FIELD EVALUATION OF IPM-BASED GUIDELINES FOR STONE FRUIT REPLANT SITUATIONS

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ABSTRACT

Six field trials in replant settings have now been concluded except for occasional data gathering in the future. The results in this report are from two field trials located at Kearney Ag Center; one in a root lesion nematode site without the rejection component of the replant problem and the other with the rejection component minus nematodes. This is the second field trial where we have shown that when Nemaguard is the rootstock being followed, the PxA (Peach x Almond) hybrids are almost unaffected by the rejection component compared to Nemaguard. We show that Agri 50 detergent plus sodium azide at 350 lb/ac rate is inadequate for nematode control and can actually appear to create a biological vacuum for phytophthora root rot and root lesion nematodes. We show that iodomethane (MI) tarped at 235 lb/acre applied to deep-dried soil can be nematicidal but phytotoxic to certain trees. The rootstock choice is not as important as the scion choice when determining which plants are sensitive to MI. With the most sensitive scions listed first it is pluot > plum > prune > cherry > and peach. Walnut, apricot, almond and apple appear unaffected by MI in sandy loam soil at 235 lb/ac. Expect fewer problems with MI phytotoxicity in clay loam soils and greater incidence of MI problems in sand soils. The electrocution treatments create a soil condition that is not the most suitable for nematode development or the growth of trees. This latter effect can be somewhat overcome with heavy fertilization but the result is tree growth similar to the non treated trees. For all *Prunus* trees we verified here that applications of metam sodium should be at least one year before replanting; again the problem is phytotoxicity. Even with the one year wait there is some of the rejection component associated with Nemaguard after Nemaguard that is not controlled by metam sodium. Repeated treatments of fertilizer alone do appear to solve some of the rejection component where Nemaguard follows Nemaguard as compared to the untreated. *Prunus* trees appear to be an intermediate host for root lesion nematode; much better than grape but not as good as cherry, apple or walnut. For a layman's summary of this work view the CTFA research report (newsletter) for Oct. 4, 2004 Vol. VIII-4. The results of this work will soon be summarized onto our web site as IPM-based guidelines for replanting without methyl bromide.

OBJECTIVES

1. Provide diagnoses and remedies in half a dozen field settings each year as growers replant stone fruit orchards.
2. Establish replicated field trials to test performance of individual remedial actions within the guidelines so guidelines can be improved.

PROCEDURES

Various field trials continue at six locations as indicated in last year's report. This report will focus on findings from two new trials planted at the Kearney Ag Center in spring 2003.

Rejection Component Site without nematodes: The first site involves removal of a second-generation orchard on Nemaguard after treating or not treating old stumps with Roundup® in 2001 and then waiting one year of fallow (2002). This site did not have a nematode problem but has previously exhibited the rejection component of the replant problem. Four soil treatments were installed during 2002.

1. In April we drenched the moist soil with 75 gallons per acre Vapam in 6-acre inches of water.
2. In October we fumigated with 350 lb/acre methyl bromide.
3. In December we drenched 6 acre-inches water containing 350 lb/acre Agracide (85 lb sodium azide plus 265 lb Agri 50).
4. Untreated.

A fifth treatment involved use of higher amounts of NPK fertilizer (1.4 lb/tree of 16-16-16) in April and again in August of 2003.

In March 2003 four trees were replanted within 2.5 feet of the location of each old tree trunk. Two of the trees were on Nemaguard rootstock and the other two were on peach X almond hybrid (Hansen's 536). At planting time all trees were fertilized with our standard starter fertilization. Trees received irrigation from a microsprinkler placed at the site of the old tree stump. Nematode samples were collected in July and October 2003. First-year tree biomass data will be collected in January 2004 and again in fall 2004.

Root-lesion nematode site without the rejection component: Since 1992 the soil in this field had not been planted to any perennial crops for more than two years. Walnuts had been planted for 1 to 2 years in 1999 but in 2001 and 2002 no trees were present and no roots could be found in the soil in spring 2003. Root lesion nematode was common in the surface 3.5 feet of soil profile, usually at population levels approximating 50/250 cc soil.

In fall 2002 the following pre-plant treatments were applied:

1. Methyl bromide non tarped at 350 lb/acre.
2. Iodomethane tarped at 235 lb/acre.
3. Sodium azide + Agri 50 at 350 lb/acre drenched in 6 acre-inches water.
4. Iodomethane tarped at 400 lb/acre.
5. Electrocution with 4000 volts and 12 amps into moist soil with and without 300 lb/acre N from KNO_3.

Fifteen different trees or vines were planted into the treated sites. There were four replicates of each treatment and eight of each kind of plant planted to each replicate. Just prior to planting, soil samples were collected at each foot down to the five-foot depth from each replicate to assess for nematode control prior to planting. It should be noted that trees planted into the electrocution site were planted in late March, 3 weeks later than the rest of the trees. Nematode samples were collected in July from Marianna rootstocks across each rep of each treatment. One year after treatments (October 2003) soil samples were collected from each grouping of four trees across all reps and treatments. These trees will remain in the field one more full year but biomass measurements will be collected in January 2004 and again in fall 2004.

RESULTS AND DISCUSSION

A site with rejection component but no nematodes: In this site we planted Avalon almond on either Nemaguard or Hansens 536 rootstock following one full year of fallow. Because of hybrid vigor, trees on Hansens 536 grew significantly greater than those on Nemaguard. Hansen 536 rootstock provided 26% more biomass in 2003 and 30% more in 2004. Our reason for selecting Hansen 536 was that it is completely different parentage (Okinawa peach x almond) compared to the parentage of Nemaguard. We believe that switching parentage, in this case Nemaguard to Hansen 536 (P x A hybrid), can alleviate some of the intensity of the rejection component.

This experiment was conducted with the intention that all treatments would perform on a par with methyl bromide. This would allow us to make recommendations as to the similarities of each treatment we have listed in our IPM-based guidelines at www.uckac.edu/nematode. First and second year growth from each rootstock is depicted in Figure 1.

The only significant growth difference was that P x A hybrid (Fig. 1b) grew poorest when the soil received a pre-plant drench of 350 lb/ac Agri 50 + sodium azide in 6-acre-inches of water. It is notable that Agri 50 + sodium azide was relatively beneficial when Nemaguard was the rootstock. Referring back to our 2002 and 2003 reports on this study, the P x A hybrids came to us from the nursery harboring visible root rot. A negative attribute of this P x A hybrid is that it is quite susceptible to Phytophthora root rot. These data show that the Agri 50 + sodium azide drench created a dramatic biological vacuum to the advantage of the root rot. We see this again in the subsequent experiment where native root lesion nematode is present and the treatment magnified population levels within 6 months after treatment.

Best growth and greenest trees in 2003 occurred following treatments of 1.4 lb/tree of NPK in mid April and again in mid August. Many growers rely on these heavier uses of nitrogen as a substitute for soil fumigation (personal communication with Kevin Day). No other treatment received this nitrogen in 2003. Trees in all other treatments were beginning to show leaf chlorosis in late summer 2003. In 2004 all trees received the 1.4 lb/ac NPK in early March and again in July. By the end of 2004 the best trees were no longer those started with the NPK treatment. Best growth was from those that had received MB or MIT pre-plant and then received adequate nitrogen. This growth spurt did not occur among non-treated, or sodium azide treatments (Figure 2). This indicates that NPK applications provide lush growth but may not provide the same level of far-reaching root growth as that provided by adequate pre-plant fumigation. It also indicates that nutrient applications are an important means for minimizing the intensity of the rejection component.

We have long been convinced that pre-plant treatments of MIT have a negative impact on replants involving Nemaguard rootstock. Although the effect here was not significant it was visible in spots across the field that Nemaguard trees in locations down Nemaguard-planted rows did not grow quite as well as where trees were on the P x A hybrid. In fact, the best growing P x A hybrids were planted to sites that had received the MIT drench (not significant). The strategy we have found best is to always wait one full year after a MIT drench before replanting to *Prunus* rootstocks. This trial provides confirmation of the strategy. We also have confirmation from a 15-acre planting north of Parlier that is now in its third leaf where trees have grown quite well and avoided Bacterial Canker thus far.

We applied Roundup prior to removal of some of the trees. This entire field also had a one-year fallow period. Figure 1 reveals that where soil was untreated for a year and Nemaguard was replanted after Nemaguard the new trees grew better if old trunks had received the Roundup (not significant). A similar but lesser growth benefit occurred where P x A hybrids followed Nemaguard. In general this growth benefit due to Roundup was lost as treatments of MIT, sodium azide, or NPK were applied in addition to the use of Roundup. In other words, Roundup applications plus one year of fallow can provide a slight growth advantage, but this advantage can become void or hidden if other solutions to the rejection component are also employed. The Roundup plus one year of fallow has application where that will be the only soil application used across the field. We continue to believe however that Roundup plus fallow followed by a different rootstock such as P x A hybrid would likely be a useful and relatively inexpensive strategy as long as the new rootstock also has broad soil pest resistance.

<u>A site with root lesion nematodes but the rejection component is absent</u>:
In fall 2002 we made a series of fumigation treatments to a site that had 50 *Pratylenchus vulnus* / 250 cc of soil, but minimal rejection component was present because the land had been used for nursery studies or fallow with no mature trees or vines residing for ten years.

We had several goals including: a) determination of which perennial crops could follow iodomethane (MI) without phytotoxicity, b) value of treating soil with 4000 Volts and 12 amps delivered by shank to the surface 20 inches of soil, c) value of sodium azide drenches that had been advertised as a MB replacement.

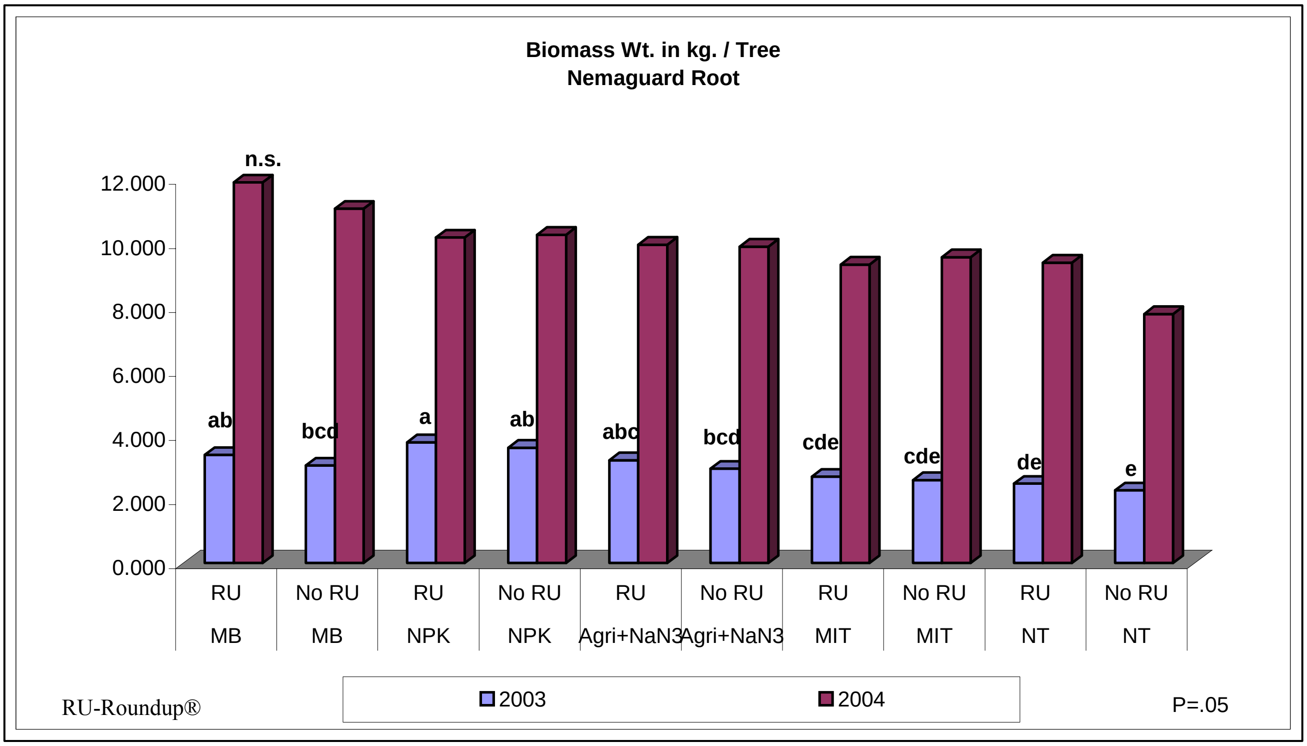
Our findings are summarized in Table 1 indicating growth of numerous scion and rootstock combinations as a percentage of that achieved in the untreated comparison. These data show that first year growth of trees following MI was not as dramatic as that achieved by MB. However, in the second year growth of trees in the MI treated soil began to increase. It is apparent that iodide phytotoxicity is influenced more by the choice of scion than the choice of rootstock. Friar plum scion is quite sensitive to Iodide ions remaining in soil and we have now observed this scion to cause slight marginal necrosis, but no reduction in plant growth, even when the application was made 6 years prior to replanting. Santa Rosa Plum scion on Marianna is also sensitive to I ions as is Marianna seedling. Prune scions also exhibit leaf necrosis but the impact on plant growth appears to be minimal at 235 lb/ac MI. Meanwhile almond on Nemaguard, peach on Lovell or Nemaguard, apricot on Nemaguard, Northern California black walnut, and apple do not appear sensitive to iodide ions that occur in soil after 235 lb/ac MI applied to sandy loam soil. These application rates applied to clay loam soils at UC Davis or Yuba City do not show an effect on Marianna seedling. Even 200 lb/ac MI one year followed by 200 lb/ac MI the next does not elicit symptoms to Marianna seedling when the treated soil is a clay loam. We have never treated a sandy, or loamy sand soil with MI but *Prunus* growers with coarse textured soil should be cautious about use of MI.

In a separate trial at KAC we have determined that cherry is slightly less sensitive than plum scions, but pluot is more sensitive than plum to MI treatments at 150 and 200 lb/ac MI. It is important to note that the leaf symptoms among pluot, plum, prune, cherry and peach are not necessarily similar in appearance. There is usually necrosis somewhere on the leaf followed by abscission of the leaf or holes within the leaf or along its margin. The listing above is in order of the most sensitive first and it is the most sensitive plants that exhibit poorest overall tree growth in the first two years after planting. Plants do appear to slowly overcome the problem but we do not know the impact there might be on fruit.

The growth data presented following the high voltage treatments were from trees that also received additions of 1.4 lb/tree NPK in April and August each year. This fertilizer addition is essential following high voltage treatments. In general the planting of stone fruits after this treatment provided minimal value. The result might be slightly different where grape is replanted. Treatments to the surface 20 inches will not be adequate when the nematodes occur within the surface five feet.

Presented in Table 2 is the population development of *P. vulnus* on a single plant selection, Friar Plum on Nemaguard, following various soil treatments. Presented in Table 3 are the raw data for plant and nematode development over a two-year period.

Figure 1. Growth of Nemaguard (1a) and P x A hybrid (1b) following various treatments



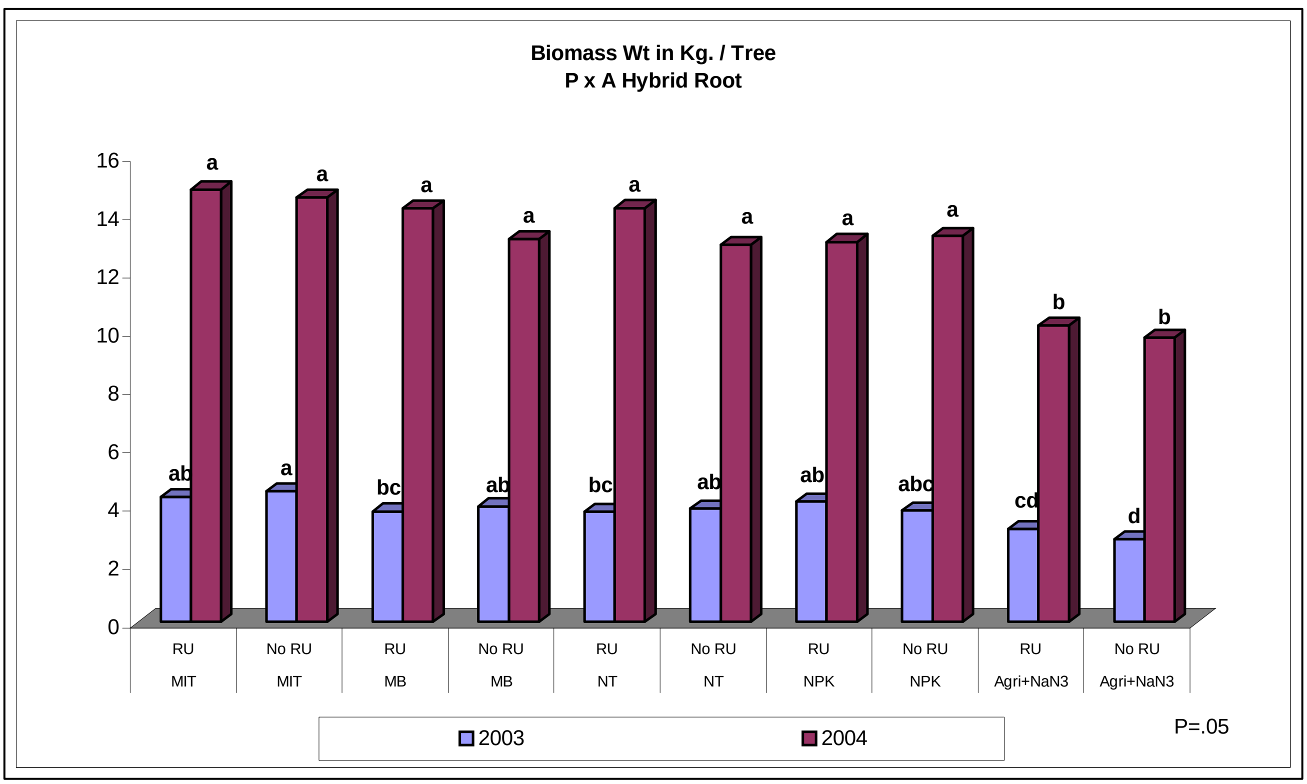


Figure 2. Two years of growth data following various treatments to mitigate the rejection component of the replant problem

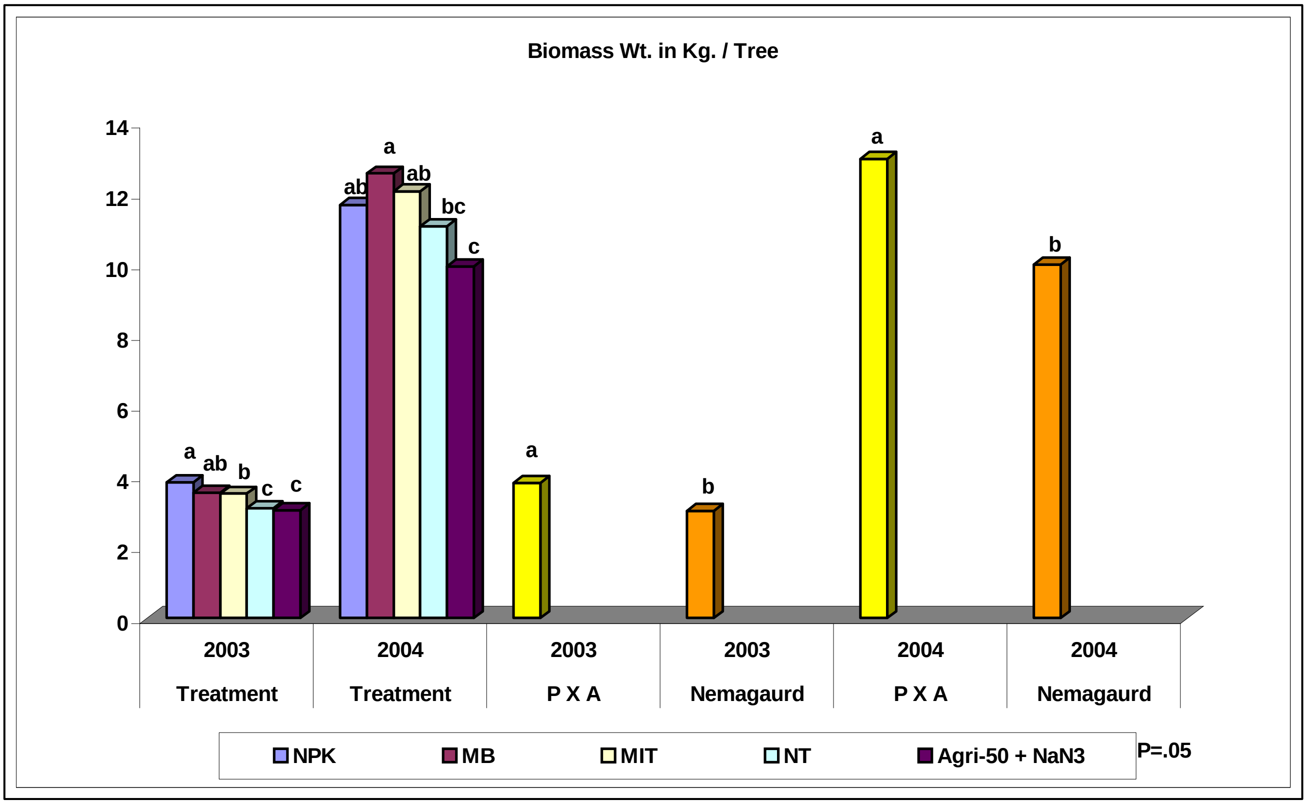


Table 1. Two years of plant growth following treatments impacting a variety of tree/vine crops

Plant Growth Following Various Soil Treatments
Growth as % of Untreated

		400lb/ac MI	
		Yr-1	Yr-1+2
Bing Cherry			
	colt	97%	**144%**
	mahaleb	92%	130%
	mazzard	126%	151%
Grape			
	barbera	123%	155%
	3309C	152%	135%
Plum			
marianna	seedling	85%	117%

	235lb/ac MI		325 lb/ac MB		Agri50 + azide		4000volts +NPK	
	Yr-1	Yr-1+2	Yr-1	Yr-1+2	Yr-1	Yr-1+2	Yr-1	Yr-1+2
Walnut								
NCB seedling	98%	109%	88%	115%	**20%**	47%	58%	78%
Apple								
golden/EMLA 26	**151%**	**180%**	**144%**	**171%**	99%	124%	86%	117%
Almond								
price/nemaguard	**133%**	146%	**148%**	133%	87%	102%	53%	80%
Peach								
suncrest/lovell	**169%**	151%	**176%**	128%	97%	100%	93%	85%
davis/lovell	**150%**	154%	**184%**	141%	89%	107%	67%	82%
friar/nemaguard	57%	89%	**139%**	120%	89%	103%	81%	90%
Apricot								
blenheim/nemaguard	**140%**	129%	**150%**	118%	79%	93%	100%	100%
Plum								
fr. prune/marianna	140%	139%	**149%**	135%	101%	116%	91%	120%
fr. prune/myrobalan	140%	134%	129%	112%	75%	87%	93%	100%
Grape								
barbera own-root	148%	205%	152%	117%	67%	73%	114%	112%
syrah/3309C	76%	112%	113%	122%	62%	111%	100%	137%
average tree or vine	127%	141%	143%	128%	79%	97%	85%	100%

% values in bold numerals are significantly different from the untreated at 0.05%

Table 2. Nematode development on Nemaguard over time

Development of *P. vulnus* on Nemaguard following various soil treatments

	pre-treat	T + 60days	T + 1 yr	T + 18 mo	T + 26 mo
350lb MB	50	0	0	0	0.25
235lb MI	50	0	0.13	2.5	0
4000 volts + NPK	50	25	127	654	346
agri 50 + azide	50	20	770	1821	3035
untreated	50	45	434	1049	1498

Table 3. Raw data depicting nematode populations level (RL) and total plant biomass (Bio) for each of two years after various soil treatments.

	Methyl Bromide	Methyl Iodide	4000V KN03 + NPK	4000V KN03 No NPK	Agri 50 sodium azide	Untreated
2003 RL	0.0 c	0.0 c	76.5 bc	176.7 bc	595.7 a	448.5 ab
2003 Bio	1.556 a	1.453 a	1.115 b	.616 d	0.821 bcd	1.039 bc
2004RL	0.0	0.0	737.0	399.5	1688.3	647.8 n.s.
2004 Bio	3.639	4.252	3.423	3.168	3.272	3.380 n.s.
2003 RL	0.0 b	0.0 b	95.5 b	123.75 b	674.2 a	84.5 b
2003 Bio	2.098 a	1.971 ab	1.286 c	.839 c	1.415 bc	1.407 bc
2004RL	0.0 b	0.0 b	431.0 b	52.5 b	1040.0 a	191.5 b
2004 Bio	5.528	5.877	6.410	5.075	5.108	4.233 n.s.
2003 RL	0.0 c	0.0 c	223.2 abc	110.7 bc	660 a	533.5 ab
2003 Bio	3.091 ab	3.346 a	2.245 bc	1.411 c	1.800 c	2.396 abc
2004RL	5.5	0.0	880.0	310.5	1011.7	883 n.s.
2004 Bio	8.857	10.965	9.670	6.845	7.490	8.263 n.s.
2003 RL	0.0 b	0.0 b	73 b	136 b	1519.5 a	478.7 b
2003 Bio	4.732 a	3.863 ab	1.585 cd	.347 d	2.299 c	2.578 bc
2004RL	0.0 b	376.0 b	833.0 b	633.7 b	3365.3 a	1071.8 b
2004 Bio	12.167	14.624	10.943	6.620	10.491	9.397 n.s.
2003 RL	0.0 c	0.0 c	41.7 c	317.0 bc	685.5 a	503.7 ab
2003 Bio	3.949 a	3.807 a	1.488 bc	.634 c	2.174 b	2.250 b
2004RL	0.0 c	144.0 c	1080.0 b	285.3 c	2040.0 a	994.0 b
2004 Bio	9.894	12.564	9.423	7.393	8.706	8.589 n.s.

2003 RL	0.0 c	0.0 c	172.5 bc	2.5 c	781.5 a	554.0 ab
2003 Bio	3.971 a	3.565 ab	1.469 de	1.218 e	2.347 cd	2.684 bc
2004RL	.3 d	0.0 d	346.3 cd	559.3 bcd	3034.7 a	1498.0 bc
2004 Bio	11.181	13.118	8.335	7.893	9.323	8.715 n.s.
2003 RL	0.0	0.3	80.5	104.7	759.7	238.2 n.s.
2003 Bio	2.948 a	1.226 c	1.649 bc	1.448 bc	1.882 bc	2.124 b
2004RL	112.5 b	12.0 b	335.5 b	209.8 b	2538.7 a	577.5 b
2004 Bio	8.108	6.969	6.660	7.495	7.542	7.054 n.s.
2003 RL	0.0 c	0.0 c	210.7 c	305.0 bc	879.2 a	802.5 ab
2003 Bio	1.839 a	1.916 a	1.175 b	1.110 b	1.260 b	1.273 b
2004RL	.3 d	.5 d	608.3 cd	697.5 cd	2554.7 a	1751.0 ab
2004 Bio	4.254 ab	4.505 a	2.690 c	3.138 bc	3.155 bc	2.288 c
2003 RL	0.0 b	0.2 b	253.7 ab	410.5 ab	707.2 a	760.5 a
2003 Bio	1.482 a	1.332 ab	.866 abc	.725 bc	.303 c	1.510 a
2004RL	4.0	25.5	865.3	953.8	1466.7	1010.0 n.s.
2004 Bio	12.063	11.589	9.153	8.463	5.301	10.294 n.s.
2003 RL	0.0	0.0	.	11.0	2.5	9.5 n.s.
2003 Bio	0.032	0.031	.	0.025	0.014	0.021 n.s.
2004RL	0.3	0.0	.	820.5	1209.0	2102.0 n.s.
2004 Bio	1.961	3.479	.	2.210	1.236	1.688 n.s.
2003 RL	0.0	0.0	.	0.0	5.3	4.5 n.s.
2003 Bio	0.089	0.06	.	0.079	0.049	0.079 n.s.
2004RL	165.0	0.0	.	247.5	1440.0	830.8 n.s.
2004 Bio	3.676	3.411	.	3.923	3.377	2.985 n.s.