# CONTROL OF SILVERLEAF WHITEFLY WITH THE ENTOMOPATHOGENIC FUNGI, *PAECILOMYCES FUMOSOROSEUS* AND *BEAUVERIA BASSIANA* IN UPLAND COTTON IN ARIZONA

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## Abstract

An important aspect of Integrated Pest management (IPM) is to use biocontrol as a strong component if not the underlying basis for IPM programs. A major problem is the use of biocontrol and chemical control in the same program. Entomopathogens provide biocontrol possibilities that may be compatible with conventional pesticides. In 1993 and 1994, we used the entomopathogenic fungus, *Beauveria bassiana* as Naturalis-L® for control of silverleaf whitefly in cotton. In this study, we present work with *Paecilomyces fumosoroseus* (PFR-97®) and additional work with the fungus *B. bassiana*, (Naturalis-L®and Mycotrol®WP). Our objective was to determine if these fungi can be used successfully to control SLWF in the arid southwestern US and hence be biocontrol components in an IPM program. Endosulfan (Phaser® 3EC and Gowan Endosulfan 50WSB) was used as a tank-mix component in some treatments; in those treatments each product was used at half rate. The study was done with Deltapine 5415 cotton. The fungi/insecticide treatments were part of a 16-treatment random block design that included a "best agricultural practice regime", a water-treated control; and nearby was a separate untreated, 1-ac solid-planted, unsprayed, block control. Treatments were replicated 4 times in a random block design. Eggs, small nymphs, and large nymphs were sampled from the fifth main-stem leaf down from the first expanded terminal leaf and reported as mean no./$cm^2$. Adults were sampled from 30 leave/plot /week, and sweep samples were taken in all plots for predators, parasites, and *Lygus*. Applications were made by ground and sprays were applied at 80 psi and 30 gal./ac. Data are presented as plots of treatments and as efficacies as % reduction from sample means of the untreated control block.

*P. fumosoroseus,* was effective at controlling SLWF during the season. The efficacy of 82.5% for eggs was in the same range as the "best agricultural regime" and the combination of Mycotrol® and endosulfan. Efficacies were 78.1 and 74.6% for small and large nymphs, respectively; these efficacies were in the same range as the "best agricultural practices regime" and both formulations of *B. bassiana*. Treatments with *B. bassiana,* both products, either alone or with endosulfan gave excellent control of SLWF. Small and large nymphs appeared to be particularly susceptible to the *B. bassiana*/endosulfan combinations but the most effective control of large nymphs was with endosulfan. Efficacies ranged from 77.5 to 93.4 % for these treatments.

There are strong environmental incentives for using the half rate combinations, the prime one being the point-source reduction in pesticide use and the likely reduction of adverse effects on beneficial populations. However, consideration must be given to the potential impact of rate reduction on resistance to that chemistry; so as not to jeopardize IRM programs. The potential for the successful use of entomopathogenic fungi in SLWF control programs is great. An important consideration is that biopathogens be specific enough to target the intended pest(s) but have low impact on beneficial organisms. These fungi and other entomopathogens may serve as a bridge between chemical and biological control to have true IPM programs.

## Introduction

The Silverleaf Whitefly (SLWF), *Bemisia argentifolii* Bellows and Perring (aka sweetpotato whitefly (SPWF) Strain B, *Bemisia tabaci* Gennadius) has been the subject of numerous studies since 1992 (see Naranjo et al. 1997). There have been continuous efforts to develop efficacious control regimes against this serious pest. Integrated Pest Management (IPM) is highly desirable for SLWF management of specific crops (Akey et al. 1996). Additional goals have been to develop control strategies that use Intergrated Crop Management (ICM). This is necessary because this pest is found on numerous crops and weeds both temporally and spatially throughout the year. An important part of IPM is to use biocontrol as a strong component if not the underlying basis for an IPM program. A major problem with conducting true IPM, is the use of biocontrol and chemical control in the same program. Entomopathogens provide biocontrol possibilities that may be compatible with conventional pesticides. Earlier, we used the entomopathogenic fungus, *Beauveria bassiana* as Naturalis-L® for control of silverleaf whitefly in cotton (Akey et al. 1993, Akey and Henneberry 1994).

An important component of IPM is insecticide resistance management (IRM) with a goal of preventing the target and other pests from losing their susceptibility to particular insecticides (Dennehy et al. 1996a, 1996b). The term "insecticide" encompasses microbial toxins, e.g., delta endotoxin from the bacteria *Bacillus thuringiensis,* along with convention insecticides and may also include biorationals and biopesticides. Strategies to implement IRM include rotating classes of insecticides that evoke different detoxification mechanisms for the insecticide class used. The more classes of pesticides that are available usually require more and different modes of pesticide detoxification by the insects.

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Here we present work with the fungus, *Paecilomyces fumosoroseus* and additional work with the fungus, *B. bassiana*, to determine if these fungi can be used successfully to control SLWF in the arid southwestern US and hence be biocontrol components in IPM and ICM programs.

## Materials and Methods

Deltapine 5415 cotton was planted and furrow irrigated in plots 192.5 ft. in length and 6 rows across (40-in. rows), 2 fallow rows and 8-ft. alleys separated plots.

*P. fumosoroseus* PFR-97® Thermo Trilogy Corp., 0.025 lbs./gal., 1x $10^9$ CFU (spores)/ gm equivalent 20% product was used in one trial only, at the rate given. *B. bassiana* as Naturalis-L®, Troy Biosciences Inc. at 10 oz. product/ac, 2.3x $10^7$ conidia/ml was used at full rate as single product applications. Dual treatments with *B. bassiana* (Naturalis-L®) and endosulfan (AgrEvo Co., Phaser® 3EC–0.75 lbs. AI/ac) used each product at ½ rate. *B. bassiana* as Mycotrol®WP, Mycotech Corp., 0.5 lbs./ac, 2 x $10^{13}$ spores/lb. was used at full rate as single product applications. Dual treatments with *B. bassiana* (Mycotrol®WP), and endosulfan (Gowan Endosulfan 50WSB 0.75 lbs. AI/ac) used each product at ½ rate.

These treatments were part of a 16-treatment random block design that included a "best agricultural practice regime"(Table 1), an a water-treated control. Each treatment was replicated 4 times in a random block design. Once a treatment was initiated, it was applied weekly. An exception was the "best agricultural practices regime" that was threshold driven and based on University of Arizona recommendations (Ellsworth et al. 1996, Ellsworth and Watson 1996). Also included was a nearby, untreated, 1-ac solid-planted, unsprayed, block control.

Eggs, small nymphs, and large nymphs (latter included large 3rd's, small 4th's, and red-eye nymphs [pupae], Akey 1992) were sampled from leaves taken from 5 plants per plot, from the fifth main-stem leaf down from the first expanded terminal leaf. Each sample was counted from a 2.22 cm diameter disk ($cm^2$ = 3.88). The disk sample was taken between the main leaf vein and the next lateral vein (Ellsworth et al. 1996, Diehl et al.1997). Numbers of 0.5-1.0 large nymphs/leaf disk are equal to 0.13-0.26/$cm^2$. Results reported here are in mean no./$cm^2$.

Adults were sampled from 30 leaves/plot, same location using a binomial decision of counting a leaf as positive if 3 or more adults were present (Ellsworth et al. 1995, Naranjo et al.1996). Weekly sweep samples were taken in all plots for predators, parasites, and *Lygus*. Sweep-sample collections and adult data will be presented elsewhere. Applications were made by ground with 3 nozzles/row; 1 overhead, and 2 with swivel nozzles angled upward on drops. Sprays were applied at 80 psi and 30 gal. /ac.

## Results

Seasonal control of SLWF eggs, small nymphs and large nymphs is shown: for *P. fumosoroseus* as PFR-97® in Figure 1; for *B. bassiana* as Naturalis-L® in Figure 2, and with endosulphan as Phaser® in Figure 3.; for *B. bassiana* as Mycotrol®WP in Figure 4, and with Gowan Endosulfan in Figure 5. Similarly, control with endosulfan as Phaser® and Gowan Endosulfan 50WSB is shown in Figures 6 and 7, respectively. For comparison, seasonal control with the best agricultural practice (based on University of Arizona recommendations) and the untreated block control are shown in Figures 8 and 9, respectively.

Efficacies, as % reduction from the untreated control block, of the agents and combinations used are given for eggs, small nymphs, and large nymphs in Tables 2, 3, and 4, respectively.

*P. fumosoroseus*, was effective at controlling SLWF during the season. The efficacy of 82.5% for eggs was in the same range as the "best agricultural regime" and the combination of Mycotrol® and endosulfan. Efficacies were 78.1 and 74.6% for small and large nymphs, respectively; these efficacies were in the same range as the "best agricultural practices regime" and both formulations of *B. bassiana*.

Treatments with *B. bassiana*, both products, either alone or with endosulfan (combinations were at half rate of each product) gave excellent control of SLWF. The weekly applications of endosulfan formulations, though not realistic as conventional control practice, give a good base line for efficacy comparisons with the other treatments. Small and large nymphs appeared to be particularly susceptible to the *B. bassiana*/endosulfan combinations but the most effective control of large nymphs was with endosulfan. Efficacies ranged from 77.5 to 93.4 % for these treatments.

## Discussion

In our earlier work (Akey and Henneberry 1994), we clearly demonstrated that *B. bassiana*, as Naturalis-L, was effective in reducing SPWF population in both drip and furrow-irrigated cotton in the arid southwest. At that time, the product was comparable to two pyrethroids for control of large SLWF nymphs. In ensuing years, some growers in Arizona experienced difficulty in controlling SLWF with *B. bassiana* (personal knowledge, DHA). Also, resistance to insecticides by SLWF increased in central Arizona and an IRS program was formed (Ellsworth et al. 1996). The need for alternatives to conventional insecticides has increased to insure the probability of having successful IRS programs and to have successful IPM. In the work reported here, *P. fumosoroseus* alone and *B. bassiana* alone and in tank mix with, endosulfan, successfully controlled SLWF. The latter finding agrees with similar work reported by Hinz and Wright (1997). Other work with *Beauveria bassiana* as Mycotrol®WP in tank mix with imidcloprid also supports the concept of using half rates of the biocontrol agent and conventional insecticide (Brown et al. 1997). There are strong environmental incentives for using the half rate combinations, the prime one being the point-source reduction in pesticide use and the likely reduction of adverse effects on beneficial populations. However, consideration must be given to the potential impact of rate reduction on resistance to that chemistry; so as not to jeopardize IRM programs.

Other pest targets of interest include *Lygus*. With the use of IGRs, and other biorational pesticides used on cotton during the early and middle season, *Lygus* is not secondarily controlled by the application of conventional insecticides. Work by Steinkraus (1996) and Brown et al. (1997) has indicated that *B. bassiana* and imidcloprid controlled the tarnished plant bug *Lygus lineolaris* and the combination (half rates) was probably less detrimental to beneficials than a full rate of either. Completion of our data analysis for *Lygus spp.* and beneficials should allow us to determine if our work resulted in control of *Lygus* and if beneficials were affected.

Further, we took great care to assure that the products were properly stored, prepared and used as indicated by their label. Additionally, we had the assurance of the companies that produced the entomopathogens that their products were of high quality and indeed met their label in respect to the concentration and germination of the respective fungal life stage represented. Brown et al. (1997), in their work with *B. bassiana* as Mycotrol®WP, actually determine the spores/gm and the germination and concluded that the product complied with its label. Also, we were diligent in the application of the agents; a consideration that must not be overlooked in bringing them to practical use in the market place.

The potential for the successful use of entomopathogenic fungi in SLWF control programs is too great to leave unexplored. An important consideration is that biopathogens be specific enough to target the intended pest(s) but have low impact on beneficial organisms. These fungi and other entomopathogens may serve as a bridge between chemical and biological control to have true IPM programs.

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## Disclaimer

Mention of a trade name, proprietary product, or specific equipment does not constitute a guarantee or warranty by the USDA and does not imply its approval to the exclusion of other products that may be suitable.

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Table 1. Best agricultural practices regime, based on recommendations of University of Arizona, against silverleaf whitefly.

| Application | Treatment | Quantity | Company |
|---|---|---|---|
| Buprofezin (July 18) | Applaud® 70WP | 0.35 lb AI/ac | AgrEvo Co. |
| Pyriproxyfen (July 30) | Knack ™ 0.86 EC | 0.54 lb AI/ac | Valent USA Corp. |
| Amitraz | Ovasyn® 1.5EC | 0.25 lb | AI/acAgrEvo Co. |
| Endosulfan (Aug 20) | Phaser® 3EC | 0.75 lb AI/ac | AgrEvo Co. |
| 3rd treatment repeated again on August 27 | | | |
| Fenpropathrin® | Danitol™ 2.4EC | 0.20 lb AI/ac | Valent USA Corp |
| Acephate (Sept 4) | Orthene™ 90s | 0.50 lb AI/ac | Valent USA Corp. |

Adjuvant Use – Nonionic organosilicone surfactant DyneAmic™ Helena Chemical Co. 0.5% v/v.

Table 2. Egg efficacy, as % reduction from block control, of agents used against silverleaf whitefly.

| Eggs/cm² entire season Agent | Mean[1] | ± SE | % Reduction from block control | |
|---|---|---|---|---|
| Block control | 188.69 | 38.68 | ------- | A[2] |
| Best Ag Practices | 36.29 | 7.04 | 80.8 | B |
| PFR-97 | 33.02 | 10.02 | 82.5 | BC |
| Mycotrol® WP + Gowan Endosulfan[3] | 22.70 | 7.52 | 88.0 | BCDE |
| 1Mycotrol® WP | 22.62 | 5.94 | 88.0 | CDE |
| Naturalis-L® | 21.38 | 5.15 | 88.7 | CDE |
| Gowan Endosulfan | 18.62 | 5.29 | 90.1 | E |
| Phaser® | 15.33 | 3.90 | 91.9 | E |
| Naturalis-L® + phaser[3] | 12.54 | 3.26 | 93.4 | E |

[1] Mean no. /cm²

[2] Treatments followed by the same letter within a column do not differ significantly (LSD, $P = 0.05$; ANOVA: $F = 116.5$, $P < 0.0001$, df 8, 237).

[3] Agents in combination treatments are each at ½ product rate.

Table 3. Small nymph efficacy, as % reduction from block control, of agents used against silverleaf whitefly.

| Small nymphs/cm² entire season Agent | Mean[1] | ± SE | % Reduction from block control | |
|---|---|---|---|---|
| Block control | 52.35 | 9.66 | ------ | A[2] |
| PRF-97 | 11.45 | 2.33 | 78.1 | B |
| Best Ag Practices | 11.04 | 2.86 | 78.9 | B |
| Mycotrol® WP | 9.04 | 1.59 | 82.7 | BC |
| Naturalis-L® | 6.71 | .87 | 87.2 | BC |
| Phaser® | 6.08 | 1.51 | 88.4 | C |
| Gowan Endosulfan. | 5.78 | 1.49 | 89.0 | C |
| Naturalis-L® + phaser®[3] | 5.44 | 1.30 | 89.6 | C |
| Mycotrol® WP + Gowan endosulfan[3] | 5.21 | .80 | 90.1 | C |

[1] Mean no. /cm²

[2] Treatments followed by the same letter within a column do not differ significantly (LSD, $P = 0.05$; ANOVA : $F = 70.3$, $P < 0.0001$, df 8, 237).

[3] Agents in combination treatments are each at ½ product rate.

Table 4. Large nymph efficacy, as % reduction from block control, of agents used against silverleaf whitefly.

| Large nymphs/cm² entire season Agent | Mean[1] | ± SE | % Reduction from block control | |
|---|---|---|---|---|
| Block control | 12.06 | 1.87 | ------ | A[2] |
| Best Ag Practices | 3.63 | 1.24 | 69.9 | B |
| PFR-97 | 3.06 | .61 | 74.6 | BC |
| Mycotrol® WP | 2.71 | .59 | 77.5 | BC |
| Naturalis-L® | 2.21 | .35 | 81.7 | BCD |
| Naturalis-L® +Phaser®[3] | 1.70 | .40 | 85.9 | CD |
| Mycotrol® WP + Gowan Endosulfan[3] | 1.67 | .34 | 86.2 | CD |
| Gowan Endosulfan | 1.53 | .29 | 87.3 | CD |
| Phaser® | .92 | .15 | 92.4 | D |

[1] Mean no. /cm²

[2] Treatments followed by the same letter within a column do not differ significantly (LSD, $P = 0.05$; ANOVA : $F = 29.5$, $P < 0.0001$, df 8, 237).

[3] Agents in combination treatments are each at ½ product rate.

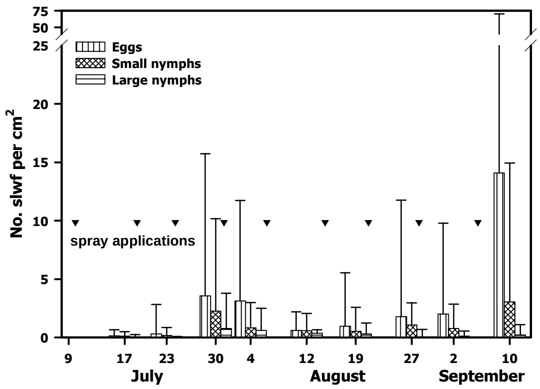


Figure 1. Seasonal control of silverleaf whitefly eggs, small and large nymphs by *Paecilomyces fumosoroseus* as PFR-97™; error bars represent 1 SE.

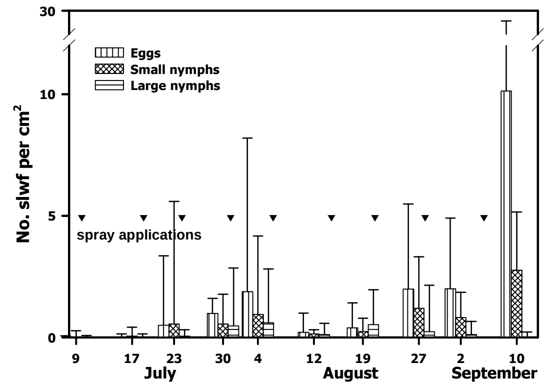


Figure 4. Seasonal control of silverleaf whitefly eggs, small and large nymphs by *Beauveria bassiana* as Mycotrol® WP; error bars represent 1 SE.

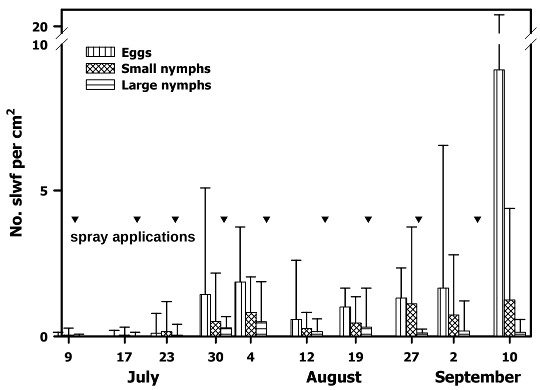


Figure 2. Seasonal control of silverleaf whitefly eggs, small and large nymphs by *Beauveria bassiana* as Naturalis-L®; error bars represent 1 SE.

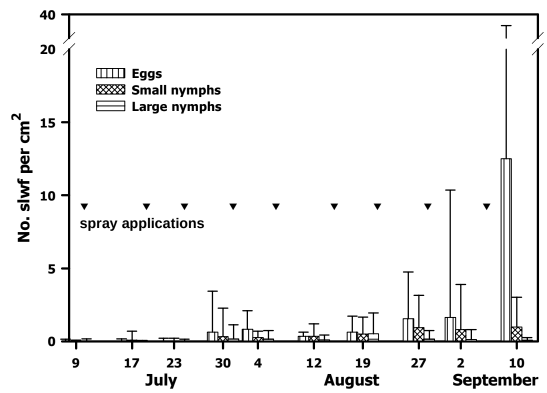


Figure 5. Seasonal control of silverleaf whitefly eggs, small and large nymphs by *Beauveria bassiana* as Mycotrol® WP and endosulfan as Gowan Endosulfan 50WSB, error bars represent 1 SE.

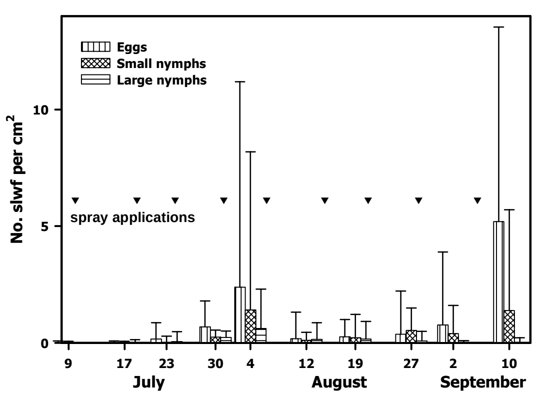


Figure 3. Seasonal control of silverleaf whitefly eggs, small and large nymphs by *Beauveria bassiana* as Naturalis-L® and endosulfan as Phaser®; error bars represent 1 SE.

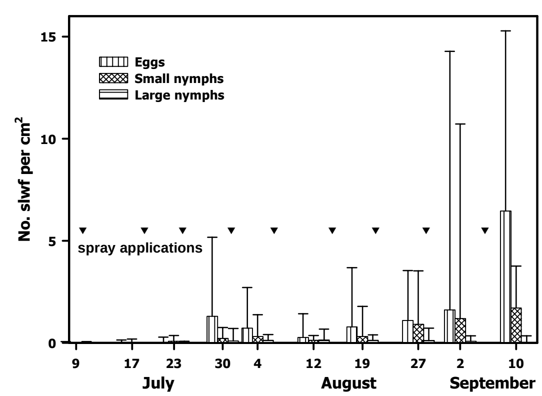


Figure 6. Seasonal control of silverleaf whitefly eggs, small and large nymphs by endosulfan as Phaser®; error bars represent 1 SE.

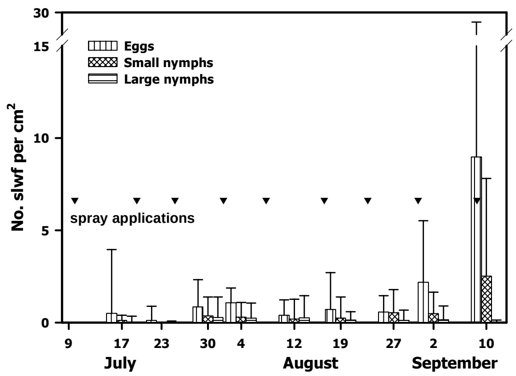


Figure 7. Seasonal control of silverleaf whitefly eggs, small and large nymphs by endosulfan as Gowan Endosulfan 50WSB, error bars represent 1 SE.

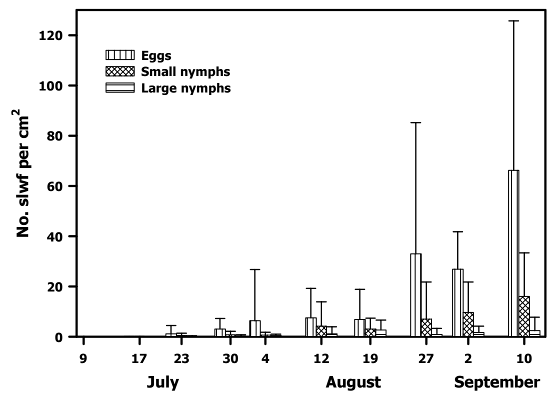


Figure 9. Seasonal control of silverleaf whitefly eggs, small and large nymphs by untreated block control, error bars represent 1 SE.

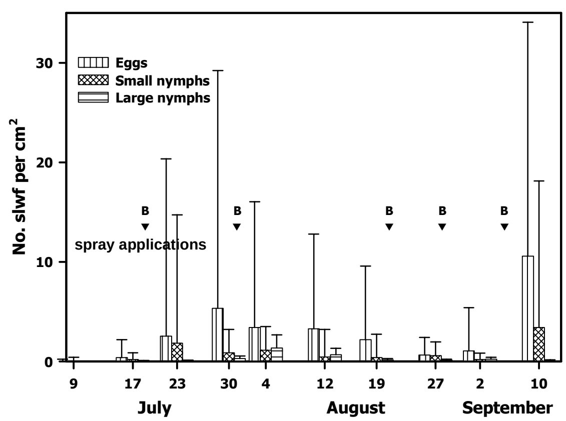


Figure 8. Seasonal control of silverleaf whitefly eggs, small and large nymphs by best agricultural practices regime (BAP), based on recommendations of University. of Arizona, error bars represent 1 SE.
B = BAP applications.