Gashua Journal of Irrigation and Desertification Studies
Available online at www.gjidsfugashua.org.ng
Maiden Edition: Vol 1, Nos. 1 & 2

GROWTH AND YIELD OF GREEN BEAN (*Phaseolus vulgaris* L.) VARIETIES AS INFLUENCED BY NITROGEN AND PHOSPHORUS FERTILIZER RATES

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Abstract

The aim of this study is to evaluate the influence of nitrogen and phosphorus fertilizer rates on growth parameters and yield of green bean varieties at Kadawa irrigation research station of the Institute for Agricultural Research, Ahmadu Bello University, Zaria, Nigeria. The treatments consisted of three varieties of green bean (Ex Brown, Dangora and Yar-Helina), four levels of nitrogen (0, 20, 40, and 60 kg N ha^{-1}) and three levels of phosphorus (0, 22.5, and 45 kg P ha^{-1}). Factorial combinations of varieties and nitrogen were assigned to the main plots, while P was assigned to the sub-plots, arrange in a split plot design and replicated three times. Dangora and Yar-Helina significantly resulted in taller plants and more number of leaves than Ex-Brown which had more number of branches. Nitrogen and phosphorus fertilizer application increased the growth and yield parameters compared to the control.

Keywords: *Growth, Green Bean, Varieties, Nitrogen, Phosphorus*

INTRODUCTION

Fertilizer application in most Nigerian savannah soils is very important as the nutrient levels are low, it increase cropgrowth and prevent failure in poor nutrient soils (Agbede, 2009). Nitrogen is important in crop growth, protein manufacture by the plant, it is a constituent of chlorophyll and it is easily deficient in the tropics. Phosphorus influence plant growth and it is an essential component of organic compound in plants (Agbede, 2009).

Green bean (*Phaseolus vulgaris* L.) whose main commercial product is the green pods and dry bean (Gepts, 1998) cultivation dates back to at least 700 years as a staple food crop (Yamaguchi, 1983). The crop is grown as a vegetable for their immature edible pods which forms a rich source of vitamins and minerals (Purseglove, 1994).Green bean in developing countries is produced in rotation with other vegetables or in crop mixture (Messiaen, 1992). The production of green bean is often limited by low availability of soil nutrient (Tahar, 2009). Nutrient requirements of green bean have not been made popular among Nigerian farmers, and production remains limited due to little documented research report on the crops nitrogen and phosphorus requirements on the growth of the crop. Research elsewhere shows that green bean responds to the application of nitrogen and phosphorus fertilizer because of their lack of nodule forming bacteria in the soil (Brian, 1971). Messiaen (1992) recommended a complete NPK fertilizer at the rate of 30: 60: 60 kg ha^{-1} in soils where *Rhizobium phaseoli* is usually present, and that the rate applied need to be double in soils where *R. phaseoli* is often lacking. There is need to develop nitrogen and phosphorus fertilizer recommendation for the crop to boost it growth. The research is under taken to determine the influence of N and P on growth of green bean varieties.

MATERIALS AND METHOD

The experiment was conducted at Kadawa Irrigation Research Station of the Institute for Agricultural Research, Ahmadu Bello University, Zaria, during the dry seasons of 2009/2010, 2010/2011, and 2011/2012. Kadawa is located at 11^{o}39`N; 08^{o}02'E at altitude of 500 m in the Sudan savanna ecological zone of Nigeria, The treatment consisted of three varieties of green bean (Ex-Brown, Dangora and Yar-Helina), four levels of nitrogen (0, 20, 40, and 60 kg N ha^{-1}) and three levels of phosphorus (0, 22.5, and 45 kg P ha^{-1}). Factorial combinations of varieties and nitrogen were assigned to the main plots, while P was assigned to the sub-plots, arrange in a split plot design and replicated three times. The gross sub-plot area was 12 m^2 consisting of 4 rows of 4 m length and a width of 3 m (4 m x3 m). The net plot consisted of two inner rows of the gross-plot with net area of 6 m^2. The experimental site in each of the three years research was cleared, harrowed, ploughed and then ridged at 75 cm apart and soil samples were taken before ridging and analysed for physical and chemical properties in accordance with Black (1965) . Seeds were sown manually at the rate of two seeds per hole, at an intra-row spacing of 30 cm, Urea (46% N) and Single Super Phosphate (18% P_2O_5) was used as source of N and P fertilizer and was applied as per treatment to the plots. N was split applied at two and six weeks after sowing (WAS) while the P doses were applied once at sowing. Cultural practices were carried out to ensure proper growth of the crop.

Observation on growth characters were conducted on five tagged plants at 8 WAS and 10 WAS in all the years. The characters observed include: Plant height (cm), number of leaves, number of branches per plant and yield per ha^{-1} were determined. The data collected were subjected to analysis of variance (ANOVA) as described by Snedecor and Cochran (1967) and Little and Hills (1978). Duncan Multiple Range Test (DMRT) was used to separate differences among treatment means (Duncan, 1955).

RESULTS AND DISCUSSION

The physical and chemical properties of the soil from 0 – 30 cm depth, for 2009/2010, 2010/2011 and 2011/2012 dry season at Kadawa are presented on Table 1.The soil of the experimental site during the three 3 years of experimentation was sandy loam, alkaline (pH of 7.8, 7.5 and 6.7), it is low in organic carbon, available phosphorus (P) and total nitrogen (N), the soil calcium (Ca) is medium in 2009/2010 but high in 2010/2011 and 2011/2012; the magnesium (Mg) and potassium (K) is in the low range with high sodium (Na) and medium range of cation exchange capacity (C.E.C.).

Tables 2 shows the influence of nitrogen and phosphorus fertilizer rates on plant height of green bean varieties at 8 WAS.Yar-Helina recorded significantly taller plants than Ex-Brown in all the years and combined mean. Each increase in N rates also from 0 – 60 kg ha^{-1} led to a significant increase in plant height, except 20 and 40 Kg N ha^{-1} which were statistically at par. Increase in P rates from 0 – 45 Kg P ha^{-1} significantly increased plant height. However, in 2010/2011, 2011/2012 and the combined mean, 22.5 and 45 kg P ha^{-1} were statistically similar and resulted in taller plants than the control. At 10 WAS, in 2010/11 and 2011/2012 the difference in height between Dangora and Yar-Helina was not significant but the varieties recorded taller plants than Ex-Brown. In 2009/2010 and the combined mean, Dangora produced significantly taller plants, followed by Yar-Helina and then Ex-Brown. Application of N fertilizer rate from 0 – 60 kg N ha^{-1} in 2009/2010 significantly increased plant height. However, in 2010/2011 and 2011/2012; 20, 40 and 60 kg N ha^{-1} produced statistically similar plant height that was taller than for the control. In the combined mean, increase in N rate from 0 to 20 kg N ha^{-1} significantly increased plant height, a further increase to 40 and to 60 kg N ha^{-1} produced statistically similar plant height. Application of P rates from 0 to 45 kg P ha^{-1} significantly increased plant height in 2009/2010, 2010/2011 and the combined mean. In 2011/2012, 22.5 and 45 kg P ha^{-1}

produced statistically similar plant height but taller plants than for the control. The interaction on plant height between variety and N in 2010/2011 and 2011/2012(Table 3) revealed that when the highest N rate of 60 kg ha^{-1} was considered, it was observed that in 2010/2011 Dangora and Yar-Helina height were statistically similar and taller than Ex-Brown. In 2011/2012, statistical similar height was recorded by Dangora and Yar-Helina that was taller than Ex-Brown. In all the years, highest value for height was recorded by Dangora at 60 kg N ha^{-1} while the least values for height was when 0-20 kg N was applied to Ex-Brown in 2010/2011 and no N in 2011/2012 with Ex-Brown. Application of 20 kg N ha^{-1} enhanced height of all varieties in 2011/2012 except Ex-Brown in 2010/2011 remained significantly unaffected. Further increases in N to 40 kg N ha^{-1}, the height of varieties in all were not significantly increased in both years. The increase in N rate to 60 kg N ha^{-1}, increased height of Dangora and Yar-Helina in 2011/2012, the height of varieties in 2010/2011 and Ex-Brown in 2011/2012 remained significantly similar. At fixed N rate of 0 kg N ha^{-1}, the three varieties show significant variation in height, in 2010/2011 where Ex-Brown was shorter than the other two varieties. When 20 kg N ha^{-1} was considered, it was observed that in 2010/2011 Dangora and Yar-Helina had statistically similar height, taller than for Ex-Brown. At fixed N rate of 40 kg N ha^{-1}, Dangora and Yar-Helina had statistically similar height in both years that is taller than that of Ex-Brown.

At 8 WAS (Table 4), the difference in number of leaves between varieties were not significant in 2009/2010 and 2010/2011, however in 2011/2012 and combined mean, Dangora and Yar-Helina produced statistically similar but significantly more number of leaves per plant than Ex-Brown. Each increase in N from 0 - 60 kg N ha^{-1} in 2009/2010 and the combined mean, increased number of leaves per plant. In 2011/2012, 40 and 60 kg N ha^{-1} produced number of leaves that were statistically similar and more number of leaves per plant than the control. There was no significant effect of N on number of leaves per plant in 2010/2011. P application of 22.5 and 45 kg P ha^{-1} in 2009/2010, 2011/2011 and combined mean produced statistically similar number of leaves per plant but more than the control. In 2010/2011, no significant effect was observed on number of leaves per plant when the P rate was increased from 0 – 45 kg P ha^{-1}. At 10 WAS, in 2009/2010, 2010/2011, 2011/2012 and combined mean, the difference in number of leaves per plant between Ex-Brown and Dangora was not statistically significant, but significantly lower than Yar-Helina. Each increase in N rates in combined mean significantly increased number of leaves per plant. In 2009/2010, 2010/2011, and 2011/2012, application of 60 kg N ha^{-1} produced more number of leaves per plant than 40 and 20 kg N ha^{-1}, however, the two rates were statistically similar but produced more number of leaves per plant than the control. Application of phosphorus rates from 0 – 45 kg P ha^{-1} significantly increased number of leaves per plant in 2010/2011, 2011/2012 and combined mean but in 2009, 22.5 and 45 kg P ha^{-1} produced significantly similar number of leaves per plant but more than 0 kg P ha^{-1}.

At 8 WAS (Table 5), a non significant difference was recorded between Ex-Brown and Yar-Helina in 2010/2011 but they produced more branches per plant than Dangora. In 2011/2012 and combined mean, Ex-Brown produced significantlymore branches per plant as compared to Dangora and Yar-Helina which were statistically similar. No significant difference in number of branches per plant among the varieties was observed in 2009/2010. In 2009/2010, there was no significant difference in number of branches per plant between 40 and 60 kg N ha^{-1}, the rates produced significantly more branches per plant than the control. In 2010/2011, increasing N rate from 0 to 40 kg N ha^{-1} significantly increased number of branches per plant but further increase of N to 60 Kg N ha^{-1} significantly decreased number of branches. In the combined mean, increasing N rate from 0 - 20 kg N ha^{-1} had no significant effect on number of branches but further increase of N to 40 kg N ha^{-1}resulted in significantly more branches but comparable to application of 60 kg N ha^{-}.[1] In 2011/2012, N rates produced non significant effect on number of branches per plant. Application of phosphorus at 22.5 and 45 kg P ha^{-1} were statistically comparable but produced more branches per plant than 0 kg P ha^{-1} in 2011/2012 and combined mean. There was no significant difference in number of branches per plant between the various rates of phosphorus in 2009/2010 and 2010/2011. At 10 WAS, in all the years and combined mean, Ex-Brown produced significantly more branches compared with Dangora and Yar-Helina. Similarly, Dangoraproduced significantly lower number of branches compared with Yar-Helina except in 2011/2012 where the varieties were statistically similar. A non significant difference was observed between 40 and 60 kg N ha^{-1} in 2010/2011 and the combined mean; the rates resulted in significantly more branches per plant than the control. Application of N rates from 0 – 60 kg N ha^{-1} in 2009/2010, significantly increased number of branches per plant. However, there was no significant effect on number of branches per plant with increasing N rates in 2011/2012. Application of P rates of 22.5 and 45 kg P ha^{-1} were statistically comparable and produced significantly more branches per plant than 0 kg P ha^{-1} in 2010/2011 and the combined mean. Phosphorus rates had no significant effect on number of branches per plant in 2011/2011, but in 2009/2010, increasing P rates resulted in significant increase in number of branches per plant. The result of the interaction (Table 6) on number of branches per plant revealed that when the highest rate of 60 kg N ha^{-1} was considered, it was observed that in all the years and the combined mean, Ex-Brown had significantly more number of branches than the other varieties. Application of 20 kg N ha^{-1} enhanced number of branches of Ex-brown in 2009/2010, Yar-Helina in 2011/2012 but Dangora in 2009/2010, all the varieties in 2010/2011 and combined mean number of branches remain significantly unaffected. Further increase to 40 kg N ha^{-1} increased number of branches of Yar-Helina in 2011/2012 but all the varieties number of branches remained significantly unaffected. The increase in N to 60 kg N ha^{-1} significantly increased number of branches of Ex-Brown in all the years and Yar-Helina in 2011/2012, number of branches of Dangora and Yar-Helina in 2009/2010, 2010/2011, Dangora in 2011/2012 Dangora and Yar-Helina in the mean remained significantly similar. At fixed N rate of 0 kg ha^{-1}, the three varieties show significant variation on number of branches, in all the years Dangora and Yar-Helina had lower number of branches to Ex-Brown. When 20 kg N ha^{-1} was considered, it was observed in 2009/2010 and combined mean, Ex-Brown and Yar-Helin had statistically similar number of branches and more than Dangora. In 2010/2011 and 2011/2012 Ex-Brown had more number of branches than Dangora. At fixed N at 40 kg N ha^{-1}, Dangora and Yar-Halina are statistically similar in number of branches in all the years and lower than Ex-Brown.

In this study, significant differences in crop performance among the varieties, observed from the result of the findings on plant height, number of leaves per plant, number of branches per plant,could be due to the varietal differences of each variety and response to environmental factors such as temperature, soil factor, soil pH and cultural practices. The efficiency with which the varieties respond to environmental treatment differs and the efficiency of photosynthesis is often associated with the degree of vegetative growth of the plant. This result supported the findings of Fawzy*et al*. (2011), who reported that growth of any crop is a function of its genotype expressed under growing environmental conditions.

The significantly increased in growth parameters as a result of N fertilizer applied could be due to the ability of N in promoting vegetative growth which resulted in higher LA and thus higher assimilate production which translated into yield. Nitrogen is an important constituent of chlorophyll, amino acid, nuclei acid, enzymes; hence it is essential in plant growth and development (Agbede, 2009).Philip *et al.* (2002), reported increased in growth with N fertilizer application.The significant increase in growth character per plant at higher P rate of 45 kg P ha^{-1} over 22.5 and 0 kg P ha^{-1} could be as a result of phosphorus essentiality in biological energy transfer processes that are vital for life and growth. Veeresh (2003), reported a significant increase in growth parameters due to increased P fertilization from 40 to 80 kg P ha^{-1}. The statistical similarity observed at some of the sampling, periods, between 22.5 and 45 kg P ha^{-1} could be that 22.5 kg P ha^{-1} application provided the plant with sufficient P nutrient for increased growth parameters, therefore increasing P level to 45 kg ha^{-1} resulted in no further increased benefit. Chatterjee and Som (1991) reported significant increase in growth parameters up to 32.7 kg P.

The effect of nitrogen and phosphorus on fresh pods yield ha^{-1} (kg) of green bean varieties at Kadawa during 2009/2010 – 2011/2012 dry seasons and the combined mean on Table (7) revealed that in 2009/2010 and the combined mean, Dangora had higher pod yield ha^{-1} than Yar-Helina which in turn out-yielded Ex-Brown in all the years except 2010/2011, statistically similar pod yield was obtained between Ex-Brown and Yar-Helina in 2010/2011. In 2011/2012, Dangora and Yar-Helina had statistically similar pod yield that was lower than for Ex-Brown. The significant differences in crop performance among the varieties observed could be due to the varietal differences of each variety and response to environmental factors such as temperature, soil factor, soil pH and cultural practices. The efficiency with which the varieties respond to environmental treatment differs and the efficiency of photosynthesis is often associated with the degree of vegetative growth of the plant. This result is in harmony with the findings of Fawzy*et al*. (2011), who reported that growth and yield of any crop is a function of its genotype expressed under growing environmental conditions, including nutrient availability. In all the years and combined mean, the result showed that application of nitrogen rate from 0-20, 20-40, and 40- 60 kg N ha^{-1} resulted in a corresponding increased in fresh pod yield ha^{-1}.This could be that N application enhanced the chlorophyll content in plants thereby improving photosynthetic and thus increased the final yield. This finding supported the observation reported byEbrahim*et al*. (2011) who reported increase in number of pod and pod yield with increased N rates. Increasing phosphorus rate from 22.5 to 45 kg P ha^{-1} resulted in statistically similar fresh pod yield ha^{-1} that was more than for the control. This could be that ample supply of phosphorus has been reported to promote earlier flowering and crop maturity (Douglas and Philip, 2008). A significant interaction on pod yield ha^{-1} was observed between varieties and phosphorus as well as nitrogen and phosphorus in 2009/2010.The interaction between nitrogen and phosphorus (Table 8) revealed that application of 22.5 kg P ha^{-1} significantly increased pod yield ha^{-1} at all N rates except 40 kg N ha^{-1} where the parameters remained significantly unaffected. Further increase to 45 kg P ha^{-1} increased pod yield ha^{-1} for all except 0 kg N ha^{-1} where the increased was not significant. At fixed P rates of 0, 22.5 and 45 kg P ha^{-1}, each increase in N from 0-20 and further to 40 kg N ha^{-1} significantly increased pod yield ha^{-1}. Further increase in N to 60 kg N ha^{-1} increased pod yield only where 22.5 kg P ha^{-1} was applied, at 0 and 45 kg P ha^{-1}, pod yield remained significantly unaffected. The interaction between variety and phosphorus (Table 9) revealed that application of 22.5 kg P ha^{-1} significantly increased pod yield of Dangora and Yar-Helina and Ex-Browm remained unaffected. Further increased to 45 kg P ha^{-1} had no significant effect on pod yield of the varieties. At fixed rate of 0 kg P ha^{-1}, Dangora recorded significantly higher pod yield, and lower yield with Ex-Brown. At 22.5 kg P ha^{-1} significant increased yield of Dangora and Yar-Helina was recorded.

In conclusion,nitrogen fertilizer at 60 kg N ha^{-1} and Phosphorus rate at 22.5 kg P ha^{-1} increase crop growth and can be adopted by the farmers in sudan savannah ecological zone with Dangora and or Yar-Helina varieties,.

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Table 1: Physical and chemical properties of the soil from 0-30 cm depth at the experimental site, during 2009/2010-2011/2012 dry seasons at Kadawa

Soil properties	2009/2009	2010/2011	2011/2012
Physical properties			
% sand	44	49	47
% silt	25	27	29
% clay	31	24	24
Textural class	Sandy loam	Sandy loam	Sandy loam
Chemical properties			
PH water	7.8	7.5	6.7
PH Cacl2	7.4	7.3	6.3
Organic Carbon (%)	0.63	0.72	0.80
Available P (mg kg^{-1})	6.9	8.3	10.8
Total N (g kg^{-1})	0.22	0.24	0.36
Exchangeable base (cMol kg^{-1})			
Ca	4.97	5.30	5.69
Mg	0.48	0.59	0.72
K	0.10	0.16	0.17
Na	2.80	2.34	0.47
C.E.C	9.0	8.20	7.10

Soil samples as analysed at Agronomy Department IAR/ABU, Zaria

Table 2: Influence of nitrogen and phosphorus on plant height (cm) of green bean varieties at 8 and 10 WAS during 2009/2010-2011/2012 dry seasons at Kadawa

	8 weeks after sowing				10 weeks after sowing			
Treatment	**2009/2010**	**2010/2011**	**2011/2012**	**Combined mean**	**2009/2010**	**2010/2011**	**2011/2012**	**Combined mean**
Variety								
Ex-Brown	43.63c	47.12c	46.29b	45.68b	73.53c	62.79b	66.89b	67.74c
Dangora	67.72b	83.19b	76.53a	75.81a	105.42a	103.28a	108.43a	105.71a
Yar-Helina	70.45a	85.25a	76.96a	77.55a	81.90b	102.88a	109.96a	98.25b
SE±	0.897	0.684	0.882	0.652	1.298	0.936	0.758	1.145
Nitrogen rate (kgNha^{-1})								
0	54.39c	62.03c	56.56c	57.66c	70.52d	81.67b	84.02b	78.74c
20	59.41b	74.47b	65.94b	66.61b	85.16c	91.40a	98.18a	91.58b
40	59.87b	72.75b	65.60b	66.07b	93.60b	92.27a	99.64a	95.17ab
60	68.72a	78.17a	78.28a	75.06a	98.53a	93.27a	98.53a	96.78a
SE±	1.0366	0.7902	1.018	0.753	1.499	1.081	0.875	1.322
Phosphorus rate (kg P ha^{-1})								
0	56.86c	69.04b	62.61b	62.84b	79.75c	84.05c	92.45b	85.42c
22.5	60.54b	72.66a	69.39a	67.53a	85.11b	89.98b	95.76a	90.28b
45	64.40a	73.86a	67.79a	68.68a	95.99a	94.92a	97.07a	95.99a
SE±	0.897	0.684	0.882	0.652	1.298	0.936	0.758	1.145
Interaction								
V x N	NS	NS	NS	NS	NS	**	**	NS
V x P	NS	NS	NS	NS	NS	NS	NS	NS
N x P	NS	NS	NS	NS	NS	NS	NS	NS
V x N x P	NS	NS	NS	NS	NS	NS	NS	NS

Means followed by same letter(s) in a column and treatment group are not statistically different at 5% level of probability using DMRT. NS = Not significant. WAS= weeks after sowing, **= Highly significant

Table 3: Interaction between variety and nitrogen on plant height (cm) of green bean variety at10 WAS during 2010/2011 and 2011/2012 dry season at Kadawa

	Nitrogen rates (kg ha^{-1})			
Treatment	0	20	40	60
Varieties				
		2010/2011		
Ex-Brown	57.81e	59.17e	63.73de	70.48d
Dangora	90.26c	105.33ab	105.20ab	112.36a
Yar-Helina	96.97bc	100.72b	104.14ab	109.72a
SE±		3.103		
		2011/2012		
Ex-Brown	59.06f	68.86e	67.43e	72.23e
Dangora	97.62d	106.19c	109.83bc	120.10a
Yar-Helina	95.39d	113.52b	111.41b	119.55a
SE±		1.757		

Means followed by same letter(s) are statistically similar at 5% level of probability

Table 4: Influence of nitrogen and phosphorus on number of leaves of green bean varieties at 8 and 10 WAS during 2009/2010-2011/2012 dry seasons at Kadawa

	8 weeks after sowing				10 weeks after sowing			
Treatment	**2009/2010**	**2010/2011**	**2011/2012**	**Combined mean**	**2009/2010**	**2010/2011**	**2011/2012**	**Combined mean**
Variety								
Ex-Brown	16.05	18.02	18.30b	17.46b	23.66b	31.08b	34.00b	29.58b
Dangora	16.55	17.94	180.94a	17.81a	23.63b	31.86b	34.22b	29.91b
Yar-Helina	16.30	18.47	19.25a	18.01a	25.30a	33.36a	36.05a	31.57a
SE±	0.160	0.195	0.151	0.116	0.344	0.331	0.428	0.238
Nitrogen rate (kgNha^{-1})								
0	14.81d	16.55	17.66c	16.35d	21.77c	29.92c	29.62c	26.11d
20	15.88c	17.81	18.92b	17.54c	22.25b	32.11b	35.18b	30.19c
40	16.88b	18.51	19.22ab	18.21b	24.22b	32.88b	35.96b	31.03b
60	17.62a	19.70	19.51a	18.95a	27.55a	36.48a	38.25a	34.10a
SE±	0.1851	0.225	0.175	0.134	0.397	0.382	0.494	0.273
Phosphorus rate (kg P ha^{-1})								
0	16.08b	17.31	18.33b	17.24b	23.25b	29.91c	32.41c	28.53c
22.5	16.25ab	18.53	18.89a	17.89a	24.44a	32.58b	35.27b	30.77b
45	16.58a	18.61	19.28a	18.16a	24.91a	33.80a	36.58a	31.77a
SE±	0.160	0.195	0.151	0.116	0.344	0.331	0.428	0.238
Interaction								
V x N	NS	NS	NS	NS	NS	NS	NS	NS
V x P	NS	NS	NS	NS	NS	NS	NS	NS
N x P	NS	NS	NS	NS	NS	NS	NS	NS
V x N x P	NS	NS	NS	NS	NS	NS	NS	NS

Means followed by same letter(s) in a column and treatment group are not statistically different at 5% level of probability using DMRT. NS = Not significant. WAS= weeks after sowing

Table 5: Influence of nitrogen and phosphorus on number of branches of green bean varieties at 8 and 10 WAS during 2009/2010-2011/2012 dry seasons at Kadawa

	8 weeks after sowing				10 weeks after sowing			
Treatment	**2009/2010**	**2010/2011**	**2011/2012**	**Combined mean**	**2009/2010**	**2010/2011**	**2011/2012**	**Combined mean**
Variety								
Ex-Brown	5.61	5.38a	7.02a	6.01a	10.27a	8.30a	7.80a	8.8a
Dangora	5.58	4.69b	5.08b	5.12b	8.63c	5.72c	6.16b	6.84c
Yar-Helina	5.77	5.33a	5.08b	5.4b	9.63b	6.38b	6.38b	7.47b
SE±	0.146	0.136	0.133	0.102	0.155	0.128	0.142	0.107
Nitrogen rate (kgNha^{-1})								
0	5.40b	4.29c	5.85	5.19c	8.51d	6.00c	7.03	7.19b
20	5.48b	5.00b	5.55	5.35bc	9.07c	6.62b	6.85	7.52b
40	5.70ab	6.07a	5.81	5.86a	9.81b	7.48a	6.59	7.96a
60	6.03a	5.18b	5.70	5.64ab	10.66a	7.11a	6.66	8.15a
SE±	0.169	0.157	0.153	0.118	0.180	0.148	0.164	0.123
Phosphorus rate (kg P ha^{-1})								
0	5.50	5.05	5.30b	5.29b	8.86c	6.30b	6.22	7.13b
22.5	5.55	5.19	6.11a	5.62a	9.47b	7.05a	7.00	7.84a
45	5.91	5.16	5.77a	5.62a	10.22a	0.05a	7.13	8.14a
SE±	0.146	0.136	0.133	0.102	0.155	0.128	0.142	0.107
Interaction								
V x N	NS	NS	NS	NS	**	**	**	**
V x P	NS	NS	NS	NS	NS	NS	NS	NS
N x P	NS	NS	NS	NS	NS	NS	NS	NS
V x N x P	NS	NS	NS	NS	NS	NS	NS	NS

Means followed by same letter(s) in a column and treatment group are not statistically different at 5% level of probability using DMRT. NS = Not significant. WAS= weeks after sowing**, **=** Highly significant

Table 6: Interaction between variety and nitrogen on number of branches of green variety at 10 WAS during 2009, 2010, 2011 dry season at Kadawa and combined mean

	Nitrogen rates (kg N ha^{-1})			
Treatment	0	20	40	60
Varieties			**2009/2010**	
Ex-Brown	8.44ef	9.56bcd	10.56b	12.56a
Dangora	8.78def	8.22f	8.56def	9.0def
Yar-Helina	8.33f	9.44cde	10.33bc	10.44bc
SE±		0.369		
			2010/2011	
Ex-Brown	7.0cd	7.67bc	7.78ab	9.78a
Dangora	4.78f	5.56ef	6.44de	6.11de
Yar-Helina	5.44ef	6.22de	6.67cde	7.22bcd
SE±		0.389		
			2011/2012	
Ex-Brown	7.89b	7.56b	7.33b	8.44a
Dangora	5.89de	6.22cd	6.33cd	6.22cd
Yar-Helina	5.33e	6.11d	6.78c	7.33b
SE±		0.187		
			Combined mean	
Ex-Brown	7.78bcd	8.26bc	8.89b	10.26a
Dangora	6.48e	6.67de	7.11cde	7.11cde
Yar-Helina	7.30cde	7.07cde	7.63cde	7.89bcd
Se+		0.431		

Means followed by the same letter(s) are statistically similar at 5% level of probability

Table 7: Influence of nitrogen and phosphorus on fresh pod yield ha^{-1} (kg) of green bean varieties during 2009-2011 dry seasons at Kadawa

Treatment	**2009/2010**	**2010/2011**	**2011/2012**	**Combined mean**
Variety				
Ex-Brown	2198.7c	2278.3b	4407.8a	2961.6c
Dangora	5099.8a	3009.6a	3759.4b	3956.3a
YarHelina	4396.5b	2635.6b	3848.b	3627.0b
SE±	73.43	130.33	135.50	107.01
Nitrogen rate (kgNha^{-1})				
0	2286.9d	1324.6d	2077.4d	2620.6d
20	3580.3c	1748.9c	2923.7c	3441.8c
40	4432.0b	3131.4b	4041.0b	4559.7b
60	5294.1a	4359.7a	5017.7a	5399.3a

SE±	84.80	150.50	123.57	156.41
Phosphorus rate (kg P ha¹)				
0	3547.2b	2291.1b	3185.9b	3719.4b
22.5	4048.5a	2715.8a	3670.4a	4246.8a
45	4099.2a	2916.6a	3688.6a	4049.9ab
SE±	73.43	130.33	135.50	107.01
Interaction				
V x N	NS	NS	NS	NS
V x P	**	NS	NS	NS
N x P	**	NS	NS	NS
V x N x P	NS	NS	NS	NS

Means followed by same letter(s) in a column and treatment group are not statistically different at 5% level of probability using DMRT. ** = Highly significant, NS = Not significant.

Table 8: Shows the Interaction between nitrogen and phosphorus on pod yield of green bean varieties kg ha^{-1}

	Phosphorus rates (kg P ha^{-1})		2009/2010
Treatment	0	22.5	45
Nitrogen rates (kg N ha^{-1})			
0	1846.17h	2266.02g	2748.50fg
20	3537.78e	3091.56f	4111.50d
40	4219.67cd	4316.33cd	4759.94b
60	4585.29bc	6520.15a	4776.74b
SE+		146.87	

Means followed by same letter(s) are statistically similar at 5% level of probability

Table 9: Show the Interaction between variety and phosphorus on pod yield of green bean varieties kg ha^{-1}

	Phosphorus rates kg P ha^{-1}		2009/2010
Treatment	0	22.5	45
Variety			
Ex-Brown	2248.97e	2049.06e	2297.93e
Dangora	4753.44c	5161.72ab	5384.21a
Yar-Helina	3639.27d	4934.77bc	4615.37c
SE+		127.201	

Means followed by same letter(s) are statistically similar at 5% level of probability