International Research Journal of Agricultural Science and Soil Science (ISSN: 2251-0044) Vol. 2(11) pp. 481-492, November 2012
Available online http://www.interesjournals.org/IRJAS

Full Length Research Paper

Effects of nitrogen fetilizer applications in a bean – maize based intercropping systems and locations on seed quality of common bean in Western Kenya

[1]Ogutu M.O., [2] Muasya R. and [3] Ouma G.

[1]Kenya Agricultural Research Institute, P.O. Box 1490, Kisumu, Kenya
[2]Moi University, Department of Seed Crop and Horticultural Sciences, P.O. Box 1125, Eldoret, Kenya
[3]School of Agriculture, Food Security and Biodiversity, Bondo University College, P.O Box 210-40601, Bondo, Kenya

Abstract

Common bean (*Phaseolus vulgaris* L.) is an important crop in western Kenya. It is usually intercropped with maize (*Zea mays*). Combined effects of N fertilizer at two levels i.e. without N fertilizer and 50 Kg N per ha and cropping systems comprising research practice and Farmers' practice at two planting locations in western Kenya were studied and evaluated in an intercrop system of maize and beans in the year 2006. The objectives of the study were to determine the effects of cropping systems and N fertilizer levels at different locations on the seed quality parameters of beans. Two field experiments were conducted at two Kenya Agricultural Research Institute (K.A.R.I) centers at Kibos and Kisii. The cultivars used were *KK8* and *H 614* for beans and maize respectively. The experiments comprised two cropping systems and two N fertilizer levels in a Completely Randomized Block design Replicated four times. Data were collected on seed germination, seed vigor, seed width, shoot length, root length, seed thickness and seedling growth rate. Statistical analysis was carried out for analysis of variance (ANOVA) and mean separation test done using Least Significant Difference at 5% in addition to correlation analysis. The results showed that Research practice increased seed germination by 10.6% while bean seed quality parameters such as seedling growth rate, shoot length and seed sizes were not affected by cropping system. Farmers' practice affected seed size, root length and 1000 seed weight. Addition of N fertilizer increased 1000 seed weight by 4.5 %, while at Kibos it reduced the shoot length by 42 percent. Planting location affected 1000 seed weight, seed germination and shoot length with these seed qualities being higher in value in Kisii than Kibos. The three way interaction of Cropping system × N fertilizer × Location increased seedling growth rate and seed vigor by 20% and 18% respectively. It is concluded that the three factors used in this study increased seedling dry matter and seed vigor and other seed quality parameters.

Keywords: Seed size, cropping, location, practice, parameters, shoot, root, length, and seedling.

INTRODUCTION

Common bean is the most important leguminous crop grown during the rainy seasons on the vertical soils of tropical Africa (Sieme *et al*., 1998). In Eastern Africa Kenya is the leading producer of beans which is a major source of protein. The area under bean production in Kenya is 500,000 ha (Kimani *et al*., 1998). Maize and bean intercropping system is one of the cropping systems practiced by most of the African farmers (Wortmann *et al*., 1991). This is due to the fact that the two crops are compatible with one another and do not compete each other (Wortmann *et al*., 1991; Norman *et al.,*1996) for nutrient especially for light. Nutrient use in intercropping system has received a considerable attention despite difficulties in quantifying its beneficial competitive effects.

*Corresponding Author E-mail: ogutumourice@yahoo.com, goumaoindo@yahoo.com

The competition for nutrients is important and begins early in the growth of component crops in a cereal intercropping system. Seed quality is one of the main factors that determine crop productivity. A major problem with bean production in western Kenya is the use of low quality seed by farmers which is caused by low soil fertility and inappropriate cropping systems. Cropping systems and N fertilizer are important factors affecting crop production. However, information is lacking on how they affect seed quality. The objective of the study was to determine the effects of two cropping systems namely: Research practice and Farmers' practice and N fertilizer levels on bean seed quality at two planting locations in western Kenya.

MATERIALS AND METHODS

The study was conducted in the year 2006 at the Kenya Agricultural Research institute (K.A.R.I) at the centre namely Kisii and Kibos in Western Kenya. K.A.R.I Kisii is located about 2 km North East of Kisii town (0^{O} 30 S and 0 degrees 58S, longitude 34^{O} , 38E and 35) at an elevation of 1500 -1600m above sea level with a mean precipitation of 2159mm per annum and a mean temperature of 16.4^{O}C. The Kisii site was previously under maize while Kibos site was under cassava (*Manihot esculenta).* The seeds used were *KK8* for beans that were tolerant to root rot disease while the maize cultivar used was *H 614*. Bean seeds were obtained from K.A.R.I, Kakamega, Kenya, while maize seed was obtained from Kenya Seed Company stockist. The experiment had two cropping systems and two N fertilizer levels. The two cropping systems were: Research practice in which maize rows alternated with bean rows in a plot (maize spacing-75cm × 30cm, bean intra spacing-15cm and Farmers' practice in which both maize and bean seeds were sown in the same hole). Two seeds of maize and three seeds of beans were sown per hole and later thinned to one to two seedlings per hole after two weeks respectively. The fertilizers were applied in the form of Calcium Ammonium Nitrate (26%N) as treatment in two splits at the rate of 50kgNha^{-1}while Triple Super Phosphate (P_2O_5) was applied at 75kg ha^{-1} as a blanket application at planting in a plot size of 3m × 3.5m.

Experimental Design and Treatments

The experimental design was a 2×2×2 factorial in a Complete Randomized Block Design (RCBD) with two pure stands of maize and common beans replicated four times. There were three factors namely: cropping systems (C) at two levels; Research practice (rows of beans are alternating with rows of maize, maize at a spacing of 75cm × 30 cm and beans planted in between the rows of maize (C_1) and Farmers' practice (seeds of both crop planted in the same hole (C_2). The second factor was N fertilizer (N) at two levels:- viz N_1-0kg N and N_2-50 kg N ha^{-1}. The third factor was location and there were two sites namely K.A.R.I Kibos and K.A.R.I Kisii. The treatments applied in this study were: **1**. C_1N_1-Research Practice + 0 kg N ha^{-1} **2**. C_1N_2-Research Practice +50kg Nha^{-1} **3**. C_2N_1-Farmers' Practice +0kg Nha^{-1} **4**. C_2N_2-Farmers' Practice+50kg Nha^{-1}. The statistical model (Gomez and Gomez, 1984) used was: $Y_{ÿklm}=\mu+ E_i + \beta_j+ C_k+ C E_{i\ k}+ N_l + CN_{kl}+ EN_{íl}+ ECN_{íkl}+ \epsilon_{íjklm}$ where:$Y_{ÿklm}$= Observations, μ=Grand mean, E_i= ith Environment, β_j =Effect of block in the i^{th} environment and C_k =Effect of cropping system in the j^{th} block in the i^{th} environment, N_l = Effect of Nitrogen in the j^{th} replicate in i^{th} environment and $\epsilon_{i\ jklm}$=The error term.

Data collection

Thousand Seed Weight (TSW)

Maize and beans were harvested at physiological maturity when the moisture content of the bean seed was between 19-25%. The beans seeds were then dried, threshed and cleaned by hand to the moisture content of 14%. Analytical purity determination was conducted on the seeds in which pure bean seeds were separated from the other crop seeds, weed seeds and inert matter. TSW was determined using tray counter with holes notched on it. The procedure was repeated ten times to give 1000 seeds which were then weighed to determine the weight per plot. Ten seeds from 1000 seeds of every plot of the experiment from both sites were sampled and their sizes (seed width, length and thickness) determined using veneer caliper.

Seed Germination Percent

One hundred seeds per treatment from 1000 seeds of every treatment from four replications were counted at random (ISTA 2004) after analytical purity determination. The seeds were then placed in a germination tray with sterilized sand as a substrate. The tray was then placed in a germination chamber with temperature maintained at 25^{o}C. Two counts were made, first count at five days and final count at seven days. Moisture content was checked every day and when necessary distilled water was added. The germination count was carried out at the end of 7 days using the following parameters: number of normal seedlings, abnormal seedlings, hard seeds, fresh ungerminated seeds and dead seeds. Germination capacity of normal seeds was based on total number of seeds planted and expressed as a percentage (ISTA, 2004).

Shoot length and Root length

These were determined by measuring from the longest tip of the leaf to the soil level and the longest root to the point of attachment just below the ground level.

Seedling Growth Rate (SGR)

Germination capacity was determined according to the ISTA rules as mentioned previously. The bean seeds were germinated in two rows of each of 25 per replicate per treatment in four replications giving a total of 100 seeds per treatment in a germination tray using sterilized sand as growth media and placed in a germination chamber. The seeds were allowed to germinate in the dark germination cabinet maintained at a temperature of 25°C. The temperature was maintained for 7 days. At the end of the period, germination count was determined according to the ISTA Rules (ISTA 2004). The normal seedlings were cut from their cotyledons and placed in a small envelope (8cm ×16cm) for drying. The seedlings were dried at a temperature of 80°C for 24 hours thereafter dry weights were determined. The total dry weights of the normal seedlings were divided by the total number of seedlings. SGR was determined using the formulae:

$$SGR = \frac{Seedling\ \ dry\ weight\ \ (g)}{Total\ \ number\ \ of\ \ normal\ \ seedlings}\ day^{-1} seedling^{-1}$$

Electrical Conductivity (EC) Test on Seed vigor

Samples of 50 seeds from every treatment from the four replicates of the experiment was weighed and placed in a 250 ml plastic container with distilled water and were set up. The containers were then placed in an incubator set at a constant temperature 25°C for 24 hours (ISTA 2004). At the end of the incubation period they were removed and the contents of the plastic container gently stirred with seeds still inside it and the EC determined by inserting a cell connected to the Conductivity Bridge into the solutions in the plastic beaker. The field Lab-Lf conductivity meter and LF613 Electrode dip type cell (Scott Gerate Glass Company, Mainz Germany (Jain *et al*., 1998) was used. The conductivity meter was frequently checked and adjusted as necessary at every start of each test. The dip cell after rinsing was set at a constant of 0.00 and water added. It was then dried by blotting paper on a filter paper before and after each replicate/sample was tested. The conductivity readings in micromhos per cm were recorded per treatment and later divided by weight (g) of each sample to give values in micromhos per cm. The electrical conductivity was then computed using the formulae:

$$EC = EC = \frac{(\mu Scm^{-1}) - Conductivity\ of\ water}{Weight\ of\ seed\ (g)} = \mu Scm^{-1} g^{-1}\ of\ seed$$:(ISTA, 2004)

Seedling Dry Matter

This was determined by dividing the seedling dry weight of the seedling after oven drying by fresh weight of the same seedling sample before oven drying and then expressed as percentage:

$$Seedling\ \ Dry\ \ Matter\ \% = \frac{Seedling\ \ Dry\ Matter\ Weight\ (g)}{Seedling\ \ Fresh\ Weight\ (g)} \times 100$$

Data Analysis

The data collected was subjected to analysis of Variance and Mean separation conducted by the Least Significant Difference method at 5 percent at 95 percent confidence level using SAS (SAS inst.1996). Correlation Analysis was done to detect association of seed and physiological parameters and detect any association of cropping-N fertilizers Interactions on the above mentioned parameters.

RESULTS

Rainfall data at Kisii and Kibos sites

Moisture is a very important factor in plant growth and development. In February the amount of rain received in Kibos was about 10mm compared to Kisii (240mm) (Figure 1). Between March and May, rainfall was distributed throughout the crop growth and development with Kisii having received more rain than Kibos. However, between June and October the temperature was relatively high and conducive for senescence and harvesting of the crop (Figure 1). Rainfall distribution patterns both for Kisii and Kibos is Bimodal, The first peak being experienced in April for Kisii (334.8mm) and Kibos (209.9mm). The second peak was in November for Kisii (256.4mm) and December for Kibos (374.5). Generally the year is considered a wet year for the two sites.

Temperature experienced at Kisii and Kibos sites

Temperature contributes economically towards crop growth, development and its productivity up to harvesting maturity stage. This is because the switch from the vegetative stage of a crop to the reproductive phase may also be influenced by temperature. Significant temperature differences between the two sites (Kibos 25°C, Kisii 22°C) were in January, February and

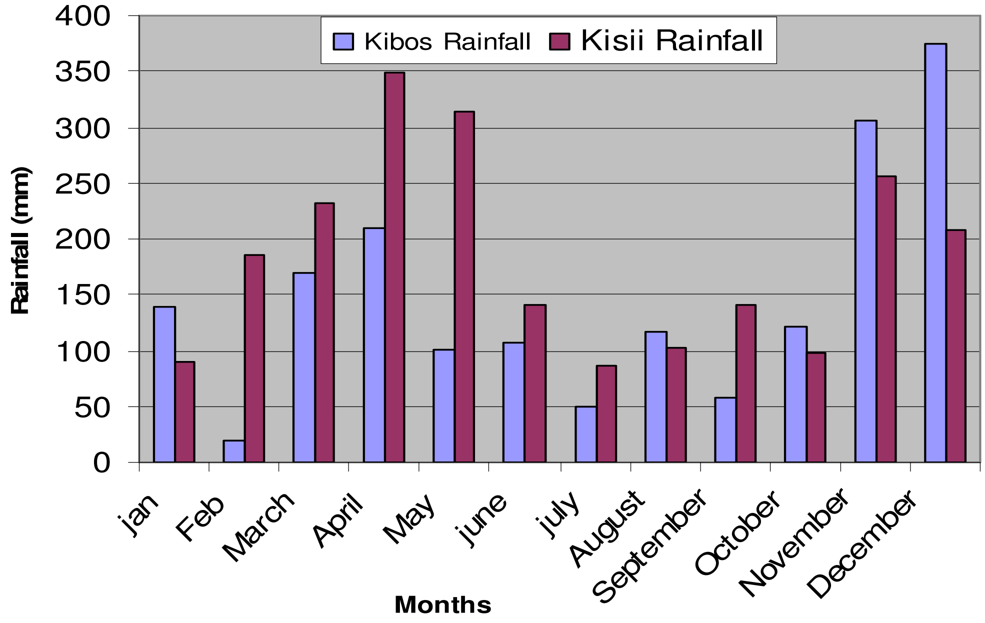

Figure 1. Rainfall received at the Kibos and Kisii sites in 2006

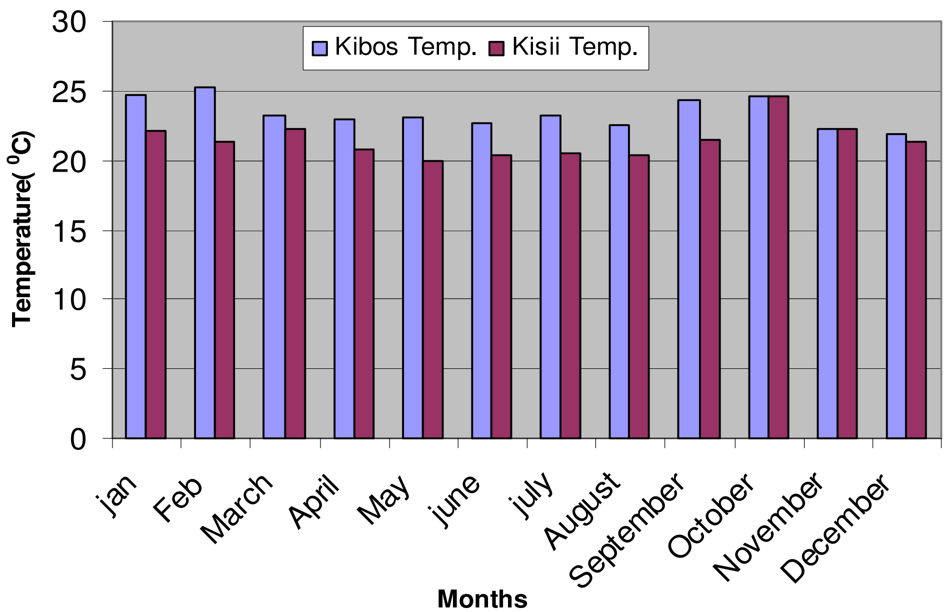

Figure 2. Temperature received at the Kibos and Kisii sites in 2006

September. In October both sites experienced the same temperature reading (Figure 2). The mean temperature for Kisii could be observed to be 20°C while that of Kibos to be 22.5°C per annum (Figure 2).

Effects of treatments on different seed qualities of beans

There were significant ($P \leq 0.05$) effects of location for seed weight, seedling growth rate (SGR), seed vigor, seedling dry weight, seed width and seed length (Table 1). Location also significantly affected 1000 seed weight and germination percent. Cropping systems significantly affected 1000 seed weight, seed vigor and seedling dry matter (Table 1 and 2). Nitrogen Fertilizer levels affected root length significantly (Table 2). There were significant Nitrogen Fertilizer x Location effects for seed vigor, seedling dry matter and seed width (Table 1). The three way interaction of Cropping system × Location × Nitrogen

Table 1. Mean squares for seedling growth rate, seed vigor, seed thickness, seed width and seed length at two rates of Nitrogen.

Sources of Variation	df	SGR	Seed vigor	Seedling dry matter	Seed thickness	Seed width	Seed length
		__g day^{-1}s^{-1})__	__µScm^{-1}g^{-1-}__	____% _____	___ cm ___	______cm	_____
Replication	3	0.003	0.216	21.123	0.004	0.007	0.024
Location (L)	1	0.024**	49.514**	1167.278**	0.001	0.043*	0.243*
Cropping system(Cs)	3	0.002	9.986**	669.974**	0.001	0.002	0.021
Nitrogen (N)	1	0.000	0.593	35.648	0.008	0.003	0.001
Cs × N	3	0.003	2.812	214.884	0.007	0.009	0.007
L × Cs	3	0.006	1.075*	438.310**	0.009	0.001*	0.014
L × N	1	0.004	4.726	105.329	0.004	0.030*	0.027
L × Cs × N	3	0.001	1.075	159.063	0.003	0.005	0.005
Error	44	0.003	4.726	105.329	0.004	0.006	0.010
CV		33.000	24.000	35.000	11.000	10.000	7.000

CV – Coefficient of Variation (%).
, *Significant values at (P≤0.05) and (P≤0.01) respectively

Table 2. Mean squares for root length shoot length, thousand seed weight, and germination%, at two levels of nitrogen across two locations.

Source of variations	df	Root	Shoot	1000 seed weight	Seed germination
		_______ lengths	_______		
		_________ cm	______	______g _____	_______ %_______
Replication	3	13.32	10.57	4530.98	104.70
Location (L)	1	22.64	379.03	163611.86**	1658.75**
Cropping system (Cs)	3	7.46	14.35	3809.93	400.14
Nitrogen (N)	1	38.16*	51.75	2690.28	722.57
Cs × N	3	4.37	14.19	2512.67	215.47
L × Cs	3	7.97	23.55	955.01	69.80
L × N	1	22.16	98.74	309.97	670.37
L× Cs × N	3	12.30	12.80	2013.42	153.11
Error	44	6.91	472.36	4118.56	199.92
CV		27.00	35.00	17.00	15.00

Coefficient of Variation (%)
*' ** Significant values at (P≤0.05) and (P≤0.01), respectively

Fertilizer was significant for shoot length, 1000 seed weight and root length (Tables 1 and 2).

Effect of cropping system on bean seed quality

Research practice (alternating rows of maize and beans) significantly (P≤0.05) increased seed germination percent by 10.6% but did not increase the seedling growth rate. Research practice and Farmers' practice increased the seed sizes, root length and 1000 seed weight (Tables 3a and 3b).

Effects of nitrogen fertilizer bean seed quality

The effects of N fertilizer applications on seedling dry matter, seed length, seed thickness, root length, shoot length, seed vigor, seed germination, seedling growth rate and 1000 seed weight are shown in Table 4.

Table 3a. Effect of cropping systems on seed length, seed thickness, seed length seed thickness, seed germination and 1000seed weight of beans

Cropping systems	Seed length	Seed width	Seed thickness	Seed germination	1000seed weight
	cm			%	g
Research methods	1.26a	0.75a	0.56a	80.00b	369.37a
Farmers practice	1.23ab	0.74a	0.59a	90.00b	368.78a
Mean	1.28	0.75	0.58	87.8	364.85
Lsds $_{0.05}$	0.07	0.06	0.05	10.16	46.11

Note: Means with the same letter are not significantly different at (P≤5%) according to Lsd

Table 3b. Effect of cropping systems on seed length, seed thickness, seed length seed thickness, seed germination and 1000seed weight of beans

Cropping systems	Seed length	Seed width	Seed thickness	Seed germination	1000seed weight
	cm			(%)	(g)
Research methods	1.26a	0.75a	0.56a	80.00b	369.37a
Farmers practice	1.23ab	0.74a	0.59a	90.00b	368.78a
Mean	1.28	0.75	0.58	87.8	364.85
Lsds $_{0.05}$	0.07	0.06	0.05	10.16	46.11

Note: Means with the same letter are not significantly different at (P≤5%) according to LSD

Addition of N fertilizer significantly increased 1000 seed weight at the Kisii site and reduced shoot length at the Kibos site. However, addition of N fertilizer did not affect the other seed quality parameters at the two sites (Table 4).

Effects of location on seed quality

Planting of beans at different sites showed significant differences for seedling dry matter seed width and vigor. These parameters were higher in Kibos than Kisii site. However, there were no significant differences between sites for seed thickness and seed length (Table 5). Planting at different sites also significantly (P≤0.05) affected seed length and seed germination (Table 6). However, there were no significant differences for seedling growth rate, 1000 seed weight and root length. The values of 1000 seed weight, seed germination percent and shoot length were higher in Kisii while the rate of seedling growth and root length were bigger at Kibos than Kisii site (Tables 5 and 6).

Effects of interactions between cropping systems, N fertilizer and location on seed quality

Addition of N fertilizer in Research practice significantly (P≤0.05) increased the rate of seedling growth (SGR) by 20%, while addition of N fertilizer in Farmers' practice had no effects on seedling growth rate, seed vigor and seedling dry matter (Tables 7 and 8). Farmers' practice significantly increased seed width and seed length by 17% and 5% respectively (Table 8) while

Research practice and Farmers' practice, on application of N fertilizer increased germination percent by 11% and 19% Research practice also increased 1000 seed weight by 15% but reduced shoot and root length by 35% on addition of N fertilizer (Table 9).

Pure bean stand and farmers practice significantly (p≤0.05) increased seed width and seed length by 17% and 5% respectively (Table 8). However planting pattern involving *mbili* technology and pure bean stand together with N fertilizer application significantly (p≤0.05) reduced seed thickness by 11% and 5% respectively (Table 8).

Coefficients for Seed Physiology and growth traits of beans at Kisii and Kibos sites

The relationships between seed characters were observed to be negative and positive. Significant linear correlations (r = 0.59**) between seed length (SL) and seed width (SW) was observed at Kisii (Table 10). However, the same seed length at Kibos was significantly

Table 4. Effects of nitrogen fertilizer on seedling dry matter shoot length, root length, seed vigor, seed length, seed width, seed thickness, seed germination, 1000seed weight and seedlings growth rate of Beans

Parameters	Kibos			Kisii		
	N fertilizer rates			N fertilizer rates		
	0 kg N ha^{-1}	50 kg N ha^{-1}	$Lsd_{0.05}$	0 kg N ha^{-1}	50 kg N ha^{-1}	$Lsd_{0.05}$
Seedling dry matter (%)	33.31a	34.20a	9.16ns	23.34a	25.83a	3.17 ns
Shoot length (cm)	8.63a	4.734b	3.47*	11.40a	12.11a	1.81 ns
Root length (cm)	11.37a	8.766a	2.71ns	9.12a	8.75a	1.37 ns
Seed vigor ($\mu Scm^{-1}g^{-1}$)	6.95a	7.49a	2.24 ns	5.38a	5.31a	0.28 ns
Seed length (cm)	1.38a	1.35a	0.10 ns	1.22b	1.27a	0.04 ns
Seed width (cm)	0.80a	0.74a	0.09 ns	0.70a	0.73a	0.03 ns
Seed germination (%)	77.33a	90.00a	19.21 ns	93.50ª	93.75a	7.16 ns
1000seeds weight (g)	301.19a	311.63a	75.47 ns	400.76b	418.32a	2.44*
Seedling growth rate ($gd^{-1}s^{-1}$)	0.20a	0.18a	0.07 ns	0.14a	0.16a	0.02ns

Note: Means with the same letter are not significantly different at P≤0.05)

Table 5. Effects of site interaction on seedling dry matter, seed width, seed thickness, seed vigor, and seed length of beans

Sites	Seedling dry matter	Seed			
		width	thickness	length	vigor
	%	cm			$\mu Scm^{-1}g^{-1}$
Kisii	24.58b	0.72b	0.58a	1.24b	5.34b
Kibos	33.76a	0.77a	0.59a	1.37a	7.22a
Mean	29.17	0.75	0.59	1.31	6.28
$Lsd_{0.05}$	5.26	0.04	0.03	0.50	0.79

Note: Means with the same letter are not significantly different at (P≤5%) according to Lsd

Table 6. Effects of site interaction on root length shoot length, seed germination percentage, and seedling growth rate, 1000seeds weight of beans

Sites	Root	Shoot	Seed germination	Seedling growth rate	Thousand seed weights
	length				
	cm		%	$gd^{-1}s^{-1}$	g
Kisii	8.94a	11.75a	93.63a	0.15b	409.54a
Kibos	10.03a	6.68b	83.87b	0.18a	308.52b
Mean	9.49	9.23	88.75	0.17	359.03
$Lsd_{0.05}$	1.33	1.706	7.18	0.03	32.59

Note: Means with the same letter are not significantly different at (P≤5%) according to Lsd.

associated with seed thickness and seed width (r = 0.48) while seed thickness was associated with 1000 seed weight at Kibos (Table 11) However, across the sites, significant correlations between seedling growth rate and germination percent (r =0.55), seedling dry matter (r = 0.60**) were observed (Table 12) while at the same time across the site, seed germination was observed to be associated with EC test on vigor (Table 12). Positive correlations (r = 0.54), (r = 0.71) and r =0.55 between shoot length at Kisii, Kibos and across sites respectively

Table 7. Effects of interactions between Cropping Systems, Nitrogen fertilizer and location on seedling dry matter, seed vigor and seedling grow rate of beans.

	Seedling		
Treatments	dry matter (%)	growth rate ($gd^{-1}s^{-1}$)	Seed vigor ($\mu Scm^{-1} g^{-1}$)
Research + 0 kg N ha^{-1}	21.14	0.15	5.75
Research + 50 kg N ha^{-1}	24.47	0.18	4.87
Farmers + 0 kg N ha^{-1}	22.88	0.17	6.39
Farmers + 50 kg N ha^{-1}	22.39	0.17	6.44
Mean	27.57	0.17	6.26
SE	3.63	0.02	0.54

SE±1 at significant value (p≤0.05)

Table 8. Effects of interactions between Cropping Systems, Nitrogen fertilizer and Location on seed width, seed length and seed thickness of beans

	Seed		
	width	length	thickness
	cm		
Treatments			
Research + 0 kg N ha^{-1}	0.75	1.27	0.56
Research + 50 kg N ha^{-1}	0.75	1.26	0.58
Farmers + 0 kg N ha^{-1}	0.73	1.29	0.59
Farmers + 50 kg N ha^{-1}	0.74	1.35	0.59
Mbili Tech.+ 0 kg N ha^{-1}	0.79	1.30	0.62
Mbili Tech.+ 50 kg N ha^{-1}	0.71	1.26	0.55
Pure beans + 0 kg N ha^{-1}	0.64	1.34	0.60
Pure beans + 50 kg N ha^{-1}	0.75	1.36	0.57
Mean	0.73	1.30	0.58
SE	0.03	0.04	0.02

SE±1 at significant value (p≤0.05)

Table 9. Mean effects of Nitrogen, Cropping Systems, and Location on shoot length, root length and 1000seed weight of beans

	Shoot	Root	Seed germination	TSW
	length (cm)		(%)	(g)
Treatments				
Research + 0 kg N ha^{-1}	11.43	10.67	78.32	337.65
Research + 50 kg N ha^{-1}	7.44	8.98	87.50	388.61
Farmers + 0 kg N ha^{-1}	8.80	9.11	82.00	368.64
Farmers + 50 kg N ha^{-1}	8.71	8.92	98.00	368.93
Mbili Tech.+ 0 kg N ha^{-1}	10.71	11.20	86.50	362.53
Mbili Tech + 50 kg N ha^{-1}	10.37	9.55	86.00	338.64
Pure beans + 0 kg N ha^{-1}	9.81	10.31	93.50	338.64
Pure beans +50 kg N ha^{-1}	6.88	7.58	96.00	332.37
Mean	9.27	9.50	88.48	354.50
SE	1.27	0.93	4.99	22.69

SE±1 at significant value (p≤0.05)

Table 10. Correlation coefficients for seed length, seed thickness, and 1000seed weight, and seedling growth rate, germination percentage, seed vigor shoot length and root length, Kisii site

	Seed thickness	Seed width	TSW	SGR	Seed germination	Seed vigor	Shoot length	Root length	SDM
Seed length	0.28	0.59*	0.15	0.20	-0.07	0.13	0.17	0.05	0.19
Seed thickness	0.00	0.48*	-0.05	0.20	0.13	0.30	-0.15	0.13	0.15
Seed width			0.01	0.20	-0.23	0.10	0.07	0.03	0.15
1000seeds weight				0.22	0.02	-0.23	0.10	0.03	0. 02
Seedling growth rate					0.12	0.16	0.38	0.22	0.98**
Seed germination						-0.16	0.32	0.01	0.28
Seed vigor							-0.14	-0.02	0.17
Root length							0.54*	0.00	0.21

*, ** Significant at p≤ 0.05 and p≤ 0.01 respectively

Table 11. Correlation coefficients for seed length, seed thickness, seed width, pod length, 1000 seed weight, seedling growth rate, germination percentage, seed vigor, shoot length, and root length, at Kibos site

	Seed thickness	Seed width	TSW	SGR	Seed germ.%	Seed vigor	Shoot length	Root length	SDM
Seed length	0.57*	0.46*	0.538	-0.36*	0.37*	-0.48*	-0.01	0.18	-0.02
Seed thickness		0.54*	0.49	-0.18	0.29	0.20	0.19	0.39	0.11
Seed width			0.14	-0.16	0.33	-0.31	0.21	0.38	-0.15
TSW				-0.16	0.72**	-0.23	-0.14	-0.13	-0.01
SGR					-0.74**	0.17	0.01	-0.12	0.36
Seed germ.%						-0.03	-0.25	0.14	-0.15
Seed vigor							0.19	0.06	0.30
Root length							0.71**	0.00	-0.05

*, ** Significant at p≤ 0.05 and p≤ 0.01 respectively

were observed. No significant association between seedling growth rate and seed size was observed (Tables 10, 11 and 12).

DISCUSSION

Significant location effects on 1000 seed weight and seed width could be attributed to differences in altitude, soil type and temperature factors associated with these two sites. The seed filling process in most crops including legumes is usually affected by temperature (Chowdhury and Wardlaw, 1978). Kibos site was relatively hotter (33.2°C) than Kisii (20.9°C) and this could have contributed to the seed filling duration differences at these two sites despite the fact temperatures did not go

Table 12. Correlation coefficients among seed length seed thickness, seed pod.1000seed weight, and seedling growth rate, germination Percentage, seed vigor, shoot length and root length across the sites

	Seed thickness	Seed width	TSW	SGR	Seed germ.%	Seed vigor	Shoot length	Root length	SDM
Seed length	0.41*	0.54*	-0.04	0.01	0.07	-0.06	0.26	0.23	0.20
Seed thickness		0.48	0.18	0.01	0.12	0.03	0.01	0.29	0.1
Seed width			-0.12	0.03	0.11	-0.07	-0.07	0.05	0.22
TSW				-0.25	0.34	-0.46	0.34	0.20	0.21
SGR					0.55*	0.29	0.10	0.40	0.60*
Seed germ.%						0.55*	0.09	0.04	0.17
Seed vigor							-0.17	0.15	0.39
Shoot length							0.00	0.39*	-0.11
Root length							0.55*	0.00	0.10

, * Significant at p≤ 0.05 and p≤ 0.01 respectively.

beyond 30°C (Figure 2). Legumes are very sensitive to extreme temperatures. Seed filling duration for beans is relatively insensitive to temperature between 20°C and 30°C (Hesketh *et al*. 1973; Egli 1994c) while that of maize decreases from 28/18 to 16/10°C (Tollenaar and Bruulsema 1988). It is therefore unlikely that variation in temperatures, particularly when it is high would have shortened the seed filling period, hence affecting the overall seed length, seed width, seed thickness and seed weight, but could be due to other factors other than temperature.

Water stress at one stage and flooding particularly between March and May (Table 1) could have shortened the seed filling process consequently reducing seed weight. Severe water stress and flooding during flowering and seed filling may have caused physiological maturity to occur earlier than usual and this reduced seed filling duration, seed weight and seed size (Brooks *et al*., 1982). However, it is not understood whether this response represents direct effects of water stress on the seed or only an indirect effect from acceleration of leaf senescence (De Souza *et al*., 1997). Significant differences observed due to location on seedling growth rate and vigor could have been due to temperature variation in both locations which affected metabolic activities in the seed, which usually respond to temperature if the supply of N and P are not limiting. The observed location differences in seedling growth rate and seed vigor in the present study tends to agree with the findings of Toshiro and Wardlaw (1989) who reported that seedling growth rate of wheat and rice decreased readily at 30/25°C.

Temperature affects seed metabolism and assimilate partitioning to the seed and this affects seedling growth rate and vigor. The low temperatures recorded at the Kisii site and the flooded conditions at the Kibos site may have curtailed enzyme activities in the seed causing accumulation of germination inhibitors. The variation in seed vigor and seedling growth rate was most probably caused by moisture regime differences. This may have reduced photosynthesis and assimilate distribution which reduced seedling growth rate. Significant location x cropping systems for seed vigor, seedling dry matter and seed size could be due to spatial arrangements of the crop which could have affected light interception for photosynthesis. This could be due to the differences in canopy photosynthetic rates for the different cropping systems. In the present study there was no significant Location x N interactions effects indicating that the supply of N fertilizer did not affect the cropping systems for the seed qualities observed. However, significant effects due to location N interaction for seed width may be attributed to the differences in the level of N and other weather related factors that influence physiological maturity.

Effects of cropping systems on seed quality

Farmers' practice increased germination percent. This could be attributed to the differences in light interception between the cropping systems. With well spaced arrangement of beans and maize there was enough light interception by beans which promoted photosynthesis. This may have increased the seed vigor and germination which depends on light and other factors for seedling growth. The results of the present study confirm that maize and beans have no serious competition for light (Wortmann *et al*., 1991; Norman *et al*.1996).

Effects of N fertilizer application on bean seed quality

The addition of N fertilizer to the bean crop planted at Kisii increased 1000 seed weight, while at Kibos shoot length was increased by the same addition of N fertilizer (Table 4). The increase could be due to high sink strength and weight which increased photosynthesis and partitioning of assimilates and this apparently increased 1000 seed weight (Duncan *et al*., 1974).

This finding is at variance with that of Songin *et al.,* (1993) who reported that the 1000 seed weight did not depend on N fertilizer application in Pea. Conversely, Ziolek and Kuling (1997) reported that N fertilizer reduced 1000 seed weight which also disagrees with the findings of the present study. These differences may be due to the different experimental set ups and conditions of their studies.

Effects of location (Site) on bean seed quality

Planting beans at the two sites, Kibos and Kisii significantly ($P \leq 0.05$) affected seedling growth rate, seed width, seed vigor, and shoot length and seed germination. This may have been due to the differences in soil chemical and physical properties, temperature and rainfall regimes at these two sites (Figure 1and 2). For instance, Kibos site comprised black heavy cotton soil that can easily get compacted and reduce root penetration while that of Kisii is of red volcanic soil which loses water rapidly (Schumacher and Smucher 1981). Significant differences could also be due to the differences in soil pH which affect all stages of bean development, preferably below soil pH 5.2 or above soil pH 7 (Kay 1979). At the Kisii site pH was 4.5 while at the Kibos site soil pH was 5.8-6.0. Differences observed at these two sites with respect to seed quality parameters could also be attributed to differences in temperature. Beans flower at an optimum temperature of between 21 to 23°C (Laing *et al*., 1984). In this study the effect of temperature was very minimal because temperature differences between the sites were almost the same (Kibos-20.7 and Kisii-23°C). Moisture availability due to rainfall duration and soil moisture retention capacity (Figure 1) could have contributed to the significant differences in seedling growth rate, seed width, seed vigor, and shoot length and seed germination at the two sites Kay 1979). It is sensitive to soil moisture particularly during flowering and flower failure (Stover 1974). In the present study rainfall variation particularly between the months of April and September, 2006 (Figure 1) could confirm that moisture variation between the two sites could have caused significant differences for the seed quality parameters mentioned above.

Effect of cropping systems fertilizer and location on seed quality

The addition of N fertilizer on the research practice treatment and their interaction increased the seedling growth rate and vigor which could have been due to the combined effects of soil N applied and N fixed by *Rhizobium* bacteria which usually enhances the development of the crop at its sowing time and reproductive stage(Gerecki1983) (Table 7) and probably less competition between Maize and beans for N as beans can fix its own N through *Rhizobium* bacteria (Wortman *et al*.1991;Norman *et al.,* (1996). The favorable effects of cropping system and N application interaction in increasing the photosynthetic rate and N application rate could also have resulted in increased seedling growth rate. Cropping systems, N fertilizer and location interactions increased the seed width and seed length (Table 8). This could be due to high seed rate development during seed filling duration resulting from availability of N. Similar results have been reported in wheat, rice and soybean (Hass 1975; Langer and Liew 1973; maize (Eck 1984), perennial rye grass (Ene and Bean 1975).Cropping systems, N fertilizer and Location interactions reduced root length and shoot length (Table 9). The inability of dry beans to get enough light could have translated into competitive limitation of soil nutrients and water (Midmore 1993) that influenced the inter-specific competitive ability. The reduced light energy due to its less canopy interception may have affected N fixation by restricting the photosynthetic process and the energy supply to the roots to carry out effective nutrient absorption resulting in reduced nodulation, nodules, number and size (Nambiar *et al*., 1986; Ghosh *et al*., 2006). This is due to the stronger competitive ability of maize as compared to common beans for soil N (Jensen 1996). Similar trends were observed by Ghosh *et al., (*2006) in a soybean/sorghum study. Intercropping systems have an advantage over the sole cropping system because of a greater soil volume. The decrease in root growth in the soil when N was applied was due to high rate of N consumption by maize. Ghosh *et al*., (2006) made similar observations in a sorghum/soybean intercropping system. This could be attributed to the less energy received by the beans (Reddy and WIley 1981). This shows that inter-specific competition between non-legumes and legumes do occur.

CONCLUSIONS

It is concluded that N fertilizer increased 1000 seed weight and seed vigor while cropping systems increased seedling dry matter and seed vigor. Planting location significantly affected seedling dry matter, seed width, seed length and seed vigor and these were higher in Kibos than Kisii while shoot length, root length, seed germination and 1000 seed weight were higher in Kisii. It is also concluded that cropping system N fertilizer × location increased the seedling growth rate and the seed vigor. In addition it can be concluded that N fertilizer application is not necessary in pure bean seed production as the crop is capable of fixing its own N by *Rhozobium* bacteria but starter fertilizer is necessary where soil is suspected to be of low soil fertility in terms of N and P. It can be concluded that seed vigor can be used as a good indicator to determine the performance of field crops under adverse conditions of high temperature, water stress, pests and diseases.

ACKNOWLEDGEMENTS

The first author is indebted to his supervisor, Dr J.O.Owuoche of Egerton University and Muasya R of Moi University, Kenya for his guidance and constructive critics during the study. The assistances provided by Mr. N.L Kidula of the Kenya Agricultural Research Institute in data analysis, MS Jane Yauru of Moi University, Kenya for laboratory analysis, Director, Kenya Agricultural Research Institute for the scholarship to undertake the MSc studies,Ms Emily Oduol of K.A.R.I,Kibos for typing the thesis and Ms Monica Oduol of K.A.R.I .,Kisii for data collection.

REFERENCES

Brooks A, Jenner CP, Aspimall D (1982). Effects of Water Deficit on Endosperm Starch Granules and On Grain Physiology of Wheat and Barley. Austr.J.Plant Physiol.9; 423-436

Callaway RM (1998). Facilitation in Plant Communities. pp 623-648.In F.I Punnaire and F. Valladares (eds) Handbook of Functional Plant Ecology. New York, Marcel Decker

Chawdhury SI, WardLaw IF (1978). The Effect of Temperature on Kernel Development In Cereals.Austr.J.Agric.Res.29; 205-223

De Souza PI, Egli DB, Bruening WP (1997). Water Stress During Seed Filling and Senescence In Soybean.Agron.J. 89:807-812

DuncanWG, McGraw OE and Boote KJ (1978). Physiological Aspects Of Pea Nut Yield Improvement. Crop Sci. 18; 1015-1020

Eck HV (1984). Irrigated Corn Yield Response to Nitrogen and Water. Agron.J.6; 421-428

Eck HV (1984). Irrigated Corn Yield Response to Nitrogen and Water.Agron.J.6; 421-428

Egli DB (1994c). Seed Growth and Development In: Boote KJ;Bennet JM ,Sinclair TR and Paulsen GM (eds.) Physiology and Determination O Crop Yield's-SSSA,Madison,Wisconsin, 127-148

Ene BN, Bean EW (1986). Yield and Yield of Sorghum Intercropped with Nodulating and Non-Nodulating Soybeans. Agron.J. 78; 780-782

Ghosh KP, Manna CM, Bandyo Padhyay, KK, Ajay AK, Tripathi RH, Wanjari KM, Hari AK, Misra CL, Achanya and Subba Rao A (2006). Inter-specific Interactions and Nutrient Use In Soybean/Sorghum I Systems Intercropping.Agron.J. 98; 1097-1108

Hesketh JD, Myhre DL, Willey CR (1973). Temperature Control Of Time Intervals between Vegetative and Reproductive Events In Soybean. Crop Sci.13:25

International Seed Testing Association (ISTA) (2004). *International Rules for Seed Testing*. Seed Science Testing Edition, 2004

Jain SK, Srinivasan K, Uprety M, Singh BB (1998). Electrical Conductivity. A non-Destructive Method for the Assessment of Seed Viability. Seed Tech. News 28 (4); 67

Jensen ES (1996). Green Yield, symbiotic N Fixation and Inter-specific Competition For Inorganic N In Pea/Barley Intercrops. Plant Soil 182(1); 25-38

Kay DE (1979). Food Legumes, London. Tropical Products Institute 435

Laing DR, Jones PG, Davies JHC (1984). Common bean (*Phaseolus vulgaris L*) In Physiology of Field Crops, (ed.) P.R Goldsworthy and N.M Fisher Chi Chester; Wiley; 305-52

Langer RHM and Liew FK (1973) Effect of Varying N supply at Different stages of the Reproductive Phase on Spikelet and grain on grain Nitrogen In Wheat. Am. J. Agric. Res. 24:647-656

Li LSC, Sun J, Zhang F, Yang S, Rengel Z (2001). Wheat/Maize or Wheat/Soybean Strip Intercropping: Field Advantage and Inter-specific Interactions on Nutrients. Field Crops Res.71:123-137

Midmore DJ (1993). Agronomic Modification of Resource Use and Intercrop Productivity. Field Crops Res., 34:357-380

Nambiar PTC, Rupela O P and Kumar Rao JVDK (1986) Nodulation and N Fixation on Ground Nut, Chick and Pigeon Pea. In N.S Subba Rao(ed.) New Trends In Biol. Nitrogen Fixation. New Delhi: Oxford and IBH Publ.21-52

Ngegi AK, Todari NP (1977). Effect of Seed Size and Weight In Germination Pattern and Seedling Development of Some Multipurpose Trees Species of Garhwal Himalya Indian Forester 123:32-36

Norman MJT, Pearson CJ, Searle PGE (1996). Tropical Food Crops In Their Environment. (Sec.ed) 6; 126-141

Reddy MS, Willey RB (1981). Growth and Resource Use Studies In an Intercrop Of Pearl Millet/Ground Nut. Field Crops Res.4:13-24

SAS Institute Inc. (1996). Soft Release 6.12TSO20 Cary,N.C,USA

Schumacher TE, Smucker JM (1981). Mechanical Impendance Effects On Oxygen Uptake and Porosity of Dry bean Roots.Agron.J.73:51-3

Sexton PJ, White JW, Boote KJ (1994). Yield Determining Processes In Relation to Cultivar and Seed Size of common bean Crop Sci.34:84-91

Songin H, Czyz H (1993). Effect Of Foliar Application with Fluorite and Macro elements on Pea Yield.Rocz.AR Pozman CCXIII,105-112(In Polish)

Stanton ML (1985). Seed Size and Emergence Time within a Stand of Wild Radish (*Raphanus sativa* L)The Establishment Of Hierarch Oelogia(Berlin) 67:524-531

Stover RH (1974). Effect of Measured Levels Sigatoka Disease of Bananas on Fruit Quality And Leaf Senescence. Trop. Agric. (Trinidad) 59:303-305

Tashiro T, Wardlaw IF (1989). A comparison Of The Effect Of High Temperature On Grain Development in Wheat and Rice .Annals Of Botany

Tollenaar M, Bruuselma TW (1988). Effects Of Temperature On Rate and Duration Of Kernel Dry Matter Accumulation of Maize. Can. J. Plant Sci.68:935-940

Wortmann CS, Sengooba T, Kyamanywa (1991). Banana and Bean Intercropping: Factors Affecting Bean Yield and Land Use Efficiency. Expt Agric.Vol.28:283-294