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Research Article

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Cultivar stability and percentage yield of mungbean (*Vigna radiata l. Wilczek*) in a lowland rainforest location in south eastern Nigeria

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Abstract Field study was carried out on a Typic Paleudult Ultisol to determine mungbean cultivars yield stability as well as its percentage yield in Umudike. Results showed that the cultivar VC 6372 (45-8-1) produced the highest yield but a regression coefficient of >1 indicating below average stability, while a coefficient of < 1 each for NM 92, NM 94 and VC 1163 demonstrating above average genotype stability, with VC 1163 being the most stable and consistent cultivar. There was a differential in production efficiency with percentage yield gap that range from 78-88 % between the potential and actual yield. It is concluded that more research is needed in crop management practices relative to genotype improvement in order to significantly close the yield gap.

Keywords Production efficiency, Actual yield, potential yield, crop introduction, yields gap analysis

Introduction

Crop introduction entails bringing a crop from its centre of origin or supposed centre of evolution to another place where it can adapt and survive. The rainforest ecology of Eastern Nigeria agricultural region is highly fragile and sensitive suited to trees and root crops production. Cultivation of pulses in the regions agro ecosystem is almost non existent making it real market price always high and agroecosystemic denied benefits of biological nitrogen fixation. Mungbean (*Vigna radiata*. L.Wilczek) is a low-input, short-duration quality pulse crop of Indian sub continent origin [1]. It has been classified as functional food [2] whose cropping deliver huge benefits to grower's land [3]. Mungbean is reported to have generated substantial positive impact on human nutrition in South Asia, measured as productivity effect [4]. Comprehensive study of the crop in the humid forest agroecosystems of Eastern Nigeria has been undertaken [5-9] in order to provide basis for its popularization and subsequent adoption in farming system of the region.

Crop-weather simulation studies using mungbean with assumed monthly sowing dates showed an average potential yield of 3.5 t/ha with a range of 3.2-3.8 t/ha in Umudike [9]. In order to validate the model results, field experiments are necessary to obtain "actual" or "realized" yield of the crop in the region. Such yield could be compared to the potential yield generated from simulation studies in a yield-gap analysis. Bingham (1967) [10] distinguished between the potential yield of a cultivar in farm cultivation but free from the hazards of lodging, winter killing, pests and diseases and the "realized" yield as a result of these and other stresses. Actual or realized yield therefore represent a fraction of the potential yield at some very favourable confluence of genotype, management, radiation, and temperature. Research goals in general seeks to bridge any gap between "theoretical" or "potential" and the "realized" or "actual" yield through ameliorating constraints that contribute to the productivity gap. Gene expression is subject to modification by the environment, therefore genotype expression of the phenotype is environmentally dependent [11].

Cultivars well adapted to a particular environment effectively balance the time available to growth between producing an adequate vegetative structure and maximum partitioning of assimilate to yield [12]. The technique of stability analysis, where the yield of a variety is regressed on the location – year mean yield of all varieties

[13], provides an indication of variety behavior across changing environments, has really been applied beyond the realm of plant breeding [14]. However, Hildebrand (1984) [15] and Raun *et al.* (1993) [16] applied the technology to evaluate fertility treatment from multiplication and single –site experiments (treatments applied to the same plots year after year), respectively. Stability analysis was assumed to be a means of visually partitioning the treatment x environment interaction, illustrating the effects of fertilizer treatments on grain yield within changing environment. This modification is further extended here with different planting dates substituted for locations to obtain adequate degrees of freedom for weight regression.

The objectives of the research were to (a) evaluate the mungbean cultivar stability and (b) determine the percentage yield of mungbean in Umudike.

Materials and Methods

Field research was carried out in 2013 and 2014 on the teaching and research farm of Michael Okpara University of Agriculture, Umudike located $05^{0}29'$ latitude north and $07^{0}33'$ longitude East and an altitude of 122 m above sea level. The soil is well drained, darkish-brown sandy-loam classified as Ultisol in the soil taxonomy group of Typic Paleudult [17].

Four mungbean cultivars obtained from the Asian Vegetable Research and Development Centre (AVRDC) Taiwan, ROC were evaluated for seed yield amongst other characteristics. Treatments comprised four mungbean cultivars and three sowing dates. The experimental design was a randomized complete block in a split-plot arrangement with four replications. Main plots were the sowing dates: early-season (April 4 2013, April 2 2014) mid-season (2 June 2013 and 3 June 2014) and late-season (12 September 2013 and 10 September 2014). The sub-plots were the four mungbean cultivars: NM 92; NM 94, VC 6372 (45-8-1) and VC 1163.

In each plot measuring 5 m x 2 m, four rows of the appropriate mungbean cultivar were planted at a spacing of 0.5 m x 0.1 m. Weather data during the crop growing period were collected from meteorological station at the National Root Crops Research Institute Umudike located less than 1.5 km to the experimental site.

Crop data: At maturity, harvest data were obtained from a net plot area in the centre of each plot left undisturbed throughout the growth duration. To obtain the yield data, number of plant harvested in $1m^2$ are per plot, pods per plant, seeds per pod and 1000 seed weight were taken. Seed yield (t/ha) was obtained from the following equation.

Number of harvested plants from $1m^2$ x number of pods/plant x number of seeds/pod x weight of 1000 seed x 10^{-5} [18].

Potential yield**:** The potential yield values for the three planting dates were extracted from previous studies [9].

Percentage yield**:** The relationship between actual yield and potential yield.

Percentage yield = actual or realized yield x 100/theoretical or potential yield

Cultivar yield stability: The methods of Finlay and Wilkinson (1963) [19] and Pederson and Lauer (2003) [20] were adapted in the determination and cultivar stability across a range of planting dates. The yield of each cultivar was regressed for each planting date on the mean of all cultivars at those planting dates to determine whether differences existed among cultivars. The production level of each planting date (the trial means) is plotted against X-axis, and the Y – axis represents yield of each cultivar in the trial.

Results and Discussion

Cultivar stability: Cultivar yield stability as indicated by the seed yield across years and sowing dates is shown in figure 1. Pederson and Lauer (2003) [20] used similar techniques to determine genotype and phenotypic stability of different soybean cultivars. The regression coefficient of these cultivars varied significantly from each other. Except VC 6372 (45-8-1) which produced a coefficient of above 1, indicating below average stability, the other cultivars yielded coefficients below 1, reflecting above average stability. From the result, cultivars NM 94 and NM 92 with regression coefficients of 0.73 and 0.98 respectively are highly stable while cultivar VC 1163 with a coefficient of 0.63 is the most stable and consistent cultivar.

Although the cultivar VC 6372 (45-8-1) showed below average stability, it proved to be the most high yielding (Table 1) and likely to be highly responsive to improved growing conditions (e.g. adequate crop protection, appropriate fertilization, optimal water requirements and adjusted plant population, etc). The cultivars NM 94 and NM 92 correspond to [19] highly stable genotypes with actual production levels remaining constant over the sowing dates, and fits [21] description of vertical stability. The cultivar VC 1163 would correspond to [22] cultivar with consistent production in each environment which Blum, (1988) [21] described as horizontal stability.

Salado – Navarro *et al.*, (1993) [23] observed similar results and concluded that older varieties tended to yield equal to or greater than newer cultivars when tested over a wide range of environments. Wilcox *et al* (1979) [24] concluded that older cultivars tested in a number of diverse environments had lower absolute yields compared with modern cultivars, but have equal stability for yield performance. The large variation in yield among these cultivars was likely the result of perhaps the relatively long time span between the releases of these cultivars.

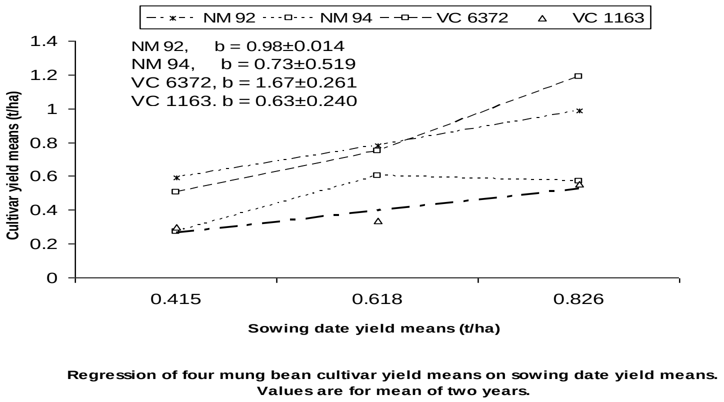

Figure 1: Slope of regression line ± 95% confidence limit

Crop percentage Yield

The potential yield (t/ha) and actual or realized yield (kg/ha) of mungbean in Umudike is shown in Table 2.

Table 1: seed yield of mungbean cultivars at various sowing dates in Umudike

Season	**Seed yield (t/ha)**	
	2013	**2014**
Early	0.84	0.82
Mid	0.61	0.63
Late	0.41	0.42
LSD	0.18	0.14
Cultivars		
NM 92	0.81	0.77
NM 94	0.46	0.48
VC 6372 (45-8-1)	0.81	0.82
VC 1163	0.32	0.42
LSD	0.15	0.14
Season X cultivar	NS	NS

The ratio of actual or realized yield to the potential yield gives an idea of production efficiency of the crop with a value close to 1 indicating small variation and tending to bridge the gap between realized yield and the potential yield of the crop in the given environment. When the production efficiency is expressed in percentage, it becomes the percentage yield of the crop. The largest yield gap of 87.9% exists in the September sowing date while to least gap of 78% exists to be bridged for April sowing date (Table 2). Agugo (2000) [25] obtained a production efficiency of 0.2 or percentage yield of 20% for sunflower grown with minimal inputs in Umudike. Other workers have reported gap between potentially achievable yield and actual seed yield ranges from 26 to 72% for various crops. Swaminathan (1984) [26] recorded relatively small gap between “practical farm yields” and present experimental station yields but a large gap between the latter and the “present farm yield”. Most of the yield gaps are largely due to technical factors [27] while socio-economic factors are also involved to a limited extent [28].

The result suggests that a great deal of research work is needed to remove the biophysical constraints or barriers that account for the 78-89% gap which must be bridged if the new crop is to actualize its potential yield in the region. Beets (1990) [28] reported that improved crop husbandry enhances the plant environment enabling the crop, plant, or genotype to better express the potential. An estimate of potential impact of improved crop husbandry and agronomic practices on output and productivity of crops range from an increase of 50% for appropriate time of planting, optimal fertilization; 40% for adequate weed control; 30% for improved field preparation and tillage practices; use of best variety; and better pest and disease control, to 20% increase for judicious spatial arrangements and adjusted plant population [28].

Table 2: Various yield values of mungbean in Umudike at three different sowing dates

Sowing dates		**Yield**		
	Potential (kg/ha)	**Realized/actual * (kg/ha)**	**Percentage (%)**	**Production efficiency**
April	3,767	830	22.0	0.22
June	3,363	620	18.4	0.18
September	3,426	415	12.1	0.12
LSD	-	160		

*Mean seed yield for 2013 and 2014

Conclusion

It is concluded that the mungbean cultivar VC 6372 (45-8-1) is high yielding with below average stability while the least yielding cultivar VC 1163 appeared to be the most stable and consistent cultivar. More studies involving greater number of mungbean genotypes to elucidate improved management practices would reduce the wide percentage yield gap as obtained in the present trial where weeding was the only applied input.

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