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Full Length Research Paper

Effects of cropping system, planting location and inorganic nitrogen on quality of bean seed in Western Kenya

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Common beans (*Phaseolus vulgaris* L.) are important crop in Kenya and the world for consumption and the attainment of quality food security. Studies were conducted in Kenya in the year 2006 to investigate the effects of N fertilizer application at the rates 0kg N per ha and 50 Kg N per ha and cropping system of *mbili* technology and pure stand of beans on bean seed quality at the Kenya Agricultural Research Institute (K.A.R.I) centre at Kisii and Kibos. Maize hybrid seed, *614D* and bean variety, *KK8* were used. The design of the experiment was a 2 × 2× 2 factorial arrangement in a Randomized Block Design replicated four times. Data was collected using standard procedures, comprising seed length, seed width, seed vigor, and seed germination percent, shoot and root length and seedling growth rate. Statistical analysis was carried out by analysis of variance and mean separation by the Least Significant Difference method at 5%.The results showed that *mbili* system significantly (p≤0.05) increased seedling dry matter and seed vigor by 42% and 42% respectively. However, bean quality parameters such as seedling growth rate, shoot length and seed sizes were unaffected by the cropping system. Addition of N fertilizer increased 1000 seed weight at Kisii by 45% while at Kibos it reduced the shoot length by 42%. Shoot length, seed germination, 1000 seed weight were higher at Kisii than Kibos while cropping System × fertilizer × location interactions increased seedling growth rate and vigor by 20% and 18% respectively. It is concluded that cropping system increased seedling dry matter and seed vigor while application of N fertilizer increased 1000 seed weight and reduced shoot length. Bean seed quality was affected by planting location while cropping system × N fertilizer location increased seed vigor.

Key Words: cropping, seed quality, fertilizer, seed vigor, seed germination, seedling growth rate.

INTRODUCTION

Common bean (*Phaseolus vulgaris* L.) is a very important crop for consumption in the world. The area under bean production in the world is more than 27 million hectares with an annual production of more than19 million metric tons and market value of more than U.S Dollars 10.7 (F.A.O, 2004). It is the leading source of dietary protein, Iron fiber and it is the third most important source of calories (Pachico, 1993).

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In Kenya, it is the most important pulse crop and is the third most important food crop (G.O.K, 1993).The average yields obtained in Kenya are 250 kg per ha, mostly under mixed cropping in pure stands but yields of up to 700 kg per ha have been reported (Songa et al., 1995). Potential yields are 3-4t per ha (Abate and Ampofo, 1996).This is far much higher than the yields obtained in Kenya.

The main constraints to common bean production in Kenya are poor production practices, pests and diseases, low soil fertility, adverse weather conditions and use of poor quality seed(Wartmann et al.,1998).There is need to investigate the factors affecting been seed quality in an cropping system involving beans and maize to ensure that farmers increase bean productivity. The objectives of the present study were to investigate the effect of N fertilizer application and cropping system on bean quality at two planting locations, namely, Kibos and Kisii in Western Kenya.

MATERIALS AND METHODS

Experimental Sites

The study was conducted in the year 2006 at the Kenya Agricultural Research Institute (K.A.R.I) canters at Kibos and Kisii in Kenya. K.A.R.I, Kisii is located about 2km North East of Kisii town O^{o} 30 S and 0^{o} and 58S longitude 34^{o},38E and 35) at an elevation of1500-1600 above sea level with a mean precipitation of 2159mm per annum and a mean temperature of 20.7^{o} C. K.A.R.I Kibos is located at 0^{o} 03'S,34^{o} I,48'E at an elevation of 1173m above sea level in a very gray to black heavy clay soil classified as plan sols with a mean precipitation of 1322mm,maximum temperature of 30.8^{o}C and minimum temperature of 16.4^{o} C. The Kisii site was previously under Cassava (*Manihot esculenta*).The varieties used were *KK8* for beans and H614 were obtained from K.A.R.I, Kakamega and Kenya Seed Company respectively.

The study comprised two N fertilizer levels, two planting locations and two cropping systems (*m*bili technology and pure bean stand). Although the recommended spacing of *mbili* technology is (Maize-50cm×30cm-bean-33.33X33.33cm), in which double maize and double bean rows were alternating, with staggered planting, the spacing used in this study was maize-50cm×30cm, bean-30cm × 30cm with a pure stand of beans at a spacing of 50cm×15cm for ease of measurement at planting. Although the recommended N fertilizer rate is 75kg ha^{-1} in Maize/bean intercrop only, 50kg N per ha was adopted to cater for the pure bean stand which does not need 75kg N ha^{-1} rate. Over fertilization of N in pure bean stand may interfere with nodulation hence poor N fixation by *Rhizobium* bacteria .Two N fertilizer levels used in this study were 0kg N ha^{-1} and 50kgN ha^{-1}. 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 a blanket treatment in two splits while Triple Super Phosphate (45% P_2O_5) was applied at 75kg ha^{-1} as a blanket application at planting in plot sizes of 3×3.5m.

Experimental Design and Treatments

The experimental design was 2 × 2 x 2 factorial in a Randomized Block Design replicated four times. The factors were two experimental locations: K.A.R.I kibos and K.A.R.I Kisii, two N fertilizer levels (0 and 50kgNha$^{-1)}$ and two cropping systems (*mbili* technology and pure bean stand).

The following were the treatments:

1. *Mbili* technology and 0 kg N ha^{-1}
2. *Mbili* technology and 50 kg N ha^{-1}
3. Pure bean stand and 0 kg N ha^{-1}

4, Pure stand bean and 50kg N ha^{-1}

Data Collection

Thousand seed weight and seed size

Maize and bean seeds were harvested at physiological maturity when the moisture content of the bean seed was between 19-25% moisture. The bean seeds were then dried, threshed and cleaned by hand to moisture content of 14%. Analytical purity of bean seeds was determined in which the pure bean seeds were separated from other crop, weed seeds and inert matter. 1000 seed weight was determined by using a tray counter having 100 holes notched on it. The procedure was repeated ten times to obtain 1000 seeds which were then weighed from 1000 seeds to determine the weight per plot. Ten seeds from both sites were sampled and their sizes (seed width, length and thickness) were determined by a veneer caliper.

Seed Germination Percent

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

Shoot Length and Root Length

Shoot and root length were determined by measuring from the longest tip of the leaf to the soil level, while the root length from the tip of the longest root to the point of attachment just below the ground level respectively.

Seedling Growth Rate (SGR)

Germination capacity was determined according to the ISTA rules as mentioned previously. The bean seeds were germinated in two rows each of 25 replications per treatment in four replications giving a total of 100 seeds per treatment in 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^{o} C. The temperature was maintained for 7 days. At the end of the period, germination count was determined according to the ISTA,2004 Rules(ISTA,2004).The normal seedlings were cut from their cotyledons and placed in small (8cm×16cm) envelop for drying. The seedlings were dried at a temperature of 80^{o} 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 formula:

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

(Shetty and Prakash, 1990)

Electrical Conductivity (EC) Test on Seed Vigor

Samples of 50 seeds for every treatment from the four replicates of the experiment was weighed, placed in a 250ml plastic container with distilled water and were set up. The containers were then placed in an incubator set at a constant temperature of 25 ^{O}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 the plastic container and EC determined by inserting in a cell connected to conductivity bridge into the solutions in the plastic beaker .The field Lab-LF conductivity meter and LF 513T 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 up at a constant of 0.00 and water added. It was then dried by blotting paper on filter paper before and after each replicate/sample was tested. The conductivity readings were recorded per treatment and later divided by weight (g) of each sample to give measurement in micromhos per cm. The electrical conductivity was then computed using the formulae:

$$EC = \frac{(\propto Scm^{-1}) - Conductivity\ of\ water}{Weight\ of\ seed\ (g)} = \propto Scmg^{-1}\ {}^{-1} of\ seed$$

:(ISTA, 2004)

Seedling dry matter

Seedling dry matter was calculated by dividing the seedling dry weight after oven drying by fresh weight of the same seedling sample before oven drying and then expressed as a percentage:

$$Seedling\ Dry\ Matter\ \% = \frac{Seedling\ Dry\ Matter\ Weight\ (g)}{Seedling\ Fresh\ Weight\ (g)} \cdot 10$$

Data Analysis: Data Analysis

Data collected were subjected to analysis of variance and mean separation by the Least Significant Difference method at 5 percent using the statistical analysis system (S.A.S Inst., 1996). Correlation Analysis was carried out to determine the relationships between the seed quality and physiological parameters.

RESULTS

Rainfall data at Kisii and Kibos locations

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, the 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).

4.1.2 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^{O}C, Kisii, 22^{O}C) were in January, February and September. In October both sites experienced the same temperature (Figure 2). The

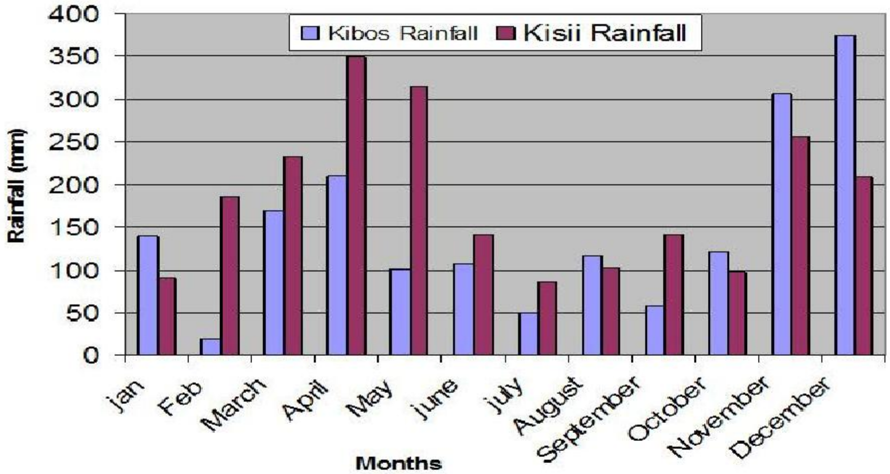

Fig 1: Rainfall received at the Kibos and Kisii sites in 2006

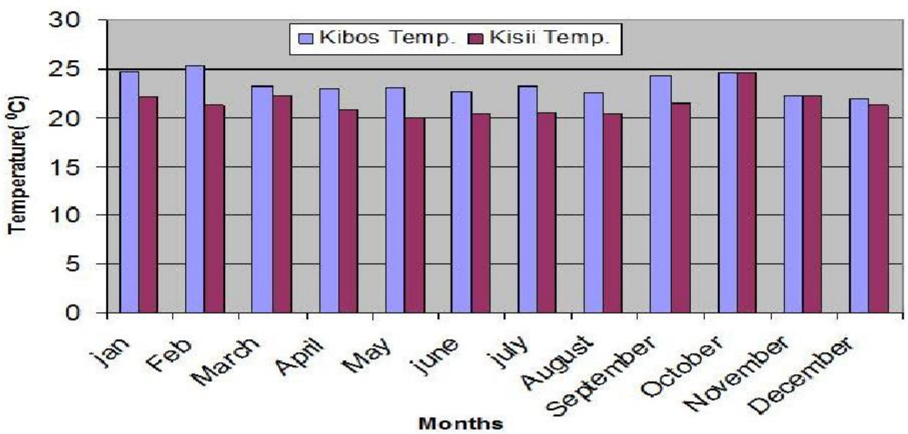

Fig 2: Temperature received at the Kibos and Kisii sites in 2006

mean temperature for Kisii could be observed to be 20 ^{O}C while that of Kibos to be 22.5 ^{O}C per annum (Figure 2).

Interactions between Cropping Systems, Nitrogen Application and Location

The various analyses of Cropping System (*mbili* technology and pure bean stand), Nitrogen application, Location and their interactions are shown in Tables 1 and 2. Significant ($p \leq 0.05$) location effects for seed weight, seedling growth rate, seed vigor, seedling dry matter, Seed width and seed length are shown in (Table 1).There were significant effects due to location for the 1000 seed weight and germination percent (Table 2), Cropping system significantly increased 1000 seed weight, seed vigor and seedling dry matter (Table 1 and 2). However application effects were significant for root length (Table 2).There was significant interaction between location × cropping system and their interaction for seed vigor, seedling dry matter

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
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

(Table 1).There was however no significant N application effects for root length (Table1) 2).There was significant interaction between location cropping system for seed vigor, dry seedling dry matter and seed width (Table 1) but other seed quality parameters were unaffected. The results showed that the effects due to location, cropping systems and Nitrogen application were significant for germination percent Table 2). However, there was no effects due to the interaction between cropping system × Nitrogen application cropping systems for shoot lenghth,1000 seed weight and root length, while effect due to N application was significant at 1 percent. No significant interactions were observed for the seed qualities such as root and shoot length (Table 2).

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 (cm)	Seed thickness (cm)	Seed length (cm)	Seed vigor ($\mu Scm^{-1}g^{-1}$)
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, seedling growth rate, 1000seeds weight of beans

Sites	Root length (cm)	Shoot length (cm)	Seed germination (%)	Seedling growth rate ($gd^{-1}s^{-1}$)	Thousand Seed Weights (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.

Effects of Locations on Seed quality of Beans

The effects of sites (Kisii and Kibos) on various aspects of seed quality of bean are shown in Tables 5 and 6.Planting of bean seeds at different sites (locations) showed significant differences between them, for seedling dry matter, seed width and seed vigor. These parameters were bigger in Kibos than Kisii locations (Table 5), however there were no significant differences between sites for seed thickness and seed length (Table 5). Planting at the two sites also showed significant differences between sites for seed thickness and seed length (Table 5), while at the same time Location differences also affected shoot length and germination percent but not seedling growth rate.1000 seed weight, seed germination and shoot length performed better at Kisii than Kibos while root length and seedling growth rate performances were better at Kibos than Kisii (Table 6).

Effects of Interactions between cropping systems, Nitrogen Fertilizer Application on bean Seed Quality

The effects of cropping systems and N fertilizer on seedling dry matter, seed vigor ,seedling growth rate ,seed width, seed length seed thickness, shoot length, root length, germination percent and 1000 seed weight are shown in Tables 7,8 and 9.Addition of N fertilizer in *mbili* technology significantly reduced the seedling growth rate by 20%(Table 7). It also increased the vigor of bean seeds by

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

Treatments	Seedling dry matter (%)	Seedling growth rate ($gd^{-1}s^{-1}$)	Seed vigor ($\mu Scm^{-1}\ g^{-1}$)
Mbili Tech.+ 0 kg N ha^{-1}	41.69	0.20	6.65
Mbili Tech.+ 50 kg N ha^{-1}	34.69	0.17	7.87
Pure beans + 0 kg N ha^{-1}	27.00	0.15	5.94
Pure beans + 50 kg N ha^{-1}	26.28	0.16	6.19
Mean	27.57	0.17	6.26
SE	3.63	0.02	0.54

SE±1 at significant value ($p \leq 0.05$)

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

Treatments	Seed width (cm)	Seed length (cm)	Seed thickness (cm)
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 ($p \leq 0.05$)

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

Treatments	Shoot length (cm)	Root length (cm)	Seed germination (%)	TSW (g)
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 ($p \leq 0.05$)

18%. Cropping system involving *m*bili technology and pure stand together with N fertilizer application reduced seed thickness by 11% and 5% respectively (Table 8).

Effects of Interactions between cropping systems fertilizer and Location on Seed Width, Seed length and seed thickness

Pure bean stand significantly reduced the shoot, root length by 35% and 30% respectively on addition of N fertilizer (Table 9).Mbili technology increased 1000 seed weight by 7 %(Table 9).

Coefficients correlation correlations for seed physiology and growth traits on beans at Kisii and Kibos sites

The correlations between different characters of bean seed quality are shown in Tables 10, 11 and 12.The relationships between seed characters were observed to be both negative and positive. Significant linear correlations (r=0.59**) between seed length and seed width was observed at Kisii(Table 10). However, the same seed length at Kibos (Table 10) was significantly (r=0.59**) related with 1000 seed weight at Kibos (Table 11) but not at Kisii (Table 10).Significant correlation between seedling growth rate and seedling dry matter was also observed (Table 10).

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

DISCUSSION

Significant location effects on 1000 seed weight and seed width observed in this study could be attributed to differences in altitude, soil type and temperature factors associated with these two sites. During the seed filling duration of most crops, temperature and moisture play critical roles (Chowdhury and Wardlaw, 1978). Kibos site was relatively hotter (33.2^{O} C) than Kisii (20.9 ^{O}C (Tables 1 and 2). This could have caused the seed filling duration differences at these two locations despite the fact that temperatures did not go beyond 30^{O}C (Figure.2).Legumes are very sensitive to temperature extremes (Hesketh et al., 1973;Egli, 1994c).It has been reported that seed filling duration for beans is relatively insensitive to temperature between 20 and 30^{O} C while that of Maize increased as temperatures decreased from 28/18 to 16/10^{O} C (Tollenaar and Bruulsoma,1988). It is then 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.

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

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.

Water stress at one stage and flooding between March and May (Table 1) could have shortened the seed filling period subsequently reducing seed weight. Severe water stress and flooding during flowering and seed filling duration may cause the physiological maturity to occur earlier than usual consequently reducing seed filling duration, seed weight and seed size. This phenomenon has been observed in wheat (Brooks et al., 1982). Although moisture stress accelerates leaf senescence in wheat (De Souza et al., 1997) it is not clear how it affects seed filling duration directly or indirectly through accelerated leaf senescence. The observed locational differences in seedling growth rate and seed vigor were apparently due to temperature and differences in altitude effects which caused significant differences in seed vigor..This observation agrees with Tashiro and Ward Law (1989) who similarly observed that seedling growth rate of wheat and rice decreased readily at $30/25^{O}$ C. Temperature affects seed metabolism and assimilate partitioning to the seed which subsequently affected seedling growth rate and vigor. The low temperatures recorded at the Kisii site and flooded field observed at Kibos may have reduced the consumption of food reserves through reduced enzymatic activities resulting in the accumulation of inhibitory substances for germination in seeds. Moisture differences that could have contributed to the variation in seed vigor and seedling growth rate .It has been reported that even moderate water stress directly affects seedling growth rate (SGR) and seed vigor in other crops. Significant location x cropping system for seed vigor, seedling dry matter and seed size could be due to spatial arrangements of the crop which influenced the rate of light interception for photosynthesis (Table 1).This could have been caused by differences in canopy interception photosynthetic rates. There was no cropping systems × N fertilizer application interaction, Application of N fertilizer did not influence the cropping systems on their effects on the seed qualities observed. In the present study, significant effects due to location × N Interaction observed for seed width could have been attributed to differences in

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 (cm)	Seed width (cm)	Seed thickness (cm)	Seed germination (%)	1000seed weight (g)
Mbili mbili Technology	1.28ab	0.74a	0.58a	86.25a	366.26a
Pure sand of beans	1.35a	0.76a	0.58a	94.75a	355.00a
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$\leq$5%) according to LSD Effects of Nitrogen Fertilizer on bean seed quality

level of N and other weather related factors that influence seed setting and filling process before physiological maturity.

Effects of Cropping Systems On bean seed quality

Mbili technology (Table 3) increased the seedling dry matter by 42% and seed vigor by 19%. This could be due to the role played by chlorophyll in determining the rate of photosynthesis and dry matter content of the crop with well spaced arrangement of bean and maize since there was enough light interception by beans. Since the vigor of any crop is affected by many factors, among them light interception, seed vigor and germination were increased. This observation confirms that maize and beans have no serious competition for light (Wortmann et al., 1991; Norman et al., 1996).

The addition of N fertilizer to the bean crop at Kisii increased 1000 seed weight, while at Kibos it increased Moisture differences due to rainfall duration and soil moisture retention capacity (Figure.1) also may have contributed to the differences in seedling growth rate, seed width, seed vigor, shoot length and seed germination at the two sites, Kibos and Kisii (Tables 5 and 6).

shoot length(Table 4).This increase could be due to high sink strength and weight which are essential in the photosynthetic process and subsequently 1000 seed weight since partitioning of assimilates in seeds is the main factor determining seed weight (Duncan et al.,1974).This is at variance with those of Songin (1993) who reported that 1000 seed weight did not depend on N fertilizer application in pea. However, (Ziolek and Kuling, 1997) reported that N fertilizer application decreased 1000 seed weight which agrees with the present study.

Effects of Location on Seed Quality

Planting beans at the Kibos and Kisii sites showed significant ($P<0.05$) differences for seedling growth rate, seed width, seed vigor, shoot length and seed germination. The differences in these seed parameters were apparently due to the differences in soil texture, chemical properties, and temperature and rainfall regimes at these two sites.

Bean requires between 300-1500mm per annum (Kay, 1979) for optimum production and it is sensitive to soil moisture particularly during flowering and reduces yield which is affected by poor seedling growth rate, poor seed vigour and poor germination, flower abortion and flower

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 (µScm^{-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

failure (Stover,1974). In the present study rainfall variation particularly between the months of April and September, 2006 (Figure 1) could have resulted into significant differences in the seed quality parameters mentioned above.

Effect of Cropping Systems, Nitrogen and Location on Bean Seed Quality

Cropping systems, Nitrogen and location interactions increased the seed width and seed length (Table 8). This could be due to the high rate of seed development during the seed filling period caused by increased N availability. Similar results were reported in wheat rice and soybean (Hass, 1975; Langer and Liew,1973, Maize (Eck,1984),perennial rye grass (Ene and Bean,1975). Cropping system, N fertilizer application and location interactions reduced root length and shoot length of beans(Table 9).The inability of dry beans to get enough light could have translated into competitive limitation of soil nutrients and water(Midimore,1993) that influence inter-specific competition. The reduced light energy due to canopy interception affected the Nitrogen fixation by restricting the photosynthetic process and energy supply to the roots to facilitate nutrient absorption causing reduced nodulation, nodule number and size (Nambiar et al.,1986,Ghosh et al.,2006).This increased the completive ability of Maize as compared to common beans for soil N (Jensen,1996).Similar trends have been reported previously insoybean/sorghum intercrop(Ghosh,2006).Intercropping systems are advantageous over sole cropping due to the spatial differences in root mass that results in utilization of 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. Similar observations were attributed to less light energy received by the beans. This shows that inter-specific competition between non-legumes and legumes do occur in the intercropping system and there is always a coexistence of negative and positive interactions in the same ecosystem (Callaway,1998),wheat and sorghum (Li et al., 2001).The increase in seed germination and 1000 seed weight in beans due to the combined effects of N fertilizer and cropping systems indicated that beans benefitted much from the intercrop in combination with N fertilizer and thus the component of Maize was a major contributor to 1000 seed weight.Jensen,1996 has reported similar advantages.

Correlations between seed length and seed width, seed length and seed thickness, 1000 seed weight, seedling growth rate and seedling germination indicated that there is very great potential in using them to determine the quality of seed lots in beans. This is due to the fact that large-sized seeds have high germination percent at all depths than small-sized seeds and plants from large seeds produce more tillers or branches accumulate more dry matter (Stanton, 1985, Ngegi and Todaria, 1997, Sexton (1994) reported that seedling growth rate was correlated to seed sizes in common beans which was contrary to what was observed in the present study which had no correlation between the two.

CONCLUSION

The combined effects of N fertilizer at two levels of 0 Kg N per ha and 50KgN per ha and cropping systems comprising Mbili technology and pure bean stand increased the seedling dry matter and seed vigor. While applications of N fertilizer increased 1000 seed weight and reduced shoot length, planting at more than one site (location effects) showed that the quality of bean seeds in terms of seedling dry matter, seed width, seed length and seed vigor were better in kibos than Kisii, while root length, shoot length, seed germination and 1000 seed weight were larger in terms of quality in Kisii. Cropping system x location interactions increased seed vigor. Finally, N fertilizer application is not necessary in pure bean seed production because it is capable of fixing its own N through fixation by *Rhizobium* bacteria.

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