California Cling Peach Board
ANNUAL REPORT-2009

Project Title: **IMPROVED ROOTSTOCKS FOR PEACH AND NECTARINE**

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Summary

The objective of this project is to develop genetically improved rootstocks for peach and nectarine that combine tree size control and resistance to important diseases and pests including nematodes. Fifty rootstocks were planted, in replicated trials, at the Kearney Agricultural Center (KAC) in 2003 through 2007. Most of these rootstocks are root-knot nematode resistant and have the potential for tree size control.

Data from a previous replicated trial at KAC identified three rootstocks from crosses of Harrow Blood peach x Okinawa peach, made by our program, that had significant size-controlling potential (selections HBOK32, HBOK10 and HBOK50, in descending order of apparent size-controlling effect). These rootstocks were also shown to be resistant to root knot nematode. Selections HBOK32 and HBOK10 were re-replicated at KAC in spring 2003 with O'Henry peach and the early nectarine May Fire. They were also grafted with Spring Crest peach and Summer Fire nectarine and planted in a replicated trial at KAC in February 2004. Selection HBOK50 was re-replicated at KAC with O'Henry peach only in spring 2003.

Data from the 2003 and 2004 plantings indicated that trees with O'Henry peach, and Springcrest peach, May Fire nectarine and Summer Fire nectarine scions on the HBOK 32 and HBOK10 rootstocks had significantly smaller trunk cross sectional areas and lower dormant and summer pruning weights than the same scions on Nemaguard rootstock. HBOK 50 rootstock that is nearly as big as trees on Nemaguard but provides an alternative Nemaguard that requires less pruning and is root-knot nematode resistant. Intensive studies of tree crop load and fruit size indicate that while trees on these rootstocks had slightly smaller average fruit sizes for specific crop loads per tree but the production of optimal size fruit for specific crop loads per tree were comparable to trees on Nemaguard rootstock.

O'Henry trees on HBOK27 rootstock appeared to be even more size-controlling than HBOK 32 or HBOK 10 and produced good crops with acceptable fruit size. O'Henry trees with a Nemaguard rootstock and a Controller 5™ inter-stem also had reduced tree size and good crops of acceptable sized fruit.

Three rootstocks from this trial, HBOK 32, HBOK 10 and HBOK 50, have been submitted for commercial release and be made commercially available as Controller 7 ™, Controller 8 ™ and Controller 9.5 ™ , respectively, beginning in 2010.

Problem and its Significance:

Many high quality scion varieties of peach and nectarine are available to producers, but relatively few rootstocks have been developed for the changing demands of the industry. In recent years there has been increasing interest in the development of size-reducing rootstocks for peaches and nectarines to reduce the labor costs involved in management and harvest of orchards. Also as the future availability of soil fumigants becomes increasingly uncertain, there is increased need for rootstocks with resistance/tolerance to soil-borne pests and diseases. To develop improved rootstocks that combine several elite traits, hybridization followed by selection is required. Within segregating seedling populations, it is possible to identify individuals that can be clonally propagated, thus developing considerable flexibility in rootstock options for growers.

The control of tree growth of peach and nectarine is usually accomplished by judicious use of management practices, i.e., planting density and pruning. However, even with the best management practices, the resultant large trees usually require large amounts of hand labor for tree care and the use of ladders for pruning, fruit thinning and harvest. An attractive alternative would be the management of tree growth by size-controlling rootstocks, such as are available for apple. This would allow trees to be managed from ground level without resultant loss of yield per acre or reduction in fruit quality while using current scion cultivars.

Several peach varieties and inter-specific hybrids have been reported to have growth controlling ability (e.g., Layne and Jui, 1994), but the inheritance of this trait is unknown. Some peach cultivars, including Harrow Blood, Siberian C, and Rubira, have shown growth controlling ability but these rootstocks are either not well adapted to California or are nematode susceptible. Concomitant with growth control in improved rootstocks is the need for resistance to nematodes and important diseases since the diminished availability of approved chemical control agents is likely to continue. New rootstocks should have nematode resistance similar to the levels found in current rootstocks, i.e., Nemaguard and Nemared. Additionally, resistance to bacterial canker would be desirable. None of the rootstocks currently in wide use has these combined attributes.

For each of the desired traits, there are several available sources of genetic materials that are potentially valuable for rootstock improvement. Resistance to root knot nematode is well defined and materials such as Okinawa, Nemared, Nemaguard, Flordaguard, etc. can be used as parents for hybridization (Sharpe, 1957; Sherman et al., 1991). However, genetic variability for growth control and bacterial canker resistance is less well defined. Therefore, systematic screening is needed to identify the most useful materials. We have done an extensive screening of *Prunus* germplasm and have identified candidate genotypes to be used as sources of resistance to crown gall disease (Bliss et al, 1999).

We also have screened a large number of *Prunus* genotypes for their resistance/susceptibility to the bacterial canker disease and root knot nematode.

<u>Goals and Procedures</u>

The goal of this project is to develop new rootstocks with pest resistance and tree size controlling ability that can be propagated economically by commercial nurseries for use with a wide range of California peach and nectarine varieties. Seedling populations from several hybrid crosses crosses have been screened for root-knot nematode resistance and size-controlling behavior. Selected genotypes form these populations have been tested in replicated production plots at the Kearney Research and Extension Center using O'Henry peach as the standard test scion cultivar and Nemaguard peach rootstock as the control. Selected rootstocks have also been tested with other scion cultivars.

Screening for graft compatibility with peach, root-knot nematode resistance and bacterial canker resistance is now complete. All rootstock selections from this program perform either comparable to, or better than Nemaguard rootstock in all these characteristics.

Current research is focused on describing and understanding the influence of the selected rootstocks on scion growth and fruit production. The primary criteria that we use to evaluate scion growth are summer and dormant pruning weights are the trees are pruned by commercial field crews and growth in trunk cross sectional area. In summer of 2009 we initiated intensive studies cropping behavior and individually sized every fruit from each tree of the 6 rootstocks that we are primarily interested in (HBOK 32, HBOK 10, HBOK 50, HBOK 28, HBOK 27) and Nemaguard.

This year we will report a summary the performance results since the plots were planted for the rootstocks that are of primary interest to us at this point in the project. We also took trunk cross sectional area, pruning weight, and general fruit production data on trees on all the other rootstocks in the field plots (for list of rootstocks in field plots see Tables 1-4) but those data will not be presented in this report for the sake of brevity.

<u>Results:</u>

<u>Plantings:</u>

A total of 50 rootstocks with various scions are being tested in this project at Kearney Ag Center. The majority of these rootstocks have been developed by this project, hove root-knot nematode resistance and have the potential for size-controlling. Tables 1, 2, 3, and 4 list the rootstocks and scions that are being tested in replicated trials planted in 2003, 2004, 2005 and 2007, respectively.

Data from the 2003 plot:

Effectiveness of the rootstocks in controlling tree size can best be shown by comparisons of seasonal growth in trunk cross sectional area(TCA). O"Henry and May Fire trees on HBOK 10 and HBOK 32 have been consistently smaller than trees on Nemaguard (and HBOK 50 for O'Henry (Figure 1). These differences in tree size also translated into consistent differences in the need for summer and winter pruning (Figures 2 and 3).

Fruit yield of O'Henry trees on HBOK 10 and 32 tended to be somewhat less than yields of trees on Nemaguard or HBOK 50 as expected because of the reduced tree size. Similar yield reductions were not as clear for May Fire trees (Figure 4).

Data from the 2004 plot:

Springcrest peach and Summer Fire nectarine trees on HBOK 32 and HBOK 10 were also significantly smaller than trees on Nemaguard rootstock as indicated by TCA (Figure 5) measurements and also required less pruning (Figures 6 and 7). Similarly trees on HBOK 27 and 28 were also smaller than trees of the same age on Nemaguard and required less pruning (Figures 5, 6 and 7). O'Henry the trees on HBOK 28 appeared to perform similar to trees on O'Henry trees on HBOK 32 in the 2003 plot except that they are a year younger whereas trees on HBOK 27 are significantly smaller for their age.

As in years past the O'Henry trees with a Nemaguard rootstock and a K146-43 (Controller 5™) inter-stem had average TCA and pruning weights that were intermediate between trees on O"Henry and HBOK 27 (Figures 5,6 and 7). This combination continues to show promise as a means for achieving some vigor reduction while still using Nemaguard as a rootstock.

Interestingly, yields of Springcrest peach on Nemaguard were less than trees on HBOK 32 or 10 (Figure 8a). This was probably due to the extreme vigor of this cultivar on Nemaguard and the need for more dormant pruning in the previous winter. On the other hand, fruit yields of Summer Fire were very similar among all rootstocks even though the trees on HBOK 32 and 10 were significantly smaller (Figure 8b). Yields of O'Henry trees on HBOK 28 were similar to those on Nemaguard but trees on HBOK 27 and the C5 inter-stem were less than trees on Nemaguard (Figure 8c). The low yields of trees on the C5 inter-stem were probably not representative because a small thinning study was imposed on those trees and there are only 5 trees on this combination in the trial.

Fruit size vs. crop load analysis fruit from the 2003 and 2004 plots.

In the summer of 2009 we did intensive studies of crop load and fruit size on individual O'Henry peach and Summer Fire nectarine trees that were on the rootstocks of primary interest in the 2003 and 2004 plots. The fruit were harvested in three picks and the fruit from each tree were separately run over a fruit sizer from each pick. The data presented are means from the three picks.

The mean fruit size vs. crop load per tree relationships of O'Henry fruit on the four rootstocks analyzed in the 2003 plot corresponded with tree size differences. The slopes of the four relationships were parallel but had increasingly high y-intercepts that corresponded to differences in tree vigor (Figure 9a). However when the number of boxes per tree of the most valuable fruit (size 56 and larger) were calculated, differences between rootstock were much less pronounced and Nemaguard rootstock appeared to be superior only at very high crop loads (Figure 9b).

The Summer Fire fruit size vs. crop load relationships were even more interesting. The slopes of the relationships appeared to be different for trees on HBOK 32 and 10 compared to trees on Nemaguard and at moderate crop loads mean fruit sizes on HBOK 32 trees were comparable to trees on Nemaguard (Figure 10 a). Surprisingly the slopes of the relationships for calculated number of boxes of size 56 or greater fruit vs. crop load was identical for all three rootstocks but crop loads tended to be somewhat less on the less vigorous rootstocks (Figure 10b).

The fruit size vs. crop load data for the trees on the HBOK 27 and 28 rootstocks was even more promising. Trees on these two rootstocks appeared to have a slight mean fruit size advantage over trees on Nemaguard at low crop loads (Figure 11a) and the relationship between crop load and number of boxes of fruit sizes 56 and larger was similar for trees on HBOK 27 and Nemaguard (Figure 11b).

These analyses of the relationships between crop load and boxes of the most valuable fruit are very promising and indicate that when tree densities are adjusted to accommodate differences in tree size, the orchard yields of fruit that are in the most marketable size categories should be comparable to orchards planted on vigorous rootstocks. Furthermore, the vegetative growth data indicate that the vigor of trees on the size-controlling rootstocks should be easier to manage.

Data from the 2004 and 2007 plot:

The 2005 plot does not contain any rootstocks that are of primary at this time so none of the results of this plot are reported here. General trees size, pruning, and yield data were collected in this plot in 2009 and those data can be made available upon request. This plot is slated for removal in 2010.

It was too early to obtain meaningful trends on trees size, pruning weights or yields from the 2007 plot but the vegetative growth data for 2009 are summarized in Table 5.

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Table 1. Rootstocks in the 2003 planting at the Kearney Research and Education Center

Rootstock	Parents	Scions	Description
Adesoto	P. isititia selection	O'Henry	Size controlling; large fruit size
Barrier	P. persica x P. davidiana	O'Henry	Good tolerance to poor soils
Cadaman	(P. persica x P. dulcis) x P. davidiana	O'Henry	Low vigour; resistant to RKN** and LN***.
HBOK 1	Harrow Blood x Okinawa	O'Henry	Size controlling; resistant to RKN.
HBOK 2	Harrow Blood x Okinawa	O'Henry	Size controlling; resistant to RKN.
HBOK 8	Harrow Blood x Okinawa	O'Henry	Size controlling; resistant to RKN.
HBOK 10	Harrow Blood x Okinawa	O'Henry May Fire	Size controlling; resistant to RKN.
HBOK 18	Harrow Blood x Okinawa	O'Henry	Size controlling; resistant to RKN.
HBOK 32	Harrow Blood x Okinawa	O'Henry May Fire	Size controlling; resistant to RKN.
HBOK 50	Harrow Blood x Okinawa	O'Henry	Size controlling; resistant to RKN and LN.
Ishtara	Belsiana plum (P. cerasifera x P. salicina) x (natural hybrid of P. ceracifera x P. persica)	O'Henry	Size-controlling; resistant to RKN and LN but susceptible to LN if both RKN and LN are present in the soil.
Sapalta 3	Sapalta-OP (P. bessyi x P. salicina)	O'Henry	Size controlling; resistant to RKN.
Sapalta 24	Sapalta-OP (P. bessyi x P. salicina)	O'Henry	Size controlling; resistant to RKN.
Nemaguard	Control	O'Henry May Fire	Vigorous; resistant to RKN

RKN** = Root Knot Nematode.
LN*** = Lesion nematode.

Table 2. Rootstocks in the 2004 planting at the Kearney Research and Education Center.

Rootstock	Parents	Scions	Description
HBOK5	Harrow Blood x Okinawa	O'Henry	Size controlling; resistant to RKN**.
HBOK9	Harrow Blood x Okinawa	O'Henry	Size controlling; resistant to RKN.
HBOK10	Harrow Blood x Okinawa	Summer Fire Spring Crest	Size controlling; resistant to RKN.
HBOK27	Harrow Blood x Okinawa	O'Henry	Size controlling; resistant to RKN.
HBOK28	Harrow Blood x Okinawa	O'Henry	Size controlling; resistant to RKN.
HBOK 29	Harrow Blood x Okinawa	O'Henry	Size controlling; resistant to RKN.
HBOK32	Harrow Blood x Okinawa	Summer Fire Spring Crest	Size controlling; resistant to RKN.
HBOK36	Harrow Blood x Okinawa	O'Henry	Size controlling; resistant to RKN.
HBOK121	Harrow Blood x Okinawa	O'Henry	Size-controlling; resistant to RKN.
HBOK122	Harrow Blood x Okinawa	O'Henry	Size controlling; resistant to RKN.
HBOK123	Harrow Blood x Okinawa	O'Henry	Size controlling; resistant to RKN.
HBOK138	Harrow Blood x Okinawa	O'Henry	Size controlling; resistant to RKN.
HBOK144	Harrow Blood x Okinawa	O'Henry	Size controlling; resistant to RKN.
HBOK160	Harrow Blood x Okinawa	O'Henry	Size controlling; resistant to RKN.
Hiawatha	OP of *P. besseyi* x *P. salicina*	O'Henry	Size controlling.
K146-43	*P. salicina x P. persica*	O'Henry	Size controlling; resistant to RKN.
KV84068-S		O'Henry	Size controlling; resistant to RKN.
Rubira		O'Henry	Size controlling; resistant to RKN.
WP 31	Weeping peach OP seedling	O'Henry	Size controlling; resistant to RKN.
WP 3	Weeping peach OP seedling	O'Henry	Size controlling; resistant to RKN.
Nemaguard	(control)	O'Henry Summer Fire Spring Crest	Vigorous; resistant to RKN

RKN** = Root Knot Nematode.

Table 3. Rootstocks in the 2005 planting at the Kearney Research and Education Center.

Rootstock	Parents	Scions	Description
HBOK 155	Harrow Blood x Okinawa	O'Henry	Size controlling; resistant to RKN**.
HBOK 162	Harrow Blood x Okinawa	O'Henry	Size controlling; resistant to RKN.
Bl 19,T110		O'Henry	Size controlling; resistant to RKN.
Bl 19,T71		O'Henry	Size controlling; resistant to RKN.
FLKV 84	Flordaguard x KV84068	O'Henry	Size controlling; resistant to RKN.
FLKV 77	Flordaguard x KV77015	O'Henry	Size controlling; resistant to RKN.
Weeping 1	Weeping peach OP	O'Henry	Size controlling; resistant to RKN.
Weeping 2	Weeping peach OP	O'Henry	Size controlling; resistant to RKN.
HBOK121	Nemaguard (control)	O'Henry	Size-controlling; resistant to RKN.

RKN** = Root Knot Nematode.

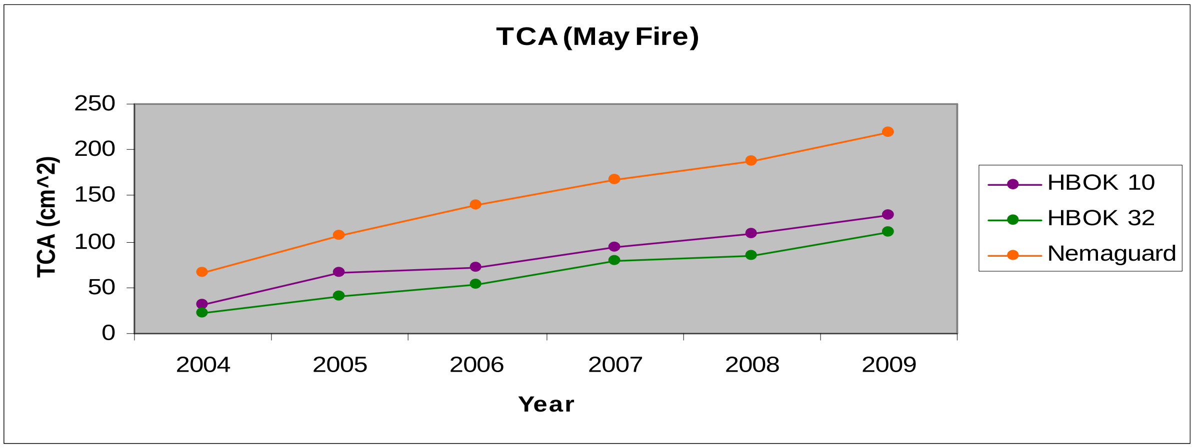
Table 4 Rootstocks in the 2007 planting at the Kearney Research and Education Center.

Rootstock	Parents	Scions	Description
95-153-141	Harrow Blood x Okinawa-141	O'Henry	Size controlling; RKN resist.
94 94 17	Harrow Blood x Okinawa-17	O'Henry	Size controlling; RKN resist.
KV-1	KV84068(3-6) selfed	O'Henry	Size controlling; RKN resist.
FL X KV-1	Flordaguard x KV84068	O'Henry	Size controlling; RKN resist.
KV-2	KV77015 selfed	O'Henry	Size controlling; RKN resist.
KV-3	KV84068 selfed	O'Henry	Size controlling; RKN resist.
FL X Weep	FlordagxWeep. p.	O'Henry	Size controlling; RKN resist.
FL X KV-2	Flordaguard x KV84068	O'Henry	Size controlling; RKN resist.
KV-4	KV77015 selfed	O'Henry	Size controlling; RKN resist.
KV-5	KV77015 selfed	O'Henry	Size controlling; RKN resist.
KV-6	KV84068 selfed	O'Henry	Size controlling; RKN resist.
HBOK10	Harrow Blood x Okinawa	Loadel Riegels Ross	Size controlling; resistant to RKN.
HBOK32	Harrow Blood x Okinawa	Loadel Riegels Ross	Size controlling; resistant to RKN.
Nemaguard	control	O'Henry Loadel Riegels Ross	Vigorous; resistant to RKN.

RKN** = Root Knot Nematode.

Table 5. Vegetative vigor indicators of rootstocks in the 2007 planting at the Kearney Research and Education Center.

Rootstock	Scions	TCA (cm^2)	Summer Prunings (kg/tree)
95-153-141	O'Henry	63.2	2.13
94 94 17	O'Henry	73.1	3.11
KV-1	O'Henry	29.9	1.08
FL X KV-1	O'Henry	50.5	2.63
KV-2	O'Henry	35.7	1.95
KV-3	O'Henry	35.3	1.55
FL X Weep	O'Henry	47.7	2.44
FL X KV-2	O'Henry	43.1	2.47
KV-4	O'Henry	45.7	2.71
KV-5	O'Henry	39.6	1.94
KV-6	O'Henry	32.6	1.56
HBOK10	Loadel	26.9	2.48
	Riegels	28.7	1.32
	Ross	31.3	1.54
HBOK32	Loadel	34.0	1.88
	Riegels	30.1	1.36
	Ross	36.3	1.97
Nemared	O'Henry	61.5	3.19
	Loadel	43.5	2.49
	Riegels	62.2	3.48
	Ross	67.1	4.26



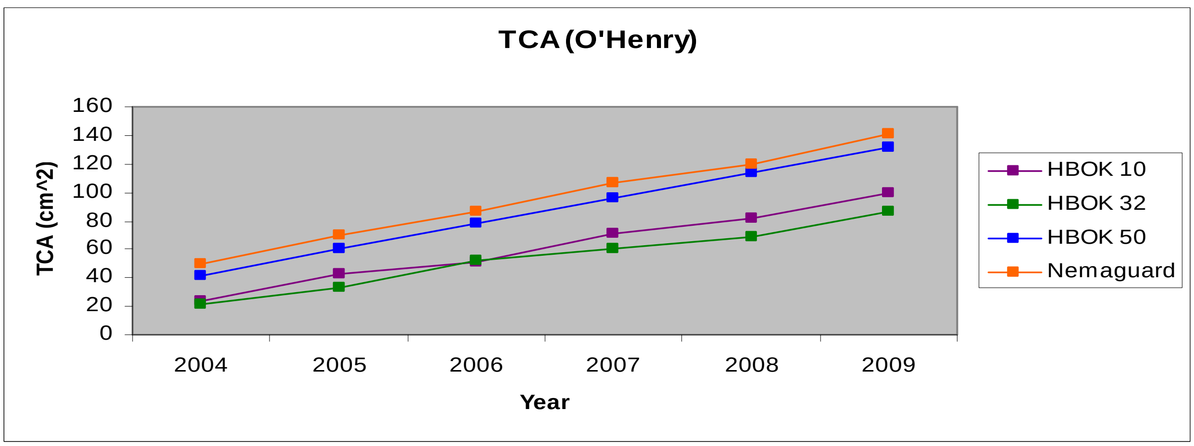
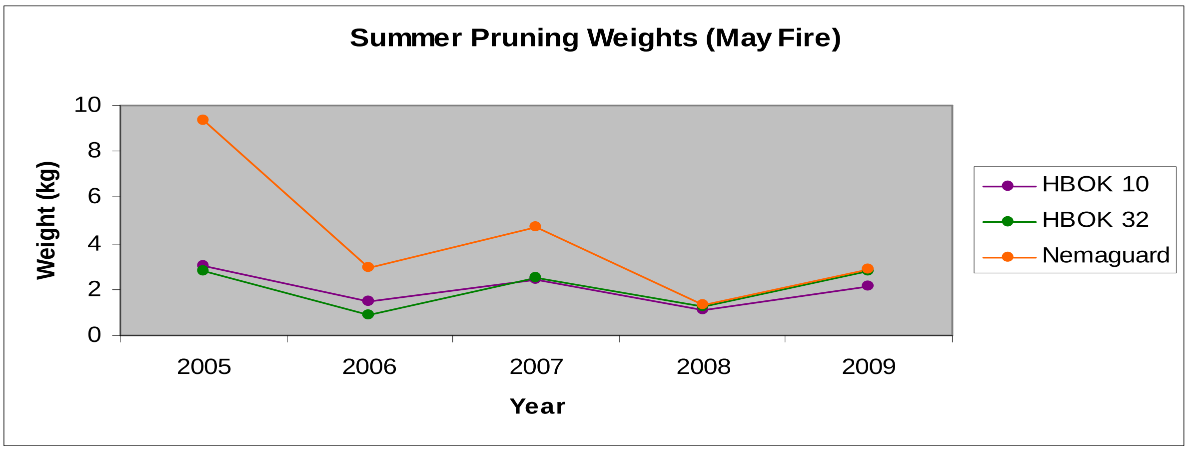


Figure 1. The seasonal progression of mean trunk cross sectional area of May Fire nectarine and O'Henry peach trees on HBOK 10, 32 and 50 rootstocks compared to trees on Nemaguard.



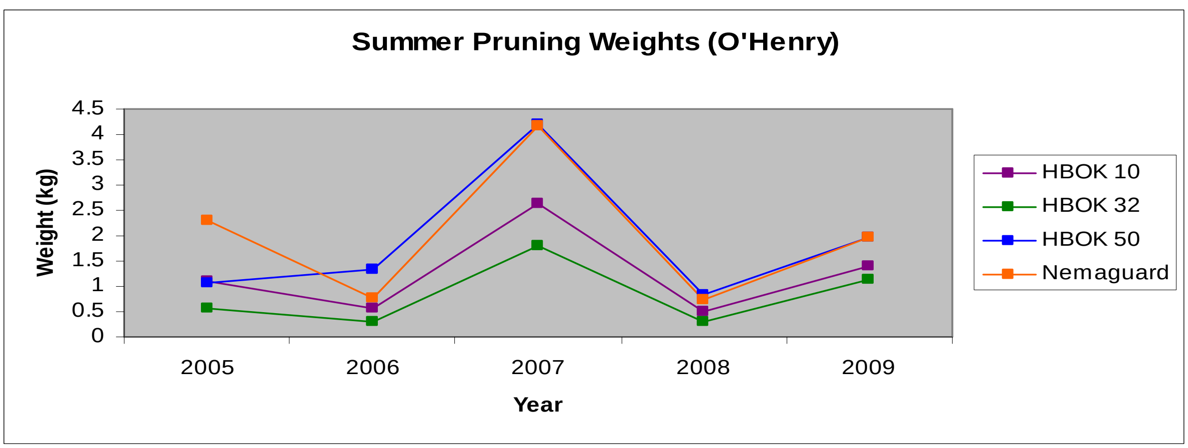
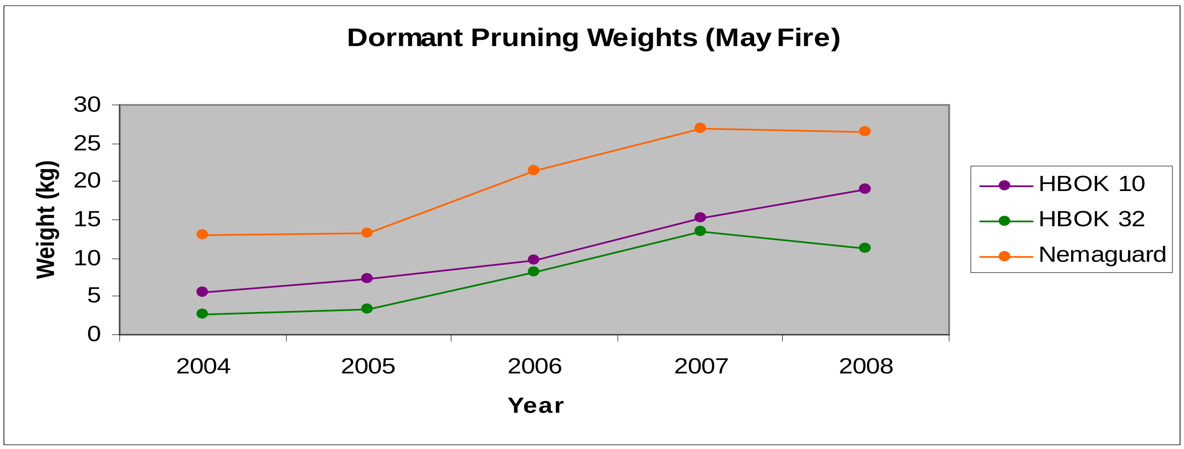


Figure 2. The seasonal progression of summer pruning weights of May Fire nectarine and O'Henry peach trees on HBOK 10, 32 and 50 rootstocks compared to trees on Nemaguard in the 2003 plot.



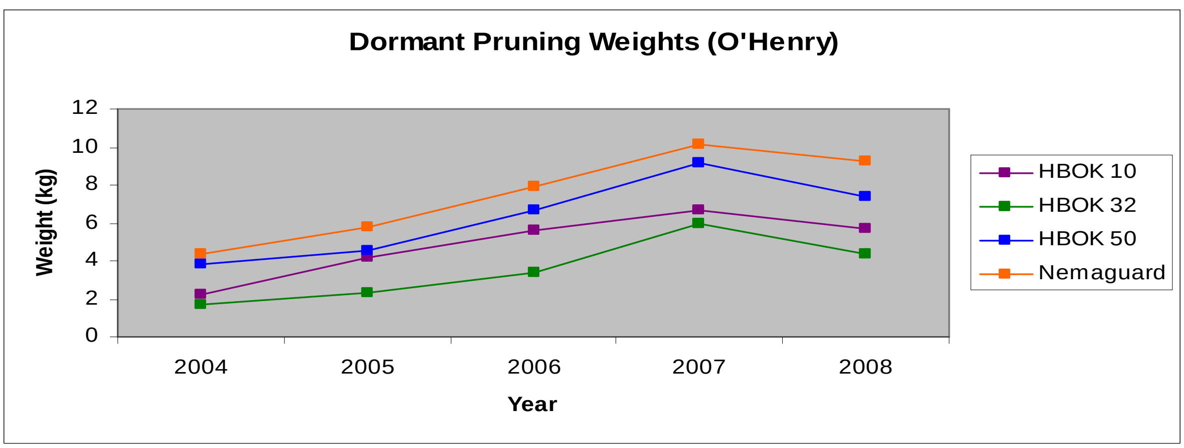
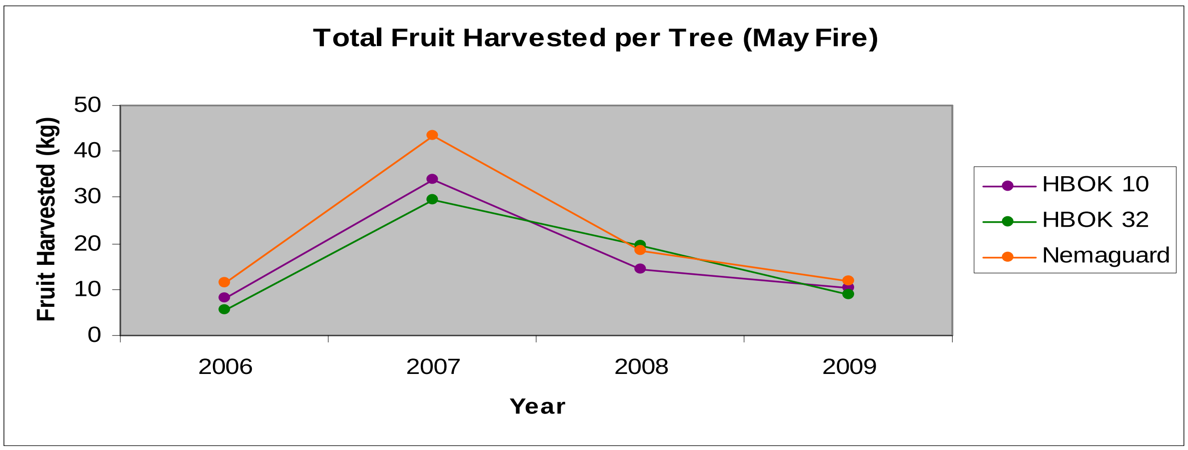


Figure 3. The seasonal progression of dormant pruning weights of May Fire nectarine and O'Henry peach trees on HBOK 10, 32 and 50 rootstocks compared to trees on Nemaguard in the 2003 plot.



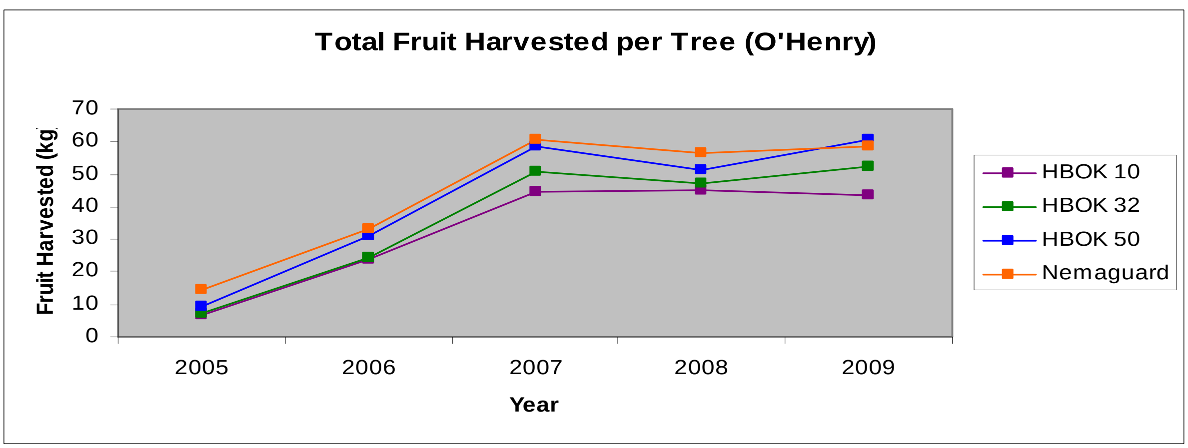
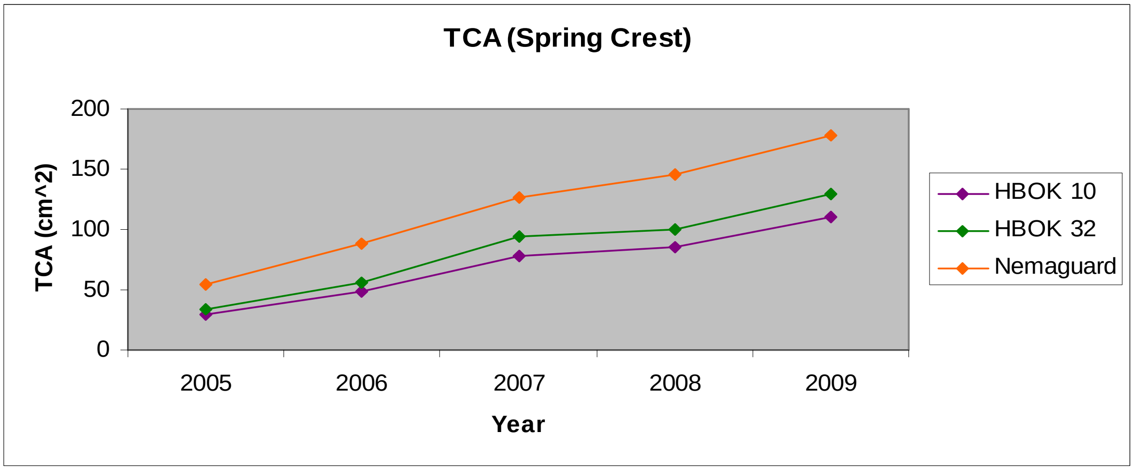
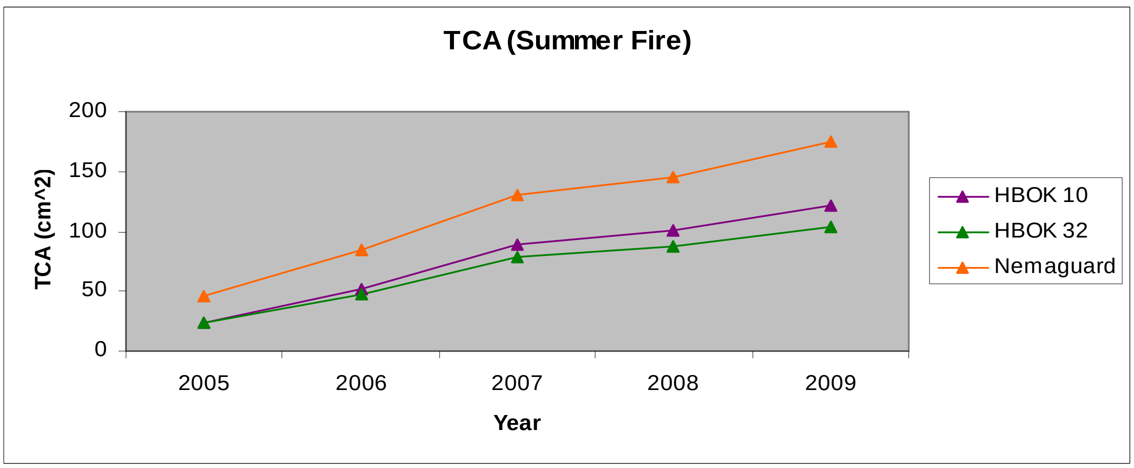


Figure 4. The seasonal progression of harvested yields of May Fire nectarine and O'Henry peach trees on HBOK 10, 32 and 50 rootstocks compared to trees on Nemaguard in the 2003 plot.





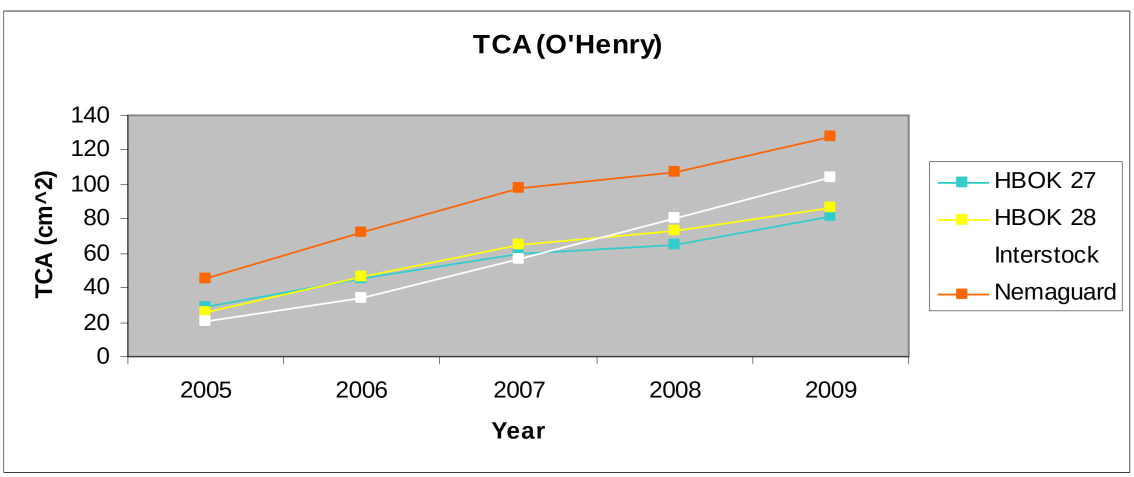
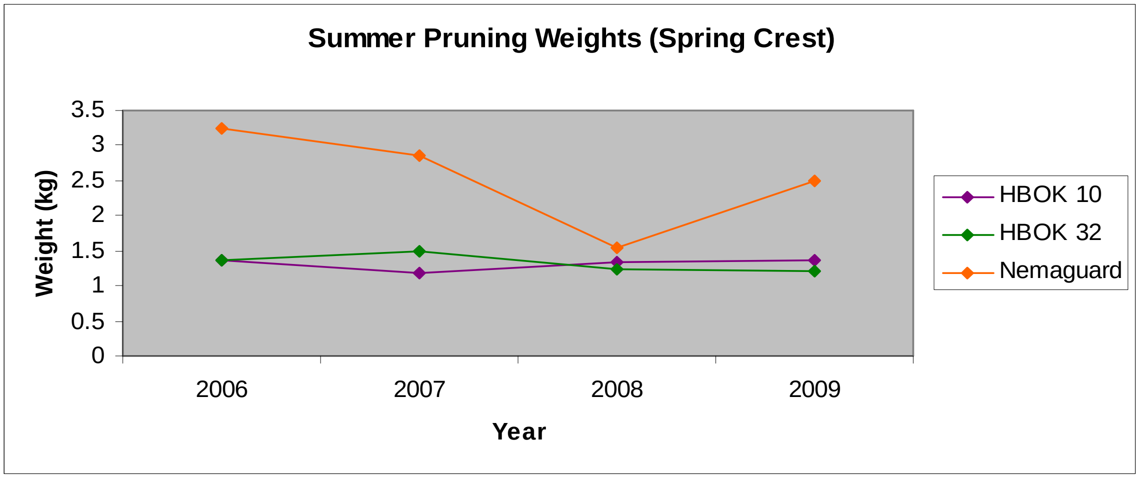
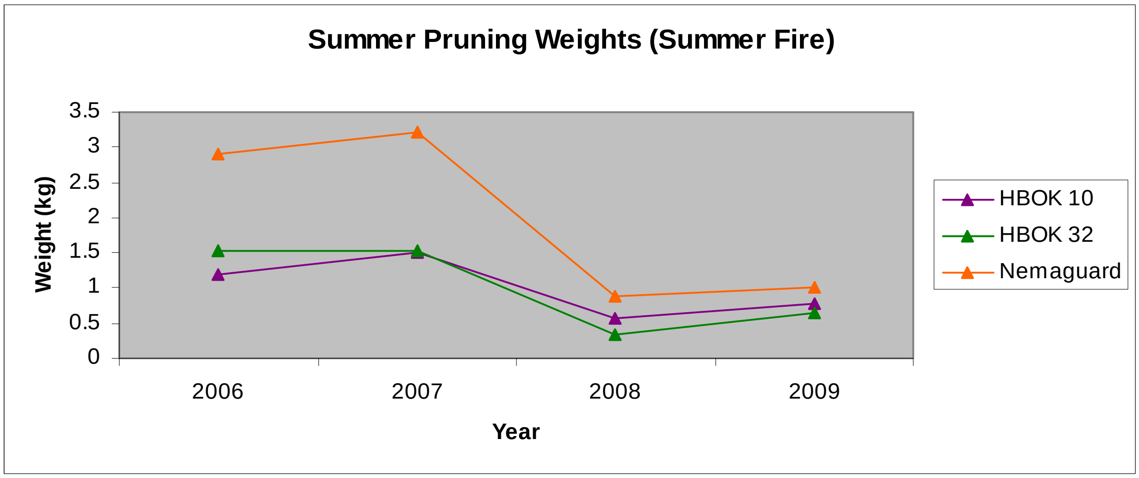


Figure 5. The seasonal progression of mean trunk cross sectional area (TCA) of Springcrest peach, Summer Fire nectarine on HBOK 10 and 32 rootstocks and O'Henry peach trees on HBOK 27, HBOK 28 and Controller 5^{TM} compared to trees on Nemaguard in the 2004 plot.





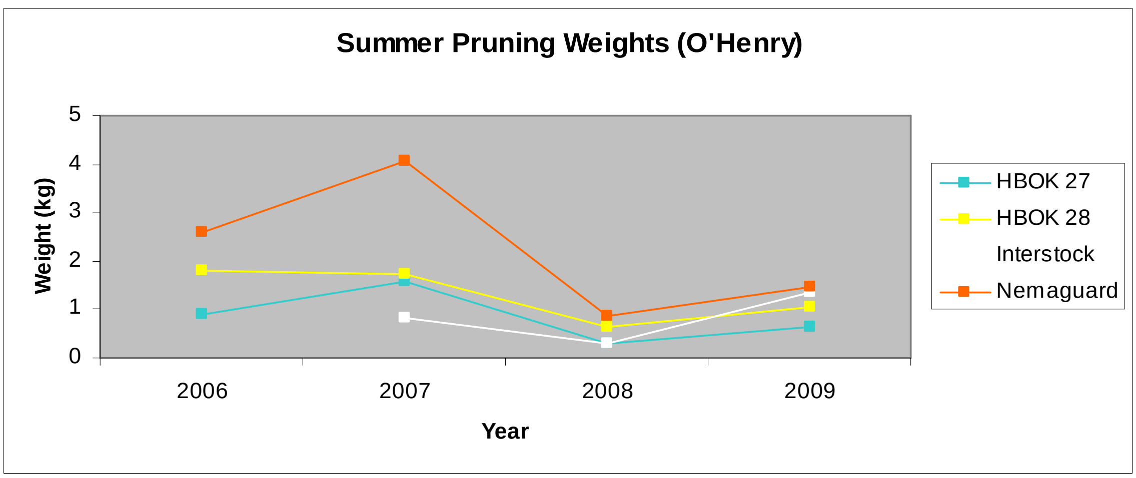
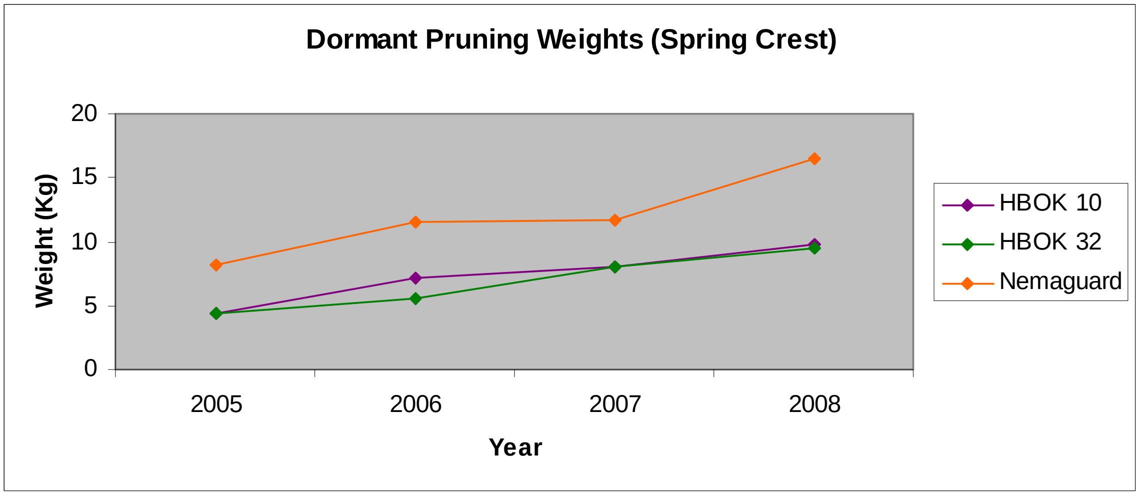
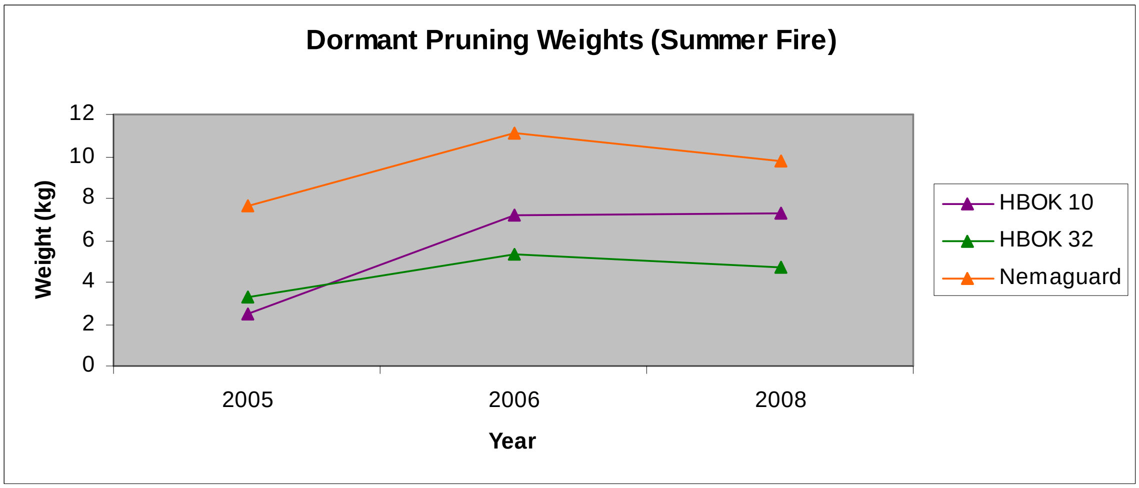


Figure 6. The seasonal progression of mean summer pruning weights of Springcrest peach, Summer Fire nectarine on HBOK 10 and 32 rootstocks and O'Henry peach trees on HBOK 27, HBOK 28 and Controller 5™ compared to trees on Nemaguard in the 2004 plot.





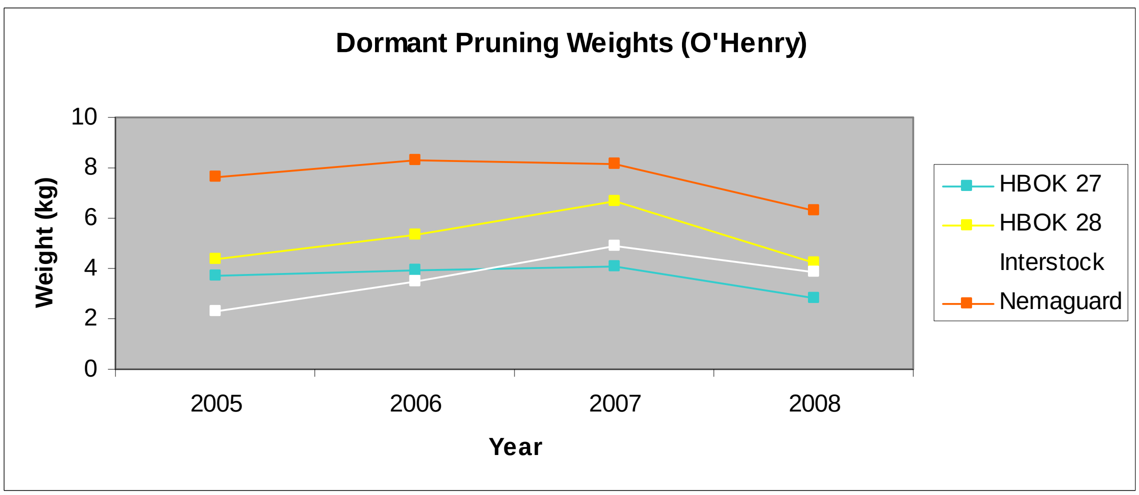
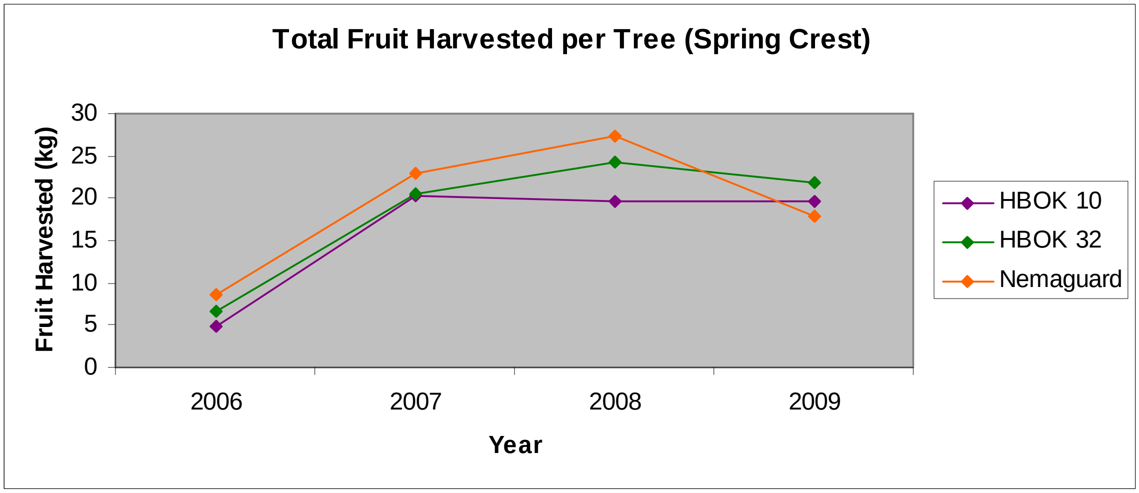
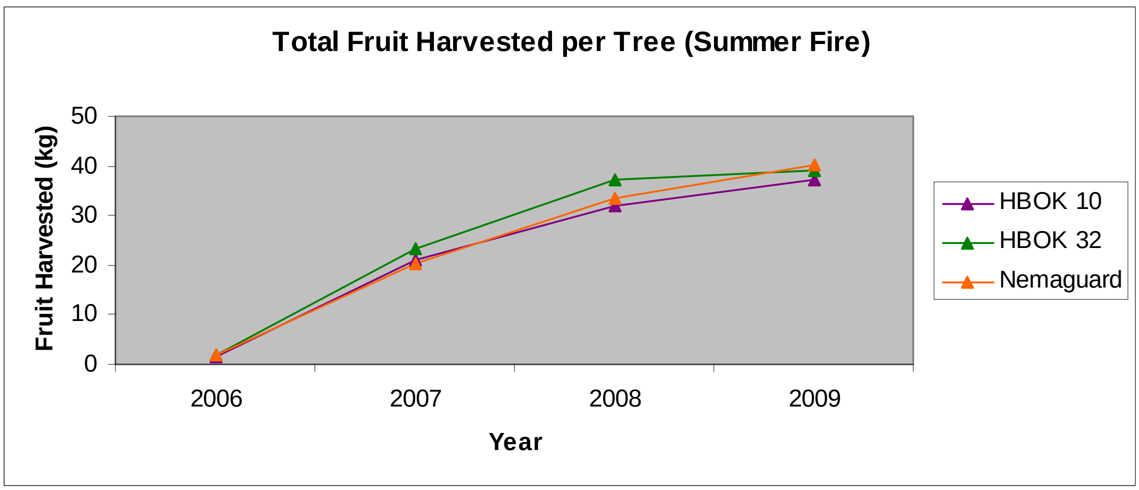


Figure 6. The seasonal progression of mean dormant pruning weights of Springcrest peach, Summer Fire nectarine on HBOK 10 and 32 rootstocks and

O'Henry peach trees on HBOK 27, HBOK 28 and Controller 5™ compared to trees on Nemaguard in the 2004 plot.





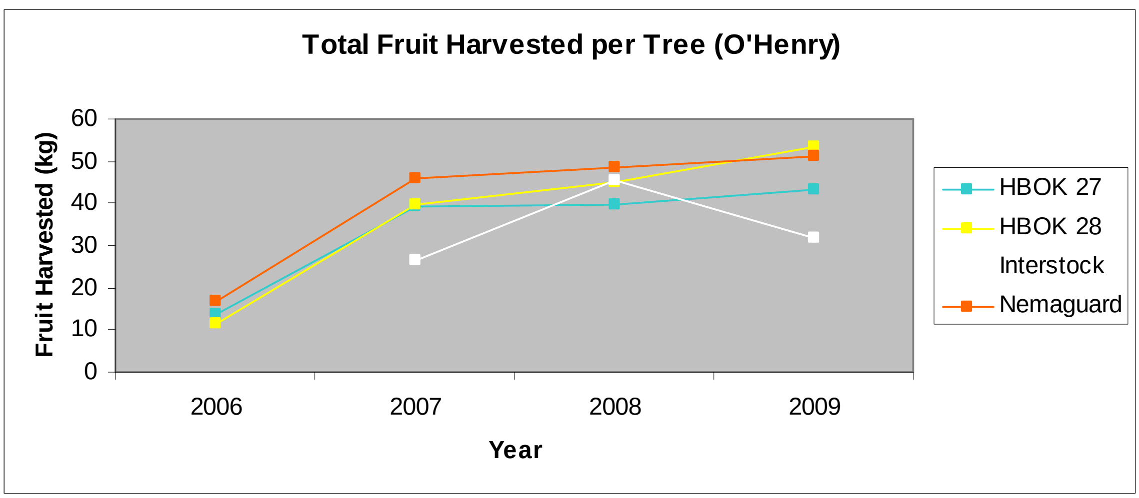
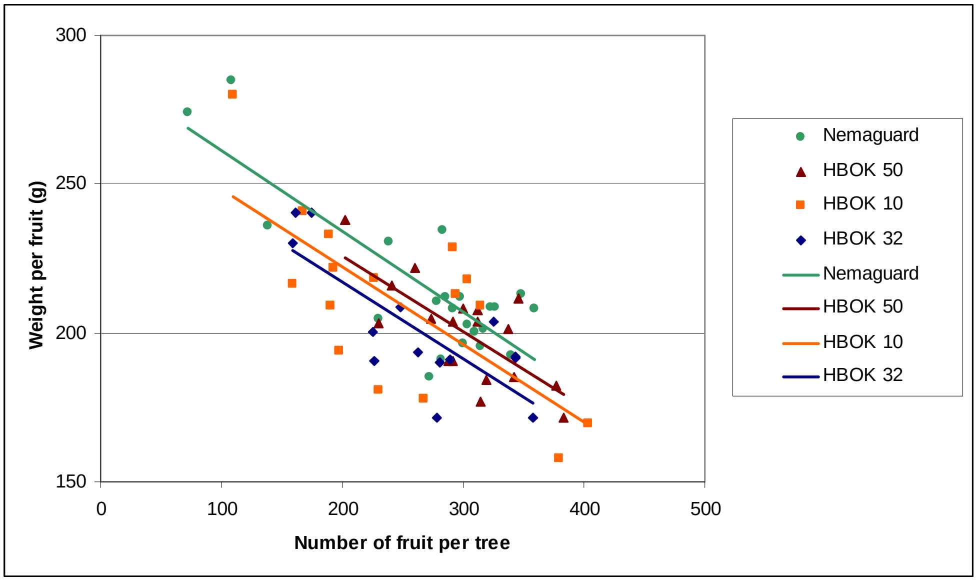


Figure 8. The seasonal progression of mean tree yields of Springcrest peach, Summer Fire nectarine on HBOK 10 and 32 rootstocks and O'Henry peach trees on HBOK 27, HBOK 28 and Controller 5™ compared to trees on Nemaguard in the 2004 plot.



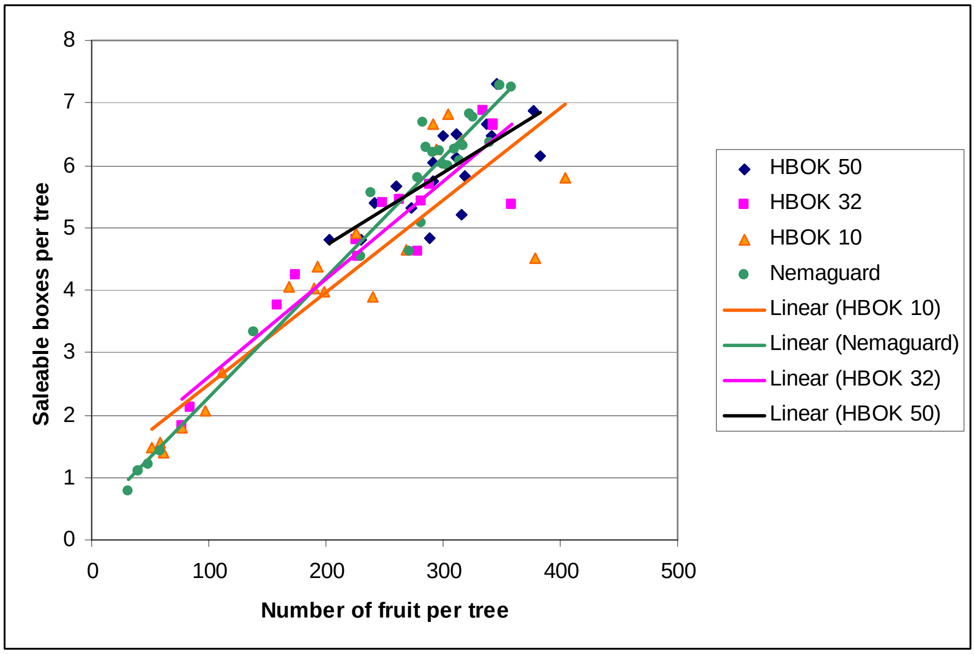
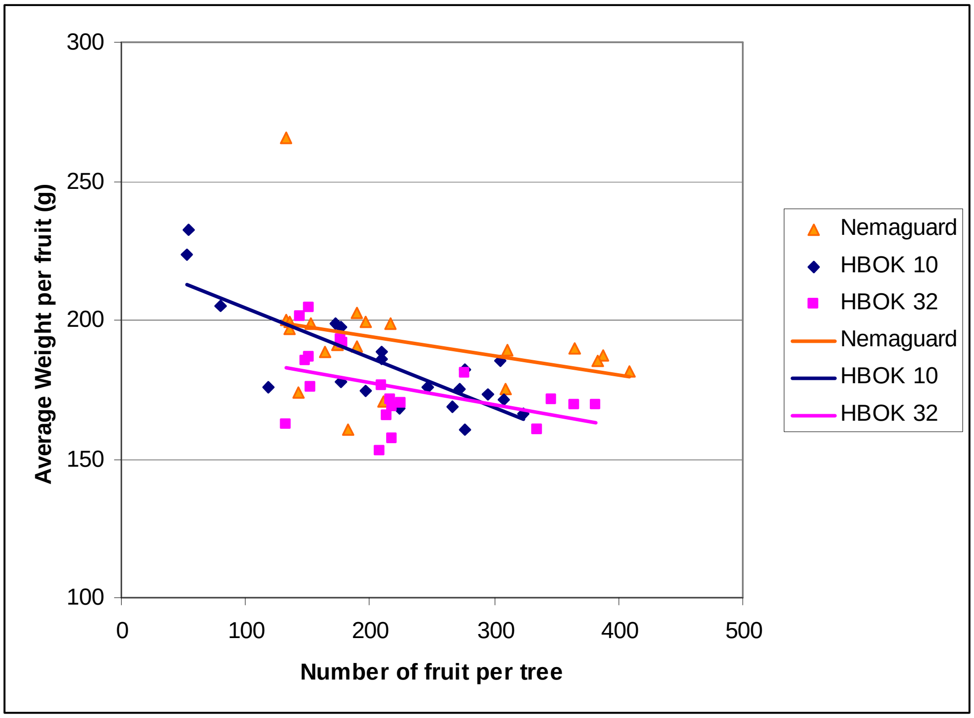


Figure 9. Relationships between mean weight per fruit and number of boxes of O'Henry fruit with fruit-per-box counts of 56 or less for trees on HBOK 10, 32 and 50 rootstocks compared to trees on Nemaguard in the 2003 plot.



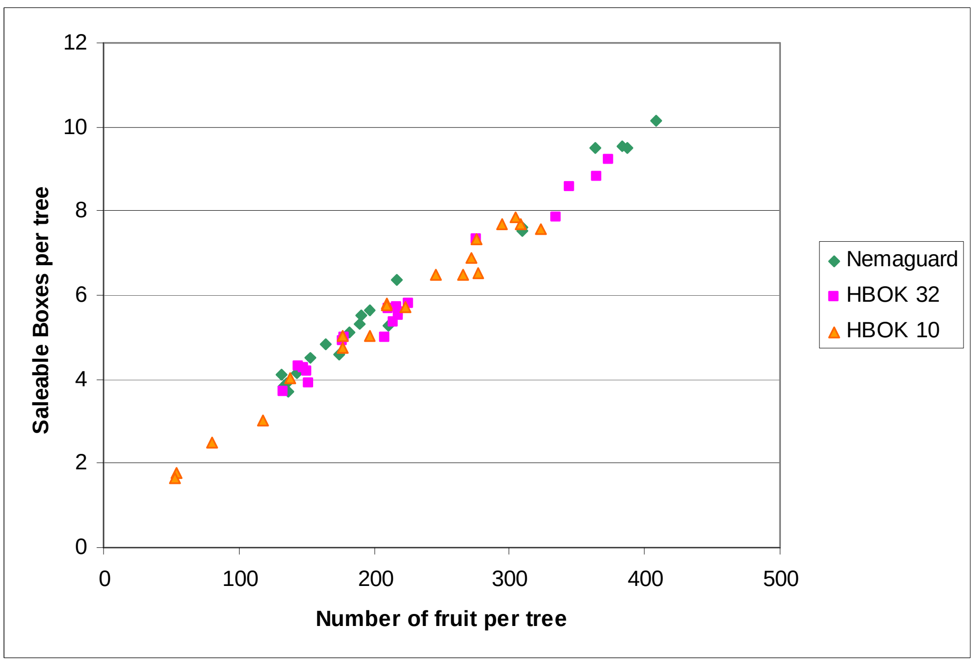
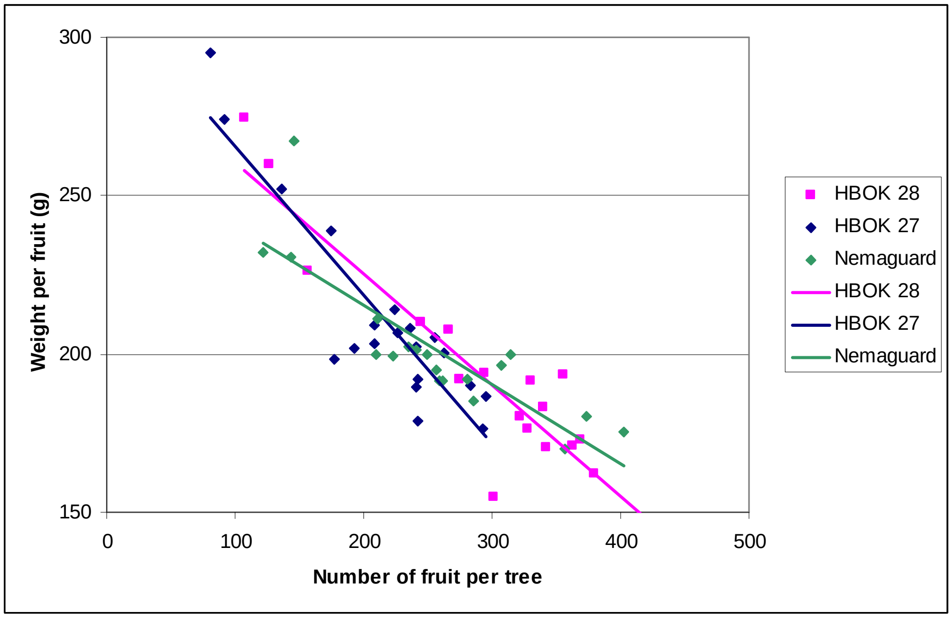


Figure 10. Relationships between mean weight per fruit and number of boxes of Summer Fire fruit with fruit-per-box counts of 56 or less, for trees on HBOK 10 and 32 rootstocks compared to trees on Nemaguard in the 2004 plot.



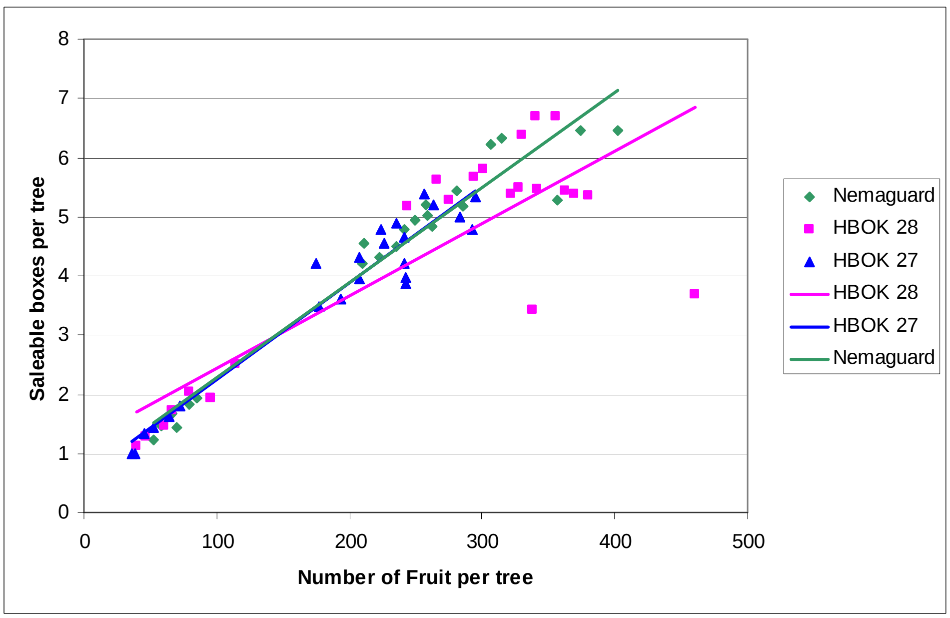


Figure 11. Relationships between mean weight per fruit and number of boxes of O'Henry peach fruit with fruit-per-box counts of 56 or less, for trees on HBOK 27 and 28 rootstocks compared to trees on Nemaguard in the 2004 plot.