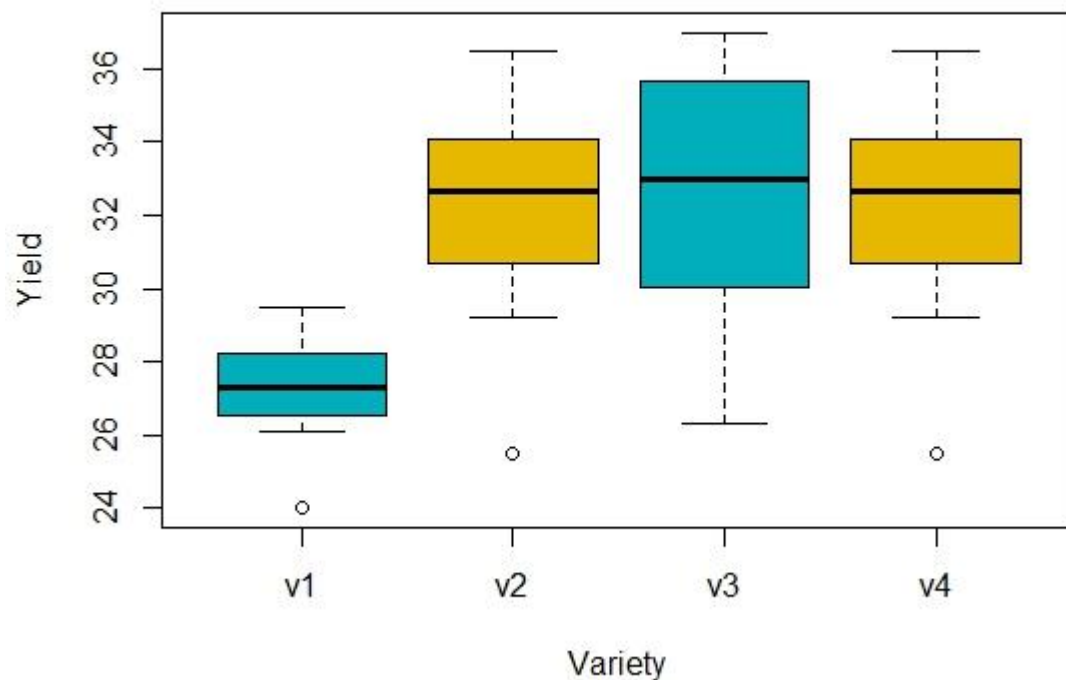


```

fac<-read.table(file="clipboard",header = TRUE)
> ## check the structure of data set
> str(fac)
'data.frame':  48 obs. of  5 variables:
 $ yld      : num  24 26.9 27.5 26.5 32.5 33.2 31.2 33.6 35.2 28.9 ...
 $ var      : Factor w/ 4 levels "v1","v2","v3",...: 1 1 1 1 2 2 2 2 3 3
 ...
 $ fer      : Factor w/ 4 levels "f1","f2","f3",...: 1 2 3 4 1 2 3 4 1 2
 ...
 $ rep      : Factor w/ 3 levels "R1","R2","R3": 1 1 1 1 1 1 1 1 1 1 ...
 $ interaction: Factor w/ 16 levels "v1f1","v1f2",...: 1 2 3 4 5 6 7 8 9 10
 ...
  ## Graphically represent factors using box plot
> boxplot(yld~var, data = fac, xlab = "Variety", ylab = "Yield",
col = c("#00AFBB", "#E7B800"))

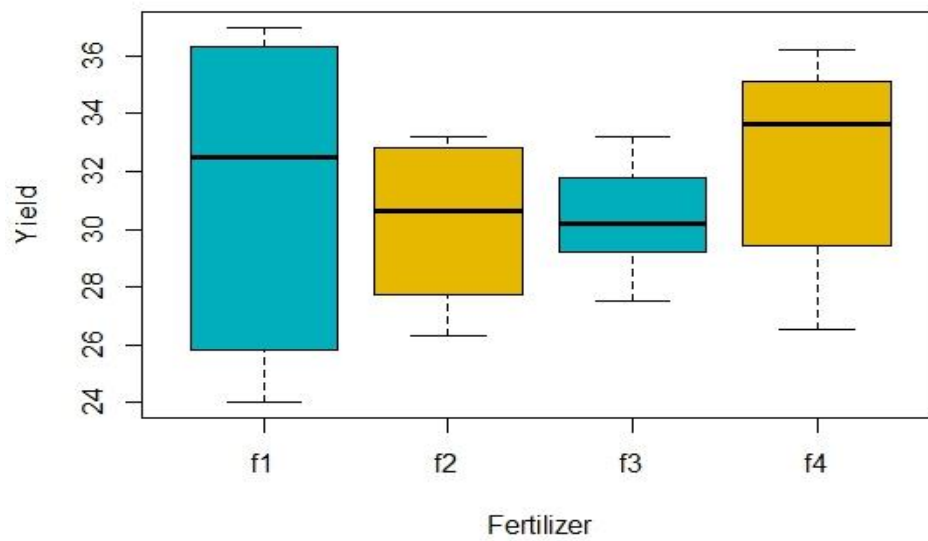
```



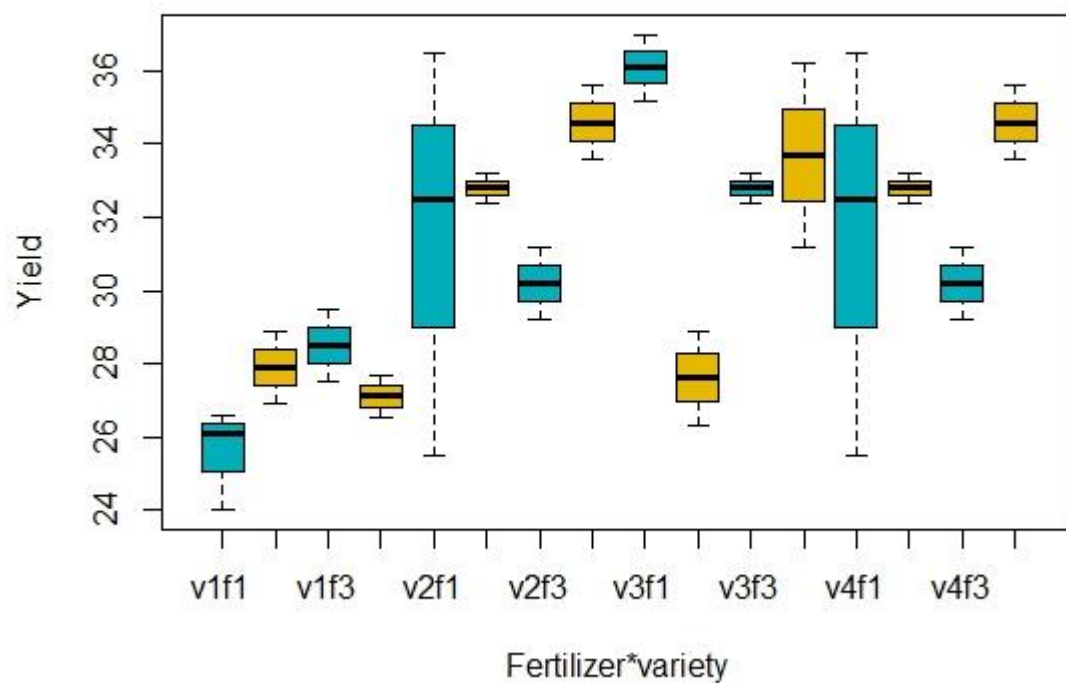
```

> boxplot(yld~fer, data = fac, xlab = "Fertilizer", ylab = "Yield",
col = c("#00AFBB", "#E7B800"))

```



```
> boxplot(yld~interaction, data = fac, xlab = "Fertilizer*variety", ylab =
"Yield",col = c("#00AFBB", "#E7B800"))
```



```
> model<-aov(yld~fer+var+fer*var, data = fac)
> summary(model)
```

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
fer	3	10.0	3.33	1.5	0.25
var	3	10.0	3.33	1.5	0.25
fer:var	9	10.0	1.11	0.5	0.95
Residuals	24	10.0	0.42		
Total	33	30.0			
Corrected Total	30	20.0			

```

fer          3  37.21   12.40   2.496  0.07750 .
var          3 234.69   78.23  15.746 1.82e-06 ***
fer:var       9 156.31   17.37   3.496  0.00413 **
Residuals    32 158.99    4.97

```

---

signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

```

> library(lsmeans)
> lm1<-lm(yld~fer+var+fer*var, data=fac)
> lsm1<-lsmeans(lm1,"var")
> pairs(lsm1)

```

contrast	estimate	SE	df	t.ratio	p.value
v1 - v2	-5.008	0.91	32	-5.504	<.0001
v1 - v3	-5.283	0.91	32	-5.806	<.0001
v1 - v4	-5.008	0.91	32	-5.504	<.0001
v2 - v3	-0.275	0.91	32	-0.302	0.9902
v2 - v4	0.000	0.91	32	0.000	1.0000
v3 - v4	0.275	0.91	32	0.302	0.9902

Results are averaged over the levels of: fer

P value adjustment: tukey method for comparing a family of 4 estimates

```

> lsm2<-lsmeans(lm1,~fer:var)
> lsm2

```

fer	var	lsmean	SE	df	lower.CL	upper.CL
f1	v1	25.6	1.29	32	22.9	28.2
f2	v1	27.9	1.29	32	25.3	30.5
f3	v1	28.5	1.29	32	25.9	31.1
f4	v1	27.1	1.29	32	24.5	29.7
f1	v2	31.5	1.29	32	28.9	34.1
f2	v2	32.8	1.29	32	30.2	35.4
f3	v2	30.2	1.29	32	27.6	32.8
f4	v2	34.6	1.29	32	32.0	37.2
f1	v3	36.1	1.29	32	33.5	38.7
f2	v3	27.6	1.29	32	25.0	30.2
f3	v3	32.8	1.29	32	30.2	35.4
f4	v3	33.7	1.29	32	31.1	36.3
f1	v4	31.5	1.29	32	28.9	34.1
f2	v4	32.8	1.29	32	30.2	35.4
f3	v4	30.2	1.29	32	27.6	32.8
f4	v4	34.6	1.29	32	32.0	37.2

Confidence level used: 0.95

```

> pairs(lsm2)

```

contrast	estimate	SE	df	t.ratio	p.value
f1,v1 - f2,v1	-2.33	1.82	32	-1.282	0.9939

f1,v1 - f3,v1	-2.93	1.82	32	-1.612	0.9543
f1,v1 - f4,v1	-1.53	1.82	32	-0.843	0.9999
f1,v1 - f1,v2	-5.93	1.82	32	-3.260	0.1349
f1,v1 - f2,v2	-7.23	1.82	32	-3.974	0.0262
f1,v1 - f3,v2	-4.63	1.82	32	-2.546	0.4659
f1,v1 - f4,v2	-9.03	1.82	32	-4.964	0.0019
f1,v1 - f1,v3	-10.53	1.82	32	-5.788	0.0002
f1,v1 - f2,v3	-2.03	1.82	32	-1.117	0.9985
f1,v1 - f3,v3	-7.23	1.82	32	-3.974	0.0262
f1,v1 - f4,v3	-8.13	1.82	32	-4.469	0.0074
f1,v1 - f1,v4	-5.93	1.82	32	-3.260	0.1349
f1,v1 - f2,v4	-7.23	1.82	32	-3.974	0.0262
f1,v1 - f3,v4	-4.63	1.82	32	-2.546	0.4659
f1,v1 - f4,v4	-9.03	1.82	32	-4.964	0.0019
f2,v1 - f3,v1	-0.60	1.82	32	-0.330	1.0000
f2,v1 - f4,v1	0.80	1.82	32	0.440	1.0000
f2,v1 - f1,v2	-3.60	1.82	32	-1.978	0.8196
f2,v1 - f2,v2	-4.90	1.82	32	-2.692	0.3772
f2,v1 - f3,v2	-2.30	1.82	32	-1.264	0.9947
f2,v1 - f4,v2	-6.70	1.82	32	-3.681	0.0532
f2,v1 - f1,v3	-8.20	1.82	32	-4.506	0.0067
f2,v1 - f2,v3	0.30	1.82	32	0.165	1.0000
f2,v1 - f3,v3	-4.90	1.82	32	-2.692	0.3772
f2,v1 - f4,v3	-5.80	1.82	32	-3.187	0.1566
f2,v1 - f1,v4	-3.60	1.82	32	-1.978	0.8196
f2,v1 - f2,v4	-4.90	1.82	32	-2.692	0.3772
f2,v1 - f3,v4	-2.30	1.82	32	-1.264	0.9947
f2,v1 - f4,v4	-6.70	1.82	32	-3.681	0.0532
f3,v1 - f4,v1	1.40	1.82	32	0.769	1.0000
f3,v1 - f1,v2	-3.00	1.82	32	-1.648	0.9457
f3,v1 - f2,v2	-4.30	1.82	32	-2.363	0.5851
f3,v1 - f3,v2	-1.70	1.82	32	-0.934	0.9998
f3,v1 - f4,v2	-6.10	1.82	32	-3.352	0.1113
f3,v1 - f1,v3	-7.60	1.82	32	-4.176	0.0158
f3,v1 - f2,v3	0.90	1.82	32	0.495	1.0000
f3,v1 - f3,v3	-4.30	1.82	32	-2.363	0.5851
f3,v1 - f4,v3	-5.20	1.82	32	-2.857	0.2890
f3,v1 - f1,v4	-3.00	1.82	32	-1.648	0.9457
f3,v1 - f2,v4	-4.30	1.82	32	-2.363	0.5851
f3,v1 - f3,v4	-1.70	1.82	32	-0.934	0.9998
f3,v1 - f4,v4	-6.10	1.82	32	-3.352	0.1113
f4,v1 - f1,v2	-4.40	1.82	32	-2.418	0.5488
f4,v1 - f2,v2	-5.70	1.82	32	-3.132	0.1746
f4,v1 - f3,v2	-3.10	1.82	32	-1.703	0.9309

f4,v1 - f4,v2	-7.50	1.82	32	-4.121	0.0182
f4,v1 - f1,v3	-9.00	1.82	32	-4.945	0.0020
f4,v1 - f2,v3	-0.50	1.82	32	-0.275	1.0000
f4,v1 - f3,v3	-5.70	1.82	32	-3.132	0.1746
f4,v1 - f4,v3	-6.60	1.82	32	-3.626	0.0605
f4,v1 - f1,v4	-4.40	1.82	32	-2.418	0.5488
f4,v1 - f2,v4	-5.70	1.82	32	-3.132	0.1746
f4,v1 - f3,v4	-3.10	1.82	32	-1.703	0.9309
f4,v1 - f4,v4	-7.50	1.82	32	-4.121	0.0182
f1,v2 - f2,v2	-1.30	1.82	32	-0.714	1.0000
f1,v2 - f3,v2	1.30	1.82	32	0.714	1.0000
f1,v2 - f4,v2	-3.10	1.82	32	-1.703	0.9309
f1,v2 - f1,v3	-4.60	1.82	32	-2.528	0.4775
f1,v2 - f2,v3	3.90	1.82	32	2.143	0.7264
f1,v2 - f3,v3	-1.30	1.82	32	-0.714	1.0000
f1,v2 - f4,v3	-2.20	1.82	32	-1.209	0.9966
f1,v2 - f1,v4	0.00	1.82	32	0.000	1.0000
f1,v2 - f2,v4	-1.30	1.82	32	-0.714	1.0000
f1,v2 - f3,v4	1.30	1.82	32	0.714	1.0000
f1,v2 - f4,v4	-3.10	1.82	32	-1.703	0.9309
f2,v2 - f3,v2	2.60	1.82	32	1.429	0.9832
f2,v2 - f4,v2	-1.80	1.82	32	-0.989	0.9996
f2,v2 - f1,v3	-3.30	1.82	32	-1.813	0.8938
f2,v2 - f2,v3	5.20	1.82	32	2.857	0.2890
f2,v2 - f3,v3	0.00	1.82	32	0.000	1.0000
f2,v2 - f4,v3	-0.90	1.82	32	-0.495	1.0000
f2,v2 - f1,v4	1.30	1.82	32	0.714	1.0000
f2,v2 - f2,v4	0.00	1.82	32	0.000	1.0000
f2,v2 - f3,v4	2.60	1.82	32	1.429	0.9832
f2,v2 - f4,v4	-1.80	1.82	32	-0.989	0.9996
f3,v2 - f4,v2	-4.40	1.82	32	-2.418	0.5488
f3,v2 - f1,v3	-5.90	1.82	32	-3.242	0.1401
f3,v2 - f2,v3	2.60	1.82	32	1.429	0.9832
f3,v2 - f3,v3	-2.60	1.82	32	-1.429	0.9832
f3,v2 - f4,v3	-3.50	1.82	32	-1.923	0.8467
f3,v2 - f1,v4	-1.30	1.82	32	-0.714	1.0000
f3,v2 - f2,v4	-2.60	1.82	32	-1.429	0.9832
f3,v2 - f3,v4	0.00	1.82	32	0.000	1.0000
f3,v2 - f4,v4	-4.40	1.82	32	-2.418	0.5488
f4,v2 - f1,v3	-1.50	1.82	32	-0.824	1.0000
f4,v2 - f2,v3	7.00	1.82	32	3.846	0.0359
f4,v2 - f3,v3	1.80	1.82	32	0.989	0.9996
f4,v2 - f4,v3	0.90	1.82	32	0.495	1.0000
f4,v2 - f1,v4	3.10	1.82	32	1.703	0.9309

f4,v2 - f2,v4	1.80	1.82	32	0.989	0.9996
f4,v2 - f3,v4	4.40	1.82	32	2.418	0.5488
f4,v2 - f4,v4	0.00	1.82	32	0.000	1.0000
f1,v3 - f2,v3	8.50	1.82	32	4.670	0.0043
f1,v3 - f3,v3	3.30	1.82	32	1.813	0.8938
f1,v3 - f4,v3	2.40	1.82	32	1.319	0.9920
f1,v3 - f1,v4	4.60	1.82	32	2.528	0.4775
f1,v3 - f2,v4	3.30	1.82	32	1.813	0.8938
f1,v3 - f3,v4	5.90	1.82	32	3.242	0.1401
f1,v3 - f4,v4	1.50	1.82	32	0.824	1.0000
f2,v3 - f3,v3	-5.20	1.82	32	-2.857	0.2890
f2,v3 - f4,v3	-6.10	1.82	32	-3.352	0.1113
f2,v3 - f1,v4	-3.90	1.82	32	-2.143	0.7264
f2,v3 - f2,v4	-5.20	1.82	32	-2.857	0.2890
f2,v3 - f3,v4	-2.60	1.82	32	-1.429	0.9832
f2,v3 - f4,v4	-7.00	1.82	32	-3.846	0.0359
f3,v3 - f4,v3	-0.90	1.82	32	-0.495	1.0000
f3,v3 - f1,v4	1.30	1.82	32	0.714	1.0000
f3,v3 - f2,v4	0.00	1.82	32	0.000	1.0000
f3,v3 - f3,v4	2.60	1.82	32	1.429	0.9832
f3,v3 - f4,v4	-1.80	1.82	32	-0.989	0.9996
f4,v3 - f1,v4	2.20	1.82	32	1.209	0.9966
f4,v3 - f2,v4	0.90	1.82	32	0.495	1.0000
f4,v3 - f3,v4	3.50	1.82	32	1.923	0.8467
f4,v3 - f4,v4	-0.90	1.82	32	-0.495	1.0000
f1,v4 - f2,v4	-1.30	1.82	32	-0.714	1.0000
f1,v4 - f3,v4	1.30	1.82	32	0.714	1.0000
f1,v4 - f4,v4	-3.10	1.82	32	-1.703	0.9309
f2,v4 - f3,v4	2.60	1.82	32	1.429	0.9832
f2,v4 - f4,v4	-1.80	1.82	32	-0.989	0.9996
f3,v4 - f4,v4	-4.40	1.82	32	-2.418	0.5488

P value adjustment: tukey method for comparing a family of 16 estimates

```
> # to provide letters for groups
```

```
> library(multcompView)
```

```
> CLD(lsm1, Letters = "abcde")
```

	var	lsmean	SE	df	lower.CL	upper.CL	.group
v1	27.3	0.643	32	26.0	28.6	a	
v2	32.3	0.643	32	31.0	33.6	b	
v4	32.3	0.643	32	31.0	33.6	b	
v3	32.5	0.643	32	31.2	33.9	b	

Results are averaged over the levels of: fer

Confidence level used: 0.95

P value adjustment: tukey method for comparing a family of 4 estimates

significance level used: alpha = 0.05

> CLD(lsm2, Letters = "abcdefgh")

fer	var	lsmean	SE	df	lower.CL	upper.CL	.group
f1	v1	25.6	1.29	32	22.9	28.2	a
f4	v1	27.1	1.29	32	24.5	29.7	ab
f2	v3	27.6	1.29	32	25.0	30.2	ab
f2	v1	27.9	1.29	32	25.3	30.5	abc
f3	v1	28.5	1.29	32	25.9	31.1	abc
f3	v2	30.2	1.29	32	27.6	32.8	abcd
f3	v4	30.2	1.29	32	27.6	32.8	abcd
f1	v2	31.5	1.29	32	28.9	34.1	abcd
f1	v4	31.5	1.29	32	28.9	34.1	abcd
f2	v2	32.8	1.29	32	30.2	35.4	bcd
f2	v4	32.8	1.29	32	30.2	35.4	bcd
f3	v3	32.8	1.29	32	30.2	35.4	bcd
f4	v3	33.7	1.29	32	31.1	36.3	bcd
f4	v2	34.6	1.29	32	32.0	37.2	cd
f4	v4	34.6	1.29	32	32.0	37.2	cd
f1	v3	36.1	1.29	32	33.5	38.7	d

Confidence level used: 0.95

P value adjustment: tukey method for comparing a family of 16 estimates

significance level used: alpha = 0.05