CHAPTER 4

Results

4.1 Field results:

Two out of the five species tested achieved acceptable germination and seedling establishment rates in the field. The best treatments were biosolids + fertilizer and the control.

4.1.1 Species effects:

Some species were more suitable for direct seeding than others. The comparisons among the species tested, described below, allow selection of the species, most likely to establish well by direct seeding.

4.1.1.1 Seed germination:

Averaging across all treatments, percent seed germination was highest for *A. xylocarpa* 88% , followed by *S. oleosa* 67.6% , *G. arborea* 28.1% , *E. cumini* 25.6% and *F. racemosa* 5.9% (Table 4-1). Differences among percent germination of species were statistically significant ANOVA ($p<0.05$). Subsequent t-tests revealed that percent germination of *Afzelia xylocarpa* and *Schleichera oleosa* was significantly higher, compared with the other species, consistently across all treatments whereas *G. arborea*, *E. cumini* ($p<0.05$) had significantly lower germination than the top two species and percent germination of *F. racemosa* was significantly the lowest of all the species tested in the field study ($p <0.05$) (Table 4-1).The significance ($p<0.05$) of differences in germination per cent among the species for each of the soil treatments is illustrated in Figure 4-1.

Table Error! No text of specified style in document.-1: Species mean across treatment of percent germination, MLD and seedling survival and establishment rates averaged across all treatments. ***Note: Standard errors are in brackets (SE).**

Species name	*Afzelia xylocarpa*	*Schleichera oleosa*	*Eugenia cumini*	*Gmelina arborea*	*Ficus racemosa*	Total	Avg.
Seed sown in one treatment	36	36	36	36	36		
No of seed sown in Five treatments	180	180	180	180	180		
No. of seed sown in three blocks	540	540	540	540	540		
No. of germinated seedlings	476	365	138	152	32	1,163	
Avg. percent germination of species in five treatments	88.1(2.55)[a]	67.6(3.24)[b]	25.6(3.95)[c]	28.1(4.28)[c]	5.9(1.03)[d]		
MLD	20(0.76)[c]	25(1.16)[b]	53(7.36)[a]	29(4.66)[abc]	53(11.10)[ab]		
No. of established seedlings (after 1 year).	244.0	216.0	49.0	22.0	21.0	552	
Percent establishment	45.2(1.61)[a]	40.0(3.29)[a]	9.07(1.14)[b]	4.07(1.03)[b]	3.89(1.56)[b]		20.44
Percent Mortality	48.6(2.13)[a]	57.4(5.81)[a]	61.2(6.58)[a]	83.5(6.04)[a]	42.6(19.07)[a]		

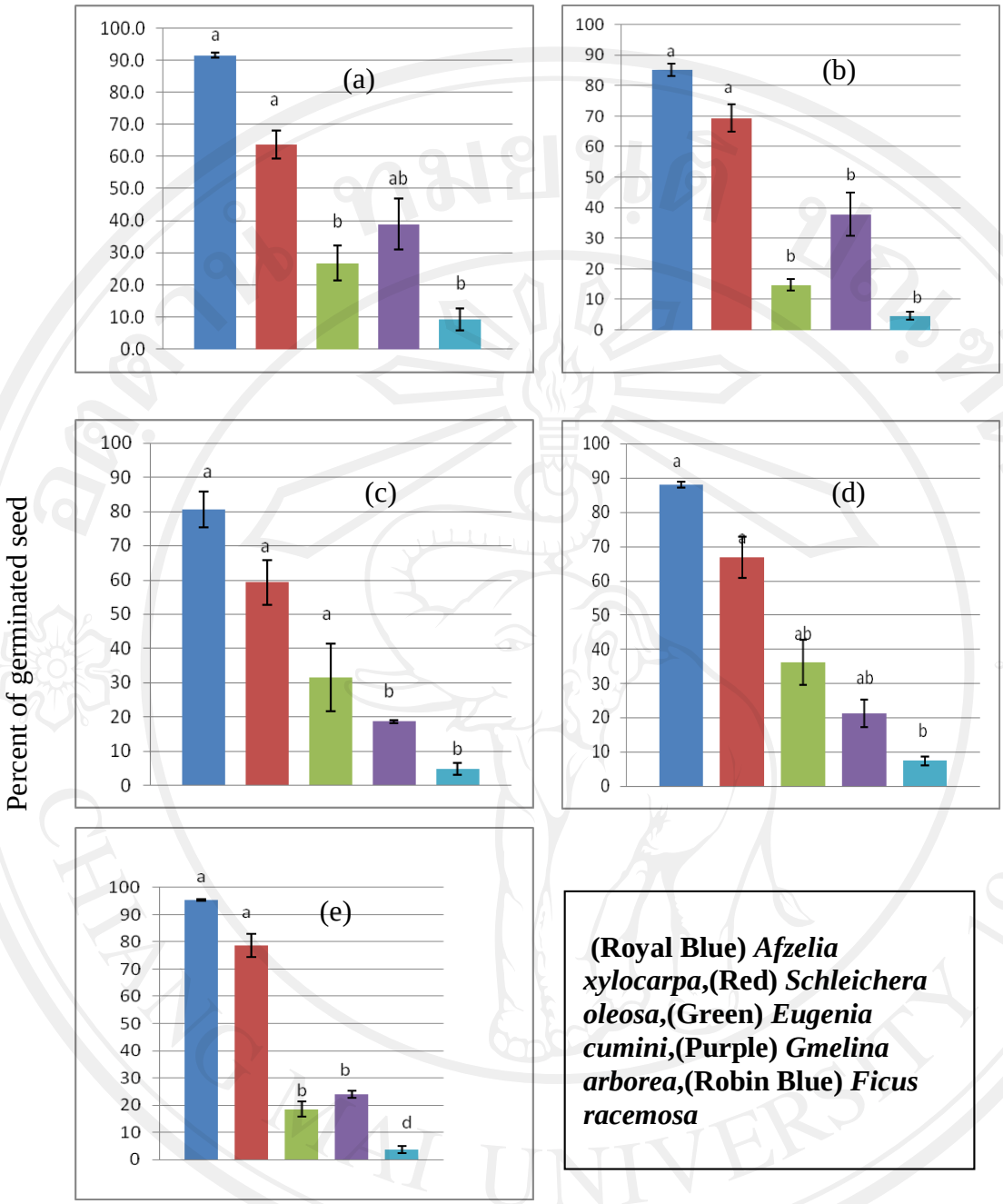
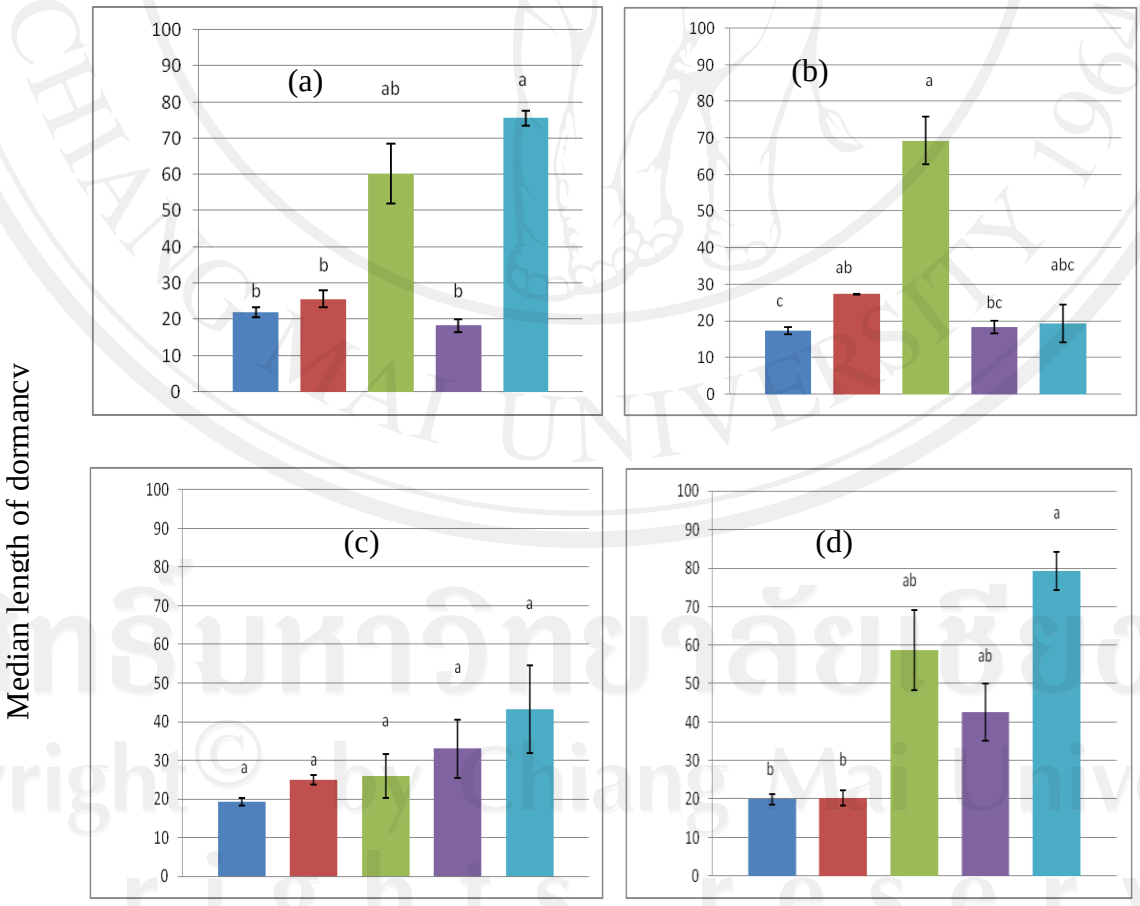
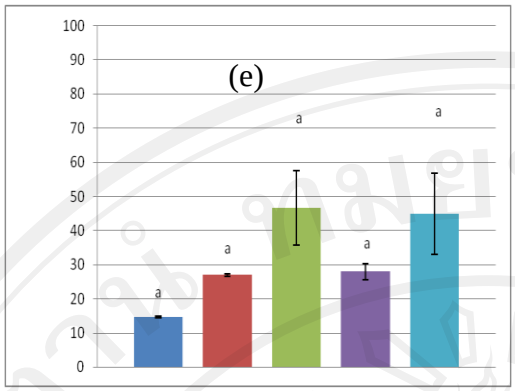


Figure Error! No text of specified style in document.-1 : Percent germination in each treatment among species (a) biosolids+fertilizer, (b) biosolids, (c) compost+ fertilizer, (d) compost, (e) control. Different letters indicate significantly differences among species ($p<0.05$); Bars are standard error (SE).

4.1.1.2 Median length of dormancy (MLD):

MLD (the number of days from seed sowing to germination of half of the seeds that finally germinated), averaged across treatments, was shortest in *A. xylocarpa*, 20 days (0.76), followed by *S. oleosa*, 25 days (1.16), *G. arborea*, 29 days (4.66), *E. cumini* 53 days(7.36) and *F. racemosa* 53 days (11.10) (Table 4-1). Differences in mean MLD's were significant among species ($p<0.05$) (ANOVA Appendix-A, Table A-3).Subsequent t-tests showed that the MLD of *A. xylocarpa* was significantly shorter than those of *S. oleosa*, *E. cumini* and *F. racemosa* ($p<0.05$). The MLD of *S. oleosa* was also significantly shorter than that of *E. cumini* ($p<0.05$) (Table 4-1).Three species had rapid germination (i.e. short MLD) in the field (*A. xylocarpa*, S. *oleosa* and *G. arborea*). Although the MLD was short also for *G. arborea*, percent germination and percent establishment were too low to enable its use as a direct seeding candidate. Significant differences in MLD among the species for each of the soil treatments are illustrated in Fig 4-2.





(Royal Blue) *Afzelia xylocarpa*, (Red) *Schleichera oleosa*, (Green) *Eugenia cumini*,(Purple) *Gmelina arborea*,(Robin Blue) *Ficus racemosa*

Figure Error! No text of specified style in document.-2: median length of dormancy (MLD) among species in the treatment (a) biosolids+fertilizer, (b) biosolids, (c) compost+ fertilizer, (d) compost, (e) control. Different letters are significantly different ($p<0.05$); Bars are standard error (SE).

1.1.1.1 Establishment & mortality across all species:

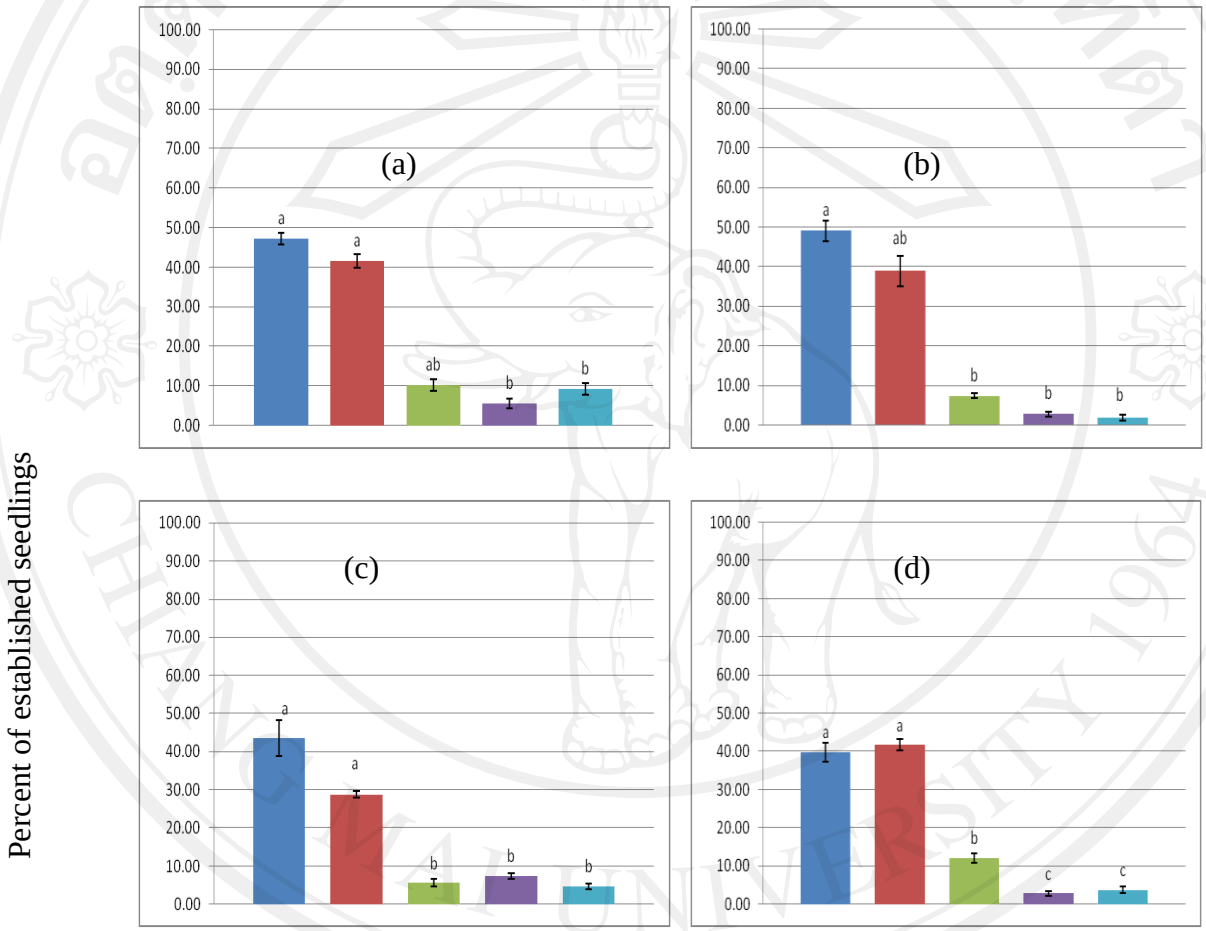
Species with high germination rates also had high seedling establishment rates (=the no. of seeds that sowing beginning of the field trial and seedlings survived at the middle of 2nd rainy season expressed as a per cent of the establishment).

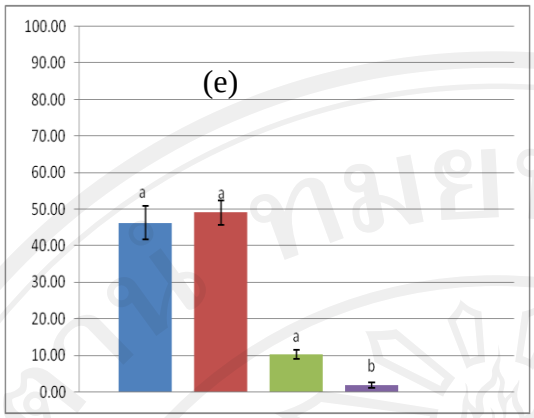
Averaging across all treatments, mean seedling establishment was highest for *A. xylocarpa* 45.2% (1.61), followed by *S.oleosa* 40% (3.29), *E. cumini* 9% (1.14), *G. arborea* 4.07% (1.03) and *F. racemosa* 3.89% (1.56) (Table 4-1).Differences in percent establishment among species were significant ($p<0.05$) (ANOVA Appendix-A, TableA-2). Subsequent T- tests showed that percent establishment of *A. xylocarpa* and *S. oleosa* was significantly higher than that of *E. cumini*, *G. arborea* and *F. racemosa* ($p<0.05$) (Table 4-1). *Afzelia xylocarpa* and *Schleichera oleosa* had significantly higher establishment rates (above 40%) compared to the other 3 species with almost every treatment ($p<0.05$) (Figure 4-3 a-e). The establishment of other three species was low (about10%) at the same time (Figure 4-3, c-e).Significant differences in establishment among the species for each of the soil treatments are illustrated in (Figure 4-2).

Mortality across all species:

Mortality= Seedlings that survived after 1 year from the germinated seedlings; expressed as a percent of the mortality.

Averaging across all treatments, mean seedling mortality was highest for *G. arborea* 83.53% (6.04), followed by *E. cumini* 61.2% (6.58), *S. oleosa* 57.4% (5.81), *A. xylocarpa* 48.61% (2.13) & *F. racemosa* 42.6% (19.07). Differences in percent mortality among species were insignificant (P<0.05) (ANOVA, Appendix-A, Table-10)





(Royal Blue) ***Afzelia xylocarpa*****, (Red)** ***Schleichera oleosa*****,(Green)** ***Eugenia cumini*****,(Purple)** ***Gmelina arborea*****,(Robin Blue)** ***Ficus racemosa***

Figure Error! No text of specified style in document.-3: Establishment among species in each treatment. (a) biosolids+fertilizer, (b) biosolids, (c) compost+ fertilizer, (d) compost, (e) control. Different letters are significantly different ($p<0.05$); Bars are standard error (SE).

4.2 Effects of soil treatments:

4.2.1 On germination:

Altogether, for all the species, 540 seeds were sown, in each of the treatments. Averaging across the species germination was on average higher in biosolids+fertilizer treatment ($\bar{x}$= 46%) and lowest in compost+ fertilizer treatment ($\bar{x}$= 39%) (Table 4-2). Overall, average establishment of seedlings of species, across all treatment was 20%. Highest seedling establishment was achieved with the biosolids+fertilizer treatment and lowest in compost+ fertilizer treatment (Table 4-2).Remarkably, percent germination, percent survival and total seedling establishment with the control were very close to those achieved with the biosolids+fertilizer treatment.

Table Error! No text of specified style in document.-2: Treatment means across species of percent germination, MLD and seedling survival and establishment rates averaged across all 5 species. ***Note: Standard errors are in brackets (SE).**

	Biosolids +fertilizer	Biosolids	Compost +fertilizer	Compost	Control	Average
No of seed sown in five species	540	540	540	540	540	
No of germinated seed	249	229	210	237	238	
Percent germination	46.1(14.44)[a]	42.4(15.44)[a]	38.9(13.77)[a]	43.9(14.77)[a]	44.1(18.04)[a]	
MLD	40(7.80)[a]	30(6.69)[a]	29(2.80)[a]	44(7.68)[a]	32(4.05)[a]	
No of survived seedlings	123	108	97	108	116	
Percent establishment seedlings	22.8(8.92)[a]	20.0(9.96)[a]	18.0(7.78)[a]	20.0(8.62)[a]	21.5(10.84)[a]	20.4
Percent Mortality	50.1(14.03)[a]	60.7(8.59)[a]	53.3(14.84)[a]	62.1(6.82)[a]	66.3(12.29)[a]	

Soil treatments appeared to have no effect on germination. Differences in mean germination per cent, averaged across all species in the field were insignificant (ANOVA, $p<0.05$)(Appendix-A, Table A-4). Figure 4-4 (A) details minor differences in per cent germination due to treatments within each species, but again these small differences were insignificant (ANOVA, $p<0.05$).

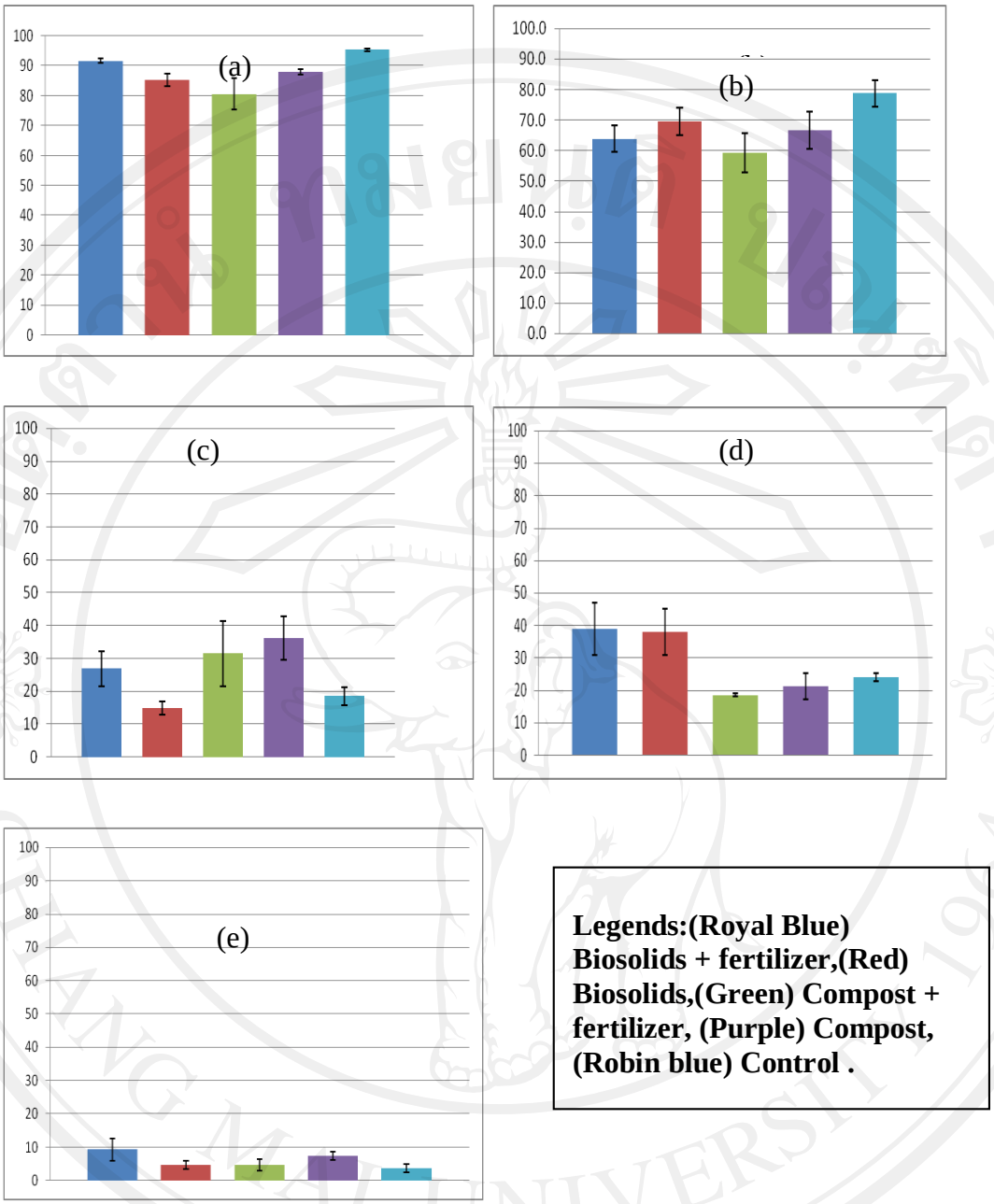


Figure Error! No text of specified style in document.-4(A)**: Percent of germination in each species among treatment in the field. a)** ***Afzelia xylocarpa*** **b)** ***Schleichera oleosa*** **c)** ***Eugenia cumini*** **d)** ***Gmelina arborea*** **e)** ***Ficus racemosa*****. Bars are Standard Error (SE).**

Similarly, soil treatments had no effect on the time course pattern of germination, as illustrated in the germination-time curves Fig. 4-5 (B) below.

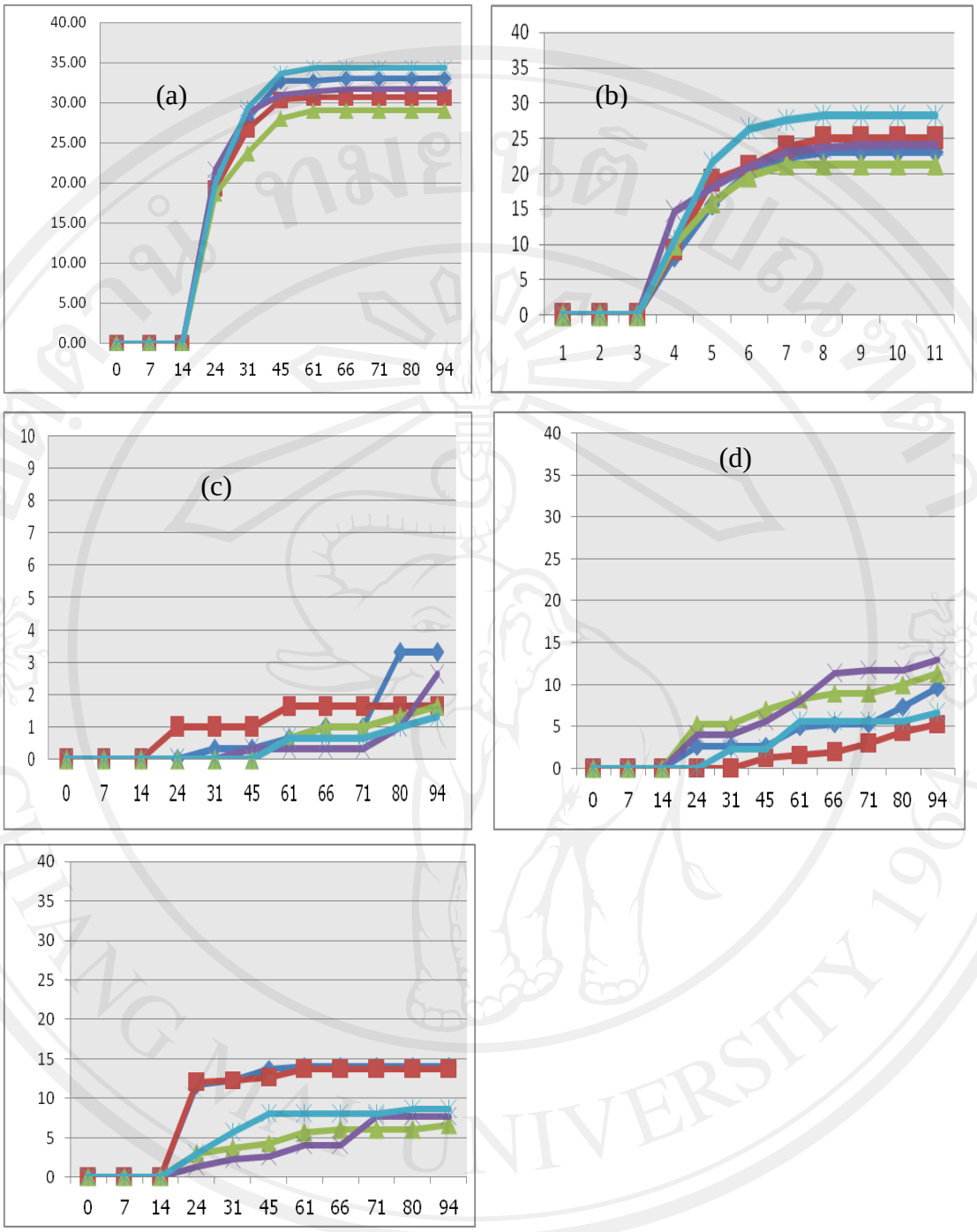


Figure Error! No text of specified style in document.-5(B): Percent of germination in each species among treatment in the field. a)*Afzelia xylocarpa* b) *Schleichera oleosa* c) *Eugenia cumini* d) *Gmelina arborea* e) *Ficus racemosa*.

4.2.2 On dormancy:

Not surprisingly, soil treatments also had no effect on MLD (as can be seen in Fig 4-6 as well). Mean MLD values, averaged across all species, did not differ significantly among soil treatments (ANOVA, $p<0.05$). It was thought that soil treatments might shorten the dormancy period and thus reduce the time that seeds are vulnerable to seed predators, but the results clearly showed that none of the soil treatments did so.

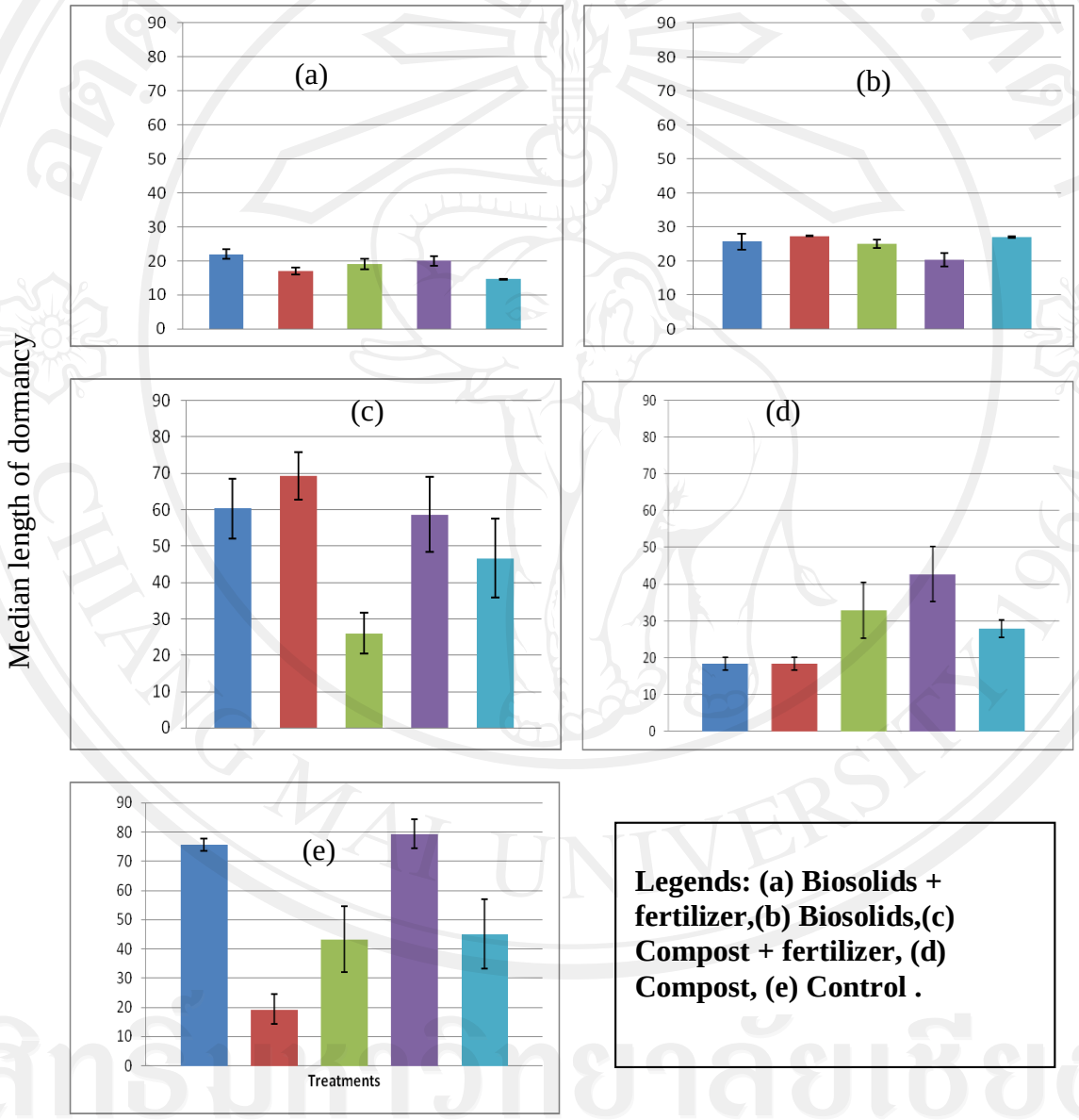


Figure Error! No text of specified style in document.-6: Median length of dormancy (MLD) of the species among treatments in the field. . a) *Afzelia xylocarpa* b) *Schleichera oleosa* c) *Eugenia cumini* d) *Gmelina arborea* e) *Ficus racemosa*. Bars are Standard Error (SE).

4.2.3 On seedling establishment:

Likewise, soil treatments had no effect on seedling establishment. Averaging across all species, differences in mean establishment rates for each treatment were insignificant (ANOVA p <0.05). Figure 4-7 shows that within species, differences in treatment effects were also insignificant (ANOVA p<0.05).

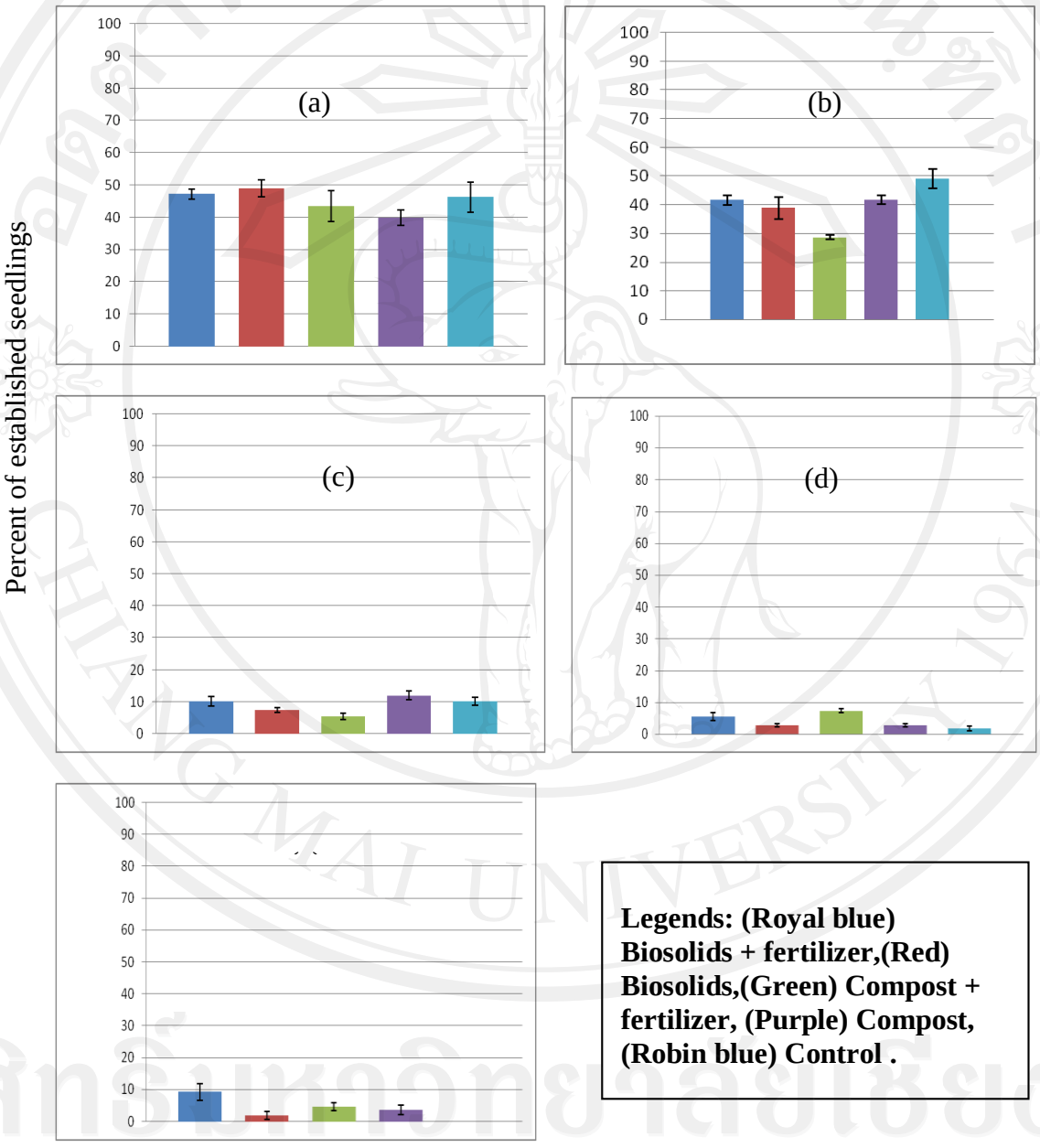
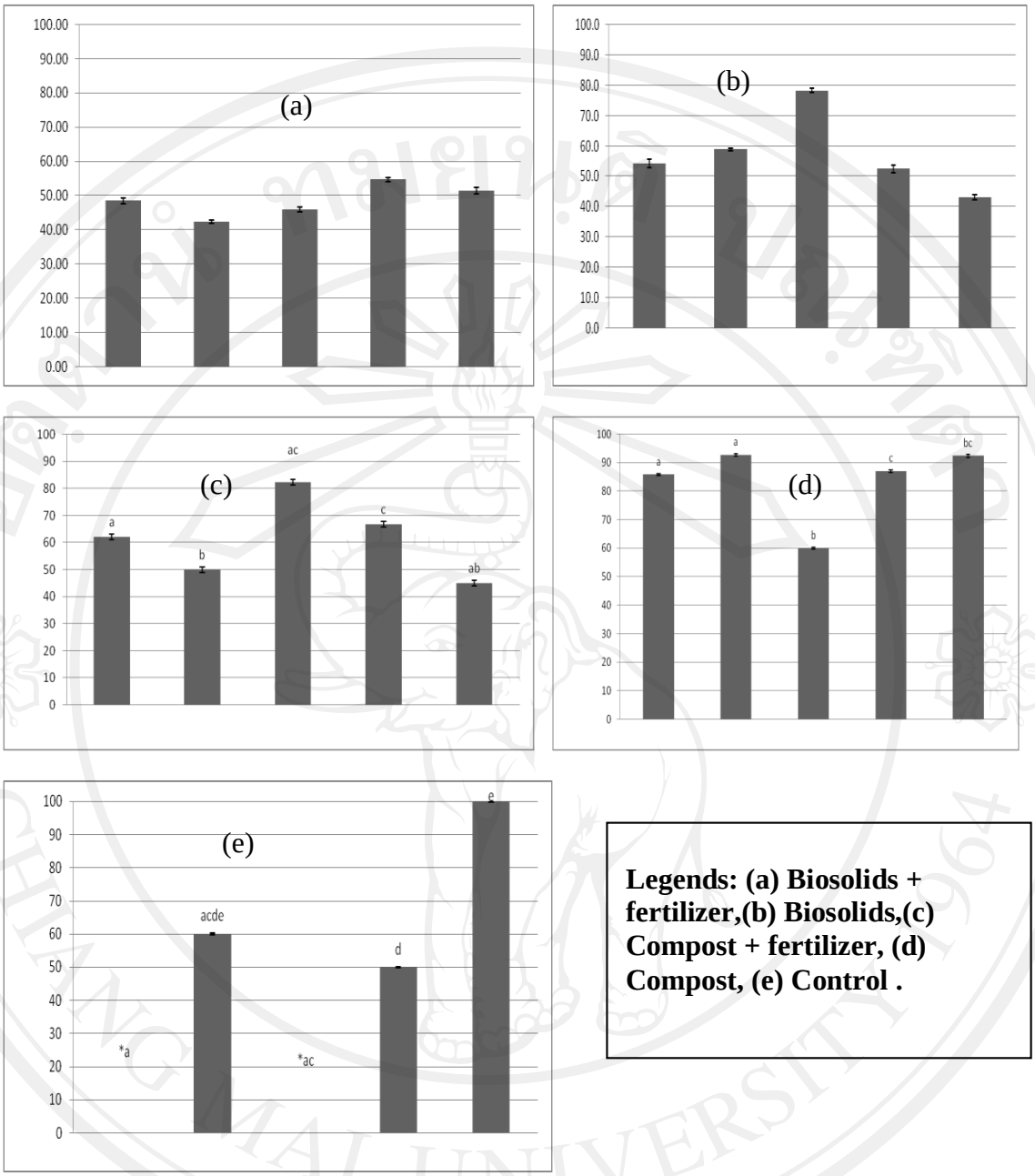


Figure Error! No text of specified style in document.-7: Differences in establishment of the species among treatments. (a) *Afzelia xylocarpa* b) *Schleichera oleosa* c) *Eugenia cumini* d) *Gmelina arborea* e) *Ficus racemosa*. Bars are Standard Error (SE).

On mortality:

Averaging across the species mortality was highest in control treatment 66.38% (14.03), followed by Compost treatment 62.18% (6.82), Biosolids treatment 60.79% (8.59), Compost+ fertilizer treatment 53.33% (14.84) and Biosolids + fertilizer treatment 50.10% (14.03) (table 4-2). On average differences in percent mortality among treatment were insignificant (Appendix-A, Table-11)

Surprisingly, some of the species got effect from Soil treatment on mortality. Differences in mean mortality rate, averaged across all species in the field were significant (ANOVA, $p<0.05$. Figure 4-8 (a-e) details differences in Percent mortality due to treatments within each species (ANOVA, $p<0.05$).



Legends: (a) Biosolids + fertilizer,(b) Biosolids,(c) Compost + fertilizer, (d) Compost, (e) Control .

Figure Error! No text of specified style in document.-8 : Differences in mortality of the species among treatments. (a) *Afzelia xylocarpa* b) *Schleichera oleosa* c) *Eugenia cumini* d) *Gmelina arborea* e) *Ficus racemosa*. Bars are Standard Error (SE).

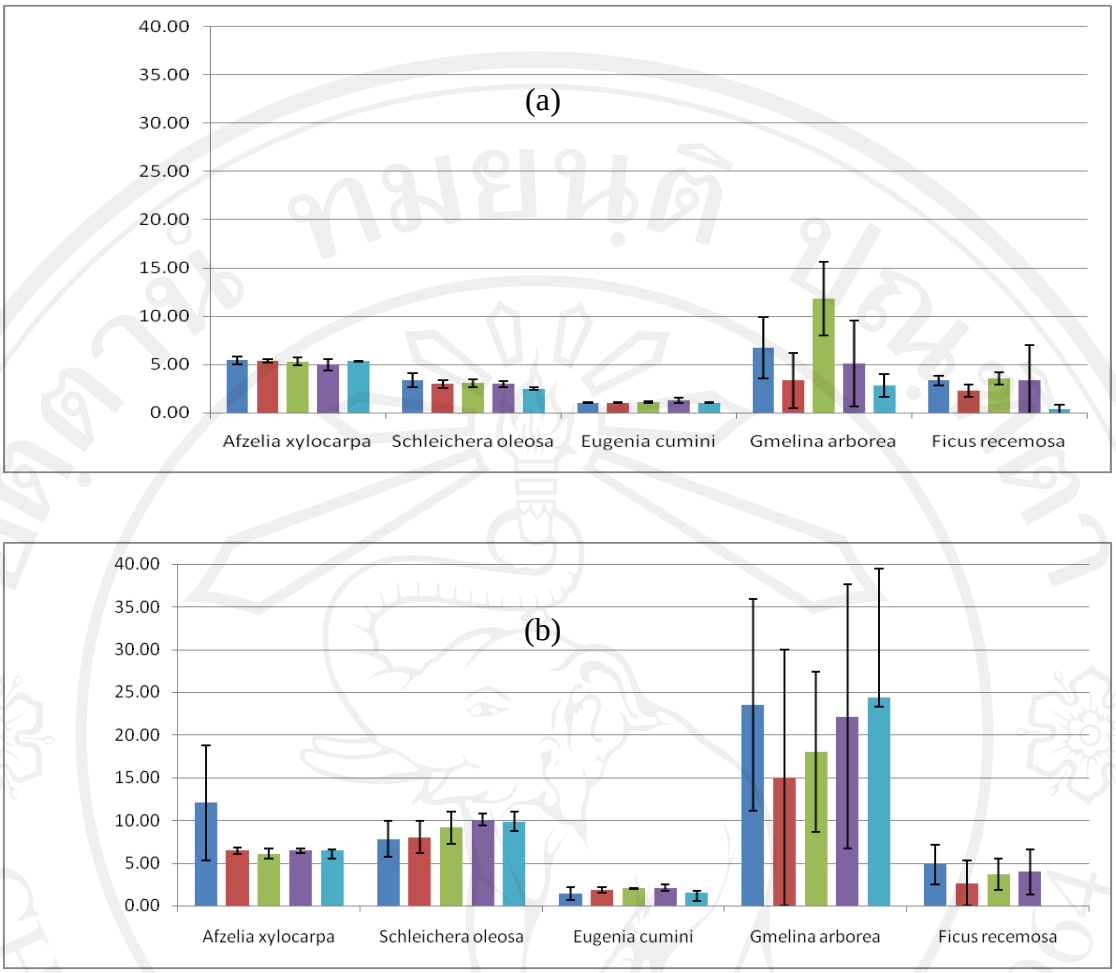
4.2.4 On growth:

In general, treatments had little or no effect on subsequent growth of seedlings after germination. Three months after germination, the growth performance was reasonably good for *Afzelia xylocarpa, Schleichera oleosa* and *Gmelina arborea*. Their mean RCD (5, 3 and 5mm), height (20, 15 and 20cm) and crown widths (9, 20 and 20cm) respectively showed no significant differences on species among treatments($p<0.05$) (Figure4-8,4-9, 4-10, a-e).

By the middle of the 2nd rainy season, *Schleichera oleosa* and *Gmelina arborea* showed satisfactory growth performances across all treatments. Their mean RCD, height and crown width exceeded 8and 20 mm, 25and 50 cm, and 27and 40 cm, respectively across all the treatments, on average (Figure4-8, 4-9, 4-10, a-e).

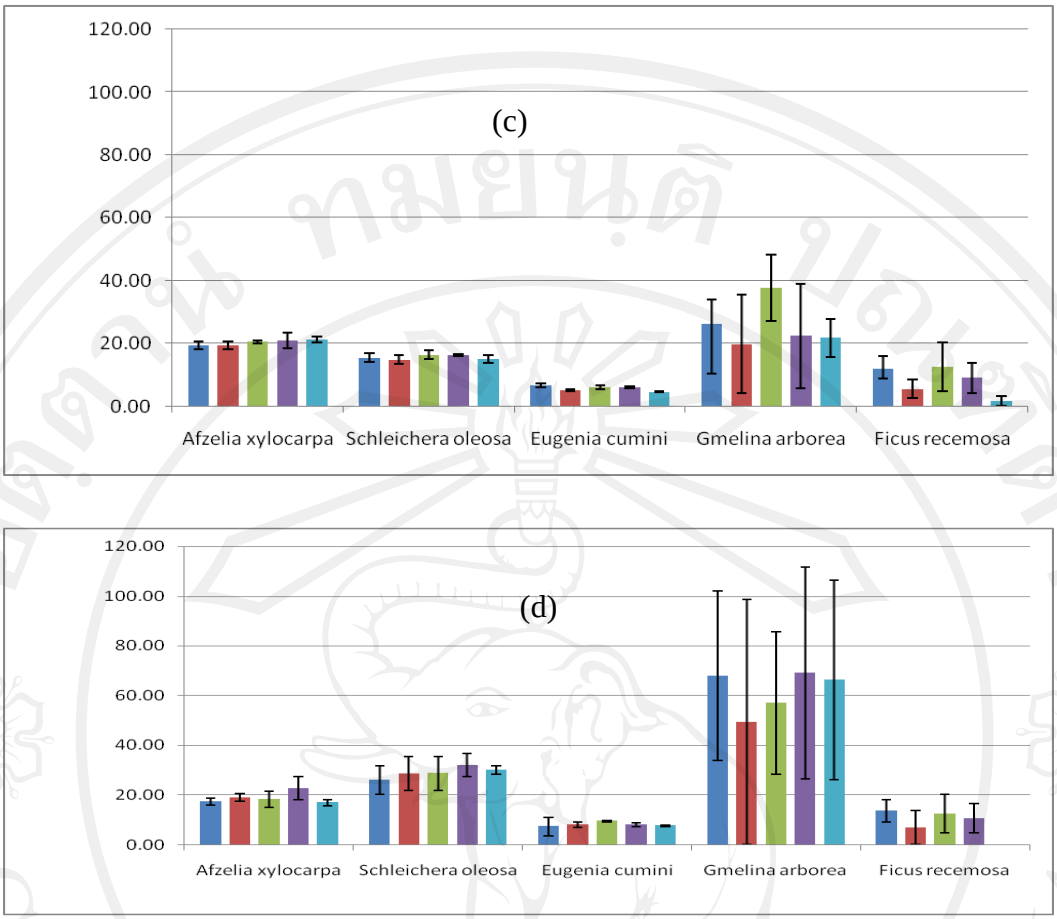
Eugenia cumini and *Ficus racemosa* growth performance was minimum for all growth parameters three months after germination due to their prolonged dormancy. So growth parameters showed lower values for these species, and the values did not differ significantly among treatments.

Also, there were no significant differences in relative growth rate (RGR) of root collar diameter (RCD), height &crown width in the species among treatments. Remarkably, RGR of *Afzelia xylocarpa* was lower because cattle browsing knocked back growth (Table 4-3).



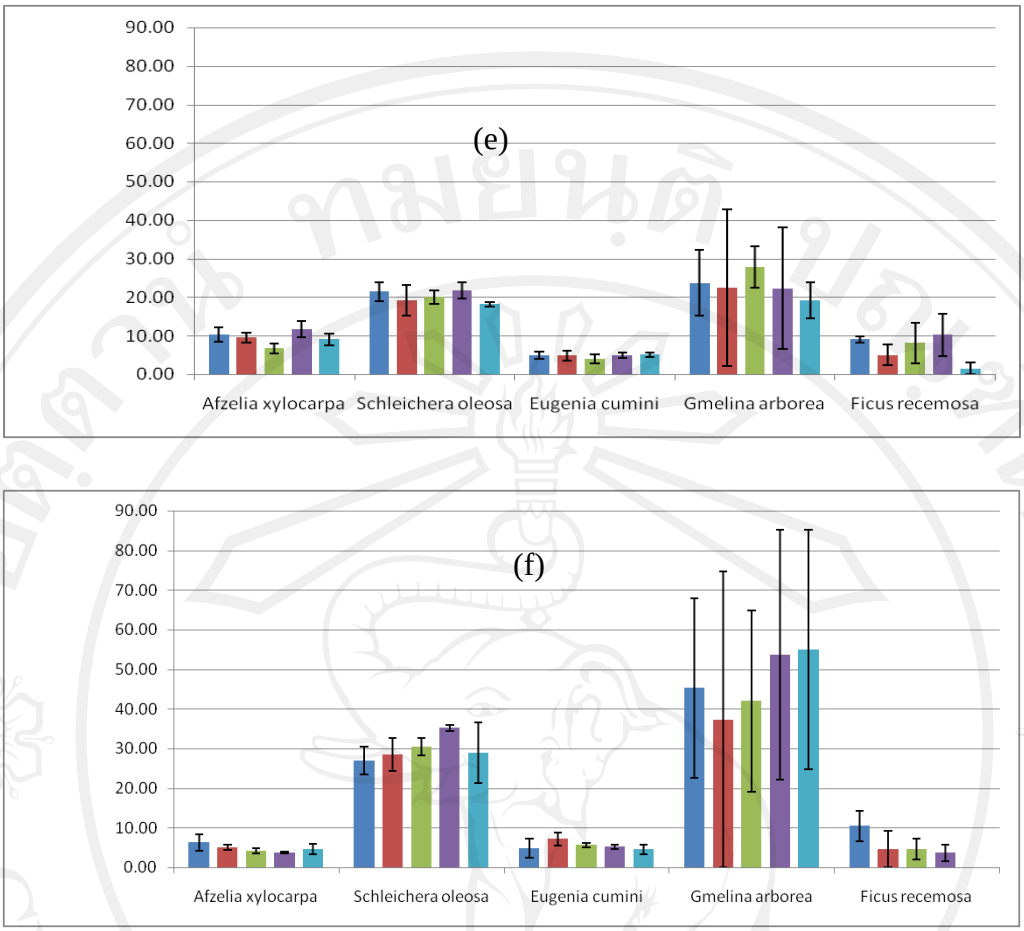
(Royal Blue) Biosolids + fertilizer, (Red) Biosolids, (Green) Compost +fertilizer,(Purple) Compost,(Robin Blue) Control

Figure Error! No text of specified style in document.-9: Root collar diameter (RCD.mm) of five species among treatments after(a) 3rd Months and after (b) 1 year.



(Royal Blue) Biosolids + fertilizer, (Red) Biosolids, (Green) Compost +fertilizer,(Purple) Compost,(Robin Blue) Control

Figure Error! No text of specified style in document.-10: Height (cm) of five species among treatments after (c) 3rd months and (d) after 1 year.



(Royal Blue) Biosolids + fertilizer, (Red) Biosolids, (Green) Compost +fertilizer, (Purple) Compost,(Robin Blue) Control

Figure Error! No text of specified style in document.-11: Crown Width (cm) of five species among treatments (e) after 3rd months and (f) after 1 year.

Table Error! No text of specified style in document.-3: Relative growth rate of five species in five treatments in the field.

Treatments	RGR RCD (SE)	RGR Height (SE)	RGR Crown width (SE)
Afzelia xylocarpa			
Biosolids+fertilizer	14.0 (22.85)	-30.4(15.79)	-76.3 (15.24)
Biosolids	30.9 (16.29)	-12.0(13.02)	-105.5 (10.21)
Compost + fertilizer	34.7 (16.34)	-23.0 (18.98)	-96.2 (37.89)
Compost	38.9(13.72)	25.4(10.96)	-103.9 (29.13)
Control	35.6 (6.67)	-108.1(67.64)	-74.9 (51.46)
Schleichera oleosa			
Biosolids+fertilizer	122.5(4.15)	65.5 (16.19)	26.0 (4.12)
Biosolids	147.5(38.8)	78.6 (24.27)	36.1 (31.0)
Compost + fertilizer	181.5(83.95)	72.9 (36.60)	68.9 (15.4)
Compost	184.7(6.24)	89.8 (27.82)	70.1 (12)
Control	165.3(24.0)	62.3 (12.39)	33.0 (42.87)
Eugenia cumini			
Biosolids+fertilizer	70.7(35.53)	51.6 (32.55)	21.9 (12.18)
Biosolids	126.4(52.16)	91.6 (18.78)	63.4(59.47)
Compost + fertilizer	56.1(31.49)	22.1 (13.75)	5.7(23.80)
Compost	69.1(55.78)	33.5 (19.79)	-12.4(29.06)
Control	49.3 (33.17)	64.1 (10.49)	-33.4(33.74)
Gmelina arborea			
Biosolids+fertilizer	147.8 (74.49)	113.8 (56.95)	75.3(38.20)
Biosolids	87.0 (87.02)	57.6 (57.60)	31.1(31.11)
Compost + fertilizer	145.9 (73.16)	114.5 (57.96)	94.8(48.49)
Compost	193.2 (106.33)	122.5 (64.02)	104.8(57.36)
Control	222.3 (119.10)	115.3 (60.23)	133.1(67.28)
Ficus racemosa			
Biosolids+fertilizer	188.0 (30.00)	169.2 (42.51)	51.167(23.01)
Biosolids	112.0 (112.01)	77.2 (77.25)	60.251(60.25)
Compost + fertilizer	143.2 (74.71)	62.2 (49.99)	(-)30.787(40.71)
Compost	149.4 (79.29)	97.1 (59.09)	(-)33.641(39.54)
Control	33.9 (33.96)	-17.4 (17.44)	(-)19.126(19.12)

4.2.5 Suitability Score:

In the field study, the performance of *Afzelia xylocarpa* & *Schleichera oleosa* were outstanding over all the treatments. The rank suitability score was more than 40%.

Highest score was found for *Afzelia xylocarpa* in Biosolids+fertilizer treatment (100%) (Table 4-4). The second highest score found in *Schleichera oleosa*, and their rank score among all the treatment was 84.5% in Control treatment. Other three species *Eugenia cumini, Gmelina arborea* and *Ficus racemosa* were not suitable for direct seeding in the field because their percent establishment was less than 10% (Table 4-4).

Table Error! No text of specified style in document.-4: Suitability score of two successful species in the field.

Species	Treatments	Percent Establishment	RCD	Raw suitability score	Rank suitability score(0-100)
Afzelia xylocarpa	Biosolids+fertilizer	47.2	12.0	569.0	100.0
Schleichera oleosa	Control	49.1	9.8	480.8	84.5
Schleichera oleosa	Compost	41.7	10.1	420.1	73.8
Schleichera oleosa	Biosolids+fertilizer	41.7	7.8	326.6	57.4
Afzelia xylocarpa	Biosolids	49.07	6.48	317.90	55.87
Schleichera oleosa	Biosolids	38.9	8.0	312.1	54.8
Afzelia xylocarpa	Control	46.3	6.5	300.9	52.9
Afzelia xylocarpa	Compost+fertilizer	43.5	6.1	266.0	46.7
Schleichera oleosa	Compost+fertilizer	28.7	9.2	262.8	46.2
Afzelia xylocarpa	Compost	39.8	6.4	256.7	45.1

4.3 Nursery result:

Field trials and nursery experiments had to be carried out at different times due to logistical problems. The nursery experiment was set up in mid-November 2012. The experiment was set up to check the percent germination and median length of dormancy (MLD) of selected species subjected to various treatments; as well as to test differences in species performance.

For all species, 864 seeds were sown in each of the treatment. Average percent germination was highest with biosolids+ mine soil (29.2%) (Table 4-5) and lowest with the control (21.8%) (Table 4-5), but ANOVA test found no significant differences among the treatments ($p<0.05$) (Appendix-A, Table A-9).

Table Error! No text of specified style in document.-5: Treatment mean across species of percent germination averaged across all eight species.

Treatment name	No. of seeds sown	No. of seeds germinated	Percent germination	MLD
Biosolids+mine soil	864	253	29.28[a]	147
Compost+mine soil	864	230	26.62[a]	151
Control(mine soil)	864	189	21.88[a]	148
	2592	672	25.93	

4.3.1 Treatment effects:

The treatments applied had no significant effect on percent germination and MLD of all species, except for *Irvingia malayana* and *Ficus racemosa* (Figure 4-12 c1-2 & h1-2).

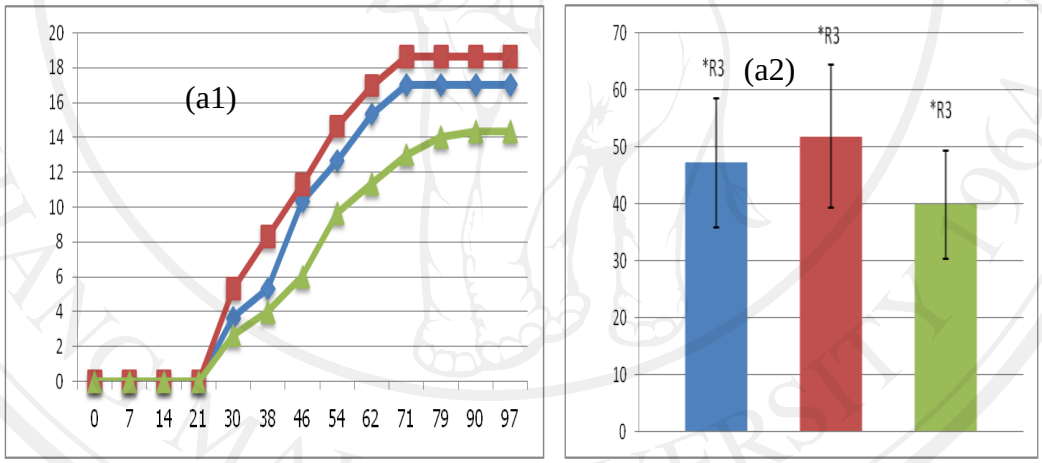
Irvingia malayana achieved significantly the highest germination per cent in the control (46%) ($p<0.05$) (Figure 4-11, c1-2). However, MLD was prolonged in the nursery for this species (Figure 4.12,c 1). Also, *Ficus racemosa* showed significantly higher percent germination with biosolids+ mine soil ($p<0.05$) (Figure11, h1-2), as percent germination

was <40% and MLD was long; so this species may not be practicable for direct seeding (Figure-11, h1-2 & Figure 12, h).

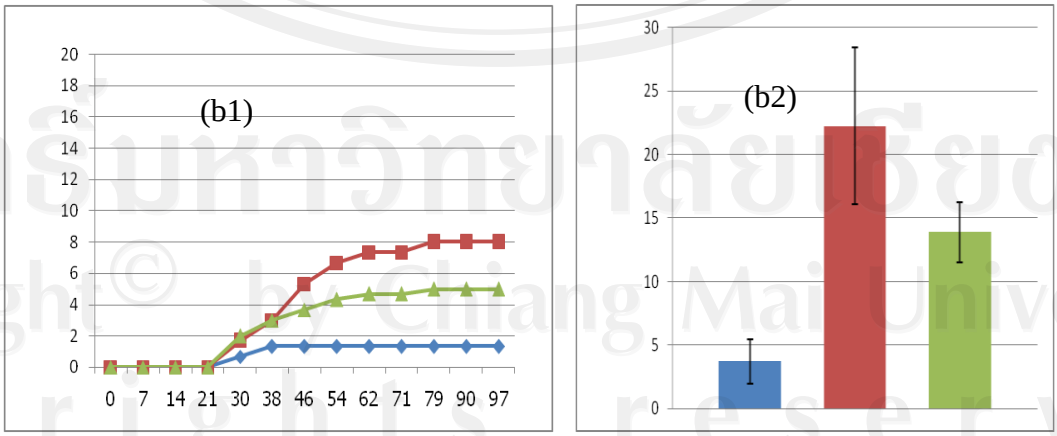
A. xylocarpa and *A. pavonina* (Figure 4-11 a, b & Figure 4-12 a, b) also germinated but treatments had no significant effects on percent germination and MLD of both of these species.

The treatments had no significant effect on length of dormancy of the remaining species. MLD was prolonged in the nursery compared with the previous data from FORRU which was about 180 days in each of the treatment (Figure 4-12 c-h).

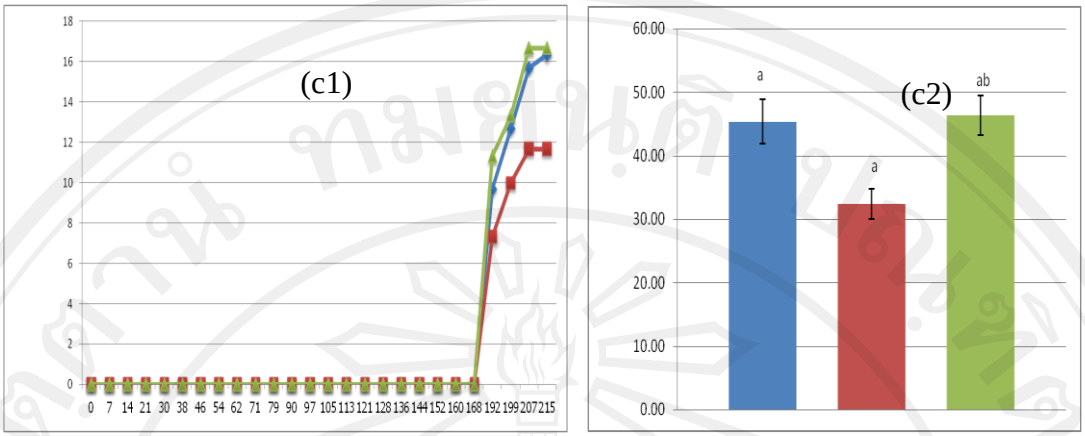
Although percent germination of *Spondias pinnata* was on average highest (>50%) in biosolids+ mine soil and compost+ mine soil and for *Catunaregam spathulifolia* percent germination (53%) was on average highest in biosolids+ mine soil, ANOVA detected no significant differences among treatments (Appendix-A, Table A-9).



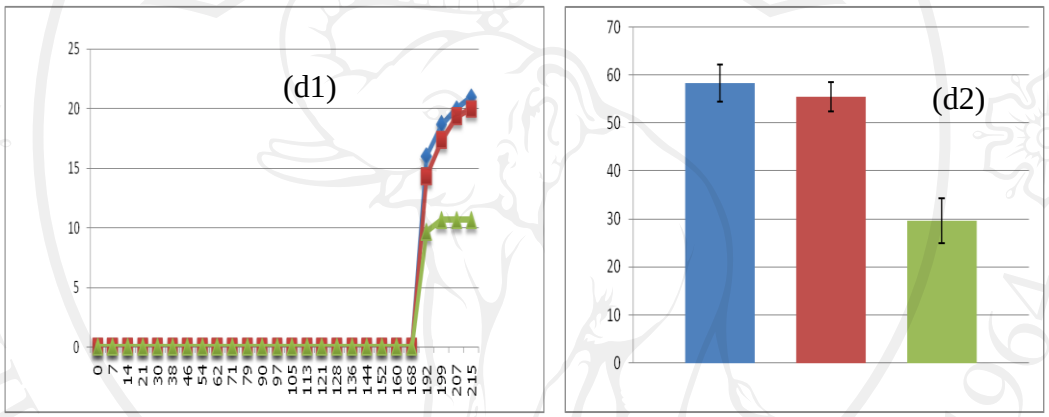
(a1, a2): Percent germination of *Afzelia xylocarpa* among treatments.



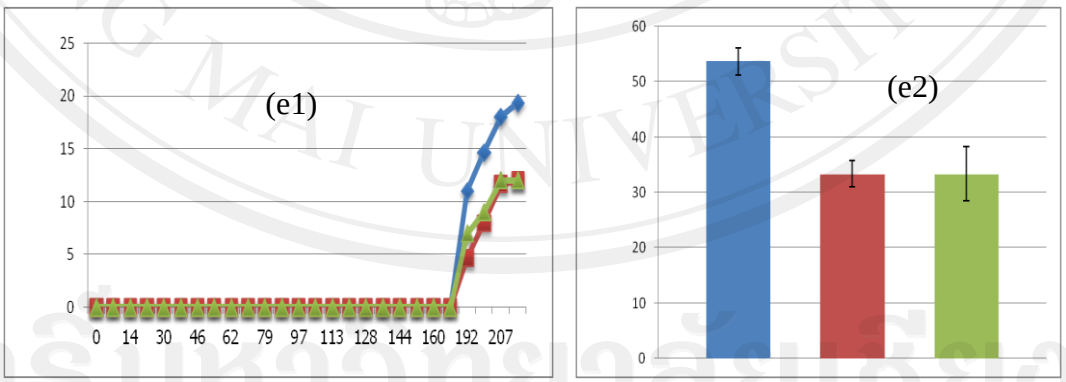
(b1, b2): Percent germination of *Adenanthera pavonina* among treatments.



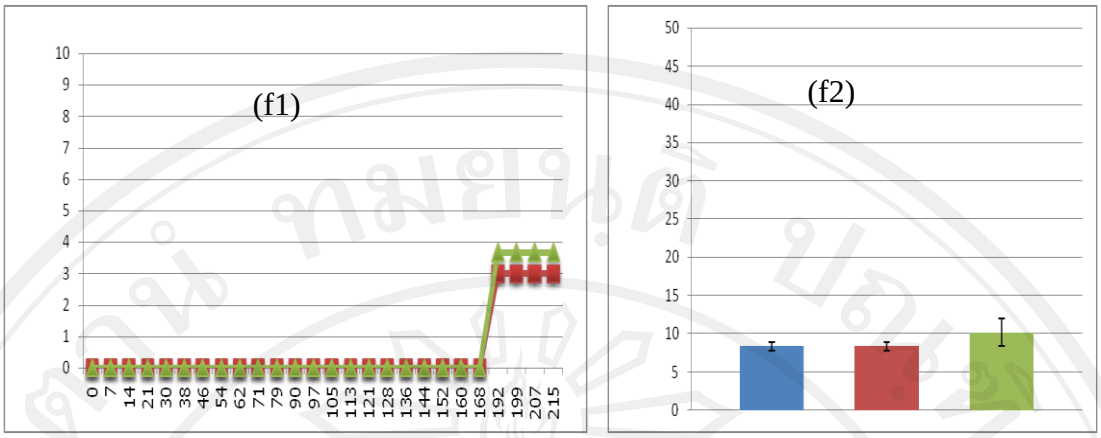
(c1-c2): Percent germination of *Irvingia malayana* among treatments.



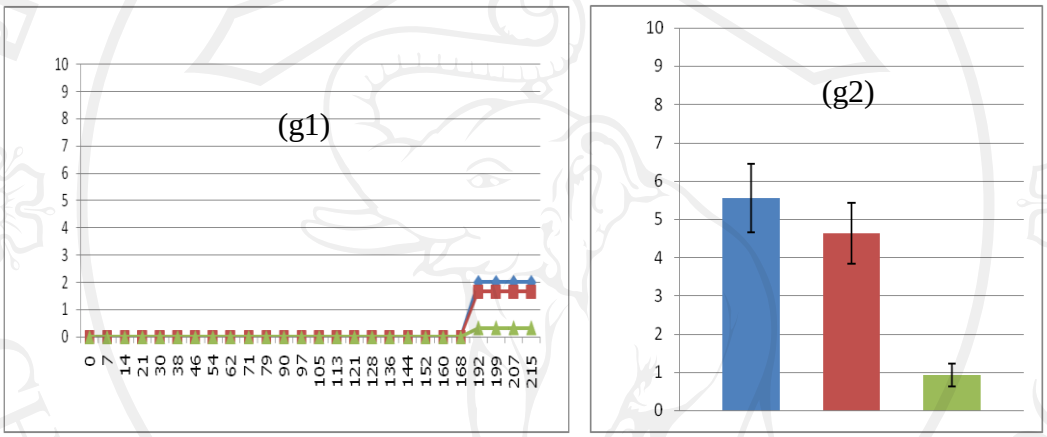
(d1 - d2) : Percent germination of *Spondias pinnata* among treatments.



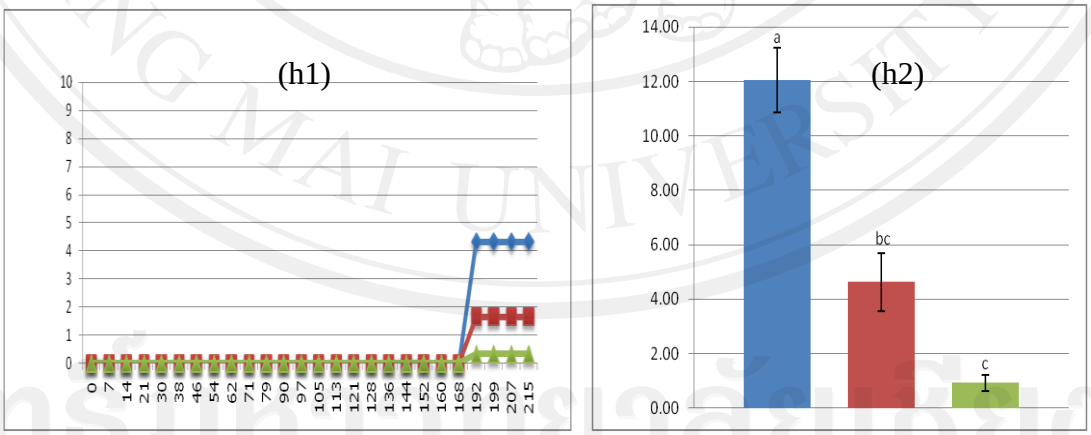
(e1 - e2): Percent germination of *Catunaregam spathulifolia* among treatments.



(f1- f2): Percent germination of *Schleichera oleosa* among treatments.



(g1 - g2): Percent germination of *Gmelina arborea* among treatments.



(h1 - h2): Percent germination of *Ficus racemosa* among treatments.

Legends:

(a) Biosolids + Mine soil (Blue)

(b) Compost+ Mine soil (Red).

(c) Control (Mine soil) (Green).

Figure Error! No text of specified style in document.-12: Percent germination of eight species among treatments.

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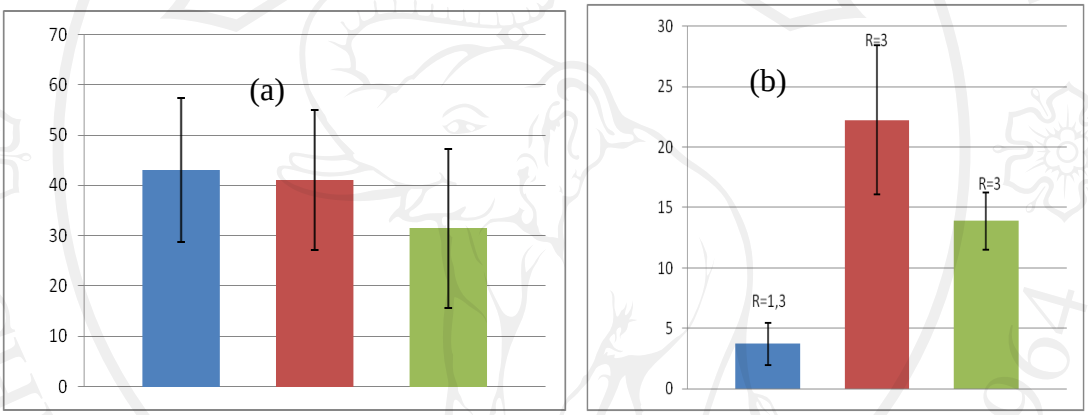
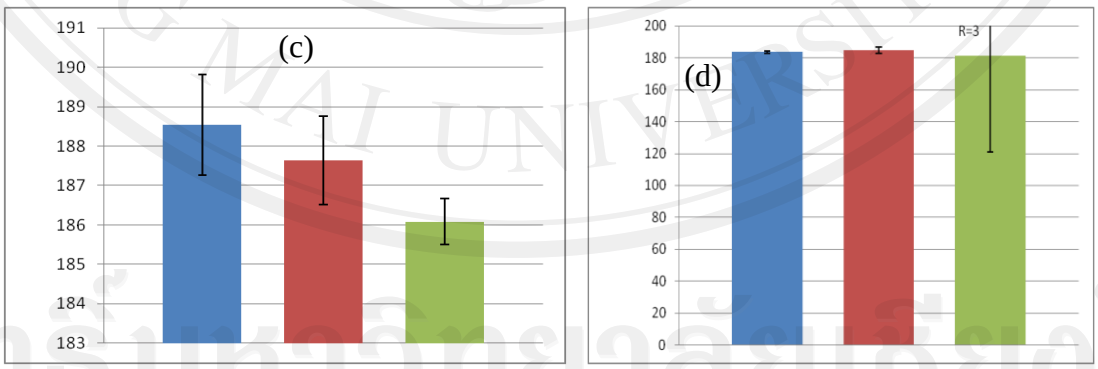
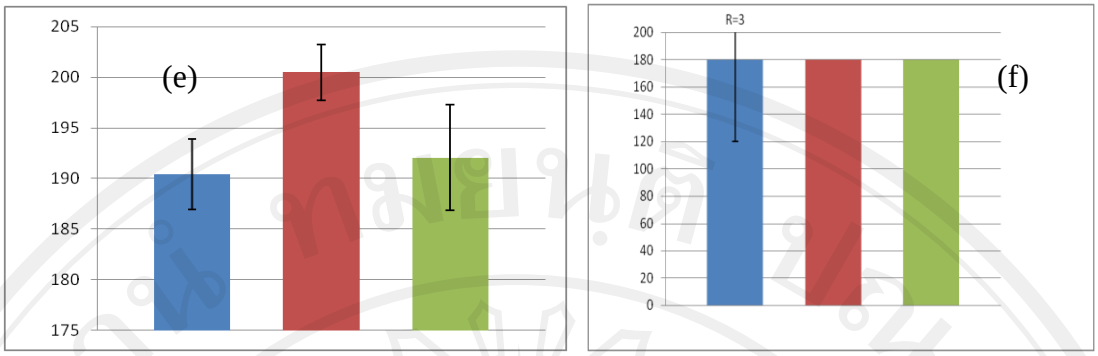


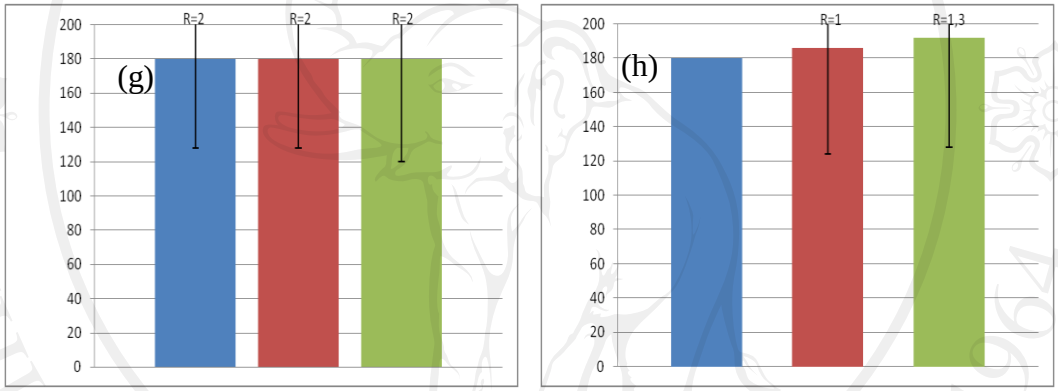
Median length of dormancy (MLD) in (a) *Afzelia xylocarpa*, (b) *Adenanthera pavonina*.



Median length of dormancy (MLD) in (c) *Irvingia malayana*, (d) *Spondias pinnata*.



Median length of dormancy (MLD) in (e) *Catunaregam spathulifolia*, (f) *Schleichera oleosa*.



Median length of dormancy (MLD) of (g) *Gmelina arborea*, (h) *Ficus racemosa*.

Note: * marked letters replication did not germinate, so MLD could not be counted.

Legends:

(a) Biosolids + Mine soil (Blue)

(b) Compost+ Mine soil (Red).

(c) Control (Mine soil) (Green).

Figure Error! No text of specified style in document.-13: median length of dormancy (MLD) of eight species among the treatments in the nursery.

4.3.2 Species effect:

A total of 2,592 seeds were sown in the nursery experiments; 324 seeds for each of the species, divided among three treatments. Highest percent germination was achieved by *S. pinnata* 47.4% (4.39), followed by *A. xylocarpa* 46.30%, *I. malayana* 41.36%, *C. spathulifolia* 40.12% (3.26), *A. pavonina* 13.27% (2.57), *S. oleosa* 8.95% (0.29), *F. racemosa* 5.86% (1.56) and *G. arborea* 3.7% (0.67) (Table 4-6).ANOVA revealed significant differences in percent germination among species ($p<0.05$)(Appendix-A, Table A-9). Subsequent t-tests showed that *A. xylocarpa* had significantly higher percent germination than *A. pavonina*, *S.oleosa*, *G. arborea* and *F. racemosa* ($p<0.05$) (Table 4-6).

On the other hand, *S. pinnata*, *I. malayana*, *C. spathulifolia* showed significantly higher percent of germination than *S.oleosa*, *G. arborea* and *F. racemosa* ($p<0.05$) (Table 4-6).

Table Error! No text of specified style in document.-6: Species mean across treatment of percent germination averaged across all three treatments.

No of germ seed	No. of seed sown in three treatments	Avg. no. of germinated seed	Percent germination	MLD
Afzelia xylocarpa	324	50	46.30[a]	39[a]
Adenanthera pavonina	324	14.33	13.27[bc]	39[a]
Spondias pinnata	324	51.67	47.84[ab]	183[b]
Irvingia malayana	324	44.67	41.36[ab]	187[b]
Catunaregam spathulifolia	324	43.33	40.12[ab]	194[b]
Schleichera oleosa	324	9.67	8.95[c]	180[b]
Gmelina arborea	324	4	3.7[c]	180[b]
Ficus racemosa	324	6.33	5.86[c]	186[b]
Avg for treatment	2592		25.93	

Comparing costs between direct seeded and nursery raised plants establishment:

Establishment costs of direct seeded plants with the help of soil conditioner in lignite mining area were little bit higher than nursery raised plants (FORRU scheme), as it is not the same environmental condition in coal mine area compare to normal restoration

site.. Though most of the activities in a nursery; germination, potting, growing will be eliminated in a direct seeded plants. Also, the transferring cost, casual labors and maintenance could be reduced compared with nursery raised plants, but in this experiment site preparation with the help of soil conditioner required 60% from the total grant. The details presented in Table 4-7.

Table Error! No text of specified style in document.-7: Comparing costs between direct seeded plants for mine site planting and nursery raised plants for general site capture establishment (The calculation was based on a stocking density of 500 trees per rai)

Items	Nursery raised plants(FORRU production cost)	Direct seeded plants
1.Establishment Costs		
Seed collection		
(0.06baht/seed, 8 hours for 3000 seeds)	180	180
Seed Preparation		
(0.1 baht/seed, 8hours for 3000 seeds)	240	240
Labour(collect seed and preparation)/3 person/300B/day	900	900
2.Germination		
Plastic tray		
(100seeds/basket,20 baht/basket, 3 planting seasons/basket	600	0
Items	Nursery	Direct

	raised plants(FORRU production cost)	seeded plants
Labour+transport to get the soil(just for the soil)	2000	0
Labour		
(1 hour/per person for 3000 seeds)	40	0
3.Potting		
Plastic bags(2.5"/9")		
(4baht/bag,200 bags/kg, 50 baht/kg(total 10kg for 2000 seedlings)	500	0
Media for soil(peanut shell +coconut husk)		
(0.37baht/basket/10g, 100 seeds/basket)(total 10kg)	44	0
Labour		
0.5 baht/bag/person(2000 seedlings)	1000	0
4.Growing		
Fertilizer(osmocoat) 10kg		
10g/seedlings,150 baht/kg, 1 times/planting season	750	0
Items	Nursery raised plants(FORRU production	Direct seeded plants

	cost)	
Watering		
5hrs/planting season, 3person	900	0
5.Site Preparation		
(Apply fertilizer, weeding), 4person/rai/3 times	1200	1200
Biosolids(15baht/kg),432 kg/rai	0	6480
Compost(10 baht/kg),432kg/rai	0	4320
Fertilizer(20baht/kg), 21.6kg	0	432
Labour(apply herbicide)		
(5 person/rai, 300 baht/person	0	0
Labor(apply biosolids, compost &fertilizer), 5 person/rai/300baht/1 time	0	1500
6.Planting/Sowing		
Seedling Transfering(Vehicle and Gasoline)	2000	0
Planting/Sowing(Vehicle and gasoline)	2000	2000
Items	Nursery raised plants(FORRU production cost)	Direct seeded plants
Planting/Sowing(Labour)		

(5 persons/planting, 5persons per sowing	1500	1500
Fertilizer	310	0
Labour(Apply fertilizer)	150	0
7.Maintenance(2nd year)		
Mannual Weeding		
(3 person/rai, 3 times/rainy season/for planting, 2 times/rainy season/ for sowing)	1350	900
Fertilizer		
(3 times/rainy season/for planting, 2 times/rainy season/for sowing	930	620
Labour(apply fertilizer)	450	0
Total	17044	20272