APPENDIX

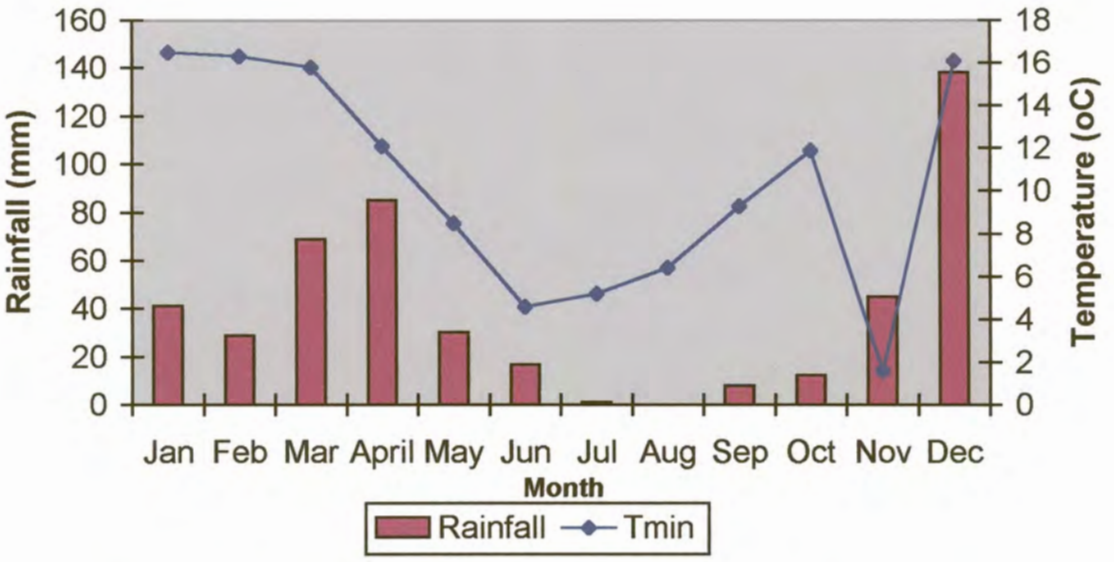

Figure 8.1 Monthly meteorological data for Hatfield showing raifall (mm) and mean minimum temperatures, 1999.

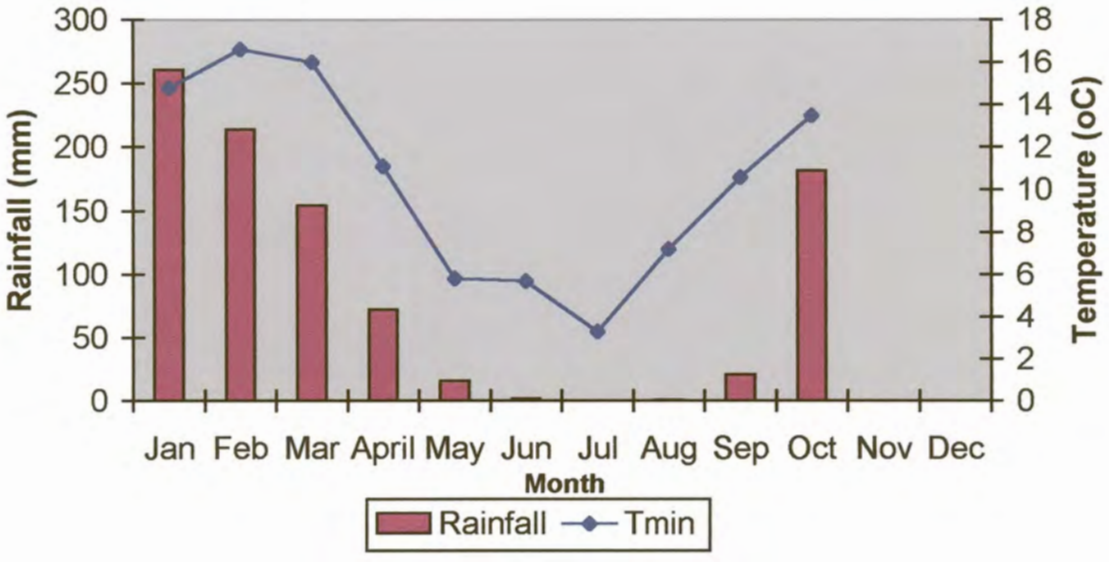

Figure 8.2 Monthly meteorological data for Hatfield showing raifall (mm) and mean minimum temperatures, 2000.

Table 8 1 Growth habit classification and description of *Phaseolus* as defined by CIAT

GROWTH HABIT	DESCRIPTION
Type I	Determinate habit; reproductive terminals on main stem and no further node production on main stem after flowering.
Type II	Indeterminate habit (vegetative terminal on main stem); further node production on main stem after flowering; erect branches borne on lower nodes; erect plant with extremely variable guide development.
Type IIIa	Indeterminate habit; moderate node production on main stem after flowering; prostrate canopy with variable number of branches borne on lower nodes; main stem guide development extremely variable but generally showing poor climbing ability.
Type IIIb	Indeterminate habit; considerable node production on main stem after flowering; heavily branched with variable number of facultatively climbing branches borne on lower nodes; guide development variable; plants generally show moderate climbing tendency on supports with resulting cone-shaped canopy.
Type IVa	Indeterminate habit; heavy node production on main stem after flowering; branches not well developed compared to main stem development; moderate climbing ability on supports, with fruit load carried relatively uniformly along length of the plant.
Type IVb	Indeterminate habit; extreme node production after flowering; branches very poorly developed; strong climbing tendencies on supports, with fruit load borne on the upper node of main stem.

Table 8. 2A ANOVA of the effect of plant density on seed yield per plant of dry bean cvs Teebus & Kranskop (Experiment 1)

Source	df	SS	MS	F- Value
Total	15	32.2		
Cultivar (C)	1	7.3	7.3	3.85ns
Density (D)	1	1.6	1.6	0.85ns
C x D	1	0.7	0.7	0.35ns
Error	12	22.7		

*, **, = significantly different from zero at P≤0.05, P≤0.01 respectively
ns = not significant

Table 8. 2B ANOVA of the effect of plant density on seed yield per square metre of dry bean cvs Teebus & Kranskop (Experiment 1)

Source	df	SS	MS	F- Value
Total	15	58538.7		
Cultivar (C)	1	8192.5	8192.5	4.35ns
Density (D)	1	27600.0	27600.0	14.65**
C x D	1	145.3	145.3	0.08ns
Error	12	22600.9		

*, **, = significantly different from zero at P≤0.05, P≤0.01 respectively
ns = not significant

Table 8. 2C ANOVA of the effect of plant density on number of pods per plant of dry bean cvs Teebus & Kranskop (Experiment 1)

Source	df	SS	MS	F- Value
Total	15	100.4		
Cultivar (C)	1	75.1	75.1	39.88**
Density (D)	1	2.2	2.2	1.19ns
C x D	1	0.4	0.4	0.23ns
Error	12	22.6		

*, **, = significantly different from zero at P≤0.05, P≤0.01 respectively
ns = not significant

Table 8. 2D ANOVA of the effect of plant density on number of seeds per pod of dry bean cvs Teebus & Kranskop (Experiment 1)

Source	df	SS	MS	F- Value
Total	15	1.2		
Cultivar (C)	1	0.3	0.3	6.40*
Density (D)	1	0.021	0.021	0.44ns
C x D	1	0.2	0.2	5.09*
Error	12	0.6	0.05	

*, **, = significantly different from zero at P≤0.05, P≤0.01 respectively
ns = not significant

Table 8. 2E ANOVA of the effect of plant density on hundred seed mass of dry bean cvs Teebus & Kranskop (Experiment 1)

Source	df	SS	MS	F- Value
Total	15	4635.6		
Cultivar (C)	1	4544.1	45.1	704.34**
Density (D)	1	14.0	14.0	2.17ns
C x D	1	0.04	0.04	0.01ns
Error	12	77.4		

*, **, = significantly different from zero at P≤0.05, P≤0.01 respectively
ns = not significant

Table 8. 3A ANOVA of the effect of plant density on seed yield per plant of dry bean cv Kranskop (Experiment 2)

Source	df	SS	MS	F- Value
Total	11	256.4		
Density	2	179.9	89.9	10.58
Error	9	76.5	8.5	

*, **, = significantly different from zero at P≤0.05, P≤0.01 respectively
ns = not significant

Table 8. 3B ANOVA of the effect of plant density on seed yield per square metre of dry bean cv Kranskop (Experiment 2)

Source	df	SS	MS	F- Value
Total	11	14.0		
Density	2	7.5	3.8	5.24
Error	9	6.4	0.7	

*, **, = significantly different from zero at P≤0.05, P≤0.01 respectively
ns = not significant

Table 8. 3C ANOVA of the effect of plant density on number of pods per plant of dry bean cv Kranskop (Experiment 2)

Source	df	SS	MS	F- Value
Total	11	49.6		
Density	2	39.3	19.7	17.18
Error	9	10.3	1.1	

*, **, = significantly different from zero at P≤0.05, P≤0.01 respectively
ns = not significant

Table 8. 3D ANOVA of the effect of plant density on number of seeds per pod of dry bean cv Kranskop (Experiment 2)

Source	df	SS	MS	F- Value
Total	11	0.2		
Density	2	0.1	0.05	4.84
Error	9	0.1	0.01	

*, **, = significantly different from zero at P≤0.05, P≤0.01 respectively
ns = not significant

Table 8. 3E ANOVA of the effect of plant density on hundred seed mass of dry bean cv Kranskop (Experiment 2)

Source	df	SS	MS	F- Value
Total	11	38.1		
Density	2	34.8	17.4	46.90
Error	9	3.3	0.4	

*, **, = significantly different from zero at P≤0.05, P≤0.01 respectively
ns = not significant

Table 8. 4A ANOVA of the effect of row, intra-row and plant density on seed yield per plant of two dry bean cultivars (Field experiment)

Source	df	SS	MS	F-value
Total	159	3591.3		
C	1	0.8	0.8	0.06ns
I	3	413.8	137.9	10.37**
C x I	3	394.0	131.4	9.88**
R	4	598.1	149.5	11.24**
C x R	4	98.0	24.5	1.84ns
R x I	12	178.1	14.8	1.12ns
C x R x I	12	312.8	26.1	1.96*
Error	120	1595.8	13.3	

*, **, = significantly different from zero at P≤0.05, P≤0.01 respectively
ns = not significant

Table 8. 4B ANOVA of the effect of row, intra-row and plant density on seed yield per square metre of two dry bean cultivars (Field experiment)

Source	df	SS	MS	F-value
Total	159	441358.3		
C	1	5226.0	5226.0	4.81*
I	3	56324.1	18774.7	17.27**
C x I	3	21141.1	7047.0	6.48**
R	4	161474.3	40368.6	37.13**
C x R	4	19380.5	4845.1	4.46**
R x I	12	25428.5	2119.0	1.95*
C x R x I	12	21927.3	1827.3	1.68ns
Error	120	130456.6	1087.1	

*, **, = significantly different from zero at P≤0.05, P≤0.01 respectively
ns = not significant

Table 8. 4C ANOVA of the effect of row, intra-row and plant density on pods per plant of two dry bean cultivars (Field experiment)

Source	df	SS	MS	F-value
Total	159	997.8		
C	1	33.3	33.3	13.20**
I	3	161.2	53.7	21.30**
C x I	3	120.0	40.0	15.86**
R	4	125.5	31.4	12.43**
C x R	4	35.9	9.0	3.56**
R x I	12	100.2	8.4	3.31**
C x R x I	12	118.9	9.9	3.93**
Error	120	302.8	2.5	

*, **, = significantly different from zero at P≤0.05, P≤0.01 respectively
ns = not significant

Table 8. 4D ANOVA of the effect of row, intra-row and plant density on number of seeds per of two dry bean cultivars (Field experiment)

Source	df	SS	MS	F-value
Total	159	47.9		
C	1	11.8	11.8	54.58**
I	3	2.1	0.7	3.23*
C x I	3	0.5	0.2	0.81ns
R	4	0.8	0.2	0.88ns
C x R	4	0.5	0.1	0.62ns
R x I	12	2.6	0.2	1.01ns
C x R x I	12	3.7	0.3	1.42ns
Error	120	25.9	0.2	

*, **, = significantly different from zero at P≤0.05, P≤0.01 respectively
ns = not significant

Table 8. 4E ANOVA of the effect of row, intra-row and plant density on hundred seed mass of two dry bean cultivars (Field experiment)

Source	df	SS	MS	F-value
Total	159	27386.7		
C	1	24163.6	24163.6	1170.86**
I	3	96.2	32.1	1.55ns
C x I	3	112.6	37.5	1.82ns
R	4	118.6	29.6	1.44ns
C x R	4	197.6	49.4	2.39ns
R x I	12	44.3	3.7	0.18ns
C x R x I	12	177.3	14.8	0.72ns
Error	120	2476.5	20.6	

*, **, = significantly different from zero at P≤0.05, P≤0.01 respectively
ns = not significant

Table 8. 4F ANOVA of the effect of row, intra-row and plant density on harvest index of two dry bean cultivars (Field experiment)

Source	df	SS	MS	F-value
Total	159	1284.7		
C	1	434.7	434.7	118.12**
I	3	27.0	9.0	2.44ns
C x I	3	46.4	15.5	4.21**
R	4	136.5	34.1	9.27**
C x R	4	90.7	22.7	6.17**
R x I	12	87.8	7.3	1.98*
C x R x I	12	19.8	1.6	0.43ns
Error	120	441.8	3.68	

*, **, = significantly different from zero at P≤0.05, P≤0.01 respectively
ns = not significant

Table 8. 5A ANOVA of the effect of nitrate / ammonium ratio and concentration on fresh biomass of dry bean cv Kranskop (Experiment 1)

Source	df	SS	MS	F- Value
Total	11	2781.9		
Ratio (R)	1	1615.6	1615.6	12.06**
Concentration (C)	1	94.9	94.9	0.71ns
R x C	1	0.003	0.003	0.00ns
Error	8	1071.4	133.9	

*, **, = significantly different from zero at P≤0.05, P≤0.01 respectively
ns = not significant

Table 8. 5B ANOVA of the effect of nitrate / ammonium ratio and concentration on leaf area of dry bean cv Kranskop (Experiment 1)

Source	df	SS	MS	F- Value
Total	11	257441.9		
Ratio (R)	1	127759.5	127759.5	13.79**
Concentration (C)	1	17065.3	17065.3	1.84ns
R x C	1	38498.2	38498.2	4.16ns
Error	8	74118.9	9264.9	

*, **, = significantly different from zero at P≤0.05, P≤0.01 respectively
ns = not significant

Table 8. 5C ANOVA of the effect of nitrate / ammonium ratio and concentration on dry biomass of dry bean cv Kranskop (Experiment 1)

Source	df	SS	MS	F- Value
Total	11	43.5		
Ratio (R)	1	25.1	25.1	12.61**
Concentration (C)	1	2.3	2.3	1.14ns
R x C	1	0.1	0.1	0.06ns
Error	8	16.0	2.0	

*, **, = significantly different from zero at P≤0.05, P≤0.01 respectively
ns = not significant

Table 8. 5D ANOVA of the effect of nitrate / ammonium ratio and concentration on shoot dry weight of dry bean cv Kranskop (Experiment 1)

Source	df	SS	MS	F- Value
Total	11	42.7		
Ratio (R)	1	22.7	22.7	10.27*
Concentration (C)	1	2.0	2.0	0.92ns
R x C	1	0.2	0.2	0.08ns
Error	8	17.7	2.2	

*, **, = significantly different from zero at P≤0.05, P≤0.01 respectively
ns = not significant

Table 8. 5E ANOVA of the effect of nitrate / ammonium ratio and concentration on root dry weight of dry bean cv Kranskop (Experiment 1)

Source	df	SS	MS	F- Value
Total	11	0.3		
Ratio (R)	1	0.1	0.06	1.81ns
Concentration (C)	1	0.002	0.002	0.09ns
R x C	1	0.008	0.01	0.25ns
Error	8	0.26	0.03	

*, **, = significantly different from zero at P≤0.05, P≤0.01 respectively
ns = not significant

Table 8. 5F ANOVA of the effect of nitrate / ammonium ratio and concentration on number of pods per plant of dry bean cv Kranskop (Experiment 1)

Source	df	SS	MS	F- Value
Total	11	38.9		
Ratio (R)	1	0.8	0.8	0.22ns
Concentration (C)	1	4.1	4.1	1.20ns
R x C	1	6.8	6.8	1.98ns
Error	8	27.3	3.4	

*, **, = significantly different from zero at P≤0.05, P≤0.01 respectively
ns = not significant

Table 8. 5G ANOVA of the effect of nitrate / ammonium ratio and concentration on number of seeds per pod of dry bean cv Kranskop (Experiment 1)

Source	df	SS	MS	F- Value
Total	11	1.2		
Ratio (R)	1	0.003	0.003	0.02ns
Concentration (C)	1	0.003	0.003	0.02ns
R x C	1	0.08	0.1	0.61ns
Error	8	1.1	0.1	

*, **, = significantly different from zero at P≤0.05, P≤0.01 respectively
ns = not significant

Table 8. 5H ANOVA of the effect of nitrate / ammonium ratio and concentration on hundred seed mass of dry bean cv Kranskop (Experiment 1)

Source	df	SS	MS	F- Value
Total	11	424.8		
Ratio (R)	1	88.6	88.6	2.16ns
Concentration (C)	1	2.8	2.8	0.07ns
R x C	1	5.3	5.3	0.13ns
Error	8	328.1	41.0	

*, **, = significantly different from zero at P≤0.05, P≤0.01 respectively
ns = not significant

Table 8. 5I ANOVA of the effect of nitrate / ammonium ratio and concentration on seed yield per plant of dry bean cv Kranskop (Experiment 1)

Source	df	SS	MS	F- Value
Total	11	910.8		
Ratio (R)	1	122.9	122.9	2.57ns
Concentration (C)	1	229.9	229.9	4.81ns
R x C	1	175.9	175.9	3.68ns
Error	8	382.2	47.8	

*, **, = significantly different from zero at P≤0.05, P≤0.01 respectively
ns = not significant

Table 8. 5J ANOVA of the effect of nitrate / ammonium ratio and concentration on harvest index of dry bean cv Kranskop (Experiment 1)

Source	df	SS	MS	F- Value
Total	11	16.8		
Ratio (R)	1	4.7	4.7	3.19ns
Concentration (C)	1	0.2	0.2	0.13ns
R x C	1	0.2	0.2	0.13ns
Error	8	11.7	1.5	

*, **, = significantly different from zero at P≤0.05, P≤0.01 respectively
ns = not significant

Table 8. 6A ANOVA of the effect of nitrate / ammonium ratio and concentration on fresh biomass of dry bean cultivar Kranskop 40 DAE (Experiment 2)

Source	df	SS	MS	F- Value
Total	26	3180.8		
Ratio (R)	2	244.3	122.2	1.49ns
Concentration (C)	2	1201.5	600.8	7.30**
R x C	4	254.2	63.6	0.77ns
Error	18	1480.7	82.3	

*, **, = significantly different from zero at P≤0.05, P≤0.01 respectively
ns = not significant

Table 8. 6B ANOVA of the effect of nitrate / ammonium ratio and concentration on leaf area of dry bean cultivar Kranskop 40 DAE (Experiment 2)

Source	df	SS	MS	F- Value
Total	26	2376514.1		
Ratio (R)	2	382753.8	191376.9	4.86*
Concentration (C)	2	1041375.8	520687.9	13.22*
R x C	4	243649.6	60912.4	1.55ns
Error	18	708734.8	39374.1	

*, **, = significantly different from zero at P≤0.05, P≤0.01 respectively
ns = not significant

Table 8. 6C ANOVA of the effect of nitrate / ammonium ratio and concentration on dry biomass of dry bean cultivar Kranskop 40 DAE (Experiment 2)

Source	df	SS	MS	F- Value
Total	26	279.0		
Ratio (R)	2	22.7	11.4	1.53ns
Concentration (C)	2	94.8	47.4	6.38**
R x C	4	27.6	6.9	0.93ns
Error	18	133.8	7.4	

*, **, = significantly different from zero at P≤0.05, P≤0.01 respectively
ns = not significant

Table 8. 6D ANOVA of the effect of nitrate / ammonium ratio and concentration on shoot dry weight of dry bean cultivar Kranskop 40 DAE (Experiment 2)

Source	df	SS	MS	F- Value
Total	26	58.5		
Ratio (R)	2	5.6	2.8	2.07ns
Concentration (C)	2	20.3	10.2	7.45**
R x C	4	7.9	2.0	1.45ns
Error	18	24.6	1.4	

*, **, = significantly different from zero at P≤0.05, P≤0.01 respectively
ns = not significant

Table 8. 6E ANOVA of the effect of nitrate / ammonium ratio and concentration on root dry weight of dry bean cultivar Kranskop 40 DAE (Experiment 2)

Source	df	SS	MS	F- Value
Total	26	5.9		
Ratio (R)	2	0.3	0.2	0.65ns
Concentration (C)	2	0.4	0.2	0.71ns
R x C	4	0.4	0.1	0.38ns
Error	18	4.8	0.3	

*, **, = significantly different from zero at P≤0.05, P≤0.01 respectively
ns = not significant

Table 8. 6F ANOVA of the effect of nitrate / ammonium ratio and concentration on seed mass per plant of dry bean cultivar Kranskop at maturity (Experiment 2)

Source	df	SS	MS	F- Value
Total	35	2206.3		
Ratio (R)	2	1340.6	670.3	44.74**
Concentration (C)	2	3.1	1.6	0.10ns
R x C	4	458.3	114.6	7.65**
Error	27	404.5	15.0	

*, **, = significantly different from zero at P≤0.05, P≤0.01 respectively
ns = not significant

Table 8. 6G ANOVA of the effect of nitrate / ammonium ratio and concentration on number of pods per plant of dry bean cultivar Kranskop at maturity (Experiment 2)

Source	df	SS	MS	F- Value
Total	35	351.0		
Ratio (R)	2	142.1	72.0	28.95**
Concentration (C)	2	2.4	1.2	0.49ns
R x C	4	140.3	35.1	14.29**
Error	27	66.2	2.4	

*, **, = significantly different from zero at P≤0.05, P≤0.01 respectively
ns = not significant

Table 8. 6H ANOVA of the effect of nitrate / ammonium ratio and concentration on number of seeds per pod of dry bean cultivar Kranskop at maturity (Experiment 2)

Source	df	SS	MS	F- Value
Total	35	8.2		
Ratio (R)	2	0.8	0.40	1.55ns
Concentration (C)	2	0.03	0.01	0.05ns
R x C	4	0.32	0.08	0.30ns
Error	27	7.06	0.26	

*, **, = significantly different from zero at P≤0.05, P≤0.01 respectively
ns = not significant

Table 8. 6I ANOVA of the effect of nitrate / ammonium ratio and concentration on hundred seed mass of dry bean cultivar Kranskop at maturity (Experiment 2)

Source	df	SS	MS	F- Value
Total	35	6074.2		
Ratio (R)	2	1969.6	984.8	12.35**
Concentration (C)	2	470.1	235.0	2.95ns
R x C	4	1482.1	370.5	4.65**
Error	27	2152.4	79.7	

*, **, = significantly different from zero at P≤0.05, P≤0.01 respectively
ns = not significant

Table 8. 6J ANOVA of the effect of nitrate / ammonium ratio and concentration on harvest index of dry bean cultivar Kranskop at maturity (Experiment 2)

Source	df	SS	MS	F- Value
Total	35	2130.6		
Ratio (R)	2	553.4	276.7	6.79**
Concentration (C)	2	105.2	52.6	1.29ns
R x C	4	372.6	93.1	2.29ns
Error	27	1099.4	40.7	

*, **, = significantly different from zero at P≤0.05, P≤0.01 respectively
ns = not significant

Table 8. 7A ANOVA of the effect of cultivar and growth regulator on seed mass per plant of dry bean

Source	df	SS	MS	F- Value
Total	17	239.6		
Cultivar (C)	1	87.6	87.6	7.32*
Growth regulator (GR)	2	4.1	2.1	0.17ns
C x GR	2	4.4	2.2	0.18ns
Error	12	143.5	12.0	

*, **, = significantly different from zero at P≤0.05, P≤0.01 respectively
ns = not significant

Table 8. 7B ANOVA of the effect of cultivar and growth regulator on number of pods per plant of dry bean

Source	df	SS	MS	F- Value
Total	17	273.1		
Cultivar (C)	1	186.9	186.9	42.05**
Growth regulator (GR)	2	11.1	5.6	1.25ns
C x GR	2	21.8	10.9	2.45ns
Error	12	53.3	4.4	

*, **, = significantly different from zero at P≤0.05, P≤0.01 respectively
ns = not significant

Table 8. 7C ANOVA of the effect of cultivar and growth regulator on number of seeds per pod of dry bean

Source	df	SS	MS	F- Value
Total	17	7.4		
Cultivar (C)	1	4.3	4.3	19.31**
Growth regulator (GR)	2	0.3	0.1	0.61ns
C x GR	2	0.2	0.1	0.44ns
Error	12	2.7	0.2	

*, **, = significantly different from zero at P≤0.05, P≤0.01 respectively
ns = not significant

Table 8. 7D ANOVA of the effect of cultivar and growth regulator on hundred seed mass of dry bean

Source	df	SS	MS	F- Value
Total	17	3005.8		
Cultivar (C)	1	2518.1	2518.1	82.88**
Growth regulator (GR)	2	50.3	25.2	0.83ns
C x GR	2	72.7	36.4	1.20ns
Error	12	364.6		

*, **, = significantly different from zero at P≤0.05, P≤0.01 respectively
ns = not significant

Table 8. 7E ANOVA of the effect of cultivar and growth regulator on harvest index of dry bean

Source	df	SS	MS	F- Value
Total	17	1951.8		
Cultivar (C)	1	26.9	26.9	0.61ns
Growth regulator (GR)	2	1042.1	521.0	11.88**
C x GR	2	356.5	178.2	4.06*
Error	12			

*, **, = significantly different from zero at P≤0.05, P≤0.01 respectively
ns = not significant