Agronomic Performance and Varietal Evaluation of Cowpea [*Vigna unguiculata* (L.) Walp] under Organic and Inorganic Fertilizers in Sri Lanka

Thaksala, H.P.N. [1*], Samaranayake, B.N. [2], Nanayakkara, D.[1], Amarasingha, R. [1], Gamage, C.S.M.[2], Ranamukaarachchi, S.L.[1]

Sri Lanka Technological Campus (SLTC Research University), Padukka 10500, Sri Lanka [1]

Grain Legume and Oil Crops Research and Development Center, Angunukolapelessa, Sri Lanka [2]

* thaksalanilni@gmail.com

Abstract – Cowpea is a widely cultivated food legume of Sri Lanka. With the banning of the importation of inorganic fertilizers cultivation of cowpea suffered and its prices drastically went up. This necessitated the finding of alternative sources of supplying essential plant nutrients. Six cowpea varieties, viz. *ANKCP 01, ANKCP 02, Dawala, Waruni, ANKCM 13-6,* and *CP 246* were evaluated at Grain Legume and Oil Crop Research and Development Centre, Angunukolapelessa both in field and simulation modeling. Both cowpea varieties and fertilizer management significantly influenced the growth and yield of cowpea. Among the levels of fertility management, the use of DOA recommended practice, and the application of compost at 10 t/ha with the recommended fertilizers significantly improved the growth and Yield parameters, while of the varieties, ANKCP 01 significantly outyielded the rest of the varieties. Crop simulation using APSIM for Dawala variety, a popular variety simulated the same results in this study, which indicated the potential of using the APSIM model for simulating crop growth and yield of cowpea.

Keywords: *Cowpea, Compost, Organic Fertilizer, APSIM*

I. Introduction

Cowpea (*Vigna unguiculata* L. Walp) is a member of the Leguminosae family [1]. The extent of production of cowpea in 2020 was 11,518 ha [4] with total seed production of 13,216 MT by 2020 [5]. Cowpea is grown in a wide range of soil conditions with well-drained loam and in a range of pH of 6-7 [2]. Cowpea thrives in regions with rainfall ranging from 500 to 1500 mm throughout the growing season [3] and at temperatures between 20-35°C [2].

At present, agricultural production in Sri Lanka suffers due to many limitations, and a lack of inorganic fertilizers because of the banning of importation. To maintain the plant protein supply to the population, there is a need for maintaining plant nutrient availability with alternative sources. The use of organic fertilizers is a way to supplement essential nutrients although they contain relatively low nutrient contents. Cowpea being a legume, possesses the ability to fix atmospheric nitrogen (N) [6]. The cultivation of cowpea would help reduce or avoid the application of inorganic fertilizers to supply N, which is a major essential nutrient of every crop. Hence, there is a need of testing potential alternatives to determine their ability to supplement N and other essential nutrient requirements to maintain the growth and yield of cowpea.

Agricultural system simulation models could be a useful tool to assess the performance of crops under different management systems. In direct agronomic research, resource requirements such as time, labor, and cost are compared with on-farm trials. This is time-consuming. The use of crop simulation helps decision-making effectively and allows the exploration of options that would not be possible using field experimentation-only approaches. In the present study, Agricultural Production Systems Simulator (APSIM) model was used to simulate the fertilizer performance of selected cowpea varieties.

II. Materials and Methods

This study was composed of two parts: 1) study the effects of fertility management on the performance of selected cowpea varieties, and 2) evaluate the performance of crop simulation using the APSIM model for predicting the growth and yield of cowpea.

The first part was a field study conducted at the Grain Legume and Oil Crop Research and Development Centre (GLOCRDC) at Angunukolapelessa in the southern province of Sri Lanka. The experimental site lies at coordinates N 6^0 9' 56.05'' and E 80^0 54' 11.22''. The experimental treatments were arranged in a Split Plot Design in a randomized complete block design with three replicates. Twenty-four treatments composed of 4 x 6 factorial combinations were tested. Four levels of soil amendments included no fertility management (control), compost at 6 mt/ha, compost at 10 mt/ha, and the Department of Agriculture (DOA) recommendation (application of compost at 10 mt/ha and N, P, and K at 16, 19.7, and 37.5 kg/ha, respectively using urea, triple super phosphate, and muriate of potash, respectively at basal dressing, and 13.8 kg/ha of N in the form urea at top dressing), while six varieties of cowpea recommended by the DOA, viz. *ANKCP 01, ANKCP 02, Dawala,* and *Waruni, ANKCM 13-6,* and *CP 246.* The fertility management practices were assigned to main plots and the varieties to subplots. Both growth and yield data were gathered during the study.

The normal data were analyzed using the Analysis of Variance (ANOVA) in SAS. When the factors were significant at $p \leq 0.05$ the means were separated using Fisher's Protected Least Significant Difference (LSD) procedure.

In the crop simulation study, the cowpea variety Dawala was used and the APSIM – cowpea module in the APSIM version 7.10 was used for growth and yield simulation. Data required for model parameterization and validation were obtained from the Grain Legume and Oil Crop Research and Development Centre (GLOCRDC) at Angunukolapelessa. Daily weather data, i.e., daily maximum and minimum temperatures, rainfall, sunshine hours, and soil data, i.e., physical and chemical properties, were obtained from the GLOCRDC and used.

III. Results and Discussion

A. Field Experiment

Performance of cowpea

The growth of cowpea was significantly influenced by both fertility management and varieties. Among the growth parameters, DOA recommended fertility management practice gave significantly the highest plant height, leaf area index

(LAI), highest chlorophyll content, and the highest branches per plant compared to the rest of the practices, except for 10 t/ha of compost use. The lowest values were observed in the control that received neither compost nor inorganic fertilizers. The variety influence was variable among the growth parameters.

Phenological stages

The time to reach growth also varied significantly among the cowpea varieties, though the differences were in the range of 1-3 days.

Seed yield of cowpea

The seed yield of cowpea ranged from 766 to 1350 kg/ha, and the highest yield was in the DOA recommended practice (1350 kg/ha) (Table 1). However, the application of 10 mt/ha alone had a non-significant seed yield (1177 kg/ha) to the DOA recommended practice. The lowest seed yield was in the control plots (749 kg/ha).

Among the varieties of cowpea used, ANKCP 01 (1468 kg/ha) had the highest seed yield while ANKCM 13-6 (1329 kg/ha) had non-significantly lower seed yield.

Table 1. Effects of fertility management and varieties on the number of pods per plant, 100-seed weight, seed yield, and gross income of cowpea.

Treatment 1/	No. of pods Per plant	100-seed weight g	Seedyield kg/ha	Gross income Rs./ha 3/
Fertility management				
No fertility management	16.18 c	16.56	749.18 c	374,592 c
Compost at 6 t/ha	22.13 b	16.89	1075.82 b	537,908 b
Compost at 10 t/ha	23.36 ab	17.06	1176.74 ab	588,370 ab
DOA Recommendation 2/	25.20 a	16.72	1350.07 a	675,037 a
LSD (p≤0.05)	2.34	ns	188.81	94,406
Cowpea variety				
ANKCP 01	20.13 b	17.83 a	1468.20 a	734,110 a
ANKCP 02	20.28 b	22.83 a	951.60 c	475,778 c
Dawala	22.14 b	17.33 b	810.90 c	405,445 c
Waruni	25.76 a	12.58 d	1329.70 b	664,862 ab
ANKCM 13-6	22.29 b	15.25 c	1200.70 b	600,333 b
CP 246	19.78 b	15.00 c	766.70 c	383,333 c
LSD (p≤0.05)	2.62	1.19	231.25	115,623
CV%	14.62	8.55	25.76	25.76

Legend:1/ LSD - Least significant difference; CV – Coefficient of variability
2/ DOA Recommendation includes application of compost at 10 t/ha and the use of recommended fertilizers., N, P, and K at 10, 7.0, and 50kg/ha, respectively.
3/ Gross income was calculated assuming a current farmgate price of Rs.500/-per kg of seeds.

Gross income

Among the gross income, the highest was in the DOA recommended fertility management practice (Table 1). However, there was no significant difference between the same treatment and 10 t/ha of compost treatment. Yet the difference was Rs. 86,667 per hectare. The rest had lower gross income values.

The varietal difference for seed yield clearly existed. The highest gross income was found in the variety ANKCP 01 (Rs. 734,110/ha). Although the variety Waruni had non-significantly lower gross income, it was Rs. 69,248/ha.

B. Modelling Experiment

Prediction of cowpea seed yield with APSIM-cowpea model for Dawala variety as shown in Figure 1 had a coefficient of variability (CV%) was 10.2 % and 0.3 % and a standard deviation of 46.46 and 1.22 for seed yield and days to flowering, respectively. The CV value of less than 20% indicates as good fit of models (REF). This indicated the potential of simulating the seed yield of cowpea varieties.

The simulated and observed yield of Dawala under fertility management practices confirmed its potential use in future research. The predicted and observed gap was due to unexpected submergence of a plot because of heavy rains that reduced the mean seed yield of the same variety.

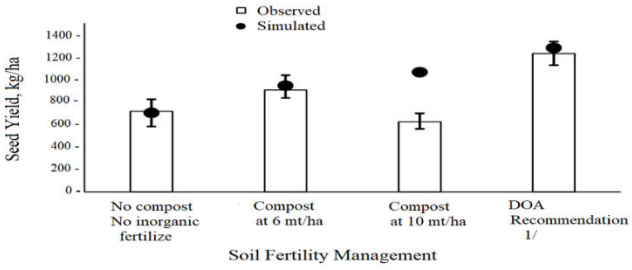

Figure 1. Simulated and observed seed yield of Dawala variety of Cowpea by the APSIM-Cowpea Model.

Legend: 1/ DOA Recommendation includes application of compost at 10 t/ha and the use of recommended fertilizers., N, P, and K at 10, 7.0, and 50kg/ha, respectively.

IV. Conclusion

The results of the field experiment, it can be concluded based on growth and yield parameters and growth parameters that the use of compost as a soil amendment provides beneficial effects. In addition, organic amendments improve soil physical characteristics thus increasing the efficiency of applied inorganic fertilizers. This has been clearly shown based on the differences among no fertility management, use of 10 t/ha compost and the latter with the addition of inorganic fertilizers as per the DOA recommendation. Varietal effects is seen clearly and ANKCP 01 giving highest yields.

The results of the crop simulation using APSIM showed its future potential to predict seed yield of cowpea.

The current study helps recommend the use of compost at 10 mt/ha combined with the DOA recommendation of inorganic fertilizers over 10 mt/ha compost alone as the recent prices provide higher advantages to the growers.

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