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MULTILOCATIONAL EVALUATION OF SELECTED LOCAL AND IMPROVED COWPEA LINES IN UGANDA

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ABSTRACT

Six improved cowpea *(Vigna unguiculata)* genotypes initially selected from International Institute of Tropical Agriculture collection were evaluated for 3 seasons at 4 locations in Uganda, with the objective of comparing their yield performance and assessing their adaptability under Ugandan conditions. The cowpea genotypes were MU-93, TVX 337-025$^{(B)}$, IT90K-109$^{(B)}$, KVU-12349, IT82D-516-2, and IT85 F-2841. Across locations and seasons, MU-93 produced highest grain yield (1586 kg ha^{-1}) while KVU-12349 produced the lowest grain yield (505 kg ha^{-1}). At different locations the genotypes' performance varied, whereby IT85F-2841 (1378 kg ha^{-1}), MU-93 (1208 kg/ha), MU-93 (1235 kg ha^{-1}) and IT90K-109$^{(B)}$ (2373 kg/ha) produced the highest grain yields in Kabanyolo, Pallisa, Kumi, and Kaberamaido, respectively. The Additive Main effects and Multiplicative Interaction (AMMI) model was used in the genotype by environment (GXE) analysis to determine the yield and stability of the genotypes in the multi – environment trial. The effect of environments, genotypes and GXE were highly significant (P<0.001). The biplot revealed that the varieties; IT85F-2841 (G1), IT90K-109$^{(B)}$ (G2), IT82D-516-2 (G3), TVX 337-025$^{(B)}$ (G4) and MU-93 (G6) were generally high yielding since AMMI placed them on the right hand side of the mid point of the axis representing the grand mean, *Ebelat* (G5), *Icirikukwai* (G7) and KVU-12349 (G8) were generally low yielding and were placed on the left hand side of the midpoint on biplot. IT90K-109$^{(B)}$ (G2) and *Icirikukwai* (G7) had the highest principal component analysis (IPCA) scores (15.4 and -22.7, respectively) therefore were considered as unstable genotypes. Genotypes IT85F-2841, MU-93, IT82D-516-2, KVU-12349 and *Ebelat* had moderate IPCA 1 scores; hence moderately stable. TVX337-025$^{(B)}$ had a low IPCA 1 score and thus was relatively a stable genotype. Within environments AMMI and unadjusted means ranked genotypes differently. However, at one location in 2003, 6 out of 8 genotypes were ranked similarly by both estimates. While AMMI alone ranked MU-93 as the best genotype in all environments, both estimates reveal that MU-93 is superior in 6 out of 12 environments. MU-93 has now been recommended for official release in Uganda.

Key Words: Adaptation, AMMI model, G X E interaction, *Vigna unguiculata*

RÉSUMÉ

Six génotypes de niébé améliores (*Vigna unguiculata*) initialement sélectionne des collections de l'IITA étaient évaluées pour 3 saisons dans quatre endroits en Ouganda avec comme objectif de comparer les performances en rendement et évaluer leur adaptabilité aux conditions Ougandaises. Les génotypes de niébé étaient MU-93, TVX 337-025 (B), IT90K-109 (B), KVU-12349, IT82D-516-2, et IT85F-2841. MU-93 a produit le rendement (1586 kg ha^{-1}) le plus élevé pour les différents endroits et saisons. Pour les différents endroits la performance des génotypes a varie, alors que IT85F-2841 (1378 kg ha^{-1}), MU-93 (1208 kg ha^{-1}), MU-93 (1293 kg ha^{-1}) et IT90K-109 (B) (2378 kg ha^{-1}) a produit le rendement en grains le plus élevé à Kabanyolo, Pallisa, Kumi, et Kaberamaido respectivement. Le modèle aux effets majeurs additifs et interaction multiplicatifs (AMMI) était utilise dans l'analyse génotype - environnement pour déterminer le rendement et la stabilité des génotypes dans un essai multienvironnemental. Les effets de l'environnement génotype et l'interaction GxE étaient très significatif (P<0.01). Le biplote a révélé que les variétés IT85F-2841 (G1), IT90K-109 (B) (G2), IT82D516-2 (G3), TVX 337-025 (B) (G4) et MU-93 (G6) étaient généralement à haut rendement parce que AMMI les a placé a droite du point milieu de l'axe représentant la grande moyenne, Ebelat (G5), Icirikukwai (G7) et KVU-12349 (G8) étaient généralement à faible rendement et étaient placé à gauche du point milieu du biplote. IT90K-109 (B) (G2) et Icirikukwai (G7) avaient de grands scores de l'analyse des composantes principales (IPCA) (15.4 et -22.7, respectivement), par conséquent ils étaient considérés comme les génotypes instables. Les génotypes IT85F-2841, MU-93, IT82D516-2, KVU-12349 et Ebelat avaient un score modéré de IPCA, alors ils sont modérément stables. TVX337-025 (B) avait un comme score (IPCA) et par conséquent c'est un génotype stable. L' AMMI et les moyens non ajustés classant les génotypes différemment. Cependant, à un endroit en 2003, 6 et 8 génotypes étaient classes de la même façon par les deux méthodes. Alors que le AMMI seul a classé MU-93 comme le meilleur génotype quelque soit l'environnement. Les deux estimations ont révélé que MU-93 est supérieur dans 50% de cas. MU-93 a été recommandé pour diffusion officiellement en Ouganda.

Mots Clés: Adaptation, Model AMMI, interaction GxE, *Vigna unguiculata*

INTRODUCTION

Cowpea (*Vigna unguiculata* (L.) Walp) can be grown in many agroecologies (Purseglove, 1987). However, cowpea varieties are not as a rule broadly adapted. Further the value of even highly favored plant genetic traits can be masked by lack of adaptation or farmer preferences if those traits are not effectively introgressed into the appropriate background (DeVries and Toenniessen, 2001). Therefore it is important to assess adaptation and yield stability of promising genotypes across environments. In Uganda there was need to test the performance of some of the genotypes from International Institute of Tropical Agriculture (IITA) lines under different agro-ecological zones before recommending them for farmer adoption. It was against this background that this study was conducted to examine performance of 6 improved lines (MU-93, TVX 337-025^(B)^, IT90K-109 ^(B)^, KVU-12349, IT82D-516-2, and IT85 F-2841) that were selected by the Makerere University Cowpea Program over a 10-year period and more recently, after a preliminary evaluation of 48 improved lines. The selected improved lines were evaluated against two local checks: *Ebelat* and *Icirikukwai* with the main purpose of identifying those for possible release to cowpea farmers especially in eastern Uganda. The two local checks are popular cultivars in eastern Uganda, the main cowpea agro-ecology of Uganda (Sabiti *et al.*, 1994). *Ebelat* is erect, relatively large and white seeded, matures in ~ 70 days, and has high market value while *Icirikukwai* is spreading, has small and whitish-brown seeds, and highly preferred by the local community because of its very palatable leaves (Isubikalu *et al.*, 1999). The specific objectives of this study were to compare yield performance of the local and improved cowpea lines, and assess their adaptability in Uganda.

MATERIALS AND METHODS

Study areas and field establishment. The experiment was established in four locations whose agroecological characteristics are shown in Table 1. The locations were: on-station at Makerere University Agricultural Research Institute, Kabanyolo (MUARIK) located in central Uganda, and at 12 on-farm sites located in Kumi, Pallisa and Kaberamaido in eastern Uganda. These later sites were earlier on identified as being the main cowpea growing areas in the country (Sabiti *et al.*, 1994). The trials were conducted during the first (March-July) and second (August-December) seasons of 2002 and were repeated during the first season of 2003. In the subsequent sections, these seasons are referred to as 2002A, 2002B and 2003A, respectively. The experiments were laid in a randomised complete block design with 4 replications at Kabanyolo, and for the on-farm trials, each of the 12 on–farm sites represented a replicate. Each variety was planted at a spacing of 60 x 20 cm (as recommended by Obuo *et al.*, 1997) in 4 m x 4 m plots. Three to four seeds were planted per hole but 2 – 3 weeks later seedlings were thinned to 2 plants per hill. To protect the plants from insect and disease damage, Dimethoate

(40% E.C, at a rate of 1.0 litre/ ha^{-1}) and antracol at the same rate were applied at budding, flowering and podding as recommended by Karungi *et al.* (2000). The experiments were maintained weed-free by hand hoeing as deemed necessary, but before flowering to avoid flower drop (Obuo *et al.*, 1997).

Data collection and analysis. At maturity grain yield per plot was recorded and used to compute average yield in kg ha^{-1}. Analysis of variance was performed initially for each environment so as to determine performance of the genotypes in the different locations. A combined analysis over locations and seasons was conducted to elucidate performance of different genotypes across seasons and locations and establish genotype x environment interactions of grain yield. To establish adaptability of the genotypes to the different environments (season and location), G X E analysis was performed using the additive main effects and multiplicative interaction (AMMI) model (Gauch, 1993). The AMMI model was used because it is more efficient in determining the most stable and high yielding genotypes in multi-environment trials compared to earlier procedures (Finlay and Wilkinson, 1963; Eberhart and Russel, 1966). The model uses the analysis of variance (ANOVA) approach to study the main effects of genotypes and environments, and a principal component analysis (PCA) for the residual multiplicative interaction between genotypes and environments (Egesi and Asiedu, 2002). With the biplot facility from AMMI analysis both genotypes and environments occur on the same scatter plot and inferences about their interactions can be made.

RESULTS AND DISCUSSION

Grain yield. The results of the combined analysis of variance for grain yield (Table 2) indicated that there were highly significant ($P \leq 0.001$) differences among genotypes over the seasons and locations. In addition, both the two and three way interactions were highly significant. Across locations and seasons MU-93 produced highest grain yield (1586 kg ha^{-1}) and KVU-12349 produced the lowest grain yield (505 kg ha^{-1}) as shown in Table 3. At different locations the genotypes' performance varied, whereby IT85F-2841 (1378 kg ha^{-1}), MU-93 (1208 kg ha^{-1}), MU-93 (1235 kg ha^{-1}) and IT90K-109 $^{(B)}$ (2373 kg ha^{-1}) produced the highest grain yields in Kabanyolo, Pallisa, Kumi, and Kaberamaido, respectively. On the other hand KVU-12349 produced the lowest yields at all locations.

Genotype by environment interaction analysis. From the analysis of variance for grain yield of the cowpea genotypes (Table 2), it was observed that there were significant ($P \leq 0.001$) differences among genotypes and environments, thus justifying genotypes and environment interaction analysis. The AMMI analysis for grain yield (Table 4) indicated that genotypes (G),

TABLE 1. Agro-ecological characteristics of the four study areas used in the multilocational trials in Uganda

Location	Latitude	Longitude	Altitude (m.a.s.l)	Min temp (°C)	Max temp (°C)	Rainfall (mm)	Soil type
Kabanyolo	0°28'N	32°27'E	1200	14.1	29.0	1300	Deep ferrallic
Pallisa	1°13'N	31°42'E	1219	16.1	30.0	1100	Brown Sandy loams
Kumi	1°31'N	33°53'E	1127	15.0	27.5	1125	Reddish brown sandy loams
Kaberemaido	1°45'N	31°42'E	1127	17.5	30.0	1220	Grey-brown sandy loams

Source: Aniku (2001)

TABLE 2. ANOVA table for grain yield of the selected cowpea genotypes grown at 4 locations during the 2002A, 2002B and 2003A seasons[1,2]

Source	Df	Ms
Genotype	7	3716304. ***
Season		2 2076594. ***
Location	3	16333032. ***
Genotype x season	14	754659. ***
Genotype x location	21	1151753. ***
Season x location	2	7338139. ***
Genotype x season x location	14	409589. **
Error	124	150220.

[1] **, *** Significant at 1% and 0.1%, respectively
[2] 2002A, 2002B and 2003A refer to the first (March- July), second (August-December) and first (March- July) seasons of 2002 and 2003, respectively

TABLE 3. Grain yield of the selected cowpea genotypes grown at 4 locations during the 2002A, 2002B and 2003A seasons[1]

Genotype	Kabanyolo	Pallisa	Kumi	Kaberemaido	Mean
IT85F-2841	1378	804	906	1018	1027
IT90K-109 (B)	1025	888	760	2373	1262
IT82D-516-2	1255	776	1047	1688	1191
TVX337-025 (B)	1130	783	647	1096	914
Ebelat	636	685	466	1905	572
MU-93	1347	1208	1235	2153	1586
Iciricukwai	509	868	835	2110	564
KVU-12349	505	350	408	931	505
Grand Mean	973	795	788	1659	958
s.e.d	274.1	274.1	274.1	27.4	274.1
C.V (%)	36.8	36.8	36.8	36.8	36.8

[1] 2002A, 2002B and 2003A refer to the first (March- July), second (August-December) and first (March- July) seasons of 2002 and 2003, respectively

TABLE 4. AMMI-1 ANOVA table of grain yield for eight cowpea genotypes grown in 12 environments (4 locations) during the 2002A, 2002B and 2003A seasons[1,2]

Source	df	SS	MS
Total	383	160101238.92762	418018.90059
Treatment	95	118883494.63562	1251405.20669 ***
Genotype (G)	7	51769837.50484	7395691.07212 ***
Environment (E)	11	41345853.53646	3758713.95786 ***
G X E	77	25767803.59432	334646.79993 ***
IPCA 1	17	11386537.98857	669796.35227 ***
Residual	60	14381265.60575	239687.76010 **
Error	288	41217744.29200	143117.16768

[1] **, *** Significant at 1% and 0.1%, respectively
[2] 2002A, 2002B and 2003A refer to the first (March- July), second (August-December) and first (March- July) seasons of 2002 and 2003, respectively

environments (E) and G X E interaction effects were highly significant ($P \leq 0.001$) on grain yield and accounted for 43.5, 34.8, and 21.7% of the treatment sum of squares, respectively. The AMMI 1 model was used since only one principal component axis (IPCA 1) was highly significant ($P \leq 0.001$) in explaining the interaction between environments and genotypes.

The residual or random variation (noise) effect constituted 12.1% of the treatment sum of squares. Therefore the sum of squares for genotypes, environments and IPCA 1 axis provided 87.9% of the treatment sum of squares which indicated that AMMI 1 model effectively partitioned treatments (IITA, 1997). This implies that the AMMI model could not explain 12.1% (as allocated to the residual term) of the treatment sum of squares. The AMMI biplot of the grain yield data is presented in Figure 1.

The biplot is a two-dimensional graph showing the main effects on the abscissa (x-axis) and the first axis principal component analysis (IPCA) scores on the ordinate (y-axis) and contains two kinds of points for genotypes and environments (Zobel *et al.*, 1998). The AMMI biplot is developed by placing both genotypes and environments means (main effects) on the abscissa, and the respective IPCA 1(eigen vectors) on the ordinate (Kempton, 1984; Zobel, 1990). Genotypes and environments, which appear almost on a perpendicular line, have similar means; those falling on a horizontal line have similar interaction patterns. Genotypes and or environments with large first IPCA scores (either plus or minus) have high interactions; those with values close to zero have small interaction (Hill *et al.*, 1998) and are considered stable (Abalo, 2001). Displacement along abscissa reflected differences in main effects, where as displacement along the ordinate exhibited differences in interaction effects; the biplot accounted for 87.9% of the treatment sum of squares. Genotypes or environment on the same

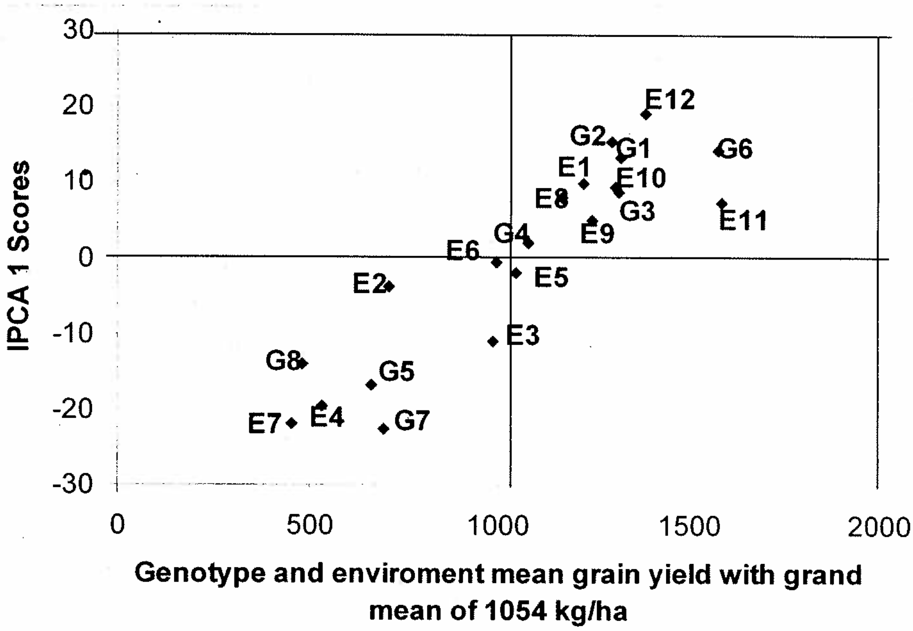

Figure 1. Biplot of additive main effects and multiplicative interaction (AMMI) and the first AMMI interaction (IPCA 1) scores for eight cowpea genotypes grown at 4 locations for 3 seasons (12 environments).

Biplot guide. Environments E1: Kabanyolo season 2002A, E2: Kabanyolo season 2002B, E3: Kabanyolo season 2003A, E4: Pallisa season 2002A, E5: Pallisa season 2002B, E6: Pallisa season 2003A, E7: Kumi season 2002A, E8: Kumi season 2002B, E9: Kumi season 2003A, E10: Kaberamaido season 2002A, E11: Kaberamaido season 2002B, E12: Kaberamaido season 2003A. Genotype codes G1: IT85F-2841, G2: IT90K-109 (B), G3: IT82D-516-2, G4: TVX337-025 (B), G5: *Ebelat*, G6: MU-93, G7: *Iciricukwai*, G8: KVU-12349.

parallel line relative to the ordinate have similar yields (Fig. 1) and genotypes or environments on the right side of the midpoint of the axis have higher yields than those on the left hand side.

The analysis of the biplot revealed that IT85F-2841 (G1), IT90K-109$^{(B)}$ (G2), IT82D-516-2 (G3), TVX 337-025' $^{(B)}$ (G4) and MU-93 (G6) were generally high yielding since AMMI placed them on the right hand side of the mid point of the axis representing the grand mean, 1054 kg ha^{-1} on the biplot. MU-93 was presented as being the overall best. This genotype had the highest mean yield of 1578.6 kg ha^{-1} and a high interaction with the environment (IPCA scores 14.2), however the biplot does not associate it with any specific environment. In contrast *Ebelat* (G5), *Icirikukwai* (G7) and KVU-12349 (G8) were generally low yielding and were placed on the left hand side of the midpoint on biplot. IT90K-109 $^{(B)}$ (G2) and *Icirikukwai* (G7) had the highest IPCA scores (15.4 and -22.7, respectively) therefore were considered as unstable genotypes. Genotypes IT85F-2841, MU-93, IT82D-516-2, KVU-12349 and *Ebelat* had moderate IPCA 1 scores; hence moderately stable. On the contrary TVX337-025 $^{(B)}$ had a low IPCA 1 score and thus was relatively a stable genotype.

With regard to environments and yields, highest yields were observed in Kaberamaido in all seasons and Kabanyolo for 2002A, Pallisa 2002B and Kumi 2002B. Kaberamaido 2002B was the highest yielding environment, producing on average 1385.3 kg ha^{-1} grain yield of cowpea. Environments Kabanyolo 2002B, Pallisa 2002A and Kumi 2002A produced low yields with Kumi 2002A giving the lowest yields.

Overall the biplot grouped the genotypes into six groups: high yielding and unstable (IT85F-2841, IT90K-109 $^{(B)}$ and MU-93), high yielding but moderately stable (IT82D-516-2), high yielding and stable (TVX 337-025$^{(B)}$), low yielding and unstable (*Icirikukwai*), low yielding moderately stable (*Ebelat*) and finally low yielding and stable (KVU-12349). The biplot further revealed that Kumi, 2002A (E7) had the highest eigen (IPCA) vector score (-21.8) followed by Kaberamaido, 2003A (E12) with IPCA score of 19.1 hence they were the most interactive environments while the least interactive environments were Pallisa, 2003A (E6) and Pallisa, 2002B (E5).

Genotype ranking by AMMI estimates. The results of comparative ranking of genotypes by AMMI estimates and unadjusted means for grain yield are presented in Table 5. Within environments, AMMI and unadjusted means ranked genotypes differently. There were no locations where genotypes received similar ranking by both AMMI estimates and unadjusted means, however at Kabanyolo in 2003A, 6 out of 8 genotypes were ranked similarly by both estimates. While AMMI alone ranked MU-93 as the best genotype in all environments, both estimates gave MU-93 as superior in 6 out of 12 environments. On the other hand AMMI estimates reveal KVU-12349 (G8) the least rank (8) at all environments. Genotype KVU-12349 was similarly ranked by AMMI and unadjusted means in 8 out of 12 environments. Although the two estimates could not match all through in the rankings, 8 out of 8 genotypes received similar ranking in at least two environments, implying that AMMI model fitted the data (Egesi and Asiedu, 2002).

DISCUSSION

The yield performance of the improved varieties was generally better than the local checks, which only out yielded one test genotype KVU-12349 at most locations and season. Genotype KVU-12349 was notably long maturing (90-109 days) genotype that took relatively long to flower (53-71 days), so it probably did not receive enough water during the critical stages of flowering and podding since most of the rains occured early in the season. Singh and Rachie (1985) reported the reproductive development, yield potential and seed yield to be notoriously sensitive to vagaries of weather. According to Wien and Summerfield (1984) water shortage has got drastic effects on dry matter production, nitrogen fixation and yield. On the contrary, KVU-12349 together with the local checks could be having inherent inabilities to convert resources to dry matter and yield (Bidinger *et al.*, 1996).

Across locations and seasons the yield of

TABLE 5. Ranking of the genotypes based on AMMI estimates and unadjusted means (in parenthesis) for grain yield in kg/ha of eight cowpea genotypes grown in 4 locations over 3 seasons (12 environments) in Uganda

Environment	IT85F-2841	IT90K-109 (B)	IT82D-516-2	TVX337-025 (B)	*Ebelat*	MU-93	*Iciricukwai*	KVU-12349
Kabanyolo, 2002A	2(2)	3(5)	4(1)	5(4)	7(7)	1(3)	6(8)	8(6)
Kabanyolo, 2002B	3(1)	4(4)	2(5)	5(3)	7(6)	1(2)	6(7)	8(8)
Kabanyolo, 2003A	3(4)	4(2)	3(3)	5(5)	7(7)	1(1)	6(6)	8(8)
Pallisa 2002A	4(5)	6(4)	2(1)	5(6)	7(7)	1(3)	3(2)	8(8)
Pallisa 2002B	3(2)	4(4)	1(5)	5(3)	7(6)	1(1)	6(7)	8(8)
Pallisa 2003A	2(3)	4(5)	3(2)	5(4)	7(8)	1(1)	6(6)	8(7)
Kumi 2002A	6(5)	7(6)	3(3)	4(7)	5(4)	1(1)	2(2)	8(8)
Kumi 2002B	2(2)	3(4)	4(3)	5(5)	6(8)	1(1)	7(6)	8(7)
Kumi 2003A	2(4)	3(1)	4(3)	5(5)	6(6)	1(2)	7(7)	8(8)
Kaberamaido 2002A	2(5)	3(1)	4(5)	5(4)	6(6)	1(2)	7(8)	8(7)
Kaberamaido 2002B	2(4)	3(2)	4(3)	5(5)	6(7)	1(1)	7(6)	8(8)
Kaberamaido 2003A	3(1)	2(3)	4(4)	5(5)	6(6)	1(2)	7(7)	8(8)

improved varieties ranged from 914 – 1586 kg ha^{-1}, which was well above the national average of less than 500kg ha^{-1} (Sabiti *et al.*, 1994). MU-93 the overall best performer across locations with mean yield of 1586 kg ha^{-1} was shown to have a moderate IPCA 1 score and was not associated with any specific environment. This implied that the genotype was relatively stable and adaptable to all environments. The yields tended to be higher in the second season (2002B) with mean yield of 1178 kg ha^{-1} compared to 923 kg ha^{-1} and 961 kg ha^{-1} in the first seasons (2002A and 2003A). This can be attributed to different weather conditions that prevailed. The two first seasons were associated with heavy rains and this favored excessive vegetative growth and fewer pods and thus lower grain yield. In addition first season is reported to exert high pest pressure (Omongo *et al.*, 1997; Karungi *et al.*, 2000). This perhaps explains why many farmers in Uganda grow cowpea mainly in the second season (Isubikalu *et al.*, 1999). Nevertheless second season received lower amount of rainfall, and experiences low pest pressure, but is more associated with frequent attacks of yellow blister and scab diseases (Iceduna *et al.*, 1994; Edema *et al.*, 2000).

The AMMI analysis revealed that the proportion of genotypic variance (43.5%) was greater than that for environments (34.8%) and G X E (21.7%) variance. This meant that variation of genotype performance was mainly due to difference in genetic constitution. From the AMMI analysis, genotypes MU- 93, IT 90K-109^{B}, IT85F-2841, TVX337-025$^{(B)}$ and IT 82D-516-2 were identified as high yielding and highly interactive with high yielding environments. On the other hand, *Ebelat, Icirikukwai* and KVU-12349 were shown to be low yielding and less interactive with the environment. Genotype KVU-12349 the lowest yielding genotype was shown to be the least interactive with environment. This is generally in line with the findings of Hill *et al.* (1998) and Abalo *et al.* (2001) indicated that yield stability is expected from low yielding genotypes that do not benefit from favorable environments.

Ranking by AMMI estimates varied in most locations from ranking by unadjusted means of the data. This concurred with the work of Gauch and Zobel (1989) that AMMI analysis gave an increased accuracy of yield estimates and tended to be less extreme than the observed data. Resistance to biotic stresses in addition to tolerance to common abiotic factors in the environment would ensure good varietal performance (Egesi and Asiedu 2002); and since stability in field performance of genotypes is influenced by prevailing biotic and a biotic stresses (Cock, 1985), for instance resistance to multiple disease and pests guarantees stability of crop performance, more genotypes should be evaluated in unstable environments like Kabanyolo and Kaberamaido to ensure identification of widely adaptable varieties for farmers use.

CONCLUSION

Five out of six improved lines (MU- 93, IT 90K-109[B], IT85F-2841, TVX337-025[(B)] and IT 82D-516-2) were identified as high yielding and highly interactive with high yielding environments, these genotypes out yielded the local checks thus may be used to improve cowpea grain yields in Uganda. Therefore their possible national release should be sought for. Genotype KVU-12349 which was out yielded by the local checks in most of the locations may not be adapted to the Ugandan agroecologies and thus not be useful to the farmers in Uganda.

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