in the fixed-Cu on a pound for pound basis, never mind the fact that the fixed Cu's are essentially insoluble in water. Our successful use of mancozeb or maneb + Zn ion formulations with liquid-Cu at relatively low rates (1 qt flowable maneb + Zn ion plus 1 qt liquid-Cu) has had some positive impact on the above philosophy insofar as Palm Beach County is concerned. These problems need to be addressed by Experiment Station scientists. Small plot trials will not be adequate for such work.

The importance of premixing Cu and mancozeb needs further investigation. Jones and Jones (11) have reported no benefit from this practice. Cox (5) has reported benefit under field conditions. The results of Marco and Stall (14) showing increased solubility of Cu derived from Kocide in the presence of mancozeb over a period of 8 hours indicates that there should be benefit from premixing. Such is probably not the case where liquid Cu formulations are used as a source of Cu. The data of Jones and Jones (11) are not as convincing as they might be. In one trial there was a large amount of within replication variability (Table 5) and in the other trial (Table 6) there was too little disease present to justify the conclusion that premixing had no effect.

Experimental trials frequently are made using application techniques very different from those used by growers. Coveage is *the critical factor* in determining efficacy of protectant chemicals. Trials with protectant chemicals should utilize plant production practices which are similar to commercial conditions and application techniques which are patterned after grower procedures.

Published results (11) indicate little difference among sources of Cu when used with mancozeb. Our field observations indicate that Cu as liquid Cu (Copper Count-N) can be used at a lower rate (1 qt/100 gal) with a low rate of maneb + Zn ion (Manex) (1 qt/100 gal) and will provide control equal to that obtained where considerably higher rates of fixed Cu (2-4 lb. of Kocide/100 gal) plus mancozeb (2 lb/100 gal). This degree of difference should show in small plot trials. I suspect that the failure to detect differences among treatments is related to lack of disease pressure in the plots as well as to utilization of inappropriate application methodology. Where protectant chemicals with similar levels of activity are being tested, it is necessary to utilize high inoculum pressure in order to separate treatment effects.

There is experimental evidence that Cu plus maneb + Zn ion (1 qt Copper Count-N plus 1 qt Manex/100 gal) applied at 400 psi spray pressure through Spraying Systems Company TX-5 nozzles provides very high protection against BLS on tomatoes (MacMillan, personal communication). In two trials, this treatment provided the highest level of control, as expressed by numerical evaluation, of any treatment in the tests. Since the gallonage used was about one-half of that where high gallonage nozzles were used (all the other treatments), it would be worthwhile to determine if the effectiveness is related to the type of nozzle used, the addition of oil, or a combination of the procedures. The results certainly refute the often heard rumor that oil sprays aggravate bacterial leaf spot.

I am convinced that the means are at hand to control bacterial leaf spot in pepper using existing chemicals and application technology. I hope that information in this report will be of value to researchers who are trying to provide growers with the best in technology.

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WEED CONTROL IN TOMATO ROW MIDDLES

J. P. GILREATH
University of Florida, IFAS
Gulf Coast Research and Education Center
5007 60th Street East
Bradenton, FL 34203

W. M. STALL AND S. J. LOCASCIO
University of Florida, IFAS
Vegetable Crops Dept.
1255 Fifield Hall
Gainesville, FL 32611

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Abstract. **Pre- and postemergence herbicides, applied alone and in combination, were evaluated in 1984 and 1987 for posttransplant weed control in tomato (*Lycopersicon esculentum* L.) row middles. Grass and broadleaf weeds were present in 1984, while grass weeds were more predominant in 1987.**

In 1984, acceptable weed control was obtained with napropamide + paraquat plus a midseason application of paraquat, metribuzin + cinmethylin + paraquat, oxyfluorfen + cinmethylin + paraquat, metribuzin + fluazifop-p plus a second application of fluazifop-p, and 2 applications of oxyfluorfen + fluazifop-p (rates of 0.125 lb./acre or higher). There was no difference in yield of marketable fruit.

In 1987, few broadleaf weeds were present and these were controlled by all of the herbicide treatments evaluated. Grass weed control was acceptable with all herbicide treatments, except 0.5 lb./acre diquat. Yield was higher with 1 application of sethoxydim + Dax than with 2 applications of 0.5 lb./acre diquat; however no other differences existed.

Although the use of polyethylene mulch and soil fumigants in tomatoes has increased production and eliminated most weeds from the bed, weed control in row middles is still a significant problem. Currently, Florida growers rely predominantly on 3 labeled herbicides: paraquat, metribuzin, and napropamide for weed control in tomato middles, with the majority of the acreage treated with paraquat. Although paraquat controls most small grass and broadleaf weeds, control decreases with increasing size. In most cases, paraquat does not control parthenium or nightshade (3) and has been observed to provide poor control of bearded sprangletop. Metribuzin provides good control of most broadleaf weeds but not grasses and nightshade (3). Growers have experienced erratic weed control with napropamide which will not control nightshade or parthenium and provides poor control of some grass species (3). Previous research (2) has demonstrated the nonphytotoxicity of sethoxydim for tomatoes and its selectivity for grasses; however, grass control resulted in less competition for broadleaf weeds which then flourished, indicating the need for use of sethoxydim with a herbicide which controls broadleaf weeds. Sequential applications of metribuzin followed by sethoxydim or fluazifop-p have been demonstrated to compensate for the poor grass control normally associated with metribuzin without injuring tomato plants (4). Metolachlor (4, 5, and 6). oxyfluorfen, and cinmethylin (1) have provided good weed control in tomato without injury, but this research was conducted on soil with greater cation exchange capacity than the typical fine sands of Florida.

Due to the diversity of weed species encountered in Florida production fields and the specific nature of individual herbicides, effective weed management will depend on herbicide combinations rather than a mono-chemical approach. Recognizing this, research was conducted to identify safe, efficacious herbicides and herbicide combinations for use in tomato row middles.

Materials and Methods

Two experiments were conducted to evaluate posttransplant applications of selected herbicides alone and/or in combination, for weed control and phytotoxicity to transplanted, polyethylene mulched, staked 'Sunny' tomatoes. In the first experiment, conducted in the fall of 1984 at the Gulf Coast Research and Education Center at Bradenton, FL, 14 herbicide treatments (Table 1) were evaluated, whereas, in the second experiment, conducted in the spring-summer of 1987 at the Horticultural Research Unit at Gainesville, FL, 13 herbicide treatments (Table 5) were evaluated. Since the weed population consisted of both grass and broadleaf weeds, the first experiment concentrated on combinations of preemergence herbicides with preemergence or postemergence herbicides. Grass weeds were more predominant in the second experiment; therefore, in this experiment more emphasis was placed on applications of postemergence grass herbicides, alone and in combination with preemergence herbicides.

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