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THE INFLUENCE OF SOME CROP PROTECTION MANAGEMENT PRACTICES ON YIELD STABILITY OF COWPEAS

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ABSTRACT

Thirty varieties of cowpeas (*Vigna unguiculata* L. Walp) were evaluated for their yield stability using two methods of field trials. One set of environments was created by using different crop protection management practices within one location. The second set was created by using different seasons and locations. The results of both methods revealed significant differences among environments, genotypes and genotype x environment interactions. Both methods showed that most of the varieties were stable with regression coefficients (b) not significantly different from unity, mean square deviations from regression (s^2d) close to zero, high coefficients of determination (r^2) and high grain yields. It was concluded that where funds, time, co-operating scientists and competent field assistants are limiting the simulation of environments could be resorted to. Five varieties IT85F-1987, TVx 3236, IT82D-716, IT82D-522-1 and TVx 274-02 were selected, using the stability parameters of both methods and other desirable traits for further testing before eventual release to farmers.

***Key Words*: Cowpeas, Crop Management Practices, yield stability**

RÉSUMÉ

Trente variétés de niébé (*Vigna unguilata*, L. Walp) ont été évaluées pour la stabilité de rendement à l'aide de deux méthodes d'essaia sur le terrain. Une série d'environnements a été crée en appliquant différentes méthodes de protection contre les ravageurs de cultures sur un même site. La seconde série a été crée par l'usage de differentes méthodes a revelé des différences significatives entre environements et génotypes, et entre les interactions génotypes et environnements. Les deux methodes ont montré que la plupart des variétés étaient stables avec un coefficient de régression (b) très proche de 1; le carré moyen des écarts par rapport à la régression proche de zéro, des coefficients de détermination très élevés de même que des rendements en grain élevés. Il a été conclu que recours pourrait être fait à la simulation de l'environnement que'en cas de manque de fonds, de temps, de coopération entre chercheurs et de personnel de terrain. Cinq variétés IT85F-1987, TVx 3236, IT82D-716, IT82D-522-1 et TVx 274-02 ont été sélectionées suivant la stabilité des paramètres des deux méthodes et autres caractères désirables pour des essais plus élaborés avant la vulgarisation.

***Mots Clés*: Niébé, practiques culturales, stabilité de rendement**

INTRODUCTION

Plant breeders are usually concerned about the interaction between the genetic and environmental factors (GxE) which affect the range of crop adaptability. Numerous studies have shown that genotype x environment interactions can and actually does play an important role in the selection of superior genotyypes of crops (Erickson *et al.*, 1982)

Environmental variation has been classified by Allard and Bradshaw (1964) as either predictable or unpredictable. Predictable variation, which is normally subject to man's control, includes such factors as planting date, plant density and arrangement, fertilizer rates and crop management practices, as well as some permanent environmental factors such as soil type and cyclic patterns in daylength. On the othe hand, unpredictable environmental factors include the amount and distribution of rainfall, variations in temperature and incidence of diseases and pests.

Conventionally, plant breeders evaluate potential varieties for their yield stability performance in a number of locations or environments for several seasons and/or years. Freeman (1973) and Lin *et al.* (1986) have extensively reviewed the statistical methods used in assessing new varieties for their yield stability. These methods were initially proposed by Yates and Cochran (1938), amplified by Finlay and Wilkinson (1963) and refined and/or used by other workers (Bilbro and Ray, 1976; Eberhart and Russel, 1966; Ntare and Aken'Ova, 1985; Opeke and Fakorede, 1987; Peterson *et al.*, 1992). The methods consist of a conventional analysis of variance followed by a joint regression of stability analysis. The regression analysis provides two major stability parameters: the regression coefficient (b), which is a measure of environmental response or adaptation, and the mean square deviation from regression (s^2d), which is a measure of stability. A genotype with b=1 is considered adapted to all environments whereas a genotype with $b>1.0$ is adapted to high yielding environments and the one with $b < 1.0$ is adapted to low yielding environments. An ideal genotype should have $b = 1.0$, $s^2d = 0$, high r^2 and a relatively high mean yield.

The conventional method, however, requires quite substantial amounts of research funds, time, as well as availability of co-operating scientists. These are, among others, serious constraints of evaluating new varieties in different locations or agro-ecological zones, most especially in developing countries. Moreover this could be compounded by the fact that the sites or locations used for the trials are not always ideal (Fakorede, 1986). Thus, plant breeders have sought alternative avenues of creating predictable microenvironments that will minimise resource outlay. The objectives of the study reported herein were twofold. First, we wanted to compare the use of some crop protection management practises of cowpeas in one location as a creation of microenvironments (Method I) with the conventional method of evaluating new varieties in a number of locations for several seasons or years (Method II). Second, we sought to identify introduced elite varieties of cowpeas which could be released after a few seasons of evaluation to farmers in Uganda.

MATERIALS AND METHODS

Thirty elite varieties of cowpeas introduced from the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria (16 varieties), Kenya (13 varieties) and Tanzania (1 variety) were evaluated for their seed yield stability at Makerere University Agricultural Research Institute, Kabanyolo (MUARIK), near Kampala, Uganda, to represent the Central Region Agroecological zone, during the second rains of 1990 and the first rains of 1991, and Ngetta DFI, to represent the Northern Region Agroecological zone, during the second rains of 1991. This gave a total of six different environments. At Kabanyolo the varieties were also evaluated using four different crop protection management practices viz: control of diseases and pests, control of insect pests only, control of diseases only and no control of diseases and pests during the second rains of 1990 and the first rains of 1991. This created a total of eight microenvironments within Kabanyolo. The thirty varieties were selected on the basis of their morphological agronomic traits as well as their high yield potential. There was no local check available to incorporate in these screening trials because most of the earlier collections were lost as a result of improper conservation and maintenance (Rusoke and Rubaihayo, 1990).

The trials in the various sites and seasons were laid out in a 5 x 6 rectangular lattice using a spacing of 0.6 m between rows and 0.3 m within rows. The plot size was 3 m long and 1.8 m wide with 44 plants after thinning thus giving approximately 5,555 plants per hectare. Plant stand count was taken one week after thinning and at harvest. The plots were kept weed free using a hand hoe. No fertilizer was applied but Dithane M45 and Ambush or Malathion were used to control diseases and insect pests, respectively.

Harvests were taken two or three times using the two middle rows of each plot. The dried pods were threshed and seed weights in grammes per plant as well as kilogrammes per hectare were determined and then converted into tons ha^{-1}. The stand count at harvest was used to determine the seed yield per plant which was subsequently used to determine the yield in kilogrammes per hectare.

Conventional analyses of variance were performed for each environment in Methods I and II. Variety means were separated using the Duncan-Waller Multiple Range Test ($\alpha = 0.05$). The joint regression or stability analyses of Eberhart and Russel (1966) were used to determine the yield stability of the 30 varieties using Methods I and II. The regression coefficient (b) were tested for significant differences from b = 1.0 using t-tests, while the significance of deviations from regression (s^2d) was tested by the F-test based on pooled error estimates. Simple correlation coefficients were computed among variety means x, b- values, s^2d or r^2 values within each of the two methods. In addition, variety means x, b-values, s^2d and r^2 values of the combined analysis of Method I were correlated with those of Method II to determine the relationship between the two methods. The MSTAT C (1986) and SAS (1982) were used for the analysis.

RESULTS AND DISCUSSION

The combined anlyses of variance for Methods I and II are presented in Tables 1 and 2. In both cases, the results reveal that there were significant differences among the genotypes ($P \leq 0.05$). This was, however, expected because the genotypes were introduced into the country from several National and International Research Programmes with various breeding objectives, and therefore had diverse genetic backgrounds. Similarly, the environments in each method were significantly different ($P \leq 0.05$). Thus the simulation of environments using different crop protection management practices was sufficiently effective in creating different microenvironments within a location and can, within limits, be used to assess the stability of new genotypes without losing much information. The genotype x environment (G x E) interaction was also significant indicating that the different varieties indeed performed differently in the different environments.

The mean performance (x), regression coefficients (b) and mean square deviations from regression (s^2d) are presented in Tables 3 and 4. In Method I (Table 3), fifteen varieties showed adaptation to low performing environments ($b \leq 1$), fourteen varieties were responsive to environmental improvement ($b \geq 1$) whereas only one variety, TV x 3636, had average stability ($b = 1$). Four varieties IT84D-446, IT81D-1205-174,

TABLE 1. Combined analysis of variance of seed yield (kg ha^{-1}) of 30 elite varieties of cowpeas evaluated in eight simulated environments at Kabanyolo, Uganda.

Source	df	Ms	Probability
Environments	7	44027521.0	0.0001
Rep/Environments	14	791251.1	0.0772
Genotypes x Environment	203	666525.8	0.0065
Pooled Error	466	986342.5	

TABLE 2. Analysis of variance of seed yield (kg ha^{-1}) of 30 elite varieties of cowpeas evaluated in six environments created using different seasons and locations.

Source	df	Ms	Probability
Environments	5	103053920.1	0.0001
Rep/Environments	12	1269887.0	0.0399
Genotypes	29	1109167.7	0.0168
Genotypes x Environment	145	445511.3	0.0150
Pooled Error	348	730844.4	

TABLE 3. Mean yield (ton ha^{-1}), regression coefficients (b), mean squared deviations (s^2d) and coefficients of determinations (r^2) of 30 elite varieties of cowpeas evaluated under different crop protection management conditions (Method I)

Variety	yield[a]	b	s^2d	r^2
IT85F-2020	2.78 a	1.91[b]	0.41	0.78
KVu/175	2.77 a	1.21	0.31	0.72
IT81D-944	2.49 ab	1.19	0.32	0.70
KVu 451	2.47 ab	1.23	0.15	0.92
KVu-530	2.39 abcd	1.23	0.26	0.79
TVx 3236	2.38 abcd	1.00	0.16	0.88
IT82D-703	2.36 abcd	0.68	0.19	0.67
KVu-M68	2.36 abcd	1.29	0.34	0.70
AT 3 1/80F	2.35 abcd	0.96	0.18	0.83
IT835-689-11	2.34 abcd	1.29	0.33	0.71
IT82D-522-1	2.32 abcde	0.86	0.17	0.81
TVx 465	2.25 bcde	1.27	0.24	0.82
Vita 6	2.24 bcde	1.35	0.25	0.83
ER-7	2.24 abcde	0.97	0.27	0.69
IT81D-7607	2.22 bcde	0.35[b]	0.24	0.27
IT82D-1032	2.21 bcde	1.27	0.19	0.88
4R-0267-01F	2.18 bcde	0.94	0.16	0.85
KVu-454	2.15 bcde	1.35	0.62	0.52
IT85F-1987	2.13 bcde	1.03	0.19	0.83
IT84D-446	2.12 bcde	0.30[b]	0.17	0.35
TVx 274-02	2.09 cde	1.05	0.15	0.89
IT82E-12	2.08 cde	0.80	0.18	0.76
IT82D-716	2.04 cde	0.86	0.14	0.86
446-1	2.04 cde	1.06	0.18	0.85
IT82D-634-2	2.03 cde	0.78	0.22	0.69
IT85F-2269	1.95 de	0.81	0.13	0.87
Katmani-80	1.93 de	0.79	0.21	0.70
IT81D-1205-174	1.78 de	0.52[b]	0.12	0.73
HB/B/5/8	1.61 de	0.72	0.16	0.76
TVx-309-1G	1.34 e	0.89	0.18	0.80

[a]Means followed by the same letter(s) are not significantly different at the 5% level of probability.
[b]Significantly different from unity at the 5% level of probability.

IT818-7607 and IT82D-730 were the only ones which had regression coefficients significantly less than unity ($P \leq 0.05$). Variety IT85F-2020 was among the fourteen with adaptation to high performing environments but was the only one with a regression coefficient which was significantly more than unity. Most of the varieties were considered to be stable since they had regression coefficients close or equal to 1.0. Furthermore, all these varieties had relatively high yield and minimum deviations from regression. The mean square deviations were not significant ($P \leq 0.05$). This shows that they were close to zero which is the desired value. Thus, depending on other characteristics of interest there was a wide array of stable varieties to select from for further testing. Only five varieties were considered unstable. The coefficient of determination (r^2) values (Table 3) were relatively high indicating that a sizeable amount of variability should be attributed to genotypes.

In Method II (Table 4) eighteen varieties were adapted to low performing environments ($b < 1$), eleven showed adaptation to high performing environments ($b > 1$). Generally, most of the varieties were considered stable under this method except five varieties which had regression coefficients significantly higher or lower than unity (Table 4). It is interesting to note that both methods identified variety IT85F-2020 as being adapted to high performing environments and has a regression coefficient significantly higher than

TABLE 4. Mean yield (tons ha^{-1}), regression coefficients (b), mean squared deviations (s^2d) and coefficients of determinations (r^2) of 30 elite varieties of cowpeas evaluated in multilocational trials over seasons (Method II)

Variety	X^a	b	s^2d	r^2
KVu-454	2.06 a	1.63^b	0.37	0.82
ER-7	1.90 ab	1.09	0.08	0.97
KVu 451	1.66 ab	0.12	0.11	0.96
IT85F-2020	1.65 abcd	1.78^b	0.25	0.92
KVu 530	1.64 abcd	1.20	0.13	0.95
AT 3 1/80F	1.61 abcde	0.88	0.07	0.97
IT81D-994	1.58 abcd	1.19	0.09	0.97
KVu/175	1.57 abcd	1.14	0.20	0.80
TVu 465	1.56 abcd	1.30	0.11	0.96
KVu-M68	1.55 abcd	1.03	0.13	0.93
IT82D-634-2	1.54 abcd	0.85	0.18	0.84
4R-0267-01F	1.52 abcde	0.87	0.11	0.93
Vita 6	1.51 bcde	1.21	0.23	0.86
IT82E-12	1.47 bcde	1.01	0.15	0.91
446-1	1.46 bcde	0.96	0.14	0.91
IT82D-1036	1.43 bcde	0.99	0.15	0.91
IT82D-703	1.42 bcde	0.77^b	0.05	0.98
IT81D-7607	1.41 cde	1.01	0.05	0.98
TVx 274-02	1.38 cde	0.92	0.05	0.98
Katmani-80	1.32 cde	0.72^b	0.07	0.95
TVx-309-1G	1.28 cde	0.88	0.18	0.94
IT835-689-11	1.27 cde	0.99	0.15	0.91
HB/B/5/8	1.21 cde	0.53^b	0.10	0.85
IT85F-1987	1.20 de	0.93	0.07	0.97
IT82D-522-1	1.14 de	1.00	0.10	0.96
TVx 3236	1.10 de	0.88	0.12	0.92
IT81D-1205-174	1.02 de	0.71	0.13	0.86
IT85F-2269	1.01 de	0.79	0.10	0.93
IT84D-446	0.96 e	0.73	0.14	0.86
IT82D-716	0.95 e	0.84	0.09	0.94

[a]Means followed by the same letter(s) are not significantly different at the 5% level of probability.
[b]Significantly different from unity at the 5% level of probability.

Table 5. Correlation coefficients among mean yield (x), regression coefficient (b), mean squared deviations from regression (s^2d) and coefficient of determination (r^2)

Statistics correlated		Method I[a]	Method II
x with	b	0.475**	0.824**
x	r^2	0.33	-0.065
x	s^2d	0.323	0.585**
b	r^2	0.459**	-0.028
b	s^2d	0.576**	0.656**
r^2	s^2d	-0.364	-0.743**

[a]Metthod I: Use of simulated environments at MUARIK
Metthod II: Use of multilocational trials over seasons.
**Significant at 1% level of probability.

unity in both cases. The other cases of the unstable varieties were not common to both methods. The coefficient of determination (r^2) values were much higher in this method (Table 4) than in the latter. This indicated that the simulated environments contributed more to the variability than when different seasons and locations were used.

Simple linear correlations among mean yield (x), regression coefficient (b), mean square deviations from regression (s^2d) and coefficient of determination (r^2) for both methods were computed (Table 5). The mean yield (x) was in most cases positively correlated with b, s^2d and r^2 except in Method II where it was negatively but not significantly correlated with r^2. Regression coefficients (b) were positively and significantly correlated with r^2 and s^2d in Method I and s^2d in Method II. In Method II, the regression coefficient was negatively related with r^2. This, however, was not significant. There were negative correlations between r^2 and s^2d in both methods although the correlation in Method I was not significant. The correlation between the means ($r = 0.72$), regression coefficients ($r = 0.81$) and coefficient of determination ($r = 0.75$) of the two methods were all positive and significant. This shows that the two methods are related and tend to give similar results, a situation that could be exploited by the plant breeder.

Both methods were able to show that most of the varieties were stable. Thus the simulation of environments could be used to test for yield stability where funds, time, co-operating scientists and competent field assistants are limiting. Fakorede *et al.* (1983) made similar observations while reporting a study on the use of planting dates in preliminary evaluation of cowpea cultivars. Moreover this could help to avoid using test sites that are not ideal for the crop and hence waste both time and money especially in developing countries.

To fulfill our second objective, the stability and adaptability indices were used to select five varieties. These were IT85F-1987, TVx 3236, IT82D-716, IT82D-522-1 and TVx 274-02. These are being further evaluated at MUARIK in large plots before being finally released to farmers. It is noteworthy, however, that these five varieties were not the best in terms of yield *per se*. Other factors such as pod placement in relation to canopy and resistance to specific diseases and pests were considered. For instance,variety IT82D-716 is resitant to the cowpea seed beetle (*Callosobruchus macultus* Fabr.) which is a notorious storage pest of cowpeas. This variety also places its pods above the canopy (upright podding habit). Similarly, TVx 3236 places its pods above the canopy and is resistant to flower thrips (*Megalurothrips sjostedti*).

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