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Effect of Seedbed Type on Yield and Yield Components of Common bean (*Phaseolus vulgaris* L.) Commercial Cultivars

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Abstract: Two experiments were conducted, one in 1997 during the long rain season (April-July) and another in 2004 during dry season (September - December) at Sokoine University of Agriculture plots, Morogoro, Tanzania to evaluate the effect of seedbed types on crop performance of beans of different growth types. Treatments were laid out in a split plot arrangement in a Randomized Complete Block Design (RCBD) with three replications. In 1997, the main plots consisted of four common bean cultivars namely SUA 90, Canadian wonder, Kablanketi and Glory. Three seedbed types constituted the sub-plots namely ridge cultivation, flat cultivation and *ngolo* cultivation. In 2004, the main plots consisted of two bean cultivars namely SUA 90 and Kablanketi. Four seedbed types constituted the sub-plots viz., ridge cultivation, flat cultivation, *ngolo* cultivation and fipa mound seedbed. The data recorded included number of harvested plants m^{-2}, number of branches $plant^{-1}$, pods $plant^{-1}$, pod length, seeds pod^{-1}, grain yield $plant^{-1}$, yield ha^{-1} and 100 seed weight. Results showed that bean cultivars differed in yield components and determinate cultivars showed consistently higher seed yield per plant while indeterminate showed consistely higher 100 seed weight. Ridge seedbed showed superiority on number of pods per plant, pod length and yield per plant only during dry season. However, flat seedbeds showed consistently good performance for many variables investigated. Increased grain yield in flat seedbeds, therefore, at both cropping seasons was reflected in increased production of pods per plant, longer pods and yield per plant. Therefore, flat seedbed type is recommended for bean production in the studied location.

Key words: Beans, cropping seasons, seedbeds, yield, yield components

INTRODUCTION

In Tanzania, the Common bean (*Phaselous vulgaris* L.) is a major leguminous crop providing a good source of protein in diets and serves as a cash crop (Misangu, 1982). However, among the major production constraints are moisture limitations and low fertility as a result of poor distribution of rainfall and environmental degradation. Thus, management practices that can easily be adopted by farmers to conserve soil moisture and nutrients will be viable options to adopt on a sustainable basis. For instance, Kusnarta *et al*. (2006) noted that the system of soil management controls root distribution and soil properties such as porosity, compaction, water content and concentration of organic matter. Several other researchers have as well noted that seedbed types have effects on seedling emergence, growth and productivity of crops through influence on soil physical, chemical and biological properties (Hadas, 1977; Goldsworth and Fisher, 1984; Hulugale *et al*., 1991; Noah, 1997; Tijan-Eniola, 2002).

Soil preparation practices that are already known to farmers if proven to be useful will provide a better option for use under farmers conditions. In Tanzania, there are local practices on seedbed preparation for various crops grown under different locations, however, their efficacy in improving crop performance under marginal conditions of crop growth has not been assessed. Such seedbeds include the *ngolo* of which is used in mountanous areas to control soil erosion, improve and conserve soil fertility and water (Edje and Semoka, 1990). Mounds seedbed is conducive to soil erosion control and increases soil fertility because weeds are composted to humus (Lunan, 1950) and the ridge seedbed which facilitate hand weeding, concentrate nutrients around root zones, prevent water logging, allows good development of roots and tubers and control soil erosion (Nangju, 1977).

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The present investigation was therefore carried out to investigate the effect of local seedbed types on crop performance of beans in Tanzania.

MATERIALS AND METHODS

Two experiments were conducted, one in 1997 during the long rain season (April-July) and another in 2004 during dry season (September-December) at Sokoine University of Agriculture in plots situated at 6° 05'S 37° 37'E at 525 m.a.s.l. In both cropping seasons, the treatments were laid in split plots using Randomized Complete Block Design (RCBD) with three replications. In 1997, the main plots consisted of four common bean cultivars viz. SUA 90 (determinate), Canadian wonder (semi determinate), Kablanketi (indeterminate) and Glory (semi indeterminate). Three seedbed types constituted the sub-plots viz., ridge cultivation, flat cultivation and *ngolo* cultivation. In 2004, the main plots consisted of two bean cultivars namely SUA 90 (determinate) and Kablanketi (indeterminate). Four seedbed types constituted the sub-plots namely ridge cultivation, flat cultivation, *ngolo* cultivation and fipa mound seedbed.

For ridge and flat seedbeds sowing was by dibbling in rows arrangement (50×50 cm) while *ngolo* and fipa mound seedbeds were prepared and sown according to the Matengo (JICA, 1996) and Fipa (Edje and Semoka, 1990) traditions of broadcasting. The plots for *ngolo* seedbed were 6×3 m in size while for fipa mound, the diameter was 1 m, 60 cm high and the distance from one mound to another was 50 cm (Edje and Semoka, 1990).

Seed was sown on 4th April, 1997 and 15th September, 2004. After three weeks of growth, nitrogen in form of Sulphate of Amonia (S/A) was applied at the rate of 20 kg N ha^{-1} in both experiments. Pest control was carried out using karate at a rate of 30 mL/20 L of water (i.e., 400 mL ha^{-1}). *Ootheca beningseni* (Weise) and white flies (*Bemisia tabaci*) were the major pests during the 1997 and 2004 seasons, respectively. Plots were maintained weed free by periodic hand weeding.

Data recorded included number of harvested plants m^{-2}, number of branches $plant^{-1}$, pods $plant^{-1}$, pod length, seeds pod^{-1}, seed yield $plant^{-1}$, yield ha^{-1} and 100 seed weight. All data collected were analysed by the Analysis of Variance (ANOVA) procedure (SAS, 1990) and Multivariate Analysis of Variance (MANOVA) for calculating partial correlation coefficients for yield and yield components. All variables recorded were analysed according to the following statistical model:

$$Y_{ijk} = \mu + R_i + V_j + (RV)_{ij} + T_k + (VT)_{jk} + (RVT)_{ijk}$$

where:
Y_{ijk} = Response, μ = general mean, R_i = ith replication effect, V_j = jth varietal effect, $(RV)_{ij}$ = Main plot error (a), T_k = kth treatment effect, $(VT)_{jk}$ = Interaction of variety and treatment, $(RVT)_{ijk}$ = Experimental error (b)

RESULTS

For 1997 trial, significant varietal effects were observed for number of branches $plant^{-1}$, pod length, seeds pod^{-1}, yield $plant^{-1}$ and 100 seed weight (Table 1). Significant differences between seedbed types were observed for all the studied variables except 100 seed weight. Canadian wonder showed superiority on number of branches, pod length, seeds pod^{-1}, yield $plant^{-1}$ and 100 seed weight (Table 2). SUA 90 and Canadian wonder showed superiority in branching, pod length and seeds pod^{-1} while Glory also displayed good performance in branching, seeds pod^{-1} and yield $plant^{-1}$. Larger seeds (100 seed weight) were only manifested in Canadian wonder cultivar. The flat seedbed was superior in all the variables studied except plant stand while *ngolo* displayed good performance on yield ha^{-1} and plant stand. Ridge seedbed displayed good performance only in number of branches.

For the 2004 trial, significant differences between cultivars were observed for pod length, yield $plant^{-1}$ and 100 seed weight (Table 3). Similarly, seedbed types varied

Table 1: ANOVA summary for investigated variables (Mean squares given) in 1997 cropping season

Source of variation	df	Yield (ton) ha^{-1}	Plant stand m^{-2}	No. of branches	Pods per plant	Pod length (cm)	Seeds per pod	Yield per plant (g)	100 seed weight (g)
Replication	2	0.72	58.69	0.19	0.48	0.61	0.01	13.15	0.19
Variety	3	0.44	208.92	5.03**	4.46	28.45***	1.85**	19.47**	654.52***
Error (a)	6	0.12	66.47	0.36	1.65	0.47	0.06	1.07	22.74
Treatments	2	1.04*	530.44**	7.00**	51.12***	4.69**	1.66**	150.6***	9.73
Variety × Treatment	6	0.07	125.89	0.89	3.11	1.41*	0.56*	4.77	20.99
Error (b)	16	0.23	65.69	0.77	1.70	0.49	0.18	3.55	14.01
Total	35								
CV (%)		34.52	26.63	27.42	21.96	6.62	11.75	29.74	9.91
R^2		0.62	0.92	0.75	0.84	0.93	0.81	0.88	0.19

*, **, *** = p<0.05, p<0.01 and p<0.001, respectively

Table 2: Effect of Variety and Seedbed types on yield and its components in 1997

(A) Variety	Yield (ton) ha^{-1}	Plant stand m^{-2}	No. of branches	Pods per plant	Pod length (cm)	Seeds per pod	Yield per plant (g)	100 seed weight (g)
SUA-90	1.32	33.89	3.36	5.98	12.16	4.08	5.22	26.31
Kablanketi	1.15	28.89	2.13	5.00	9.26	3.01	5.04	41.16
Canadian Wonder	1.68	25.56	3.87	6.02	12.04	3.80	8.11	46.43
Glory	1.39	36.22	3.47	6.71	8.82	3.56	6.98	37.18
$\overline{X}$	1.39	31.14	3.21	5.93	10.57	3.61	6.34	37.77
SE	1.49	24.20	0.20	0.60	0.21	0.19	1.00	5.50
$LSD_{0.05}$	NS	NS	1.19	NS	0.94	0.57	2.54	5.05
(B) Seedbed types								
Ridge	1.06	19.25	3.10	5.65	9.99	3.33	5.50	37.13
Flat	1.64	18.75	4.02	8.12	11.24	4.03	10.23	38.80
Ngolo	1.46	54.42	2.50	4.02	10.49	3.47	3.29	37.38
$\overline{X}$	1.39	30.81	2.21	5.93	10.57	3.61	6.34	37.77
SE	5.73	21.00	0.20	0.50	0.10	0.12	0.81	4.71
$LSD_{0.05}$	0.50	8.54	0.93	1.37	0.74	0.45	1.99	NS

NS = Not Significant different

Table 3: ANOVA summary for investigated variables (Mean squares given) in 2004 cropping season

Source of variation	df	Yield (ton) ha^{-1}	Plant stand m^{-2}	No. of branches	Pods per plant	Pod length (cm)	Seeds per pod	Yield per plant (g)	100 seed weight (g)
Replication	2	0.03	5.38	4.67	21.17	1.04	3.04	253.04**	2.81
Variety	1	0.01	57.04	7.04	48.17	30.38**	4.17	2795.04*	573.30*
Error (a)	2	0.03	28.79	1.17	11.17	0.38	0.29	133.04*	11.28
Treatments	3	0.21	376.04***	1.49	36.11***	2.71**	0.17	456.26***	41.02**
Variety x Treatment	3	0.32	40.04	0.26	1.17	0.26	1.06	36.93	9.11
Error (b)	12	0.25	17.42	0.58	2.06	0.32	0.28	31.40	5.07
Total	23								
CV (%)		34.42	18.24	12.80	12.29	7.30	13.50	13.50	6.96
R^2		0.37	0.87	0.77	0.90	0.92	0.81	0.93	0.93

*, **, *** = p<0.05, p<0.01 and p<0.001, respectively

Table 4: Effect of variety and seedbed types on yield and its components in 2004 cropping season

(A) Variety	Yield (ton) ha^{-1}	Plant stand m^{-2}	No. of branches	Pods per plant	Pod length (cm)	Seeds per pod	Yield per plant (g)	100 seed weight (g)
SUA-90	1.42	21.33	5.42	13.08	6.67	3.50	52.33	27.44
Kablanketi	1.46	24.42	6.50	10.25	8.92	4.33	30.75	37.22
$\overline{X}$	1.44	22.88	5.96	11.67	7.79	3.92	41.54	32.33
SE	0.16	1.12	0.44	0.98	0.22	0.27	1.79	0.59
$LSD_{0.05}$	NS	NS	NS	NS	1.08	NS	20.26	5.90
(B) Seedbed types								
Ridge	1.50	15.67	6.50	14.17	8.17	4.00	50.50	33.52
Flat	1.45	17.17	5.83	13.33	8.33	4.00	47.33	30.75
Ngolo	1.64	32.50	6.17	10.00	7.83	4.00	35.83	35.40
Mound	1.19	26.17	5.33	9.17	6.83	3.67	32.50	29.65
$\overline{X}$	1.45	22.88	5.96	11.67	7.79	3.97	41.54	32.33
SE	0.16	1.12	0.44	0.98	0.22	0.27	1.79	0.59
$LSD_{0.05}$	NS	7.15	NS	2.46	0.97	NS	9.61	3.86

NS = Not Significant different

Table 5a: Partial correlations coefficients among yield and yield components in 1997 cropping season

Variables	1	2	3	4	5	6	7	8
Yield (ton)/ha	1	-0.34	0.40	0.50*	0.28	0.18	0.65**	0.29
Plant stand		1	-0.45	0.17	0.06	0.16	0.10	-0.44
No. of branches			1	0.54*	0.01	0.11	0.55*	0.39
Pods per plant				1	0.06	0.19	0.81**	0.03
Pod length (cm)					1	0.73***	0.36	0.03
Seeds per pod						1	0.34	0.08
Yield per plant (g)							1	0.08
100 seed weight (g)								1

*, **, *** = p<0.05, p<0.01 and p<0.001, respectively

Table 5b: Partial correlations coefficients among yield and yield components in 2004 cropping season

Variables	1	2	3	4	5	6	7	8
Yield (ton)/ha	1	0.22	-0.31	0.48*	-0.06	-0.10	0.75**	0.65*
Plant stand		1	0.09	-0.16	-0.08	-0.15	-0.17	0.35
Number of branches			1	-0.53	-0.31	0.16	-0.51	-0.14
Pods per plant				1	-0.09	0.02	0.65*	0.16
Pod length (cm)					1	0.12	-0.08	0.04
Seeds per pod						1	0.05	-0.18
Yield per plant							1	0.10
100 seed weight (g)								1

*, **, *** = $p<0.05$, $p<0.01$ and $p<0.001$, respectively

significantly in all the variables studied except yield ha^{-1}, number of branches and seeds pod^{-1}. Kablanketi displayed superiority over SUA 90 in pod length and 100 seed weight while SUA 90 significantly excelled kablanketi on yield plant^{-1} (Table 4). The ridge and flat seedbeds gave superior performance in pods plant^{-1}, pod length and yield plant^{-1}, while *ngolo* seedbed gave good performance in pod length and 100 seed weight. *Ngolo* and mound seedbeds promoted higher plant stand during the season.

There were significant and positive correlations between yield plant^{-1} with yield ha^{-1} and pods plant^{-1} in all cropping seasons (Table 5). The other components did not show consistent relationships.

DISCUSSION

The experiments were conducted to evaluate varietal response of common beans to different seedbed types. Usually, beans are grown on a variety of seedbed types depending on topography and the amount and intensity of rainfall. In highland areas for example, beans are grown on ridges or *ngolo* seedbeds while in flatland, the crop is grown on *sesa* or ridges. Ridges are used in flatland which are susceptible to flooding during the heavy rains. Thus, differences in grain yields could be attributed to differences in soil fertility and the variety grown (Azam and Squire, 2002).

In this study, the non significant differences observed in terms of grain yield ha^{-1} among bean cultivars in both cropping seasons could be associated with genetic similarities (Tarimo and Hamza, 1998; Azam and Squire, 2002). Despite these similarities, yields were also significantly influenced by seedbeds through increased number of branches, pods, seed and pod length. The observed seasonal differences in bean response to seedbed type indicate seasonal weather differences (Goldsworthy and Fisher, 1984; Mulungu, 1998; Tarimo and Hamza, 1998). The effect of seedbed type on crop performance occurs due to differences in the available moisture (Squire, 1993). For example, during the dry period in 2004 moisture supply was through irrigation, thus causing minimal effect of seedbed type on bean grain yield (Squire, 1993; Azam and Squire, 2002). Results of 1997 cropping season agreed well with those reported by other workers (Lal, 1974; Harrison-Murray and Lal, 1979) in which planting on ridges was associated with increased soil temperature in the vicinity of the plant that resulted to reduction of yield in the maize crop. It is apparent that different seedbed types result into differences in yield among bean cultivars due to differences in sensitivity to adverse conditions in the crop environment e.g., high soil temperatures and high water deficit around root zones (Andrew, 1975). The *ngolo* system has traditionally been in use among the Ngoni and Matengo tribes of Tanzania residing in the mountaneous areas of the Sourthern Highlands. The system has the advantage of improving water retention and improved soil fertility due to incorporated vegetation under the *ngolo* (Tarimo, 1997). These conditions influence plant performance and yield. It was apparent from this study that the number of plants on *ngolo* or mound was higher than that on flat or ridge seedbeds.

Number of pods in flat seedbeds was consistently higher than that in other seedbed types because of better plant development. Overal, flat seedbeds are associated with higher number of reproductive sites such as number of branches (Ney *et al.*, 1993; Egli, 1993). Many plants respond to good growth conditions by increasing the number of meristematic apices, thereby producing many branches. This type of response is associated with greater assimilates produced during the growing period (Egli and Zhen-Wen, 1991; Squire, 1993).

Pod length differences among the bean cultivars were associated with seasonal weather variations. During the wet season, determinate bean cultivars usually produce longer pods but during the dry season indeterminate types produce longer pods. This suggests that pod length is early influenced by environmental changes and probably the trait is polygenic in nature (Squire, 1993). Beans grown on flat seedbeds consistently gave longer pods than in the other seedbeds an observation closely related to higher assimilate production (Goldsworthy and Fisher, 1984; Andrew, 1975; Tarimo, 1997). Different seedbed types influence crop growth and productivity differently depending on the way they are prepared

(Mulungu, 1998; Mulungu and Tarimo, 1998). The superiority of flat seedbed was attributed to higher number of pods per plant which resulted into higher seed yield per plant. Similar results were reported by Mulungu and Tarimo (1998).

In this study, bean cultivars having many seeds per plant had low 100 seed weight while those with fewer seeds per plant had larger seed weight. For cultivars with fewer seeds, compensation is often nearly complete when number of seeds per plant decreases. This happens because individual seed mass is conserved (Squire, 1993). Therefore, a change in the dry mass of a structure caused by any factors is accompanied by changes in the size and number of the units that constitute the structure (Squire, 1993).

Positive correlations between yield per hectare with seed yield and pods per plant in both cropping seasons entails stable genetic indicators for improved yield of bean cultivars. The other yield components are of little predictive value for yield in common beans (Mhina, 1985; Maingu and Nzao, 1987).

In this study, determinate bean cultivars showed consistent superiority in many of the yield components, indicating better performance than the indeterminate types in this location. Overall, flat seedbeds are superior to raised seedbeds in the common bean culture. Therefore, it is recommended that flat seedbeds could be used by subsistence farmers where topography permits for improved bean production.

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