African Crop Science Journal, Vol. 19, No. 4, pp. 247 - 254
ISSN 1021-9730/2011 $4.00

INFLUENCE OF TIME OF PLANTING ON YIELD AND GRAIN QUALITY OF BEAN GENOTYPES GROWN ON AN ANDOSOL IN THE WESTERN HIGHLANDS OF CAMEROON

M. NGUEGUIM, T. MÉKONTCHOU, M. FOBASSO and L. NOUNAMO[1]
Institute of Agricultural Research for Development (IRAD), Foumbot Station
P. O. Box 163 Foumbot, West Region-Cameroon
[1]Institute of Agricultural Research for Development (IRAD), Nkolbisson Center
P. O. Box 2123, Yaounde - Cameroon
Corresponding author: martinngueguim@yahoo.fr

ABSTRACT

Determining the best combinations of variety choice and planting date may be crucial for farmers in view of optimising bean yields. A study was conducted to assess the agronomic performance of selected dry bean (*Phaseolus vulgaris* L.) lines when planted sequentially under rain fed conditions in the Western Highlands of Cameroon (WHC). Forty two introduced lines and three local checks were used, namely, 15 bush lines, 15 semi climber lines, and 15 climber lines. Three sequential dates of planting were chosen at 15 days intervals starting from 15th of September 2007. Delaying bean planting up to the 15th of October resulted in a 50 to 77% yield reduction. The highest losses were recorded by climber and semi-climber lines which have a relatively longer growth cycle. Consequently, grain quality also deteriorated as the weight of 100 seeds dropped by 11.4, 15.8 and 3.3% for bush, semi- climber and climber lines, respectively. The causative factors were likely soil moisture deficit coupled with insect pests damages to grains during formation and towards maturity. Disease incidence on the crop varieties was mild and scores ranged from resistant (1-3) to tolerant (4-6). In this environment, it is better to plant beans up to 1st October; beyond this date, it may be advisable for farmers to go for a high yielding bush variety. Climber and semi-climber varieties yielded at least 25% higher than bush ones under prevailing environmental conditions.

Key Words: *Phaseolus vulgaris*, planting dates, soil moisture deficit

RÉSUMÉ

La détermination des meilleures combinaisons de choix de variétés et dates de semis pourrait être cruciale pour les fermiers afin d'optimiser les rendements du haricot. Une étude était menée pour évaluer la performance agronomique des lignées de haricots secs (*Phaseolus vulgaris* L.) sélectionnés, plantés sequentiellement en conditions de pluie. Quarante deux lignées introduites et trois témoins locaux étaient utilisés, à savoir, 15 lignées naines, 15 lignées semi volubiles et 15 lignées volubiles. Trois dates de semis séquentielles étaient choisies à 15 jours d'intervalle du 15 Septembre 2007. Le semis retardé jusqu'au 15 Octobre avait induit une réduction de rendement allant de 50 à 77%. Les pertes les plus élevées étaient enregistrées par les lignées volubiles et semi-volubiles qui ont relativement un plus long cycle de croissance. En conséquence, la qualité du grain avait aussi détélioré par la perte du poids de 100 grains de 11.4, 15.8 et 3.3% pour les lignées naines, semi-naines et volubiles, respectivement. Les facteurs responsables étaient le déficit en humidité du sol associé aux dommages par des insects aux grains durant la formation et vers la maturité. L'incidence maladie sur les variétiés de cultures était modeste et l'echelle de cotation s'élevait du résistant (1-3) au tolérant (4-6). Dans cet environnement, il vaut mieux de planter les haricots jusqu'au 1er Octobre au-delà duquel, seules les variétés naines à haut rendement devraient être les plus recommandées aux fermiers. Les variétés volubiles et semi volubiles avaient produit au moins 25% plus que les haricots nains en conditions environmentales pre-citées.

Mots Clés: *Phaseolus vulgaris*, dates de semis, déficit en humidité du sol

INTRODUCTION

Common bean (*Phaseolus vulgaris* L.) is an important dietary legume for more than 300 million people especially in developing countries with total production exceeding 23 million metric tonnes, seven million of which are produced in Latin America and Africa (Broughton *et al*., 2003). Under rain fed agricultural systems, developing agronomic strategies that help crop varieties escape or withstand adverse biotic and abiotic conditions may greatly influence yield and yield components of the crops.

The Western Highlands of Cameroon are the biggest common bean producing zone of the country with more than 90% of the national production (Anonymous, 2010). It is situated between 5 and 13 degrees north (latitude) and 11 degrees east (longitude). The rainy season stretches from mid-March to mid-November, which allows the growing of two bean crops per year. The first bean crop is grown between March and July, while the second crop, which is grown from August to December, is by far the most important bean crop in the zone. This second crop usually matures towards dry season, some times relying on residual soil moisture when rains have gone away. As such, there are frequently high hazards of crops failure to farmers when improper varieties are used or planting has been done beyond recommended time limits.

After maize harvest which occurs between July and August, farmers usually are under high pressure to till enough land and plant the second season bean crop to mature before the dry season completely sets out. Selection of appropriate varieties coupled with timing of the bean planting, therefore, are crucial decisions to take by farmers; late planting would generally result in poor yields due to moisture deficit at grain filling particularly on the volcanic ash soils, which are low in clay but rich in silt and as such, they rapidly become droughty when rains stop. However, these soils are among the most fertile soils group in the region with coverage estimates above 100,000 hectares (Moukam, 1985). A great percentage of these soils are usually put to second season beans and it appears necessary, in view of yield improvement, to help farmers take appropriate decisions on how late not to plant in the season or on which variety types to go for when they are forced to plant late. In fact, farmers are generally confronted either with the wrong option of optimum planting time or with the wrong choice of a proper variety to plant to escape the drought spell or minimise its detrimental effects on crops yield. There is further justification of the importance of this decision taking by farmers on the basis of the large areas. Justification for what affected by drought in East, Central and Southern Africa, causing severe yield losses. In these regions, drought affects bean production, causing losses of more than 395 000 tonnes each year (Tilahun *et al*., 2004). Hence, this huge magnitude of crops losses to drought prompts that appropriate strategies be put in place to ensure better crop yields to farmers, thereby contributing towards fight against food insecurity in these regions of the continent.

The objective of this study was to bridge the information gap needed by bean farmers of the Western Highlands of Cameroon (W.H.C.) as to when to plant their second season crops and what variety types to select in order to escape the detrimental effects of the end of season drought spell on crops in the area.

MATERIALS AND METHODS

Study site. The experiment was conducted at the Foumbot IRAD station which is medium altitude with 1,100 meters above sea level (m.a.s.l.). Mean annual rainfall is 1538.8 mm and the heaviest rainy period of the year ranges from July to September. The onset of the dry season usually occurs between October and mid-November. Depending on the abruptness of this drought spell, rain fed crops may suffer soil moisture deficit during their maturity period. The soil at the experimental site was a Mollic Vitrandept, ashy over cindery, according to the US Soil Taxonomy (Moukam, 1985). Selected chemical properties of surface soil (0-20 cm) at the experimental site indicated C = 3.52%, total N = 0.35%, C/N ratio =9.97, P (Bray-2) = 11.62 mg kg^{-1}, pH (H_2O) = 5.75, exchangeable K^+ = 0.80 cmol kg^{-1}, Mg= 2.27 cmol kg^{-1} and Ca = 9.97 cmol kg^{-1}.

Plant materials. A total of 45 common bean genotypes were tested including 42 lines introduced from the Centro Internationale de Agricultura Tropicale (CIAT) through the Pan Africa Bean Research Alliance (PABRA), and 3 local checks selected from among the market class varieties (Table 1). The exotic genotypes were selected from among the best performing materials being evaluated in country for resistance to biotic and abiotic stress factors, for grain quality (e.g. micronutrients density), productivity, and/or production components (IRAD-CIAT/PABRA, 2006; 2007; 2008 Annual Reports), with the ultimate aim to release the most potent lines for large scale cultivation in the country and sub-region of Africa. All the genetic materials used indifferently belonged to the Andean and the Mesoamerican gene pools.

Experimental procedure. A randomised complete block design was used for each growth type with 3 replications. Three sequential dates of planting were chosen at 15 days intervals and starting on 15th of September 2007. The 3rd and last planting was done on October 15th. The 3 sequential dates were used as replications.

The bean accessions were grown in 3 m, single row plots without replication at each planting date. Planting hills were spaced at 25 cm within rows and 1 m between rows. Sowing was done at three seeds per hill, and 13 hills per line-plot for a total of 39 plants per plot. Planting was done on flat and earthing up was done 3 weeks after germination so as to control the emerging weeds and prevent the effects of root rot disease which often prevails at this growth stage in the area.

The following parameters were recorded: Stand count 10 days after planting (P10 DAP) was done by physically counting plants emerged in each plot 10 days after planting. Diseases scoring of mainly angular leaf spot (ALS) at reproductive stage (R8) was recorded using the CIAT Standard System for Disease Scoring (CIAT, 1987). In this system, scores 1-3 mean resistant, 4-6 mean tolerant, and 7-9 means susceptible.

Seed yield at harvest was recorded by weighing the dried, threshed and winnowed grains using an electronic scale sensible to 0.1 g. The weight of 100 grains (100SWT) was measured following seed yield recording by first counting 3 samples of 100 seeds each from each plot, then recording the average weight using the same scale as above. Data were analysed with the generalised linear models (GLM) procedure of the

TABLE 1. Bean genotypes by growth habits in a planting date experiment at Foumbot in Cameroon, 2007

Varieties and growth types		
Bush (B)	Semi-Climbers (S/CL)	Climbers (CL)
GLP-190 (Check)	PH 201 (Check)	PB (Check)
KNX 122 (MCR)	FEB -192 (Bilfa)	MAC 107
ECAB 0019	GLP-2 (Biofort)	MAC 55
KNX 114 (MCR)	FEB-200 (Bilfa)	MAC 75
PVA-8 (Biofort)	Nm12659/144-1	ROBA-1 (Biofort)
Vttt926/S-7	MCM 2001 (Biofort)	MAC 119
ECAB 0063	ECAB 0056	MEX 142 (Biofort)
ECAB 0241	UBR (92)25 (Bilfa)	MAC 18
ECAB 0043	MANSEKI	MAC 16
RWR-10 (Biofort)	Iq (NDUNDU)	LUNDAMBA
ECAB 0027	BF-10	MAC 27
ECAB 0240	ECAB 0421	SEPE
ECA PAN 021 (Bilfa)	TY 3396-12 (Biofort)	MAC 34
FEB 193	T 842 6F-11-6 (Bilfa)	KJ4-3
CIM 9331-1 (Bilfa)	G 20854 (MCR)	MAC 33

MCR = Multiple Constraints Resistant bean genotype; BILFA = Bean genotype adapted to low fertility areas and acid soils; BIOFORT = Bean genotype with high content in proteins and micronutrients (Fe and Zn)

SAS statistical package (8th Ed.). Means were separated using Least Significant Difference (LSD) test at the 5% level of probability.

RESULTS

Data for bush lines across planting dates are presented in Table 2. There were significant differences among genotypes for seed yield. Line KNX-114 significantly out-yielded the control variety. All the exotic lines yielded above the control variety, GLP-190, although not always significantly. Mean seed yield per plot was 210.5 g which surpassed the check variety, but not significantly (P>0.05). There were no significant differences among the genotypes for stand count 10 days after planting. The weight of 100 seeds ranged from 21.7 to 40.1 g, and there were significant differences among the genotypes.

Table 3 contains data for semi-climber lines across all planting dates. Mean seed yield was 287.8 g, which did not surpass the check variety PH 201. There were, however, significant differences among genotypes for seed yield. Line TY 3396-12 tended to out-yield the control variety, PH 201, though not significantly (P>0.05). There were significant differences among the genotypes for stand count 10 days after planting, but these seemed not to have influenced grain yield in the same manner. The weight of 100 seeds ranged from 16.7 to 42.2 g, and there were significant differences among the genotypes.

Data for climber lines across all the planting dates are contained in Table 4. There were significant differences among genotypes for seed yield. Line KJ4-3 out-yielded the control variety, PB, significantly. There were significant differences among genotypes for stand count 10 days after planting, but these seemed not to have influenced grain yield in the same manner. The weight of 100 seeds ranged from 17.6 to 48.9 g, and there were significant differences among the genotypes.

There were significant differences for seed weight among the planting dates (Table 5). The first and second planting dates appeared to be the best, but were not significantly different from each other. However, date 1 (planting on 15th September) and date 2 (planting on 1st of October) were significantly different from date 3 (planting on 15th October) independently from the growth habit.

TABLE 2. Bush bean yield and growth parameters, and angular leaf spot disease scores at R8 stage over a span of a planting dates in Foumbot - Cameroom

Bean genotypes	Seed yield (g plot^{-1})	100 Seed weight (g)	P10DAP	ALS_R8
GLP-190 (Check)	166.7	40.1	37	5
KNX 122 (MCR)	241.7	21.7	35	2
ECAB 0019	216.7	27.4	37	5
KNX 114 (MCR)	258.3	17.4	36	3
PVA-8 (Biofort)	200.0	30.0	35	5
Vttt926/S-7	216.7	38.8	36	4
ECAB 0063	175.0	36.1	34	5
ECAB 0241	233.3	31.2	37	3
ECAB 0043	233.3	36.3	35	4
RWR-10 (Biofort)	200.0	31.2	37	2
ECAB 0027	233.3	41.1	36	3
ECAB 0240	216.7	33.7	37	4
ECA PAN 021 (Bilfa)	183.3	34.5	37	4
FEB 193	175.0	35.5	34	3
CIM 9331-1 (Bilfa)	208.0	32.2	35	4
LSD (0.05)	75.7	4.7	4	-

P10 DAP = Number of plants 10 days after planting; ALS_R8 = Angular Leaf Spot disease scoring at the reproductive stage R8

TABLE 3. Semi-climber bean yield, and growth parameters, and angular leaf spot disease scores at R8 stage over a span of a planting dates in Foumbot in Cameroon

Bean genotypes	Seed yield (g $plot^{-1}$)	100 Seed weight (g)	P10DAP	ALS_R8
PH 201 (Check)	358.3	19.5	35	4
FEB -192 (Bilfa)	216.7	21.9	34	3
GLP-2 (Biofort)	316.7	31.4	37	4
FEB-200 (Bilfa)	233.3	16.3	36	3
Nm12659/144-1	258.3	31.0	28	3
MCM 2001 (Biofort)	308.3	19.7	36	2
ECAB 0056	250.0	42.2	32	4
UBR (92)25 (Bilfa)	333.3	19.8	24	5
MANSEKI	300.0	21.1	30	5
Iq (NDUNDU)	275.0	30.9	34	4
BF-10	300.0	23.8	30	5
ECAB 0421	275.0	19.3	35	3
TY 3396-12 (Biofort)	366.7	24.9	30	4
T 842 6F-11-6 (Bilfa)	333.3	18.3	35	3
G 20854 (MCR)	191.7	32.9	35	5
LSD (0.05)	173.6	4.1	5	-

P10DAP = Number of plants 10 days after planting; ALS_R8 = Angular Leaf Spot disease scoring at the reproductive stage R8

TABLE 4. Climber type bean yield, and growth parameters, and angular leaf spot disease scores at R8 stage over a span of a planting dates in Foumbot- Cameroon

Bean genotypes	Seed yield (g $plot^{-1}$)	100 Seed weight (g)	P10DAP	ALS_R8
PB (Check)	383.3	19.9	35	4
MAC 107	291.7	31.1	37	3
MAC 55	325.0	48.2	31	3
MAC 75	208.3	39.1	33	4
ROBA-1 (Biofort)	266.7	18.7	34	3
MAC 119	283.3	30.4	37	4
MEX 142 (Biofort)	300.0	17.6	28	4
MAC 18	233.3	39.8	30	3
MAC 16	333.3	45.9	36	3
LUNDAMBA	333.3	39.7	36	4
MAC 27	191.7	42.8	35	4
SEPE	291.7	34.7	32	4
MAC 34	191.7	48.9	33	3
KJ4-3	408.3	38.4	37	5
MAC 33	108.3	48.9	35	4
LSD (0.05)	152.5	12.8	5	-

P10 DAP = Number of plants 10 days after planting; ALS_R8 = Angular Leaf Spot disease scoring at the reproductive stage R8

TABLE 5. Selected parameters of bean genotypes as influenced by variety types and date of sowing in a planting date experiment in Foumbot - Cameroon

Varieties types	Dates of planting	Seed yield (g plot^{-1})	100 Seed weight (g)	P10DAP	ALS_R8
	D1	241.7	34.1	35	4
	D2	260.0	33.2	37	4
Bush	D3	130.0	30.2	36	3
	LSD (0.05)	33.8	2.1	1.8	-
	CV (%)	21.5	8.7	6.6	-
	D1	360.0	26.6	33	4
	D2	378.3	25.7	33	4
Semi climbers	D3	125.0	22.4	32	4
	LSD (0.05)	77.6	1.8	2.4	-
	CV (%)	36.1	9.9	9.8	-
	D1	366.7	36.7	31	4
	D2	378.3	36.6	33	4
Climbers	D3	85.0	35.5	31	3
	LSD (0.05)	58.2	5.7	2.3	-
	CV (%)	32.9	21.1	9.5	-

P10DAP = Number of plants 10 days after planting; ALS_R8 = Angular Leaf Spot disease scoring at the reproductive stage R8; D1 = First planting date; D2 = Second planting date; D3 = Third planting date

Delaying planting up to 15th October led to 50 to 77% yield reduction, the highest yield losses being recorded by climber and semi-climbers which had a longer growth cycle.

Plant stand count 10 days after planting (P10DAP) did not exhibit significant differences among planting dates as with seed yield (Table 5).

There were significant differences among planting dates for the parameter seed weight of 100 grains (100SWT) in bush and semi climber, and climber lines (Table 5). In clear, the 100 seed weight dropped within the same variety types as planting was delayed from the first to the third planting dates probably due to increasing poor grain filling resulting from soil moisture decrease at the onset of the dry season.

Angular leaf spot disease scores were in the range of resistant (1-3) and tolerant (4-6) according to the CIAT Standard System for disease scoring.

DISCUSSION

The bean genotypes across all growth types responded to planting scheduling in the same pattern; delaying bean planting beyond the 1st of October caused yield reductions and even serious grain quality deterioration as seed yield and the weight of 100 seeds significantly reduced with delayed planting time (Table 5). In fact, within each of the growth types (bush, semi-climber and climber), the weight of 100 seeds consistently dropped with lateness in planting although this reduction was not significant for the climbers (Tale 5). The factors likely to cause this were soil moisture deficit coupled with insect pests damages to grains during formation and towards maturity.

According to Nilson and Orcutt (1996), limited water availability to the bean crop can be caused by the soil-precipitation relationship amongst other physical and climatic factors of the environment. In clear, the water holding capacity of the soil, in conjunction with the amount of precipitation in time scale, influences the moisture supply to plant roots, especially in light textured soils as this one, amongst other factors which interplay notably ambient temperature and the soil-plant relationship.

As noted by Tilahun *et al.* (2004), drought, which includes moisture and heat stress, acts in conjunction with biotic stresses, especially diseases and pests. The highest yield losses were recorded by climbers and semi-climbers, which have a longer growth cycle and as such, could not escape the detrimental effects of the drought spell through early harvest. Probably, soil moisture deficit at grain filling and maturity led to poor grain filling and seed quality. Thus, 100 seed weight consistently decreased with delayed planting as a sign of poor grain filling, and this trait was particularly significant at the 5% level of probability for bush and semi-climber genotypes.

Observation time for P10DAP generally coincides with the critical period for root rot incidence in the area; soil conditions at the trial site were probably not very conducive to severe infestation of the disease. Summarising studies conducted on root rots in Kenya, Otsyula and Buruhara (2001) observed that the disease prevailed mostly at seedling stages of the bean plant and that severity would depend on the soil moisture status and type of micro organisms responsible. *Pythium* tended to occur on crops grown when there was high rainfall in a season, while the severity of *Rhizoctonia, Sclerotium*, and *Fusarium* did not depend on the moisture status of the soil.

Angular leaf spot disease infection was only minimal throughout the growth cycle of the crop. This was likely due to the fact that dry weather conditions that prevailed towards grain formation and maturity were not very conducive to leaf diseases spread. In fact, previous field experience in the area indicated a higher prevalence of this disease at those developmental stages of the bean plant (IRAD-CIAT/PABRA, 2006; 2007; 2008 Annual Reports).

Sindhanand Bose (1980), in a study of the epidemiology of ALS on French bean, observed that the disease attack varied with planting dates or years due to different climatic factors such as relative humidity and temperature. This could explain the pattern of variations as observed in this case, indicating that climatic factors such as temperature and relative humidity were likely not conducive to high ALS incidence on the bean genotypes.

For the purpose of identifying the best performing varieties for release, a good number of exotic lines performed better than check varieties within growth types. This is an indication that there are good prospects for identification of potential candidates for release to farmers among these growth types varieties. On average, climber and semi-climber varieties yielded at least 25 to 37% higher than bush ones. Musoni *et al.* (2001) reported yield advantages of climbers over bush varieties of dry beans in the range of 150 to 300%, coupled with better disease resistance when grown under conditions of appropriate staking and improved soil fertility.

CONCLUSION

Our results provide useful information indicating that on the volcanic ash soils of the highlands of Cameroon, which have a considerable land cover, it may be best to schedule bean plantings up to 1st of October at the latest, and if a farmer is forced to delay his bean planting beyond this date, it may be advisable to go for a high yielding bush variety rather, because yield losses due to soil moisture deficit could be reduced from 77 to only 50%.

ACKNOWLEDGEMENT

Financial support for this study was provided by the Pan-Africa Bean Research Alliance (PABRA) which is hereby acknowledged. The authors also gratefully thank the Institute of Agricultural Research for Development (IRAD) as well as the International Center for Tropical Agriculture (CIAT) for the setting up of the Collaborative Bean Research Project in Cameroon, under which the study was conducted.

REFERENCES

Anonymous. 2010. Annuaire des Statistiques du Secteur Agricole du Cameroun: Campagnes 2007-2008. In: On-line: www.minader.cm/.../ documents -de-statistiques-de-la-direction-des-études-et- statistiques-agricoles.

Broughton, W.J., Hernandez, G., Blair, M., Beebe, S., Gepts, P. and Venderleyden, J. 2003. Bean (*Phaseolus* spp.) - model food legumes. *Plant and Soil* 252:55-128.

CIAT (Centro Internacional de Agricultura Tropical). 1987. Standard system for the evaluation of bean germplasm. Van Schoonhoven, A. and Pastor-Corrales, M.A. (Eds.). Cali, Colombia. 54 pp.

Cook, R.J. and Baker, K.F. 1996. The nature and practice of biological control of plant pathogens. APS Press, Minnesota, USA. 539pp.

IRAD-CIAT/PABRA Annual Reports for 2006, 2007 and 2008. (Personal communication). IRAD Headquarters library-Yaounde-Cameroon.

Moukam Appolinaire. 1985. Etude des sols et des contraintes du verger de la Station IRA de Foumbot. 32pp.

Musoni, A., Buruchara, R. and Kimani, P. 2001. Climbing beans in Rwanda: Development, impact and challenges. In. Proceedings of PABRA Millenium Workshop. Novotel Mt Meru, Arusha, Tanzania.

Nilsen, E.T. and Orcutt, D. 1996. Soil processes and plant stress physiology. pp. 1-177. In: The physiology of plants under stress: Soil and biotic factors.

Otsyula, R.M. and Bruchara, R. 2001. Research on bean root rots in Kenya. pp. 159-166. In: Proceedings of the PABRA Millenium Workshop.

Sindhan, G.S. and Bose, S.K. 1980. In: Epidemiology of angular leaf spot of french bean caused by *Phaeoisariopsis griseola*. *Indian Phytopathological Journal* 33(1): 64-68.

Tilahun, A., Kimani, P., Ronno, W., Lunze, L. and Mbikay, N. 2004. In: Coping with drought: Strategies to improve genetic adaptation of common bean to drought proned regions of Africa. CIAT Occasional Publications Series No. 38.