Acacia koa genetic improvement

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The objectives of our koa genetic improvement are to collect *Acacia koa* germplasm in the Hawaiian Islands, to quantify the genetic variability among koa populations, to identify quality seed sources for reforestation, and to select superior koa as the basis for long-range genetic improvement programs. Progeny testing of *Acacia koa* population collected from natural areas is the basis for genetic improvement.

There are a total of more than 500 koa accessions collected by the University of Hawaii under Dr. Brewbaker's koa improvement program and HARC. Most of these accessions are made from single trees on the islands of Kauai, Oahu, Molokai, Maui, and Hawaii. They were tested in a series of progeny trials at the UH Hamakua Research Station (2000' elevation) on the Big Island and at the HARC Maunawili experimental station (600' elevation), on Oahu and (Table 1). Growth data of these trials at Maunawili and Hamakua were collected and analyzed. A study was also conducted to verify the koa breeding system using controlled selfing and crossing. The preliminary result revealed that *Acacia koa* is self-incompatible.

The koa populations clearly showed great variation in many characteristics: seed size, seed shape, seed weight, seedling growth, juvenile growth, earliness of phyllode development, phyllode, nectary, flowering pattern, duration of vegetative stage, tree form, and disease resistance. These variations are essentially genetic in origin and are useful in selecting superior progenies for tree improvement (Sun 1996; Sun et al. 1997; Daehler et al. 1999). For example, in the SET 91-1 koa progeny trial thirty months after planting, the average tree height was 6 m (ranging from 2 to 7.6), and the average DBH (diameter at breast height) was 7.6 cm (ranging from 2 to 11). The fastest growing trees of a single family were from Kauai (2PH1-1 and 2PK3-1), Oahu (1M6-2 and 1N2-5), and Maui (5K1-2) with an average DBH of 15 cm in five years (Table 2). After 8 years, some individual trees have exceeded 15 m in height and 25 cm in DBH. The SET 92-2 trial showed that koa trees in the mixed tree plots grew slower and had more mortality than koa trees grown alone (Table 3a and 3b). The results suggested that the idea of using other fast-growing trees like *Leucaena* as a guide tree to push koa grow straight and tall was not practical. The SET 94 and 95 trials at Maunawili and Hamakua clearly showed that there was a significant interaction between genotype and environment among the tested koa progenies. The fast growing families were mostly from Kauai. Estimated family heritabilities for both tree height and DBH from the SET 95 trials were 75%. Some progenies of the SET 95 trial produced seeds in the second year at Hamakua. Predicted genetic gain for the earliest family selection at two years was about 1.0 m in height and 15 mm in DBH.

Koa twig and stem (or trunk) borers are a problem for lower elevation koa reforestation. The twig borer was identified as *Xylosandrus compactus,* which is identical to coffee black twig borer and only be found on living koa twigs, and the stem (or trunk) borer was identified as *Xyloborus sp*. The secondary borers, *Hypothenemus sp.*, were also found on the dead koa twigs. No koa progeny or family has been identified to resist to borers, however, individual koa trees from some progenies at Maunawili 94-95 trials showed tolerent to borer attack. It is also interesting to notice that an assumed koa hybrid between a koa tree from Maui and one from

Hawaii showed promising for low elevation koa reforestation with borer tolerence, fast growing, and good tree form characters.

Future koa genetic improvement program will focus on collecting koa population as wide as possible to represent diverse koa population, especially on Maui. Seed collections will also be made in the areas where fast-growing koa families were identified, and these seeds will be composited as recommended provenance for koa reforestation program in Hawaii. Future progeny testing should include the advanced progenies selected from the fast-growing families, in addition to the newly collected koa accessions.

Reference

Sun, W. 1996. Genetic improvement of *Leucaena* and *Acacia koa*. Ph.D dissertation. Department of Horticulture, UH at Manoa. Honolulu, Hawaii.

Sun, W, J.L. Brewbaker, and M.T. Austin. 1997. Genetic variation of *Acacia koa* seed, seedlings, and early growth traits. Koa: A decade of growth. Hawaii Forestry Association Annual Symposium 1996.

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Table 1. SET Trials for *Acacia koa* genetic improvement

SET	Trials	Entry	Reps.	Location	Date planted
91-1	Koa Progeny	48	2	Hamakua, Hawaii	May 23, 1991
92-2	Koa & Leucaena	5(1)	3	Hamakua, Hawaii	May 27, 1992
93-1	Koa Progeny	14	3	Hamakua, Hawaii	May 27, 1993
94-1	Koa Progeny	43	2	Hamakua, Hawaii	May 26, 1994
94-3	Koa Progeny	59	2	Maunawili, Oahu	June 22, 1994
95-1	Koa Progeny	68	2	Hamakua, Hawaii	May 19, 1995
95-2	Koa Progeny	64	2	Maunawili, Oahu	June 1, 1995
96-1	Koa Progeny	59	2	Hamakua, Hawaii	May 23, 1996
96-2	Koa Progeny	63	2	Maunawili, Oahu	June 6, 1996
96-3	Koa demonstration	10	2	Hamakua, Hawaii	May 23, 1996
97-1	Koa progeny	77	2	Hamakua, Hawaii	May 21, 1996
97-2	Koa progeny	77	2	Maunawili, Oahu	may 28, 1996
99-2	Koa Progeny	50	2	Hamakua, Hawaii	July, 99
99-1	Koa progeny	50	3	Maunawili, Oahu	June, 99

Table 2. Average Tree Height (cm) and DBH (mm) of Acacia koa provenance (91-1)

Entry	Plant Height (cm) in month						DBH (mm) in month					
	7/91	11/91	7/92	11/92	7/93	12/93	5/93	12/93	6/94	12/94	5/95	5/96
	2	6	14	18	26	31	26	31	37	42	47	59
1M2-1 L	46	196	316	440	530	670	74	110	115	115	115	125
1M2-2 R	44	170	346	480		660	63	79	92	99	130	137
1M6-2	43	120	226	400	520	576	74	92	109	124	132	166
1M7-1 L	47	195	342	460	430	640	74	77	81	109	113	118
1M8-3	48	153	320	430	470	584	61	71	80	88	92	99
1M8-4	45	162	341	440	590	634	54	65	75	86	87	92
1MC	57	215	396	470	580	659	72	87	92	99	105	115
1N1-2 R	49	228	285	400		623	38	92	106	106	106	106
1N1-3	45	164	314	440	500	613	59	82	94	103	111	121
1N1-4	56	206	315	425	535	631	57	65	76	80	91	95
1N1-5	52	212	336	480	545	637	60	85	95	103	109	124
1N2-1	58	208	356	470	530	656	71	90	108	118	125	136
1N2-2 L	65	204	364	450	570	640	68	92	95	113	121	126
1N2-4 R	57	246	368	440		635	57	97	109	109	110	118
1N2-5 L	50	194	346	440	410	605	90	105	125	136	149	165
1N4-2	50	193	353	410	540	616	72	69	81	90	91	105
1PU1-2	43	161	285	402	498	550	55	69	72	78	93	93
1Pu2-1 R	46	203	390	470		690	67		95	111	117	126
1SL1-1 R	41	196	300	430		560	45	60	60	60	60	60
1SL3-1	41	147	264	375	475	547	53	63	70	74	74	89
1SL3-4 L	38	77	297	300	370	570	50	74	93	102	108	116
1SL3-5	42	182	293	390	480	528	47	65	70	75	81	89
2DT2-1 L	19	118	63	160	290							
2HA1C	57	193	341	418	518	651	66	81	92	101	110	127
2KU1-1	49	184	353	441	566	696	71	86	94	105	106	123
2KU2-1	58	176	314	405	545	615	64	79	90	102	102	117
2KU3-1 R	24	44	213	250		320	24	21	27			
2MA2-1 L	15	163	240	270	460	200	22					
2MA3-1	23	46	83	100			23					
2ML1-1	53	215	367	440	564	692	66	87	96	105	112	122
2NU2C	55	204	388	477	557	701	69	97	111	121	137	137
2OV1-1	27	58	126	200	320		20					
2PH1-1	44	159	287	415	550	629	75	94	107	116	120	159
2PH2-1	47	196	371	447	550	635	57	76	82	86	74	107
2PK3-1	40	163	265	465	610	630	77	97	127	127	127	159
5HM1-1 R	53	55	223	400		640	102	101	106	115	122	124
5K1-1	52	199	343	423	573	683	70	83	91	103	107	130
5K1-2	58	241	377	500	650	760	74	98	109	119	127	142
5K1-6 R	29	138	220	340		423	40	41	45	61	64	65
5OL1-2	47	161	222	357	365	471	45	51	57	57	68	68
6-0191	26	150	294	390	430	517	38	49	54	64	64	69
6-1288b	28	191	325	425	448	554	49	60	65	70	82	88
6-1288c	19	85	266	403	453	528	32	54	62	76	76	100
6-1288d	29	175	305	388	435	506	45	58	64	66	66	81
6KA1-1	34	153	300	453	540	653	56	73	82	101	101	114
6WA1-1 L	47	182	352	420	470	610	43	52	58	69	72	73
NFTA890C R	34	190	353	420		508	44	60	51	54	58	68
NFTA891C L	42	178	356	440	550	550	48	55	55	55	55	55
AVG.	43	168	302	402	499	593	57	75	84	94	99	109
MAX.	65	246	396	500	660	760	102	110	127	136	149	166
MIN.	15	44	63	100	290	200	20	21	27	54	55	55
LSD .05	11	50	67	56	120	100	19.4	18.6	23.4	29.8	32.9	38.5
LSD .01	15	68	92	77	165	137	25.3	26.6	32.2	41.1	45.3	59.0

Table 3a. Average plant height (m), DBH (cm), and survival rate (%) of five koa progenies interplanted with or without *Leucaena diversifolia* (K784) at different growth stages (0.5 to 5 years) at Hamakua, Hawaii

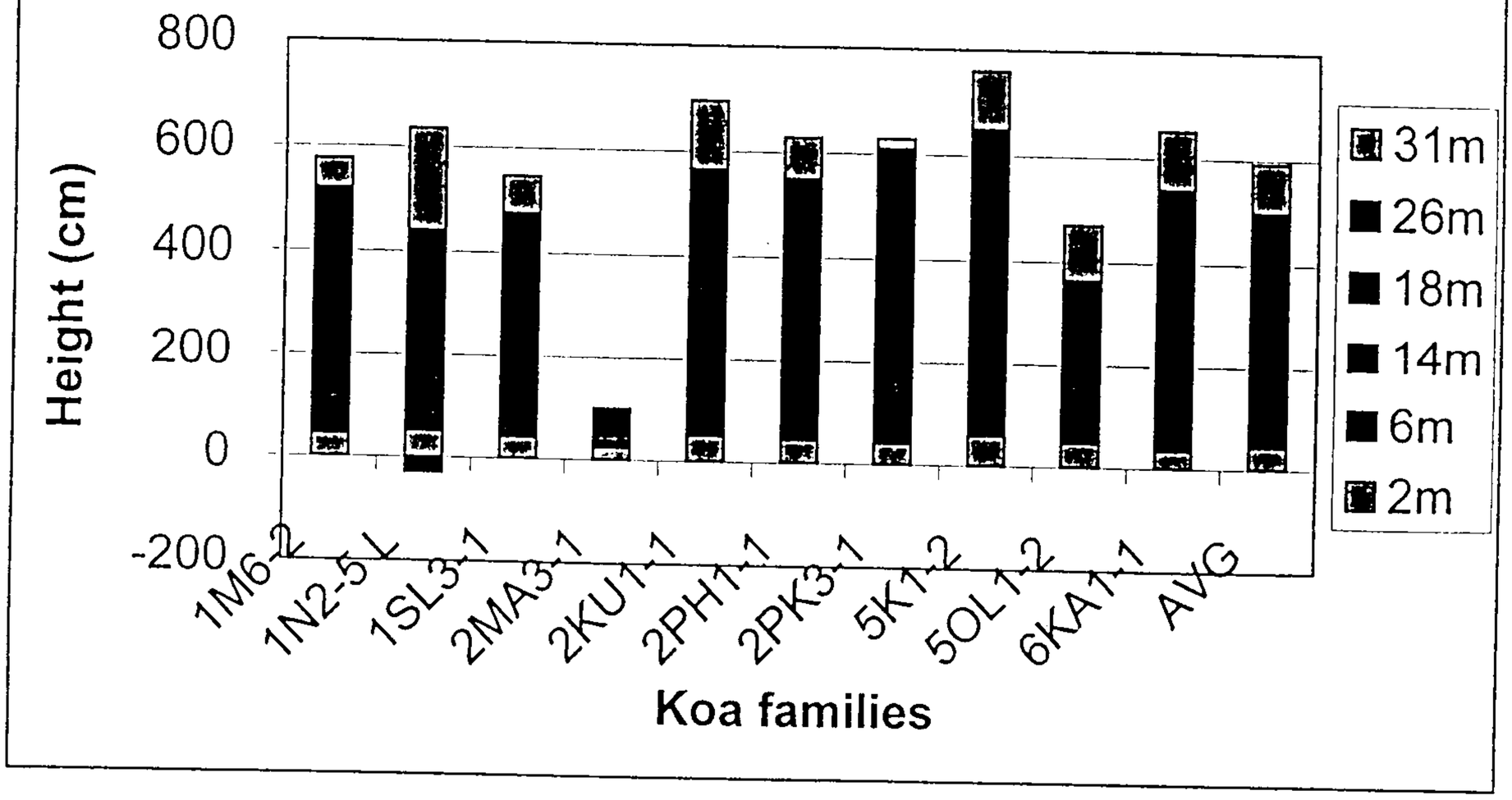
Progeny		HT (m)		DBH (cm)				Survival rate (%)		
	Leucaena	0.5	2	2	3	4	5	2	3	4
6-1188	Yes	1.2	3.3	4.1	5.7	6.2	6.2	89	81	77.8
	No	1.1	3.0	4.2	5.5	6.7	6.7	83	81	69.4
6-0191	Yes	1.0	3.1	3.5	4.7	5.6	7.3	72	64	41.7
	No	1.2	3.1	3.8	4.8	5.3	7.0	72	64	36.1
1PU1-1	Yes	1.2	3.5	6.0	8.3	9.2	11.1	83	69	66.7
	No	1.2	3.9	7.0	9.6	10.5	11.3	75	69	61.1
2ML1-1	Yes	1.3	4.7	6.3	8.1	9.9	11.2	100	100	86.1
	No	1.2	4.7	7.0	9.7	10.6	12.3	81	69	69.4
2PH2-1	Yes	1.2	4.3	7.0	8.5	8.9	9.9	94	94	80.6
	No	1.3	5.0	9.1	11.3	11.5	14.1	94	94	75
AVG		1.2	3.7	5.8	7.2	8.5	9.7	84	79	66.4
LSD.05			0.5	1.1	1.4	1.7	2.5			

Table 3b. Analysis of variance for plant height, DBH, and survival rate of five koa progenies interplanted with or without *Leucaena diversifolia* (K784) at different growth stages (0.5 to 5 years) at Hamakua, Hawaii

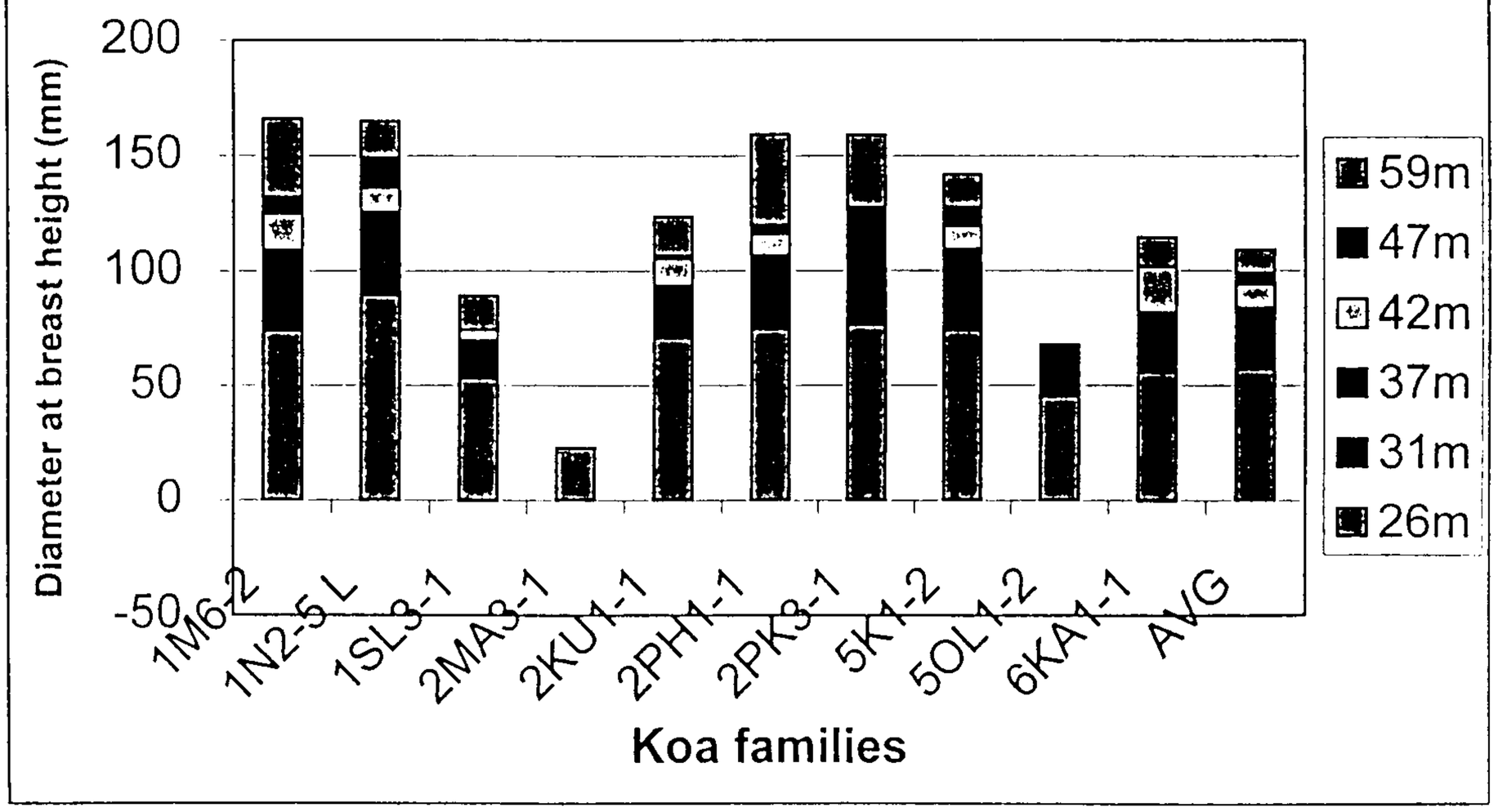
		Height		DBH				Surv. Rate		
Source	Df	0.5	2	2	3	4	5	2	3	4
Var.	4	NS	**	**	**	**	**	NS	NS	NS
Rep.	2	NS	NS	NS	NS	*	NS	NS	NS	NS
Error a	8									
L+ vs L-	1	NS	NS	**	**	*	*	NS	NS	NS
L x Var.	4	NS	**	NS	*	NS	NS	NS	NS	NS
Error b	10									
Total	29									

**: at P<0.01 level and * : P< 0.05 level

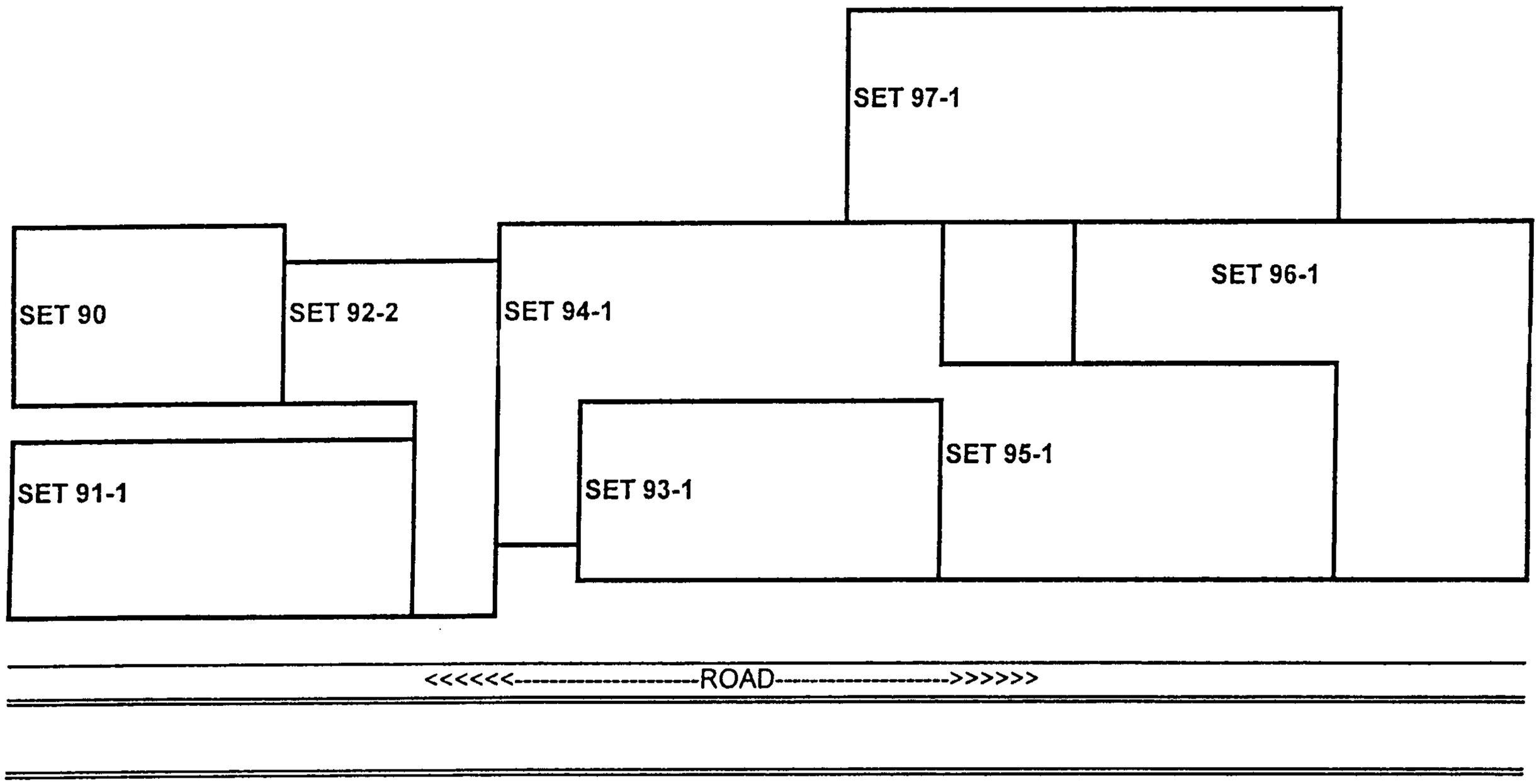
Growth of koa families in two and half years at Hamakua , Hawaii



Growth of koa families in five years at Hamakua, Hawaii



Hamakua Koa trial field layout



Growth of koa families in two and half years at Hamakua , Hawaii