SODIUM AZIDE [SEP-100] FOR CONTROL OF NUTSEDGE, ROOT-KNOT NEMATODE , AND FUSARIUM CROWN ROT IN TOMATO PRODUCTION

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ABSTRACT

The efficacy of SEP-100, a liquid formulation of Na azide, as an alternative for methyl bromide (MB) in soil fumigation was studied in field experiments with tomato for two years. Pre-plant applications of SEP-100 by drip irrigation to plastic covered beds at rates of 50, 75, 100, 125, 150, and 200 lbs.a.i./A, were effective in controlling root-knot nematode (*Meloidogyne incognita*), nutsedges (*Cyperus* spp.), and other important weeds of the southeastern United States. Na azide rates $\geq$ 75 lbs/A consistently equaled or outperformed MB (300 lbs/A) in controlling plant pathogenic nematodes, weeds and other soilborne pests. MB failed to control Fusarium crown rot of tomato (*Fusarium solani* f.sp. *lycopersici*) but Na azide controlled the disease when applied at $\geq$ 100 lbs/A. Results indicate that Na azide in the SEP-100 formulation is a practical and safe compound for substitution of MB for soil fumigation in tomato production.

Key Words: azides, inorganic azides, herbicide, horticultural crops, hydrazoic acid, methyl bromide alternatives, nematicide, pest management, root-knot nematodes, soil-borne pests, soil fumigation, weed control.

INTRODUCTION

Na and K azides are salts of hydrazoic acid [HN_3] that have been explored in a limited manner for their pest controlling properties in the past [MBTOC, 2002]. These compounds are solids, readily soluble in water, and can be formulated as granules or liquids. Azides are potent metabolic inhibitors affecting the activities of a variety of oxidative enzymes, notably those involved in the electron transport system of respiration. There is ample information on the toxicological properties of sodium and potassium azides on humans [TOXLINE, 2001]. These compounds are hypotensors [Merck Index, 1989] and were used in the 1950's for treatment of certain types of cancers in humans and more recently in formulations to fight AIDS. Extensive studies have demonstrated that azides are not carcinogenic. Currently, Na azide is used principally by the auto industry in air bags. While azides of heavy metals such as Cu, Pb, Hg, are unstable and explosive, those of Na and K are considered safe and stable under ordinary conditions [Moeller, 1952]. Na and K azides when added to soils release HN_3 which is converted to NH_4^+ and to nitrate through the action of nitrifying bacteria. [Parochetti & Warren, 1970]. Field research at Auburn University in the 1970's showed that granular formulations of Na azide applied to soil had broad spectrum activity against weeds, nematodes, and soil-borne phytopathogenic fungi (Kelley & Rodríguez-Kábana, 1979b; Rodríguez-Kábana & Robertson, 2000a,b; Rodríguez-Kábana, *et al.*, 1975; Rodríguez-Kábana *et al.*, 1972). Similar results were obtained in other areas of the U.S. and in Belgium with high-value horticultural crops (van Wambeke *et al.*, 1984, 1985; van Wambeke & van den Abeele, 1983). Microbiological studies of soils treated with NaN_3 for several years indicated that in contrast to MB-fumigated soils those treated with azide showed increased population levels of a group of fungi [principally species of *Trichoderma* and *Gliocladium*] antagonistic to a broad spectrum of soilborne phytopathogenic fungi (Kelley & Rodríguez-Kábana, 1975, 1979a, 1981). The mode of action of Na and K azides on soil-borne pathogens is based on short-term direct toxicity, but may also involve as yet undetermined long-term effects through enrichment of the soil with microbial species antagonistic to the pathogens.

Sodium and K azides can be formulated as granules or in a variety of liquid formulations. Key to the stability of these formulations is that pH remains greater than 9.00 [Rodriguez-Kabana, 2001b]. Granular formulations were used to control weeds and soil-borne pests typically located in the top 7 - 10 cm of the soil profile. However, for other pests [nematodes, *Armillaria, Verticillium*] and deep-rooted crops [grapes, fruit, and nut trees], liquid formulations are more suitable. Delivery of azide to the desired fumigation zone may be difficult if reactivity of HN_3 in the soil-air space and atmosphere is too rapid and results in a concentration of the active compound too low for effective pest control. One way to achieve a more uniform distribution of the chemical is to apply the chemical through drip irrigation.

The generally favourable properties of Na azide as a potential substitute for MB prompted research at Auburn University to develop new formulations for field use [Rodriguez-Kabana, 2000a, 2001a; 2002a,b,c] and evaluate the compound as an alternative to MB for control of nematodes, weeds, and other soil-borne pests in high-value cropping systems. This paper presents results from field evaluation of one of the new formulations: SEP-100.

MATERIALS AND METHODS

Field experiments were conducted in 2002 and 2003 to assess the value of Na azide in the SEP 100 formulation, for control of weeds, plant pathogenic nematodes and other soil-borne pest problems. To this end one experiment in 2002 at the E. V. Smith Center, near Auburn, AL, focussed on herbicidal activity with no crop, and 2 trials with tomato, on other pesticidal activities at the Brewton Agricultural Research Unit, near Brewton, AL: one in 2002 and the other in 2003.

E. V. Smith Center. The experiment was conducted at the Horticultural Research Unit within the Center, in a field infested near 100% with false yellow nutsedge [*Cyperus strigosus*]. The soil was a sandy loam [pH 6.2; org. matter <1.0%; C.E.C. <10 meq/100 gms soil]. The objective of the experiment was to determine the relationship between dosage and degree of weed control. No crops were planted and SEP 100 was applied at rates of: 0, 50, 75, 100, 150, and 200 lbs a.i./A. A treatment with methyl bromide [300 lbs/A] was included in the experiment. The material was delivered through 2 drip tapes set 10" apart on the surface of plant beds covered with standard black polyethylene. The beds were 3' wide, 100' long and approx. 6" high. SEP 100 was applied in 3/4" water during a 5 hr period and this was followed 7 days later with an additional 3/4" of water to move the residual material deeper in the soil profile. The number of weeds per metre of bed was determined for each treatment at 2-3 wks intervals for 4 months. For each treatment and controls there were 8 replications each 10' of bed length.

Tomato Experiments. The 2002 experiment was set up for fall production in a field severely infested with root-knot nematode [*Meloidogyne incognita*] and purple nutsedge [*C. rotundus*] as the principal weed. The field had severe incidence of Fusarium crown rot [*Fusarium solani* f. sp. *lycopersici*]. The soil was a silt loam of similar characteristics to the one in the E. V. Smith Centre [EVSC] experiment. SEP 100 was applied at rates of: 0, 100, 200, and 300 lbs.a.i./A in 1" water [5 hrs] to the mulch-covered beds as described before. A MB treatment [300 lbs/A] was included for comparative purposes. The beds were 100 ft long and of the same width and height as for the EVSC expt. The beds were divided in 17' long plots and there were 6 plots per treatment. One week after application of the material an additional 1" water was applied and this was followed by another 1" of water 2 wks later when 'Paragon' tomato seedlings were planted 18" apart along the bed centre between the two drip tapes. Fertilization and control of insects and foliar diseases were according to standard recommendations for the area. Tomatoes were harvested at 7-10 day intervals beginning on Sept. 30 with the final harvest Oct. 23. Soil samples for nematode analyses were taken from every plot on Oct. 10 when the plots were rated for crown rot incidence, and the number of weeds was determined. Soil samples consisted of 1-inch diam. soil cores taken from the root zone of each plant to a depth of approx. 10" have 8-10 cores/plot. The cores were composited and a 100 cm^3 sub-sample was used to extract nematodes with the salad bowl incubation technique [Rodriguez-Kabana & Pope, 1981]. Roots from 2 plants/plot were dug out and after washing were rated for root-knot according to a 0-10 scale where 0 represents no galls and 10 maximal galling [Zeck, 1971].

A Spring 2003 experiment was set up in a field near the 2002 trial with the same soil characteristics but without Fusarium crown rot problem. SEP 100 was applied at rates of: 0, 50, 75, 100, 125, 150, 175, and 200 lbs a.i./A. Application was in 0.75" of water [5hrs], followed 8 days later with 0.75" water, a third 1" water was applied 5 days later, and 0.5" immediately before planting 'FLA-47' tomato 3 weeks after initiation of the experiment on April 22, 2003. All other details were as described for the 2002 experiment. Soil samples for nematological analyses were collected on July 30, when the weed population density was determined. Tomatoes were harvested at weekly intervals beginning on July 17 with the last harvest on August 4. Root samples were collected on August 8.

All data were analysed following standard procedures for analyses of variance. Fisher's least significant differences [FLSD] were calculated when F values were significant. Unless otherwise stated all differences referred to in the text were significant at $p \leq 0.05$.

RESULTS

In the **EVSC Experiment** applications of SEP-100 at all rates reduced weed populations as illustrated for nutsedge in Figure 1. The relation between numbers of weed and SEP-100 dosage was best described by a negative exponential model [Fig. 1B] with the greatest reductions in weed population obtained with doses [D] in the range $50 \leq D \leq 100$. Although weed populations increased with time in all plots [Fig. 1A], the 200 lb rate maintained nutsedge numbers near 0 throughout the experiment. Nutsedge control by MB never approached that obtained by the 200 lb rate of SEP-100.

Tomato Experiments. Results from the **2002 experiment** are presented in Figs. 2 and 3. All applications of SEP-100 resulted in significant reductions in: purple nutsedge density, incidence of Fusarium crown rot, and root-knot nematodes; rates $\geq$ 200 lbs a.i./A practically eliminated these problems. Fumigation with MB was effective in reducing nutsedge and root-knot populations but failed to decrease Fusarium crown rot. SEP-100 applications at the two highest doses resulted in definite increases in populations of beneficial microbivorous nematodes Commercial yield response to SEP-100 treatments followed a lineal model [Figs. 3A-B]. In contrast, the MB treatment had an almost insignificant effect on yield [Fig.3A].

Data from the **Spring 2003 Experiment** are presented in Figures 4, 5, & 6. All doses of SEP-100 were effective in practically eliminating nutsedge [Fig. 4A]; the same was true for *Panicum* spp. but with doses $\geq$ 75 lbs a.i./A. Fumigation with MB eliminated both weeds. Root-knot and soil populations of *M. incognita* were effectively controlled by MB and all SEP-100 applications [Fig. 4B]. While the MB treatment practically eliminated microbivorous nematodes SEP-100 did not affect their populations. [Fig. 4B] Total commercial yield [all size categories] increased with MB and SEP-100 treatments [Figure 5]. Yield response to SEP-100 doses was positive and linear [Fig. 5B]. The distribution in size categories [Fig. 6] showed linear responses to SEP-100 doses for X-Large [diam 2.9"] and Large [diam 2.5"]. Jumbo tomatoes [diam >3.5"] were recorded only for SEP-100 treatments with the exception of the 150-lb dose; significant increase in this category was only in response to the 75-lb rate. There were no Jumbos in the MB treatment. MB and SEP-100 treatments resulted in increased Cull tomatoes. In general, applications of SEP-100 resulted in equal or increased yields for all categories compared with MB.

CONCLUSIONS

Applications of Na azide using the SEP-100 formulation resulted in tomato yield response and control of weeds and root-knot nematodes equal or better than that obtained with MB fumigation. SEP-100 treatments either did not affect or increase populations of beneficial microbivorous nematodes; MB fumigation drastically reduced numbers of these nematodes. Na azide controls Fusarium crown rot but MB failed to do so. Sodium azide in the SEP-100 formulation is a viable, practical, and safe compound for substitution of MB in for soil fumigation in tomato production.

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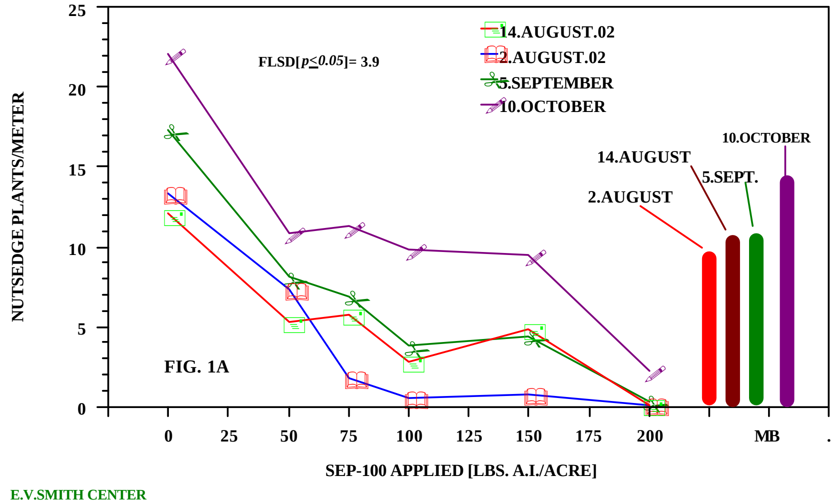


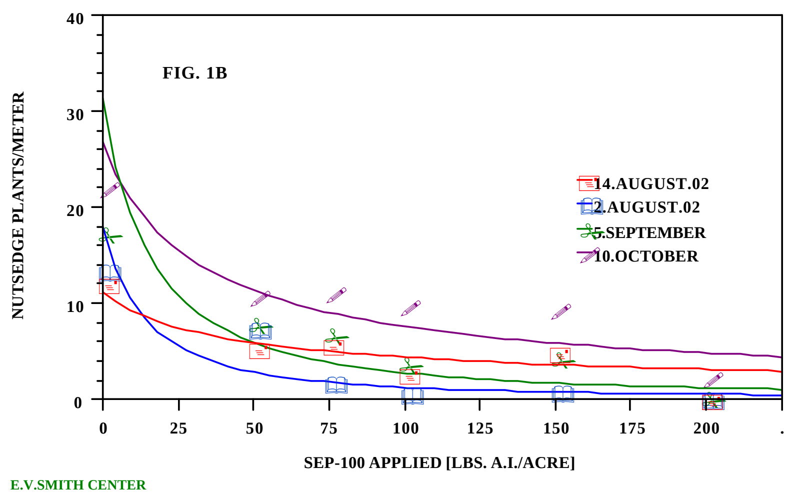


Figure 1. Population density of false yellow nutsedge [*Cyperus strigosus*] in a 2002 field experiment with Na azide [SEP-100] and methyl bromide [MB] at the E. V. Smith Centre, near Auburn, AL.

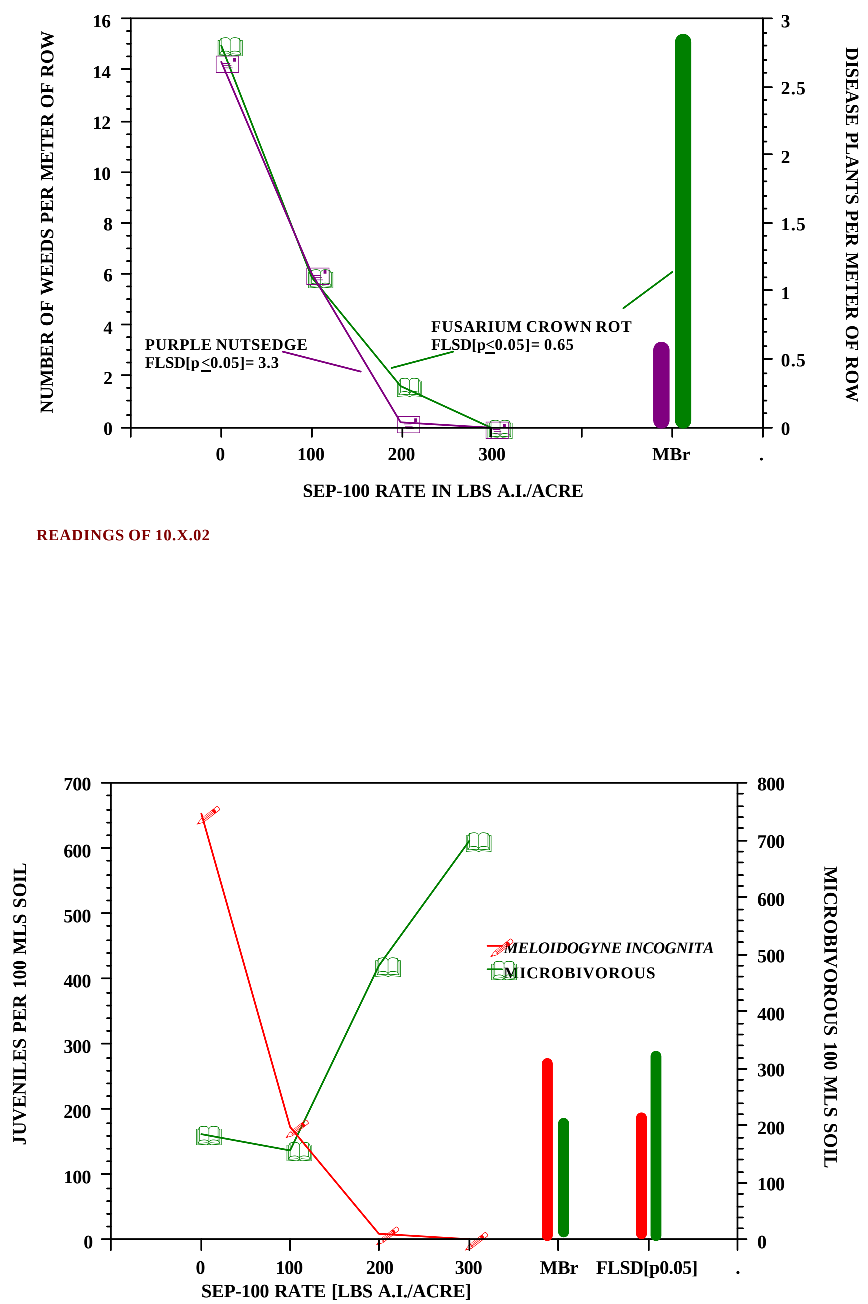
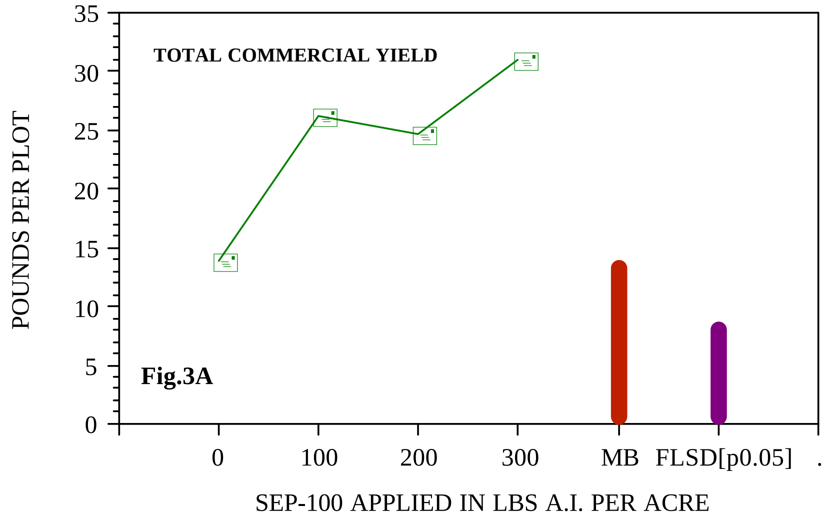


Figure 2. Relation between SEP -100 doses and population density of purple nutsedge [*C. rotundus*] and the incidence of Fusarium crown rot [*F. solani* f. sp. *lycopersici*] (A), and populations of root knot nematode [*M. incognita*] and microbivorous nematodes (B).



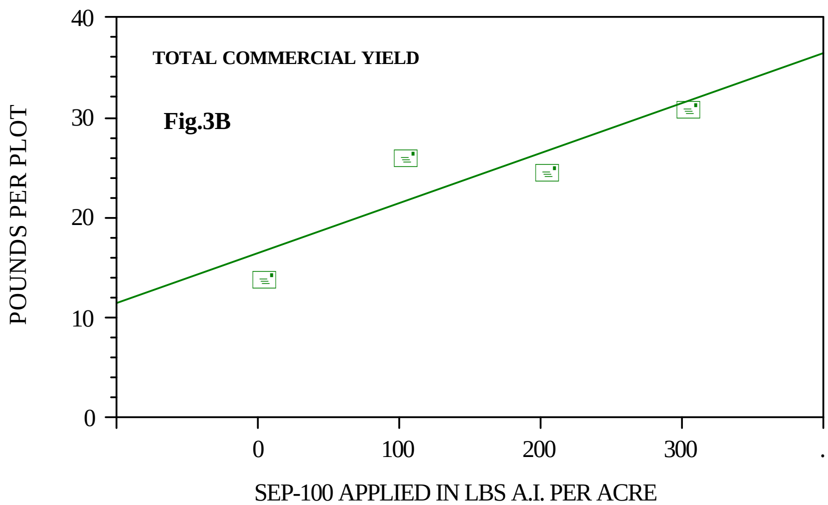
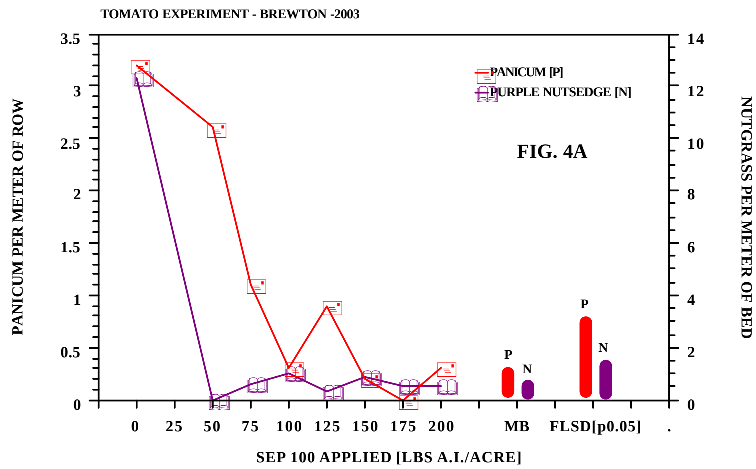


Figure 3. Commercial tomato yield response to applications of SEP-100 and of methyl bromide in a field with purple nutsedge as predominant weed, and with severe incidence of root-knot and Fusarium crown rot. Brewton, 2002.



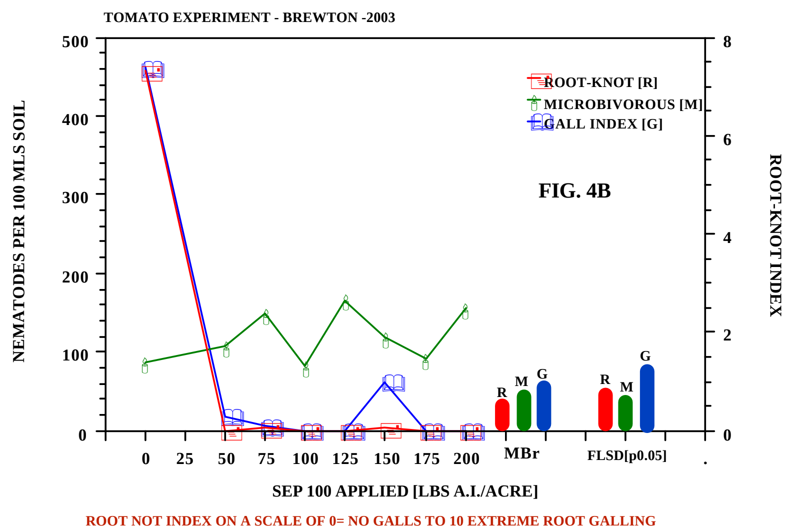
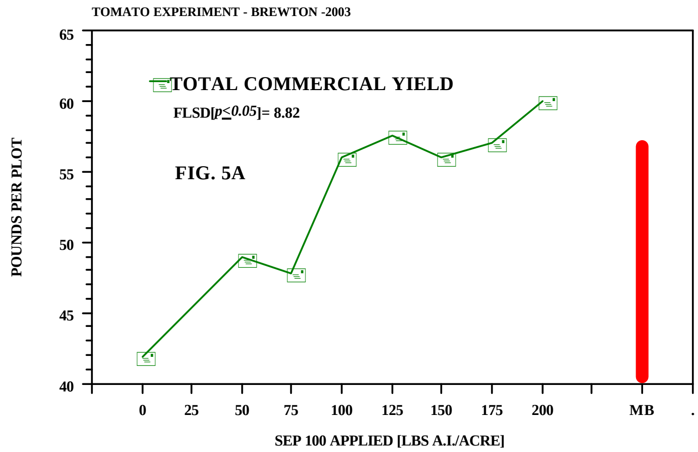


Figure 4. Comparison of the effects MB fumigation and SEP -100 doses on weed population density [A], and populations of root knot nematode [*M. incognita*], microbivorous nematodes, and root-knot indices [B], in a 2003 tomato experiment at Brewton, AL.



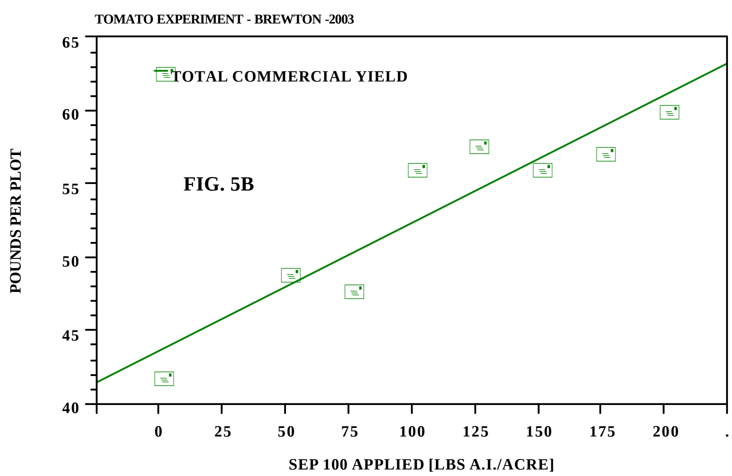
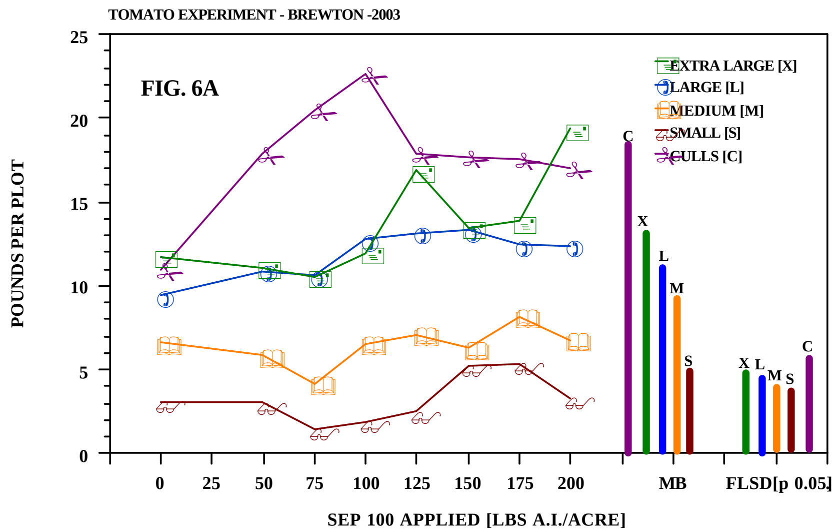


Figure 5. Commercial tomato yield response to applications of SEP-100 and MB in a 2003 experiment in a field at Brewton, AL, with purple nutsedge and *Panicum* spp. as predominant weeds and severe infestation of root knot nematode [*M. incognita*].



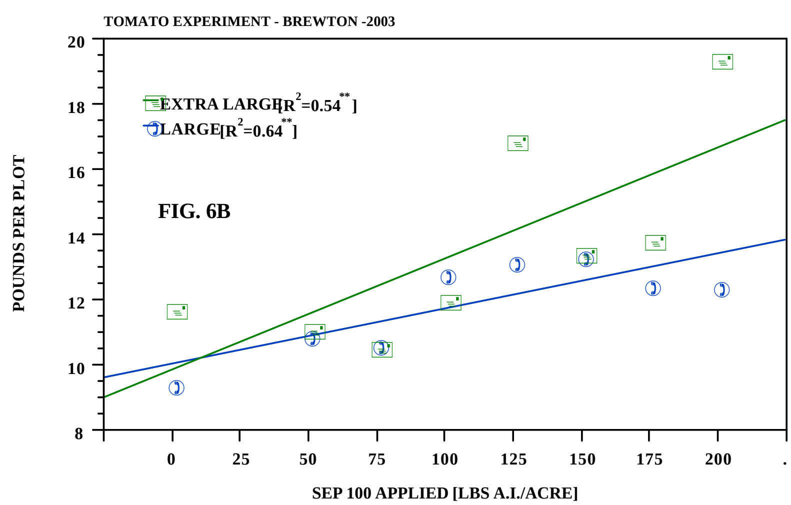


Figure 6. Distribution of tomato yield by size categories from a 2003 field experiment with MB and SEP-100, at Brewton, AL.